Thurrock Strategic Flood Risk Assessment
Level 1 Report

Final Report
September 2009

Prepared for

THURROCK COUNCIL

Revision Schedule

Thurrock Strategic Flood Risk Assessment: Level 1 Report
September 2009

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Acronyms and Abbreviations

Abbreviation	Description
AONB	Area of Outstanding Natural Beauty
BAR	Broad Areas for Regeneration
BGS	British Geological Society
CFMP	Catchment Flood Management Plan
CLG	Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DPD	Development Plan Document
DTM	Digital Terrain Model
FRA	Flood Risk Assessment
GIS	Geographical Information System
IDB	Internal Drainage Board
KCDC	Key Centre for Development and Change
LDDs	Local Development Documents
LDF	Local Development Framework
LDS	Local Development Scheme
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
ODPM	Office of Deputy Prime Minister
PCPS 2004	Planning and Compulsory Purchase Act 2004
PPS	Planning Policy Statement
RBMP	River Basin Management Plan
RFRA	Regional Flood Risk Appraisal
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy (East of England Plan)
SA	Sustainability Appraisal
SAC	Special Area for Conservation
SFRA	Strategic Flood Risk Assessment
SPA	Special Protection Area
SPD	Supplementary Planning Document
SPZ	Source Protection Zone
SUDS	Sustainable Drainage Systems
WCS	Water Cycle Study
WFD	Water Framework Directive

Glossary

Term	Definition
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert	A channel or pipe that carries water below the level of the ground.
Flood Defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Inundation	Flooding.
Local Development Framework (LDF)	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Local Planning Authority (LPA)	Body that is responsible for controlling planning and development through the planning system.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Risk	The probability or likelihood of an event occurring.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

Table of Contents

1 Non-Technical Summary

1.1 SFRA Background

Scott Wilson Ltd was commissioned by Thurrock Borough Council (BC) to undertake a review of the Strategic Flood Risk Assessment (SFRA) for their local authority area. This project has been carried out in collaboration with the Environment Agency's Anglian and Thames Regions.

The Thames Gateway South Essex SFRA was carried out by Scott Wilson in 2006 and addressed flood risk across the whole of South Essex. This report is due to undergo review and update; however, in order to achieve the projected timescale for their Local Development Framework, Thurrock BC has commissioned this SFRA separately from the TGSE Partnership.

1.2 SFRA Planning Objectives

The primary objective of the study is to enable Thurrock BC to undertake the Sequential Test inline with the Government's flood risk and development policy document - Planning Policy Statement 25 (PPS25): '*Development and Flood Risk'* - to inform the development of their emerging Local Development Framework (LDF) documents. In particular this study will form the evidence based for the development of the Core Strategy DPD, Site Specific Allocations and Policies DPD and the Minerals and Waste DPD.

PPS25 requires Thurrock BC to review flood risk across their district, steering all development towards areas of lowest risk. Development is only permissible in areas at risk of flooding in exceptional circumstances where it can be demonstrated that there are no reasonably available sites in areas of lower risk, and that the development provides wider sustainability benefits that outweigh the risk of flooding. Such development should incorporate mitigation/management measures to minimise risk to life and property should flooding occur.

The SFRA is the first step in this process. It will assist with the development of LDF documents by identifying flood risk areas and outlining the principles for sustainable development policies, informing strategic land allocations and integrating flood risk management into the spatial planning of the area. The SFRA thereby forms an essential reference tool providing the building blocks for future strategic planning.

1.3 SFRA Report Layout

In accordance with recommendations within the PPS25 Practice Guide, this SFRA has been structured in two phases. This report forms a Level 1 SFRA, which provides an overview of the flood risk issues throughout Thurrock in order to facilitate a sequential approach during the allocation of sites for future development.

1.4 Thurrock Borough Council Considerations

The study area covers the administrative area of Thurrock BC within South Essex. It is bordered by the River Thames to the south and Greater London to the west; and to the north and east by the districts of Basildon, Brentwood and Castle Point.

The study area covers approximately 160 km^2, most of which is low lying. It can be divided into two broad areas; the more heavily developed alluvial marshes adjacent to the River Thames; and the sparsely populated low lying valleys in the central and northern parts of the district.

Land use immediately adjacent to the Thames Estuary is predominantly industrial, including the Tilbury Docks, areas around the West Thurrock Marshes and Purfleet; and the Petrol Plus oil refinery on the eastern edge of the district. Residential land use is concentrated within Stanford-le-Hope/Corringham, Tilbury, Chadwell St Mary, Grays, West Thurrock, South Ockendon and Aveley.

In the central and northern district land use is semi rural with large open spaces. Strips of open space and public access land also follow the River Mardyke that flows through this part of the Thurrock district.

1.4.1 Flood Risk

The main sources of flooding for this area are the River Thames Estuary; the River Mardyke, which discharges into the Thames Estuary at Purfleet; the Stanford Brook; and the arterial drainage network which drains low lying areas of Thurrock to the River Thames.

The most significant events in this area, in terms of potential for flooding, tend to be storm surges coupled with high spring tides which produce high tidal water levels in the Thames Estuary. Additionally, the River Mardyke poses some fluvial flood risk in the northern part of the district.

The study area was flooded during the North Sea storm surge in January/February 1953, which affected much of the east coast of England. The River Mardyke also has the potential to cause flooding and flood alleviation measures have been put in place to mitigate adverse effects during extreme rainfall events.

In addition to tidal and fluvial sources, this study considers the risks associated with groundwater, surface water, sewer flooding and flooding from artificial sources.

1.4.2 The Sequential Test

The Sequential Test outlined in PPS25 aims to steer development to areas of lowest flood risk. The SFRA aims to facilitate this process by identifying the variation in flood risk across Thurrock and allowing an area-wide comparison of future development sites with respect to flood risk.

Thurrock has been delineated into the Flood Zones outlined in PPS25 as Flood Zone 1, low probability, Flood Zone 2, medium probability, Flood Zone 3a, high probability and Flood Zone 3b functional floodplain. Table D.1 of PPS25 provides information on which developments might be considered appropriate in each Flood Zone, subject to the application of the Sequential Test and the Exception Test, as well as a site-specific Flood Risk Assessment (FRA).

In order to provide additional information regarding the nature of flood risk within these Flood Zones, Hazard mapping for the present day (2009) has been included in the Level 1 SFRA. The hazard rating has been calculated for the flood risk associated with fluvial systems and the flood risk resulting from breaches in tidal defences. Flood risk is divided into four hazard categories, Extreme, Significant, Moderate and Low, based upon the depth and velocity of flood water.

In accordance with PPS25, Thurrock BC will use the Flood Zone mapping and Hazard mapping presented within this SFRA to complete the Sequential Test during the production of their spatial strategies. The Sequential Test identifies the flood risk and vulnerability of various proposed developments in order to assess the suitability of each development location, and where possible to steer more vulnerable developments to areas of lower flood risk.

1.4.3 The Exception Test

Where the Sequential Test demonstrates that it is necessary to locate a particular development in a flood zone because no land of a lesser flood risk exists, there will be some circumstances when the Exception Test will also need to be applied. Table D.3. of PPS25 summarises the instances in which the application of the Exception Test is necessary. All three elements of the Exception Test, as set out in paragraph D9 of

PPS25 must be passed in order to establish the principle of development and satisfy the requirements of PPS25.

The purpose of the Exception Test is to ensure that new development is only permitted in medium and high flood risk areas in exceptional circumstances i.e. where flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, taking the impacts of climate change into account.

1.5 Way Forward

The risk of flooding posed to development within the study area arises from a number of different sources including tidal flooding, river flooding, groundwater, surface water flooding as well as flooding from sewers.

A spatial planning solution to flood risk management should be sought wherever possible. It is necessary for Thurrock BC to consider, through the application of the PPS25 Sequential Test, how to steer vulnerable development away from areas affected by flooding. This should also take into consideration other relevant strategies and studies in the area seeking to reduce flooding to those already at risk.

Where other planning considerations must guide the allocation of sites and the Sequential Test has been satisfied, further studies can be carried out to assist Thurrock BC and developers to meet the Exception Test. These will be detailed in a Level 2 SFRA following completion of the Sequential Test.

Engagement with the Emergency Planning Team, Local Resilience Forum and emergency services is imperative to minimise the risk to life posed by flooding within Thurrock. It is understood that Thurrock BC are in the initial stages of preparing a flood risk response plan for the borough. We recommend that the findings and recommendations from the Level 1 SFRA are taken into consideration during the preparation of the flood risk response plan.

In the light of the recommendations from the Sequential Test report for Thurrock (prepared by Scott Wilson, 2009), it is considered likely that details of emergency planning procedures will be required in order for development to pass the Exception Test and be considered 'safe'.

1.6 A Living Document

The SFRA has been completed in accordance with PPS25 and it supporting Practice Guide (June 2008).

The SFRA has been developed by building heavily upon existing knowledge with respect to flood risk within Thurrock. Further modelling may significantly improve current knowledge of flood risk within Thurrock over time, and may alter predicted flood extents. This may therefore influence future development control decisions within these areas.

In summary, it is imperative that the SFRA is adopted as a 'living' document and is reviewed regularly in light of emerging policy directives and an ever improving understanding of flood risk across Thurrock.

2 Introduction

2.1 Overview

The Planning and Compulsory Purchase Act 2004 (PCPA 2004) requires Local Development Documents (LDDs) to undergo a Sustainability Appraisal (SA), which assists Planning Authorities in ensuring that their policies fulfil the principles of sustainability.

Strategic Flood Risk Assessments (SFRAs) constitute a component of the SA process and should be used in the review of LDDs or in their production.

The introduction of Planning Policy Statement 25 (PPS25): '*Development and Flood Risk'* promotes a positive approach to planning, taking due consideration of flood risk, in order to deliver appropriate sustainable development in suitable locations. PPS25 and its supporting Practice Guide, published in June 2008, emphasise the active role that Borough Councils should have in ensuring that flood risk is considered in strategic land use planning.

To assist in strategic land use planning, the SFRA should present sufficient information to enable Thurrock Council to apply the Sequential Test to their proposed development sites. The Sequential Test seeks to guide development to areas of lowest flood risk or, where necessary, to ensure development vulnerability is appropriate to the flooding probability of an area. To achieve this, SFRAs should have regard to river catchment-wide flood issues and also involve a – '*process which allows the Local Planning Authority to determine the variations in flood risk across and from their area as the basis for preparing appropriate policies for flood risk management for these areas'.*

In addition, where development sites cannot be located in areas of lesser flood risk, "*the scope of the SFRA should be increased to provide the information necessary for the application of the Exception Test."*

2.2 Aim of the SFRA

Scott Wilson was commissioned to develop a SFRA for the Thurrock area. The primary purpose of the SFRA is to determine the variation in flood risk across the area. Robust information on flood risk is essential to inform and support Thurrock BC's revised flooding policies in their emerging Local Development Framework (LDF).

2.3 SFRA Objectives

Inline with the PPS25 Practice Guide, the objectives of this SFRA are to:

- Identify the extent of all PPS25 Flood Zones across the study area, with particular focus on areas within Flood Zone 3 and areas where new development is likely to be concentrated;
- Identify areas at risk of flooding from all potential sources within the study area;
- Provide evidence-based reports which inform Thurrock BC's Local Development Framework and other Development Planning Documents about managing potential flood risk and are also suitable to inform the Sustainability Appraisal of related documents;
- Provide an assessment of flood risk to and from proposed minerals and waste sites to inform the Minerals and Waste Development Framework;
- Advise Thurrock BC on suitable polices to address flood risk management in a consistent manner across Thurrock;

- Advise Thurrock BC on the baseline requirements of site-specific Flood Risk Assessments based on local conditions and policy recommendations;
- Advise Thurrock BC on the objectives of Sustainable Drainage Systems throughout the study area, including soil conditions and suitability; and,
- Present sufficient information to inform Thurrock BC and Local Resilience Forum of the flood considerations necessary in emergency planning.

2.4 SFRA Structure

The PPS25 Practice Guide recommends that SFRAs are completed in two consecutive stages. This provides Thurrock BC with tools throughout the LDF and SFRA process sufficient to inform decisions regarding development sites.

2.4.1 Level 1 SFRA – Study Area, Flood Source Review & Data Review

The objective of the Level 1 SFRA is to collate and review available information on flood risk from all sources of flooding within the study area. Information has been sought from a variety of stakeholders including the Environment Agency, Anglian Water, Essex and Suffolk Water and Thurrock BC.

The deliverables from the Level 1 SFRA should be used by Thurrock BC to complete the Sequential Test, and to establish whether development can be located within areas of low flood risk, or whether areas of higher flood risk will need to be considered and the sequential approach and Exception Test applied. Where the Sequential Test identifies the need to develop in areas at risk of flooding, further data collection and/or analysis will need to be carried out in a Level 2 report.

This report presents the findings of a Level 1 SFRA study.

2.4.2 Level 2 SFRA – Detailed Assessment

The purpose of the Level 2 stage is to provide more detailed information regarding the flood risk posed to the area, taking into account the presence of current flood risk management measures such as flood defences. This will allow for a sequential approach to be applied within a flood zone and inform the application of the Exception Test where necessary.

The increased scope Level 2 SFRA incorporates consideration of residual risk in the event of a breach in the defences. Outputs of the Level 2 include maps showing the nature of flood hazard, including variation in floodwater depth and velocity, hazard classification and time to inundation. This will continue to enable a sequential approach to be maintained for site allocation within a Flood Zone. This information will supplement the Level 1 SFRA to provide Thurrock BC with an evidence base sufficient to inform the strategic planning of Thurrock.

3 Sources of Flooding In Thurrock

The study area is defined by the administrative area of Thurrock BC within South Essex and is shown in Figure 1. The study area covers approximately 160 km^2 of land and includes the heavily developed alluvial marshes adjacent to the River Thames, and the sparsely populated valleys in the central and northern parts of the district. An overview of the study area, with respect to flood risk, is presented below.

3.1 History of Flooding in Thurrock

South Essex has historically experienced flooding on a large scale, which is of no great surprise given its location adjacent to the River Thames estuary system. The South Essex area has suffered two major flood events during in the 20th century; in 1928 and 1953. The 1953 flood affected eastern England and had the most significant impact with 307 people losing their lives, a further 30,000 being evacuated and 24,000 properties destroyed. The overall cost of the disaster is estimated at over £5 billion in the current economic state.

In January 1953, a major storm surge coincided with a high spring tide and resulted in the widespread flooding. Flood levels at Tilbury reached six feet above its predicted level and inundation depths were approximately 2-3m (Thamesweb 2003). Major devastation was commonplace throughout other areas of the region following the flood event, none more so than Canvey Island, just to the east of the Thurrock district, where 58 of the 307 fatalities occurred. Canvey Island acts as an example of the unpredictable nature of flooding: the 1953 floods occurred despite extensive flood defence operations following the minor flood event in 1938 (Barsby, 2001).

In response to the major flood events, the UK Government initiated the construction of an improved flood defence scheme. Flood defence measures include barriers at Purfleet, Grays, Tilbury, Tilbury Fort, Shell Refinery, Canvey Island and the Holehaven and Benfleet barriers, as well as many kilometres of raised walls in both the upper and lower reaches of the estuary. The loss of life during the 1953 floods could have been avoided through a more comprehensive forecasting and warning system. Therefore, in addition to the hard-engineered structural defences, the local authorities also aimed to improve the warning systems in the area (Thamesweb, 2003).

3.2 Local Rivers

3.2.1 River Thames Estuary

The River Thames poses the greatest flood risk to Thurrock. It flows from the Cotswolds through London and divides the southeast into the counties of Essex and Kent before meeting the sea at Southend. The section of the Thames within the Thurrock study area has a continuous form of flood defence from the River Mardyke in the west to Fobbing Horse Barrier in the east. The defences along the Thames frontage of Thurrock are predominantly defined as ‘hard defences’, and provide a high but varying standard of defence, offering protection up to, and in excess of, a 1 in 1000 year level.

Extreme water levels can be generated in the Thames Estuary by intense low pressure systems over the North Sea, which artificially increase sea levels due to the pressure differential. This effect, combined with wind and wave action, is referred to as a storm surge. The height of the surge typically increases as the weather system travels south, and the North Sea becomes narrower and shallower causing a funnelling effect. The highest water levels in the North Sea will be generated when storm surges are combined with high spring tides generated by gravitational forces.

The Thames Tidal Barrier lies 7km upstream from the Thurrock's westerly boundary and provides the city of London with a high standard of river and tidal flood defence. Tidal barriers have also been constructed at the mouth of Tilbury Docks to protect this area, much of which is at or below mean high tide level.

3.2.2 River Mardyke

The River Mardyke drains a semi rural catchment of approximately 112km^2 and has a main river length of 18.5km. Beginning in the Brentwood Hills, the River Mardyke has two main sources at Langdon Hills and Cranham. The tributaries then converge to flow through a more enclosed valley, eventually discharging into the River Thames at Purfleet.

The land in the north of the catchment comprises open space and public access land, and there are a number of tributaries and agricultural drains across the Thurrock Plain which feed into the River Mardyke. The catchment is generally low-lying, with low channel gradients and therefore has a wide floodplain. This area is predominantly rural and therefore there are few population centres under threat from flooding associated with the River Mardyke.

In the south there is more development including residential and industrial land uses. Downstream of Orsett Fen the topography begins to increase and restricts the floodplain, which results in a greater risk of flooding to residents in Purfleet.

The River Mardyke has been modified as part of a flood relief scheme. This includes channel widening and raised banks to protect it from flooding except in extreme events. Wooden floodgates exist on the River Mardyke, where it joins the Thames at Purfleet. These gates are self-activating, closing under pressure from the rising Thames, thereby protecting the River Mardyke from excessive tidal movements.

3.2.3 Stanford Brook

The Stanford Brook has a small catchment and flows southwards through Stanford-le-Hope and the Mucking Marshes into the Thames Estuary. In Stanford-le-Hope the Victoria Road Brook joins the Stanford Brook. Due to the higher surrounding topography and its urban nature, this catchment responds rapidly to rainfall and a number of properties are therefore at risk from fluvial flooding.

3.2.4 Vange Creek / Holehaven Creek

The eastern edge of the study area includes the marshes of Fobbing and Vange which drain into the Vange Creek and the Holehaven Creek Sites of Special Scientific Interest. These watercourses then flow to join the Thames Estuary at the Sea Reach section. Before the 1953 floods, the route along the Vange Creek was navigable to the sea. There are now several flood barriers across the creek, forming part of the flood defence system for this area.

3.2.5 Arterial Drainage Networks

A collection of drainage channels drain large areas of Thurrock including West Thurrock and Tilbury, as well as the northern parts of the study area in the River Mardyke catchment. Urban areas along the edge of the Thames Estuary generally have a combination of gravity outfalls and pumps and low lying areas around Tilbury have numerous pumping stations to drain the marsh areas. The grazing marshes have extensive channel networks to provide storage when the gravity outfalls are tide locked and the control of water levels has an important influence on their habitat and landscape value.

The arterial drainage network may experience flooding as a result of the following; high rainfall events in the local catchment, blocked channels, rainfall exceeding pump capacity at channel outlets or pump failure at the downstream end of drainage channels, which may cause out of bank flows or the backing up of water behind defences at the channel outlets.

3.3 Hydrogeology / Groundwater

The Solid and Drift deposit geologies of the area have been established from British Geological Survey mapping. This information has been reproduced as Figures 2A and 2B.

Adjacent to the Thames Estuary, the Solid geology is Chalk and Red Chalk; to the north there is a band comprising Oldhaven, Blackheath, Lambeth Group and Thanet Beds; and to the north of the A13, these layers are overlain by London Clay.

The Chalk is the principle underlying aquifer in the area. Rainfall percolates into the aquifer and recharges it. The London Clay prevents infiltration of rainfall over the northern part of the study area and may therefore encourage flows of surface water; the River Mardyke responds rapidly to heavy rainfall, which is linked to the impermeable London Clay underlying the upper catchment.

The Drift deposit geology consists of Alluvium in the south of the study area, adjacent to the Thames Estuary. Alluvium is also present within the floodplain of River Mardyke in the northern part of the study area. Alluvium consists of clays, silts, sands and gravels and the permeability can be highly variable depending on the exact composition of the material. Since this material has been deposited in riverbeds, it tends to be relatively impermeable. In between these two areas of Alluvium, there runs a band of undifferentiated river terrace deposits.

3.4 Sewers

All sewer systems are typically designed to accommodate rainfall events up to a 1 in 30 year return period. Consequently, rainfall events with a return period greater than 1 in 30 years would be expected to result in flooding of some parts of the sewer system.

In addition, as towns and villages expand to accommodate growth, the original sewer systems are rarely upgraded and may become overloaded. This problem is compounded by climate change, which is forecast to result in milder wetter winters and increased rainfall intensity in summer months. The combination of these factors will increase the pressure on existing sewer systems, effectively reducing their design standard and increasing the frequency of flooding.

3.5 Overland Flow / Surface Water Flooding

Surface water flooding typically arises because of intense rainfall, often of short duration, that is unable to soak into the ground and/or enter drainage systems. It can run quickly off land and result in localised flooding. . The Pitt Review (2008) revealed that two-thirds of the flooding in Summer 2007 was a result of surface runoff in urban areas, as rainwater runs over the surface of the ground or ponds in low lying areas, and there is a growing likelihood of similar flooding in the future.

The key factors for surface water flooding are the volume of rainfall, its location and its intensity.

In urban areas, overland flow typically occurs during sudden and intense rainfall events when surface water cannot enter conventional drainage systems quickly enough, or where the finite design capacity of these systems is overwhelmed. There is therefore an inherent link between sewer flooding and overland flow/surface water flooding. This form of flooding is likely to occur in the urban parts of Thurrock such as Purfleet, Thurrock, Grays, Tilbury and Stanford-le-Hope. Strategic mapping and historic records of surface water flooding events are detailed further in Chapter 6.

Large areas of impermeable surfaces, such as car parks and paving areas, are likely to be created during future development and these will generate large volumes of surface water runoff during rainfall events unless suitable mitigation measures, such as flood routing are implemented.

In Thurrock, the presence of impermeable clay soils also intensifies this source of flooding since the ability for water to be absorbed into the ground is limited.

3.6 Artificial Sources

Artificial sources include any water bodies not covered by the previous categories. These typically include canals, lakes and reservoirs. The most well known lake in Thurrock is Alexandra Lake, a 6 hectare lake adjacent to the Lakeside Shopping Centre which provides facilities for water sports and activities.

There are numerous other water bodies throughout the Thurrock district, predominantly located within parks and used for nature conservation and recreational purposes. Grangewaters Park contains two lakes used for fishing and water sports. There are two lakes in Belhus Woods Country Park and a pond used entirely for wildlife and conservation purposes with reedbeds and marginal vegetation, as well as further lakes used for recreational activities. Warren Gorge has been formed from a disused chalk quarry and is an open site containing areas for nature conservation.

4 Policy Context

4.1 Introduction

This chapter provides a summary of both national and regional policies that provide direction and guidance with respect to flood risk. The information presented in the SFRA should be used by Thurrock BC to establish robust policies in relation to flood risk as part of their emerging Local Development Framework (LDF) due for completion in 2010.

4.2 National Policies

4.2.1 Making Space for Water

In 2004 the Government's Making Space for Water strategy set out a new national direction for flood risk management planning in England over the next 20 years. The report recognised the requirement for a holistic approach between the various responsible bodies, including flood defence operating authorities, sewerage undertakers and highways authorities, to achieve sustainable development. The report also highlighted the need for a more integrated approach to urban drainage. The protection of the functional floodplain forms an integral aspiration of the strategy.

In February 2009, Defra published a technical guidance document for preparing Surface Water Management Plans (SWMPs) inline with the objectives and principles of the first Government response to Making Space for Water consultation (March 2005) for better integrated urban drainage management.

The guidance also forms part of the Government's response to Sir Michael Pitt's Review of the Summer 2007 floods, in particular recommendation 18 which suggested that "local surface water management plans as set out under PPS25 and co-ordinated by local authorities should provide the basis for managing all local flood risk".

A number of SWMPs have been prepared using the Living Draft guidance. Outputs from these initial plans will be used to update the guidance, with a revised version available in the autumn/winter 2009.

Amongst several other key drivers[1], the Making Space for Water document intended to improve the manner in which land use planning was undertaken. Since 2004, the particular goals alluded to in this document have been achieved. The Environment Agency's role as a statutory consultee has been extended in areas that are at risk of flooding. An integral part of this new direction for flood risk management planning in England was the production of a new Planning Policy Statement (PPS). As discussed within the Making Space for Water document itself, the intention was 'to replace and improve the operational effectiveness of', Planning Policy Guidance Note (PPG) 25. The overriding document PPS25 was released in December 2006 and is discussed below.

4.2.2 Planning Policy Statement 25: Development & Flood Risk

Planning Policy Statement 25 requires that local planning authorities achieve the following when preparing the local development framework:

1. Set out policies that seek to avoid flood risk wherever possible and manage it elsewhere;

[1] Including coastal erosion, management of water in a rural setting, improved provision of data and research and an improved incorporation of the three pillars of sustainable development (i.e. economic, social and environmental) in risk management activities.

2. Seek opportunities to relocate particularly vulnerable developments to locations at less risk of flooding, taking into account the impacts of climate change;
3. Safeguard land from development that is required for current and future flood management.
4. Allocate all proposed development sites in accordance with the 'Sequential Test', reduce the flood risk and ensure that the vulnerability classification of the proposed development is appropriate to the Flood Zone classification;
5. Require site-specific Flood Risk Assessments to be submitted for all developments within Flood Zones 2 and 3 or over 1 hectare in size in Flood Zone 1 and for sites with identified flood sources, to assess the risk of flooding to the development and identify options to mitigate the flood risk to the development, site users and surrounding area;
6. Flood Risk to development should be assessed for all forms of flooding;
7. Where floodplain storage is removed, the development should provide compensatory storage on a level for level and volume for volume basis to ensure that there is no loss in flood storage capacity.

PPS25 aims to ensure that flood risk is taken into account at all stages in the planning process from the inception of regional and local policy through to individual development control decisions.

The document seeks to avoid inappropriate development in areas at risk of flooding and to direct development away from areas of high risk through the application of the sequential approach and the precautionary principle. It is acknowledged that, in some exceptional circumstances, it might not be possible to deliver available sites in lower risk zones through the sequential approach. Here policy will aim to ensure that the development will be safe, without increasing flood risk elsewhere and, where possible, reducing flood risk overall.

4.3 Regional Policies

4.3.1 Regional Spatial Strategy: East of England Plan, 2008

The East of England Plan or Regional Spatial Strategy (RSS), published in May 2008, sets out the regional strategy for planning and development in the East of England to the year 2021. The Plan provides policy direction for matters such as economic development, housing, the environment, transport, and waste management.

Whilst the RSS covers the period to 2021, it also provides a vision, objectives and core strategy for the longer term. It particularly seeks to reduce the region's impact on and exposure to, the effects of climate change and aims to formulate a development strategy with the capability to support continued sustainable growth beyond 2021.

The RSS recognises the need to put in place a framework for sustainable development to address housing shortages and support continued economic growth whilst improving energy efficiency, carbon performance, water efficiency and recycling an increasing percentage of waste.

Policy H1 states that the East of England as a whole will provide at least 508,000 additional dwellings between 2001 and 2021. Thurrock BC is required to provide a minimum of 18,500 additional dwellings within Thurrock Urban Area between 2001 and 2021.

Furthermore, a key objective of the East of England Plan is to minimise the risk of flooding to people, property and wildlife habitats within the region. The Plan notes that coastal and river flooding pose significant risk in parts of the East of England. The coastline is naturally dynamic, with strong natural processes at work and it is particularly vulnerable to the effects of storm surges, sea level rise and saline intrusion. The priorities are therefore to defend existing properties from flooding and locate new development in areas where there is little or no risk of flooding. Local Development Documents should ensure that new development is compatible with shoreline management and other longer-term flood management plans in order to avoid constraining effective future flood management or increasing the need for new sea defences.

The Plan identifies key requirements of LDDs with regard to flood risk management. Policy WAT1 states that LDDs should:

- Use SFRAs to direct development away from areas of high flood risk and those likely to be at risk from flooding in the future, and areas where development would increase the flood risk elsewhere;
- Include policies which protect floodplains and land prone to flooding from development, as informed by the Environment Agency's flood maps and SFRAs, as well as historical and modelled flood risk data, Catchment Flood Management Plans and policies in Shoreline Management Plans and Flood Management Strategies;
- Only propose departures from these principles in exceptional cases where suitable land at lower risk of flooding is not available, the benefits of development outweigh the risks from flooding, and appropriate mitigation measures are incorporated; and
- Incorporate sustainable drainage systems in all developments, as appropriate.

In addition, areas of functional floodplain needed for strategic flood storage in the Thames Estuary should be identified and safeguarded by local authorities in their LDDs.

Given the long-term nature of these development plans, careful planning will be required to ensure the impact of climate change is accounted for when assessing flood risks. The Plan states that climate change will be inevitable over the period of this strategy and for many years into the future. It will impact on existing development and natural resources and must influence our decisions about the location of future development.

Essex Thames Gateway Sub-Regional Strategy

The core strategy within the RSS applies to all parts of the region and in most cases is sufficient to guide LPAs in preparation of LDDs. However, in some circumstances sub-area policies are required to amplify the spatial strategy and resolve matters that cannot be left to the local level. Thurrock lies within one of these areas, referred to as the Essex Thames Gateway, which comprises the Essex part of the Thames Gateway Growth Area.

This Thames Gateway Growth Area is a regional and national priority for urban regeneration within the Sustainable Communities Plan. This is the largest corridor of urban development in the East of England, incorporating the area south of the A13 in Thurrock and A127 in Basildon together with the Boroughs of Castle Point and Southend-on-Sea and London Southend Airport in Rochford District.

The Thurrock Urban Area (from Purfleet in the west to Tilbury/Chadwell St Mary in the east) has been identified as a Key Centre for Development and Change (KCDC) within the Essex Thames Gateway. The aims are to substantially improve the quality of the urban environment, diversify the employment base of the Borough, develop policies to preserve the strategic functioning of the Port of London and develop a long term strategy for renovating the Lakeside Basin area.

The risk of flooding to this area must be considered at all stages in the planning process to avoid unsuitable development in areas at risk and to ensure that development does not constrain options for future flood management measures in the Thames Estuary as part of the Environment Agency's Thames Estuary 2100 Project.

4.3.2 Regional Flood Risk Appraisal, 2009

The Regional Flood Risk Appraisal (RFRA) for the East of England was commissioned by the East of England Regional Assembly (EERA) and was prepared by Capita Symonds. This document contains information on the approach to assessing flood risk and the evidence that should be used to inform the

East of England Regional Spatial Strategy. It draws on flood risk evidence available from Catchment Flood Management Plans (CFMP) and Strategic Flood Risk Assessments (SFRA) that have already been prepared to provide a high level assessment of flood risk across the East of England.

4.4 Local Policies

The planning system is currently undergoing a period of major change. Every local planning authority is required to replace its current Local Plan with a new Local Development Framework under the requirements of the Planning & Compulsory Purchase Act 2004, which came into force on 28 September 2005. It is envisaged that the LDF will promote a more accessible and sustainable planning system in which local communities and other stakeholders will have more say in the planning issues which affect their locality.

4.4.1 Core Strategy Preferred Options Consultation, 2007

The aim of the Thurrock Core Strategy is to set out the spatial vision and objectives for the Thurrock area until 2021. This framework of spatial options and policies seeks to take into account flood risk across Thurrock. Two of the overarching principles following the Preferred Options Consultation are:

- To seek to adapt to or mitigate impacts of climate change and increased flood risk
- To deliver naturalistic strategic flood management elements such as SuDS, water storage and other features whenever possible.

One of the Strategic Spatial Objectives, particularly relevant to flood risk is SSO18, to *'reduce and manage the risk of flooding to and from development through its location, layout and design'*. The preparation of this SFRA will inform the location of developments within areas of appropriate flood hazard classification.

4.4.2 Local Development Framework

The Preferred Options Consultation Document will inform the production of the final Core Strategy, which is the lead document in the portfolio of documents in the Local Development Framework (LDF). The Local Development Framework is currently programmed for adoption in 2010 and will replace the Local Plan, which was published in 1997. Thurrock BC is currently carrying out the initial stages of LDF preparation, which involves evidence gathering and undertaking scoping sustainability appraisals. The Development Plan Documents (DPD) which form part of the LDF are as follows:

- Core Strategy and Policies for Control of Development DPD
- Site Specific Allocations and Policies DPD
- Minerals and Waste DPD

4.5 Environment Agency Policies

4.5.1 Thames Estuary 2100 (TE2100) Flood Risk Management

Thames Estuary 2100 is an Environment Agency initiative, which aims to determine the appropriate level of flood protection needed for London and the Thames Estuary for the next 100 years. The Project has split the Thames Estuary into 23 separate Policy Management Units (PMU) based upon the character of the local area and where the floodwaters would flow during a flood event. Each PMU offers different opportunities for managing flood risk, both at a local level and on an estuary-wide scale and has therefore been subject to a number of detailed studies and appraisals to assist TE2100 in identifying a flood risk management policy specific to the area.

The following table summarises the preferred policy options for PMUs present within Thurrock.

Table 4-2: TE2100 Preferred Policy Options for PMUs across Thurrock district

Policy Management Unit PMU	Recommended Preferred Option
Rainham Marshes and Mardyke (within Action Zone 4)	This PMU contains extensive freshwater marshes which form a RSPB nature reserve, a large landfill area, development and major transport links. The eastern boundary of the policy unit is the River Mardyke which is covered by the Purfleet, Grays and Tilbury policy unit. **The recommended flood risk management policy is Policy P4: to take further action to sustain the current level of flood risk into the future, responding to the potential increases in risk from urban development, land use change and climate change.** This policy unit is within the Thames Gateway regeneration area and as new developments are implemented there are likely to be opportunities to improve the area. Much of the frontage in this policy unit has raised ground or landfill which reduces the risk of tidal flooding. Measures may be required to alleviate fluvial flooding associated with the River Mardyke, which is covered by the Purfleet, Grays and Tilbury policy unit. Management measures for fluvial flood risk on the marsh drainage systems include improvements to outfalls and pumps and provision of local fluvial flood storage.
Purfleet, Grays and Tilbury (within Action Zone 5)	This is a large PMU and includes two main areas of floodplain at Tilbury and West Thurrock / Purfleet. Much of the marsh areas are low lying, less than 1m AOD and some of the developed areas are very vulnerable to flooding. **The recommended flood risk management policy is Policy P4: to take further action to sustain the current level of flood risk into the future, responding to the potential increases in risk from urban development, land use change and climate change.** Purfleet, Grays and Tilbury forms part of the Thames Gateway regeneration area and is covered by the Thames Strategy East and Thames Gateway Parklands vision. This area is expected to continue as an important commercial and industrial centre, but there are also likely to be major changes following extensive development and redevelopment in the area. Future flood defences may provide an important catalyst for improvement to the area and there is opportunity to create a safer floodplain with flood resilient buildings and safety for people during flood events. It is noted that the drainage systems in this policy unit will require upgrading as sea levels rise and storm rainfall is expected to increase. Mitigation measures include improved outfalls and drainage channels, additional pumping capacity, additional flood storage and new or improved flood defences.
East Tilbury and Mucking Marshes (within Action Zone 6)	East Tilbury and Mucking Marshes comprise an area of marshes to the west of the Lower Hope reach of the Estuary. An area of designated intertidal habitat runs along the frontage parallel to the defences. A large part of the freshwater marsh is being used for landfill and gravel extraction and the landscape is likely to change significantly in the future. **The recommended policy for East Tilbury and Mucking Marshes is Policy P3: to continue with existing or alternative actions to manage flood risk at the current level, accepting that flood risk will increase over time from this baseline.** East Tilbury includes the main area of residential development. To the north east is an area of community parklands designated under the Thames Gateway Parklands (TGP) vision. There is public access along the defences, and under the TGP vision it is anticipated that continuous public access will be provided in the future. The policy unit is dominated by landfill and gravel extraction, but there are important opportunities for flood management such as

Policy Management Unit PMU	Recommended Preferred Option
	- potential managed realignment of the tidal SPA along the foreshore; - TGP vision that much of the area including the landfill becomes a community parkland; - Floodplain restoration following completion of gravel extraction. It is expected that it will be difficult to justify replacing defences when they reach the end of their design life due to the low value of assets in this area. A more appropriate solution may be local defences for important assets, including East Tilbury. As tidal flood defences will not be raised, flood risk will increase. A secondary defence is proposed for East Tilbury and the adjacent railway line, subject to appraisal and justification. New and improved defences should be designed to enable public access and adequate access points. Fluvial flood risk within the marshes is likely to increase due to rising sea levels and increase fluvial flows. Possible mitigation measures include outfall improvement, flood storage and local flood defences.
Shell Haven & Fobbing Marshes (within Action Zone 7)	Shell Haven and Fobbing Marshes PMU is divided into two distinct areas either side of the A1014 access route to the Coryton refinery. In the north are the freshwater marshes, much of which is designated SSSI, and in the south is the industrial area along the Thames frontage including the new London Gateway container port. **The recommended policy for Shell Haven and Fobbing Marshes is Policy P3: to continue with existing or alternative actions to manage flood risk at the current level, accepting that flood risk will increase over time from this baseline.** The remaining defences along the River Thames and the Holehaven Creek are primarily full height defences. It is anticipated that the new London Gateway port at Shell Haven will include improved flood defences. In association with this development, managed realignment is proposed for Mucking to provide a replacement intertidal area and salt marsh. As sea levels rise and rainfall increases, it is likely that drainage systems on Fobbing and Vange marshes will require improvements to channels and outfalls. Saline intrusion and siltation of outfalls will also need to be addressed. The marshes provide an important area for creation of freshwater habitat to compensate for losses elsewhere in the estuary. In order to maintain this important rural landscape in the midst of an otherwise highly industrialised area, no new development should therefore be permitted in the marsh areas.

With these policies in mind, managing the consequences of flooding will become increasingly important and emphasis should be placed upon emergency planning and applying the sequential approach to new development.

4.5.2 South Essex Catchment Flood Management Plan (CFMP) December 2008

Catchment Flood Management Plans are high-level strategic planning documents that provide an overview of the main sources of flood risk and how these can be managed in a sustainable framework for the next 50 to 100 years. The Environment Agency engages stakeholders within the catchment to produce policies in terms of sustainable flood management solutions whilst also considering the land use changes and effects of climate change.

The South Essex CFMP provides information relating to the fluvial flood risk, as well as risk from surface water drainage systems and sewers across South Essex. The Plan highlights the main sources of flood risk to people, property and infrastructure in South Essex and recommends broad policies for the management of the present and future flood risk in the South Essex CFMP area.

This CFMP covers Thurrock and provides valuable records of historical flooding from fluvial systems, as well as surface, sewer and ground water flooding in the area. This information has been used to inform this Level 1 SFRA. The South Essex CFMP also presents preferred policy options for several Policy Units within Thurrock. These have been summarised in Table 4-1 below.

Table 4-1: Summary of Preferred Policies for Policy Units in Thurrock, South Essex CFMP, 2008

Policy Unity	Recommended Preferred Option
9. Stanford-le-Hope	**Policy 5: Take further action to reduce flood risk now and in the future.** This policy unit is subject to high fluvial flood risk from the Horndon Brook / Stanford Brook. The high surrounding topography and urban nature of the unit contribute to rapid responses to rainfall. The following actions are suggested for this policy unit: A new flood defence scheme could be implemented to reduce the number of people and property at risk both now and in the future. Increased flood storage and managed runoff in upstream locations such as the upper Mardyke catchment could help to reduce flood risk in Stanford-le-Hope. Develop an Urban Drainage Plan for Stanford-le-Hope to investigate the risk from surface water flooding. Develop Emergency Response Plans for sites at risk of flooding. Investigate the feasibility of creating a flood forecasting and warning system for Stanford-le-Hope.
10. Upper Mardyke / Horndon Catchment	**Policy 6: Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.** The predominant land use in this policy unit is agricultural and therefore there is limited flood risk to people or property. As part of the Plan a Flood Storage Strategy is suggested for the area. Creating flood storage within the policy unit will benefit downstream areas of Tilbury, Purfleet and Stanford-le-Hope. Suitable storage options may include the creation of floodplain wetlands or attenuation sites. Alternatively, the floodplain could be naturally restored which would save on expense and potentially deliver environmental benefits. No development should be permitted within the floodplain, as this is deemed to be functional floodplain. A Land Management Plan is proposed, to explore changes in land use and to develop sustainable land management practices.
11. River Mardyke	**Policy 6: Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.** The main source of flooding in this unit is from the River Mardyke and agricultural drainage networks. A small number of scattered farms and isolated properties are at risk of flooding. A larger risk is evident downstream and is of primary concern when considering policy options for this unit.

Policy Unity	Recommended Preferred Option
	As a result, the key aim within this unit is to attenuate flows through the provision of floodwater storage. This may be provided through engineered formal flood storage areas which would help to protect people and property from flooding. An alternative, more cost beneficial option would be natural floodplain storage which would involve changes in land use, flood proofing measures and flood awareness campaigns for properties at risk in this policy unit. As a result the CFMP suggests the development of a Land Management Plan to explore changes in land use and develop sustainable land management practices, and development of an Environmental Enhancement Project to improve the natural state of the river and its habitat.
12. Thames Urban Tidal	**Policy 4: Take further action to sustain current level of flood risk into the future.** The majority of this policy unit is at risk from tidal flooding associated with the Thames Estuary. Fluvial flooding from the River Mardyke as well as a system of arterial drains, dyke and sewers also pose a risk to a number of people and properties. Much of the low lying land within the policy unit relies on pumped drainage system, the failure of which would result in an unacceptable level of risk in the policy unit. The tertiary drainage system is poorly maintained and leads to localised surface water flooding problems. These are likely to worsen with increased frequency of precipitation and river flows in the future. In order for the current level of risk to be sustained into the future, existing maintenance actions will need to be increased. This will be supported through the development of an Integrated Urban Drainage Plan for Tilbury and Purfleet and increased encouragement of the use of sustainable drainage systems (SuDS) in future developments to alleviate surface water flooding issues.

4.5.3 Shoreline Management Plans

The Shoreline Management Plan is a large scale assessment of the risks associated with coastal processes and measures to reduce and manage these risks. The first SMP for Essex was published in 1997. The Plan provides a foundation for sustainable coastal defence policies within a particular sediment cell and establishes objectives for future management of the shoreline. Thurrock lies within the first Coastal Unit, of the Shoreline Management Plan, which covers the ‘Mardyke to North Shoebury’ and the preferred coastal defence policy for this coastal unit is to hold the existing line of flood defence.

Since the production of this SMP, there have been several major studies such as Futurecoast, Foresite, UK Climate Impacts Programme, Catchment Flood Management Plans and SFRAs. It has therefore become necessary to prepare second generation SMPs. These documents will provide guidance for local authorities and other decision makers as they seek to manage their coastline and introduce management schemes.

The SMP2 for Essex will build on the findings of the Environment Agency initiative ‘Thames Estuary 2100’. It is recommended that the results of the revised SMP are taken into account within future revisions of this SFRA.

4.6 Other Strategic Flood Risk Assessment Status

4.6.1 Thames Gateway South Essex Strategic Flood Risk Assessment

Scott Wilson Ltd was commissioned by the Thames Gateway South Essex Partnership in January 2006 to undertake a Strategic Flood Risk Assessment for South Essex. This Client Group comprised the Thames

Gateway South Essex Strategic Planning Authorities of Essex County Council, Southend-on-Sea and Thurrock Borough Councils and the Local Planning Authorities of Rochford District, Castle Point Borough and Basildon District Councils.

This SFRA is currently undergoing review, including the same partner authorities with the exception of Thurrock BC. In order to achieve the projected timescale for their Local Development Framework, Thurrock BC has commissioned this report separately from the TGSE Partnership.

It is recommended that the results of the revised TGSE SFRA are considered to provide information about flood risk in neighbouring areas during future revisions of this SFRA.

4.7 Other Relevant Policies

4.7.1 Sewers for Adoption (A Design and Construction Guide for Developers)

The Sewers for Adoption Guide is to be used by developers undertaking new development when planning, designing and constructing conventional foul and surface water gravity sewers, lateral drains and pumping stations intended for adoption under an Agreement made in accordance with Section 104 of the Water Industry Act 1991. The developer should consult the sewage undertaker and all other relevant bodies at the earliest opportunity before a planning application has been made, so that drainage arrangements can be agreed.

5 Data Collection and Review

The objective of this Level 1 report is to collate and review the information available relating to flooding in the study area and present this in a manner suitable for Thurrock BC to apply the PPS25 Sequential Test within the district. This information should also be used to inform the production of suitable flood risk management policies within the emerging LDF.

This section presents the available data and discusses its benefits and limitations. A comprehensive record of all the data collected through the production of the Level 1 SFRA is presented in a data and contacts register in Appendix B.

5.1 Project Approach

The Level 1 SFRA assessment methodology is based on using available existing information and data where suitable to determine the variation in flood risk across the study area.

5.1.1 Stakeholder Consultation

In the preparation of this Level 1 SFRA, the following stakeholders were contacted to provide data and information:

- Thurrock BC;
- Environment Agency;
- Essex and Suffolk Water, and;
- Anglian Water.

5.1.2 Data/Information Requested

Information and data requested from the stakeholders was based on the following categories:

- Terrain Information e.g. LiDAR, SAR;
- Hydrology e.g. the main and ordinary watercourses;
- Hydrogeology e.g. groundwater vulnerability zones;
- Flood Defence e.g. flood walls/embankments, sluices;
- Environment Agency Flood Levels e.g. at flood monitoring points;
- Flood Risk Assessments e.g. on previous development sites;
- Environment Agency Flood Zone Maps;
- Local Authority Information e.g. Local Development Schemes, Minerals and Waste sites; and,
- Drainage Standards.

5.2 Data Review

5.2.1 Topographic Data

The Environment Agency has provided Light Detection and Ranging (LiDAR) data for the study area. LiDAR is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground. The data varies in accuracy depending on the nature of the terrain such as in woodlands, complex urban areas and near lakes, where the accuracy reduces due to the limitations in the technique. However, LIDAR is generally recognised to have an accuracy of +/- 300mm.

The data set covers the entire study area. It was captured by the Environment Agency during September 2006. The topographic data is presented as Figure 3.

This data is important because an accurate and up to date Digital Terrain Model (DTM) is required in order to produce high-resolution flood risk mapping.

5.2.2 Extreme Tidal Water Level Derivation

The extreme tidal water levels along the stretch of the River Thames adjacent to Thurrock have been obtained from the report *Thames Tidal Defences Joint Probability Extreme Water Levels 2008* (Halcrow, April 2008) prepared for the Environment Agency. The levels within the report have been calculated by estimating a matrix of water levels at various nodes along the estuary and calculating the statistical frequency, or return period, within which a particular water level might be expected to occur at each of these nodes.

5.2.3 Flood Zone Maps

PPS25 Flood Zones subdivide the spatial variation of flood probability from rivers and the sea into 4 zones; the functional floodplain and the High, Medium and Low probability Flood Zones.

The Environment Agency has provided present day Flood Zone extents for Flood Zones 2 and 3 for the River Thames by extrapolating extreme water levels onto a DTM of the study area for the River Thames.

The Flood Map shows the estimated extent of Flood Zones 2 and 3 (ignoring the presence of flood defences) for all main rivers and/or watercourses with identified critical drainage problems and provides a good indication of the areas at risk of tidal flooding in the study area. However, it does not provide detail on individual properties, or information on flood depth, speed or volume of flow. It also does not show flooding from other sources, such as groundwater, direct runoff from fields, or overflowing sewers.

5.2.4 Fluvial Hydraulic Modelling

Broad scale modelling has been undertaken for the River Mardyke and Stanford Brook as part of the Environment Agency's South Essex CFMP and provides information regarding fluvial flood risk in the study area associated events of a range of return periods.

In order to obtain a realistic understanding of flooding, the models represent current conditions and include the main flood defence schemes. The broad-scale model is then combined with a GIS software tool called 'Modelling Decision Support Framework' which provides flood levels, extents, depths and flood velocities for a number of different probability flood events.

It should be noted that this modelling is based on relatively coarse data and includes several simplifying assumptions. The results from these models provide a reasonable representation of how the catchment is likely to respond to flooding, however, they do not represent the details very accurately.

5.2.5 Hydrodynamic Breach Modelling

As part of the Level 2 SFRA, Scott Wilson has been commissioned to undertake hydrodynamic modelling at 21 breach locations along the Thurrock frontage. This provides a revision of the modelling that was undertaken as part of the Thames Gateway South Essex SFRA, using up-to-date water levels and improved modelling methodologies. The results of this modelling will be presented in the Level 2 SFRA, for the 1 in 200 year return period event including climate change to 2109 and 1 in 1000 year return period event including climate change to 2109.

As part of the Level 1 SFRA, modelled results have been presented for the 1 in 200 year and 1 in 1000 year events for the current day, 2009. The output available from this modelling is the Hazard Rating, which is a function of the flood depth and flow velocity at a particular point in the floodplain. The full methodology for this modelling is included within the Level 2 Report.

5.2.6 Flood Defences

Information on flood defences throughout the study area has been provided by the Environment Agency from the National Flood and Coastal Defence Database (NFCDD). The NFCDD provides details of the asset reference, location, type of defence, level of protection provided by the structure, and the geographical extent of the defence or structure. Details of all NFCDD flood defences in the study area are presented as a GIS layer.

5.2.7 Historical Flooding Records

The South Essex CFMP provides information regarding historic flood events within the study area. The records cover all sources of flooding including surface water and sewer flooding as well as fluvial and tidal flooding events. Records such as this will be of particular use in the identification of key problem areas when assessing the flood risk across Thurrock.

Caution should be applied when using historic records. It should be noted that as with all historic flooding records, this information is largely anecdotal and does not always include a record of the antecedent conditions giving rise to the flooding (therefore typically not attributed to a flood source) or reference to a flood return period.

Furthermore, whilst records of past events may help to identify critical areas that experience problems with surface water flooding or groundwater flooding, it should not be assumed that those areas where flood events have not been recorded are free from flooding of that nature.

5.2.8 Overland Flow / Surface Water Flooding

Overland flow / surface water flooding typically arise following intense rainfall, often of short duration, that is unable to soak into the ground or enter receiving drainage systems. It can run quickly off land and result in local flooding. In developed areas, overland flow tends to occur when surface water cannot enter overloaded drainage systems during significant rainfall events. There is therefore an inherent link between sewer flooding and overland flow/surface water flooding.

The LiDAR topographic data has been analysed to identify areas of land that are particularly steep and could potentially cause rapid surface water run-off during rainfall events. Topography is a major influencing factor with respect to run-off and therefore it is a considered to be a suitable technique for a strategic study such as this.

In addition, the South Essex CFMP, completed in 2008, identifies areas at high risk to surface water flooding in Thurrock and provides a record of historic surface water flooding events.

5.2.9 National Environment Agency Mapping: Areas Susceptible to Surface Water Flooding

Following the Summer 2007 flood events, the Environment Agency have undertaken broad scale surface water mapping in order to provide an initial indication of areas susceptible to surface water flooding. The mapping for Thurrock has been supplied by the Environment Agency and is shown in Figure 9.

The map has been produced using a simplified method that excludes urban sewerage and drainage systems, excludes buildings, and uses a single rainfall event. The mapping is primarily intended for use by Local Resilience Forums (LRFs) and to inform emergency planning, but has recently been released for use in SFRAs to inform the most strategic levels of land use planning. It is not intended for use in allocating individual sites or determining individual planning applications.. This mapping has the following limitations:

1) The mapping does not show the interface between the surface water network, the sewer systems and the water courses;

2) It does not show the susceptibility of individual properties to surface water flooding;

3) The mapping has significant limitations for use in flat catchments, which is important in Thurrock.

In the light of these limitations, it is recommended that the mapping be used only as an initial review of surface water flooding in order to identify areas requiring further investigation.

5.2.10 Sewer Flooding

Sewer systems are typically designed and constructed to accommodate rainfall events with a 30-year return period or less, depending on their age. Consequently, rainfall events with a return period greater than 30 years would be expected to result in surcharging of some parts of the sewer system.

Records of sewer flooding have been obtained from Essex and Suffolk Water and Anglian Water via a query of their DG5 registers. In order to fulfil statutory commitments set by OFWAT, water companies maintain verifiable DG5 registers which record flooding arising from public foul, combined or surface water sewers and identify where properties suffered internal or external flooding.

The South Essex CFMP provides a large-scale overview of sewer flooding in the catchment. The Environment Agency highlight that it is unlikely the report will represent the true scale of sewer flooding; these factors are generally better assessed at the local scale and therefore cannot always be completed at the strategic scale.

Colin Buchanan have prepared an Infrastructure Deficit Study for Thurrock for 2004 – 2021 which identifies sewers that are nearing capacity and which may therefore pose a flood risk.

It is recommended that information regarding localised sewer flooding issues is requested when preparing site-specific Flood Risk Assessments (FRAs).

5.2.11 Geological Mapping

Groundwater flooding is usually associated with chalk and limestone catchments that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather.

Information regarding the solid and drift geology within the study area has been obtained from BGS mapping and is presented in Figures 2A and 2B. This provides an overview of the geology in the study area and therefore a coarse level overview of the probability of groundwater flooding issues.

However, this does not take account for local phenomena; for example the South Essex CFMP provides information regarding the impact commercial chalk quarrying may have on groundwater levels within Thurrock, which may lead to groundwater flooding. This highlights the importance of carrying out groundwater investigations as part of site-specific FRAs.

5.2.12 Artificial Sources / Infrastructure Failure

Artificial sources of flooding can include reservoirs, canals and lakes where water is retained above natural ground level. Failure of such a structure could result in rapid inundation of the surrounding area with little or no warning. These artificial sources can be identified on Ordnance survey mapping along with the presence of any embankments, which would retain water above ground level.

5.2.13 Emergency Planning

The South Essex CFMP identifies areas within Thurrock that fall within Environment Agency flood warning areas. Thurrock BC has also provided a GIS layer of the refuge centres used in the event of an emergency as well as a GIS layer of those buildings deemed more vulnerable according to PPS25 vulnerability classifications. These include hospitals, adult care homes, special schools, secondary schools and primary schools.

Thurrock BC is in the process of preparing a Flood Response Plan for the borough to support the Local Development Framework.

5.2.14 Development Sites

Thurrock BC has provided a GIS layer of the broad areas for regeneration within the district to enable their identification in relation to the different flood sources. These broad areas for regeneration are noted below:

- Purfleet Urban Area
- Aveley Urban Area
- South Ockendon Urban Area
- West Thurrock Urban Area
- Grays Urban Area
- Stifford Clays / North Grays
- Chadwell St Mary Urban Area
- Tilbury Urban Area East Tilbury
- Villages
- Stanford-le-Hope and Corringham Urban Area
- London Gateway

5.2.15 Minerals and Waste Sites

Thurrock BC is currently preparing their Minerals and Waste Allocations DPD and a selection of sites have been put forward as possible allocations. A supplementary document has been prepared to identify the flood risk posed to each of these suggested sites from different flood sources, and to enable the application of the Sequential Test.

6 Level 1 Assessment

The Level 1 SFRA assessment methodology is based on available existing information and data. This section forms the main results of the Level 1 SFRA; it describes the data used in the production of mapping and GIS deliverables for the project as well as a summary of the results presented.

6.1 Requirements of PPS25

Planning Policy Statement 25 and its accompanying Practice Guide requires SFRAs to present sufficient information on all flood sources to enable local planning authorities to apply the Sequential Test in their administrative areas. Information is required on the probability (High, Medium and Low) associated with flooding from the different flood sources. This information should be presented graphically where possible as a series of figures and/or maps.

In addition, the assessment of probability should also account for the effects of climate change on a flood source for the lifetime of any development that would be approved through the emerging Local Development Framework. In this case, climate change has been considered for 100 years as advised by Paragraph 3.88 of the PPS25 Practice Guide.

For flood sources other than tidal and fluvial, the current lack of data makes definition of robust classifications of probability unreliable. For example to define high, medium and low probabilities for groundwater flooding within the study area when no information has been provided regarding previous incidents is not particularly robust. Consequently, for all flood sources other than tidal and fluvial, where only anecdotal evidence of flooding is available, subjective assessments of probability have been made where the data allows.

In some cases, definitions of probability are not practical or are unreliable; in these situations the flood risk from a particular source should be considered as 'medium' until proven otherwise and should be investigated through a site-specific assessment of flood risk submitted as part of a planning application. Details of the requirements for site-specific Flood Risk Assessments (FRAs) are presented in Section 13.

6.2 GIS Layers and Mapping

Geographical data such as flood extents and watercourse routes have been presented as maps (Appendix A) and published through Geographical Information System (GIS) layers.

GIS is an effective management tool for the coordinated capture, storage and analysis of data of a geographical nature. GIS handles data in a hierarchical manner by storing spatial features within various layers, which are allied to an underlying database. GIS is an increasingly valuable resource for Local Planning Authorities for informing planning decisions.

A summary of GIS layers generated for use in this SFRA is presented below including a summary to identify which GIS layers have been used in the production of the maps and figures presented with Appendix A of this Level 1 SFRA.

Table 6-1: GIS Layers

Name	Details	Presented within Figure No's
Council_boundary_thurrock	Study area boundary, Thurrock BC	All
Main_Rivers	EA designated main river centrelines	1
Main_urban_centres	Key urban centres in Thurrock Borough	1,9
Bedrock	British Geological Survey solid geology, 1:50,000 scale	2A
Drift_geology	British Geological Survey drift deposits geology, 1:50,000 scale	2B
LiDAR_DTM	LiDAR Topographic Data	3
Slope_LiDAR_DTM	Slope grid calculated from LiDAR DTM	4
Flood_Zone_2	EA Flood Zone 2 extents - 2009	5
Flood_Zone_3	EA Flood Zone 3 extents - 2009	6
Flood_defences_NFCDD	EA national flood and coastal defences database	10
Broad_areas_for_regeneration	Key areas identified for regeneration in Thurrock	D1-14
Call_for_Sites New_Identified_Sites	Minerals and Waste sites	E1-8
Suds_recommended	Type of SUDs appropriate, based on geology	13
Rest_centres	Emergency planning rest/reception centres	11
Adult_care_homes Special_schools Secondary_schools Primary_schools Hospitals	Highly vulnerable buildings for consideration during emergency planning	12
Surface_water_flooding	Surface water hotspots	9
Sewer_flooding	Sewer flooding problem areas	9

6.3 Tidal Flooding

6.3.1 Requirements

PPS25 requires definition of the following tidal Flood Zones:

Table 6-2: Tidal Flood Zone Definitions (as defined in PPS25, Table D.1)

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	Land at risk from flood event less than the 1 in 1000 year event (less than 0.1% annual probability of flooding each year)	Low Probability
Flood Zone 2	Land at risk from flood event between the 1 in 200 and 1 in 1000 year event (between 0.5% and 0.1% annual probability of flooding each year)	Medium Probability
Flood Zone 3a	Land at risk from flood event equal to, or greater than, the 1 in 200 year event (greater than 0.5% annual probability of flooding each year)	High Probability
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The 1 in 20 year annual probability floodplain is the starting point for consideration but local circumstances should be considered and an alternative probability can be agreed between the Local Planning Authority and the Environment Agency	Functional Floodplain

6.3.2 Climate Change

The Flood Zones should also be defined considering the effects of climate change. When mapping climate change Flood Zones for tidal systems, PPS25 requires that sea level rise is applied up to 2115 along the East coast of England as shown in Table 6-3.

Table 6-3 Recommended contingency allowances for net sea level rise (from PPS25 Table B.1).

Administrative Region	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, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0

6.3.3 Data Sources & Mapping

Flood Levels

The water levels for this stretch of the Thames are presented in the *Thames Tidal Defences Joint Probability Extreme Water Levels 2008, Final Modelling Report*, prepared by Halcrow for the Environment Agency and published in April 2008.

Flood Zones (2009)

Figure 5 shows the Flood Zones affecting Thurrock for the present day (2009). The Flood Zones associated with the River Thames are those provided by the Environment Agency, produced by projecting the extreme tidal levels for the River Thames onto a DTM to determine the extent of flooding.

This mapping does not take into consideration the presence of existing flood defence structures. Figure 10 shows that Thurrock is protected from a 1 in 1000-year tidal flood event under normal circumstances. However, there is always a risk that the defences may be overtopped and/or breached; the presence of defences can only reduce, and not remove the risk of flooding.

Flood Zones (2109)

Figure 6 shows the Flood Zones affecting Thurrock with allowances made for climate change (2109). The Flood Zones for the River Thames have been determined using a similar methodology to the present day Flood Zones, by projecting the extreme tidal levels for the River Thames onto a DTM to determine the extent of flooding.

Flood Hazard Rating (2009)

Hydrodynamic breach modelling has been carried out at 21 locations along the Thurrock frontage to assess the residual risk behind the tidal defences. The precise breach locations and detailed methodology are included within the Level 2 SFRA report.

As part of the Level 1 SFRA, these breach models have been run for the following return period events during the present day conditions (i.e. with no consideration for climate change):

- 1 in 200 year tidal breach event for the current day 2009
- 1 in 1000 year tidal breach event for the current day 2009

The results from this modelling have been used to map Flood hazard. Flood hazard is a function of the flood depth and flow velocity at a particular point in the floodplain. Each element within the model is assigned one of four hazard categories ‘Extreme Hazard’, ‘Significant Hazard’, ‘Moderate Hazard’, and ‘Low Hazard’.

The derivation of these categories is based on Flood Risks to People FD2320 (DEFRA & EA, 2005), using the following equation:

$$\text{Flood Hazard Rating} = ((v+0.5)*D) + DF$$

Where v = *velocity (m/s)*

D = *depth (m)*

DF = *debris factor*

The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor. For this SFRA, a precautionary approach has been adopted inline with FD2320; a debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

Table 6-4: Hazard categories based on FD2320, DEFRA & Environment Agency 2005

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

Hazard outputs have been processed for the 1 in 200 year event and 1 in 1000 year events for the present day (2009) and are included in the Figures in Appendix D of this report.

Historical Records

The South Essex CFMP records details of major tidal flooding along the east coast of England in January/February 1953. An intense low-pressure system developed in the North Sea sending a storm surge south along the east coast and creating a tide level if 5.03m AOD, the highest ever recorded. Existing flood defences were overtopped and a significant proportion of Tilbury, Purfleet and land to the east of Corringham was flooded, as detailed in Table 6-5.

Table 6-5: Historic Flood Events within Thurrock, extracted from South Essex CFMP, 2008

Event	Locations Affected	Consequences of Flooding
Tidal flood Jan/Feb 1953	Canvey Island	Whole island inundated; 58 people died.
	West Thurrock	Most large industrial sites flooded.
	Purfleet	Most large industrial sites flooded.
	Tilbury	2,500 houses and a fire station flooded.

Figure 7 was extracted from the South Essex CFMP. It identifies those areas within Thurrock that experienced flooding by the River Thames Estuary/North Sea in January/February 1953.

6.4 Fluvial Flooding

6.4.1 Requirements

In order for the Level 1 SFRA to assist in the completion of the Sequential Test, PPS25 requires definition of the following fluvial Flood Zones:

Table 6-6: Fluvial Flood Zone Definitions (as defined in PPS25, Table D.1)

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	Land at risk from flood event less than the 1 in 1000 year event (less than 0.1% annual probability of flooding each year)	Low Probability
Flood Zone 2	Land at risk from flood event between the 1 in 100 and 1 in 1000 year event (between 1.0% and 0.1% annual probability of flooding each year)	Medium Probability
Flood Zone 3a	Land at risk from flood event equal to, or greater than, the 1 in 100 year event (greater than 1.0% annual probability of flooding each year)	High Probability
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The 1 in 20 year annual probability floodplain is the starting point for consideration but local circumstances should be considered and an alternative probability can be agreed between the Local Planning Authority and the Environment Agency	Functional Floodplain

The PPS25 Practice Guide states that all areas within Flood Zone 3 should be considered as Flood Zone 3b unless, or until, appropriate assessment shows to the satisfaction of the Environment Agency that the area falls within Flood Zone 3a. Therefore, in areas where the functional floodplain has not been defined and no suitable surrogate data is available the functional floodplain (Flood Zone 3b) should be defined as the extent of Flood Zone 3a.

PPS25 states that functional floodplain should be determined considering the effects of defences and other flood risk management infrastructure. The functional floodplain relates only to river and coastal flooding, it does not include areas at risk of flooding solely from other sources of flooding (e.g., surface water, sewers).

6.4.2 Climate Change

The Flood Zones should be defined considering the effects of climate change. For fluvial systems, PPS25 requires an increase of 20% in peak flows to be used when mapping climate change Flood Zones up to 2115.

6.4.3 Data Sources & Mapping

Flood Zones (2009)

Flood Zone mapping for the River Thames has been produced based on extreme tidal levels since this presents a more conservative scenario than the fluvial level.

The Flood Zones for the River Mardyke and Stanford Brook for the present day (2009) have been created from outputs from the CFMP hydraulic models provided by the Environment Agency. The 1 in 1000 year event, 1 in 100 year event and 1 in 20 year event were used to map Flood Zones 2, 3a and 3b respectively.

The maximum water level at each node within the hydraulic model has been extracted and used to create a water surface which can then be compared with the DTM of the study area to determine the extent of the flood outline.

Flood Zones (2109)

Figure 6 shows the Flood Zones including an allowance for climate change.

Flood Zones 2, 3a and 3b including climate change for the River Mardyke have been determined using the outputs of the CFMP hydraulic modelling provided by the Environment Agency. The 1 in 1000 year event plus climate change, the 1 in 100 year event plus climate change and the 1 in 20 year event plus climate change were used to map Flood Zones 2, 3a and 3b respectively.

The hydraulic modelling completed for the Stanford Brook only included one climate change scenario, for the 1 in 100 year event. The extent of Flood Zone 3a has been mapped using this information.

In order to map Flood Zones 2 and 3b including an allowance for climate change for the Stanford Brook, the following methodology has been employed.

Maximum levels were available for both the present day and climate change cases of the 1 in 100 year scenario. The difference between these two levels at each node in the model were used as the basis for extrapolating the 1 in 20 year plus climate change and 1 in 1000 year plus climate change (2109) cases from their respective present day (2009) cases. To do this, the known level changes between the present day and climate change cases were multiplied by the differences in the peak inflows of the present day input hydrographs.

New maximum flood levels can then be derived. These are compared with the DTM, in the same manner as the other modelled cases, to determine the depth grids and therefore flood outline.

Flood Hazard Rating (2009)

Flood hazard has been calculated for the River Mardyke and Stanford Brook flood outlines using the same formula applied for the breach assessments described above. For these fluvial systems, the 1 in 100 year event has been used, as this is considered comparable with the 1 in 200 year tidal event. The velocity has been assumed as 0. A debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

The hazard rating for the River Mardyke and Stanford Brook has been mapped with the tidal hazard rating resulting from the breach scenarios. Where these overlap, the highest hazard rating at each point in the floodplain has been presented.

Historic Records

Table 6-7 details two fluvial flood events associated with the Stanford Brook and the River Mardyke in Thurrock.

Table 6-7: Historic Flood Events within Thurrock, extracted from South Essex CFMP, 2008

DATE	SOURCE	LOCATIONS AFFECTED	CONSEQUENCES OF FLOODING
Sept 1958	Stanford Brook	Stanford-le-Hope	76mm rainfall fell in 2 hours. 500 houses flooded above floorboard level in Stanford-le-Hope
Sept 1968	Mar Dyke	Purfleet	Fenchurch Street line affected. 2,400 acres of farmland flooded.

6.5 Surface Water Flooding / Overland Flow

6.5.1 Requirements

Overland flow and surface water flooding results from rainfall that fails to infiltrate the surface and travels over the ground surface. This is exacerbated by low permeable urban development or low permeability soils and geology (such as clayey soils). Overland flow is likely to occur at the base of an escarpment and low points in terrain.

Local topography and built form can have a strong influence on the direction and depth of flow. The design of development down to a micro-level can influence or exacerbate this. Overland flow paths should be taken into account in spatial planning for urban developments. In addition, surface water flooding can be exacerbated if development increases the percentage of impervious area. An assessment of overland flow must be undertaken and the risks assessed as part of a site-specific FRA.

The SFRA only provides a summary of existing and available data on surface water flooding and does not include probabilistic modelling of surface water flooding.

6.5.2 Data Sources & Mapping

Topographic Data

Figure 3 shows the variation in the topography of the Thurrock study area. Land adjacent to the River Thames is low lying, at approximately 1-4m AOD. An area of higher land is present in central Thurrock including Chadwell St Mary and the edge of Grays, where the elevation is reaches 30m AOD. North of the Thurrock Borough, the elevation is approximately 100m AOD in the built up area around Basildon. This area slopes down relatively steeply towards the River Mardyke valley and may be conducive to significant quantities of surface water runoff.

Slope Analysis

GIS analysis has been carried out to determine the location of steep sloping ground, which could potentially generate significant volumes of run-off during extreme rainfall events. This has been achieved by production of a slope grid from the DTM, which is shown in Figure 4. The slope grid has been colour coded to identify the variation in gradient across the study area.

This should also be compared with the topographic data presented in Figure 3 to determine local low points where ponding of surface water could potentially occur. The slope grid provides an indication of the overall terrain however there will be a significant variation in risk due to the absence or presence of flow barriers on the ground. As a result, it was not considered appropriate to attempt to classify these areas further into high, medium and low risk.

Regional Flood Risk Assessment, 2009

The RFRA states that surface water flooding in South Essex is primarily the result of under-capacity culverts, inadequate highway drainage, blocked pipes and overgrown watercourses. One area that is particularly affected in Thurrock is the urban area of Grays.

National Environment Agency Mapping: Areas Susceptible to Surface Water Flooding

The Environment Agency has undertaken broad scale, national mapping of areas susceptible to surface water flooding which is shown in Figure 9. Due to the high level nature of this mapping, it is not considered suitable as a basis for strategic planning within Thurrock however it provides a useful overview to identify those areas that will require further investigation in relation to surface water flooding sources and pathways.

The information presented in Figure 9 defines the land to the north west and east of Tilbury as 'more susceptible' to surface water flooding, which is to be expected given the low lying nature of the land. The land to the north west constitutes the a Flood Storage Area, which is detailed further in Chapter 9. The area to the east of Tilbury forms the West Tilbury marshes. Land in Grays and West Thurrock has also been identified as 'more susceptible' to surface water flooding and this is likely to be the effect of ponding of surface water runoff behind the railway embankments. A large part of Stanford-le-Hope is also shown to be 'more susceptible' to surface water flooding and it is recommended that surface water flooding issues in this area are investigated further.

Based on a review of the existing information, the level of anticipated growth in Thurrock and our engineering judgement, it is recommended that a Surface Water Management Plan (SWMP) is undertaken following the Defra guidance (February 2009).

Catchment Flood Management Plan, 2008

Figure 8 has been provided by the South Essex CFMP. It identifies those areas that are likely to experience surface water flooding because of urbanisation and the associated high proportion of impermeable surfaces in these areas. Areas at risk include the urban area around Purfleet, Thurrock, Grays, Tilbury and Stanford-le-Hope.

Figure 9 shows details of past surface water flood events as recorded in the South Essex CFMP. Between December 2002 and January 2003, an episode of surface water flooding is recorded to have affected several houses in Bulphan in the upper River Mardyke valley (South Essex CFMP, 2008). Similarly, several houses were affected in Tilbury during the same period; it is likely that this is partly due to its positioning, with higher elevations to the north around Chadwell St Mary.

6.6 Sewer Flooding

6.6.1 Requirements

PPS25 requires that SFRAs provide information regarding areas at risk of flooding from sewers, and data from water companies is typically provided to allow this to be undertaken.

6.6.2 Data Sources & Mapping

Historic Records

The South Essex CFMP records an exceptional rainfall event in September 1968 that affected the East Dock Sewer in Tilbury and caused significant flooding in the area. In Tilbury the flooding affected 1km^2 of the marshes and 1.25km^2 of agricultural land. 1,750 houses were flooded and a further 950 affected by the event and Dock Road was closed for 4 days.

The Plan highlights that sewer flooding is a particular problem in Stanford-le-Hope, Purfleet and Tilbury due to inadequate maintenance of sewer infrastructure leading to blockages or systems being overwhelmed by the quantity of discharge. Anglian Water is involved in investing in schemes to reduce the number and frequency of sewer floods and surface water drainage incidents.

Records of sewer flooding have been obtained from Essex and Suffolk Water and Anglian Water via a query of their DG5 registers. Figure 9 shows those locations that have been identified as experiencing sewer flooding in the past

Infrastructure Deficit Study

The Infrastructure Deficit Study for Thurrock prepared by Colin Buchanan states that the Aveley trunk sewer is effectively at capacity. Any further development at Purfleet and the west end of Thurrock will require replacement of this sewer to preclude possibilities of sewer flooding in the area.

Water Cycle Study

Thurrock BC have commissioned a Water Cycle Study to identify whether sufficient water supply and waste water infrastructure is in place to support the growth and development projected for Thurrock. The scope of the Water Cycle Study encompasses a more detailed assessment of sewer flooding and measures required to improve the infrastructure. This document should therefore be used in conjunction with the SFRA considering this form of flooding.

6.7 Groundwater Flooding

6.7.1 Requirements

Groundwater flooding occurs when water levels in the ground rise above surface elevations. Groundwater flooding may take weeks or months to dissipate, as groundwater flow is much slower than surface water flow therefore water levels take much longer to recede.

An assessment of the risk of groundwater flooding needs to be carried out; however, a quantified assessment of risk from groundwater flooding is difficult to undertake, especially on a strategic scale. This is due to lack of groundwater level records and the lack of predictive tools (such as modelling) that can assess the risk of groundwater flow and flooding following rainfall events.

6.7.2 Data Sources & Mapping

Geology

The BGS geological mapping has been used as the primary data source to determine the risk of groundwater flooding in Thurrock. Mapping of the solid and drift geology across Thurrock is presented in Figures 2A and 2B. No mapping has been produced to review groundwater flooding across Thurrock.

Groundwater flooding is usually associated with chalk and limestone catchments that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather. Groundwater flooding can also occur in areas where Made Ground has been deposited above impermeable subsoils, typically during ground raising or levelling works.

It is unlikely that groundwater flooding will pose a significant flood risk within northern Thurrock, due to the presence of clay, which creates a highly impermeable layer and restricts the movement of water both from the surface to the ground as well as the ground to the surface. The presence of Chalk geology in southern parts of Thurrock around Aveley and Purfleet, covered by permeable alluvial deposits, sand and gravel, indicates that this area could be susceptible to groundwater flooding. The problem is exacerbated by the low-lying nature of the land, which is between 0-5m AOD.

The South Essex CFMP draws attention to the impact commercial chalk quarrying may have on groundwater levels within Thurrock. During extraction of the chalk, the quarried areas become de-watered. Since manufacturing came to an end and with it the de-watering activities, groundwater levels have risen by approximately 60mm a year. Continued increases in groundwater levels could lead to local flooding or structural problems for development located in close proximity to former quarries where restored ground levels may be lower than natural ground levels.

Despite this, it is considered unlikely that groundwater flooding will pose a significant flood risk within Thurrock on a strategic scale, as the presence of London Clay will generally prevent groundwater rising to the surface. Further guidance can be found within the Water Cycle Study currently under preparation for Thurrock (Scott Wilson 2009).

Site-specific FRAs should include full consideration of the ground conditions on site and assess the risk of groundwater flooding occurring. This is particularly important for potential development sites near former quarried areas and developments in which basement areas are proposed; it must be demonstrated that the site does not lie on a key groundwater flow route such that introducing a flow barrier within the system would increase the risk of groundwater flooding elsewhere.

6.8 Artificial Sources

6.8.1 Requirements

PPS25 requires that artificial water sources within the study area are identified as part of a SFRA. These include canals, reservoirs, ponds, and any feature where water is held above natural ground level.

6.8.2 Data Sources & Mapping

Figure 1 shows artificial water sources within the study, which may need to be taken into consideration when carrying out site-specific FRAs for individual development sites in close proximity. A summary of these water bodies and the presence of embankments are shown in Table 6-9 below:

Table 6-9: Ponds/Lakes located within Thurrock

Location	Approximate Coordinates		Approximate Plan Area (km^2)	Embankments Present
	Easting	Northing		
Alexandra Lake	558376	178923	0.08	-
Belhus Woods lakes	557235 558153	182637 182507	0.07 0.045	- -
Oak Wood	557989	179492	0.08	✓
Hangman's Wood	557901	180306	0.04	-
Grange Farm	560981 561290 561008	181675 182319 181944	0.09 0.07 0.03	✓ ✓ ✓
Orsett Fen Reservoir	563186	183010	0.025	✓
Fobbing	571033 571298	183498 183681	0.015 0.013	✓ ✓
Little Mollards Farm (4 small ponds)	560391	182052	Total 0.07	-
Alexandra Lake	558376	178923	0.08	-
Belhus Woods lakes	557235 558153	182637 182507	0.07 0.045	- -

None of the stakeholders contacted throughout this study hold any records of flooding arising from artificial sources and/or infrastructure failures.

7 Guidance on Applying PPS25 Sequential Test

7.1 What is the PPS25 Sequential Test?

The PPS25 Sequential Test is a process by which the precautionary principle is applied to the strategic land allocation process. PPS25 requires local planning authorities to review flood risk across their districts, steering all development towards areas of lowest risk. Development is only permissible in areas at risk of flooding in exceptional circumstances where it can be demonstrated that there are no reasonably available sites in areas of lower risk, and the benefits of that development outweigh the risks from flooding. Such development is required to include mitigation/management measures to minimise risk to life and property should flooding occur, and wherever possible identify opportunities to reduce the overall flood risk posed to the local community.

A Level 1 SFRA is designed to be sufficiently detailed to allow the application of the Sequential Test to the Core Strategy Document, on the basis of PPS25 Table D.1 (reproduced as Tables 6-2 and 6-4) and Figure 4.1 of its Practice Guide. In order to apply the Sequential Test to the Site Specific Allocations DPD a Level 2 SFRA will be required which provides a more detailed assessment of the variation in flood risk across Thurrock.

PPS25 acknowledges that some areas will (also) be at risk of flooding from sources other than tidal and fluvial. Consequently all sources of flooding must be considered when looking to locate new development. The other sources of flooding requiring consideration when situating new development allocations include:

- Surface Water / Overland Flow;
- Groundwater;
- Sewers; and
- Artificial Sources.

These sources are typically less well understood than tidal and fluvial sources and as a result, data only exists as point source data or through interpretation of local conditions. In addition, there is conflicting guidance on suitable return periods to associate with floods arising from these sources. For example, modern surface water drainage systems are constructed to a 1 in 30-year standard. Any rainfall event in excess of the 30-year return period would be expected to result in some flooding through insufficient capacities. Consequently when assessing these sources through the Sequential Test, where a location is recorded as having experienced repeated flooding from the same source this should be investigated further in a site-specific Flood Risk Assessment (FRA).

7.2 Development Vulnerability Classifications

Planning Policy Statement 25 classifies developments according to their vulnerability. Five vulnerability classifications are defined, these are:

- Essential Infrastructure;
- Highly Vulnerable;
- More Vulnerable;
- Less Vulnerable, and
- Water Compatible.

Table 7-1 shows the types of development that fall under these different classifications.

Table 7-1: PPS25 Table D2 Flood Risk Vulnerability Classification (DCLG, 2009)

Vulnerability Classification	Development Uses
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes), which has to cross the area at risk, • Essential utility infrastructure which has to be located in a flood risk area for critical operational reasons, including electricity generating power stations and grid and primary substations; water treatment plants; and sewage treatment plants if adequate measures to control pollution and manage sewage during flooding events are in place. • Wind turbines.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.[2] (Where there is demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are <u>not</u> required to be operational during flooding • Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non–residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment plants.
Water-Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

[2] DETR Circular 04/00, paragraph 18: *Planning controls for hazardous substances.*
See www.communities.gov.uk/index.asp?id=1144377

PPS25 also stipulates where the differing types of vulnerable development may be appropriate based on flood risk. This is presented in Table D.3 of PPS25, which is reproduced below.

Table 7-2: PPS25 Table D3 Flood Risk Vulnerability and Flood Zone 'Compatibility' (DCLG, 2006)

Flood Risk Vulnerability Classification (Table D.2 PPS25)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
FLOOD ZONE	1	✓	✓	✓	✓	✓
	2	✓	✓	Exception Test required	✓	✓
	3A	Exception Test required	✓	X	Exception Test required	✓
	3B	Exception Test required	✓	X	X	X

✓ – Development is appropriate ✗ – Development should not be permitted

Using the information documented and mapped within this Level 1 SFRA, the Sequential Test should be undertaken for development within Thurrock. This process should be accurately documented to ensure decisions can be transparently communicated and reviewed where necessary.

The Sequential Test should be carried out on all development sites and seek to guide development to the lowest flood risk areas. Only where there are no reasonably available alternative sites to accommodate the development should sites in Flood Zones 2 or 3 be considered.

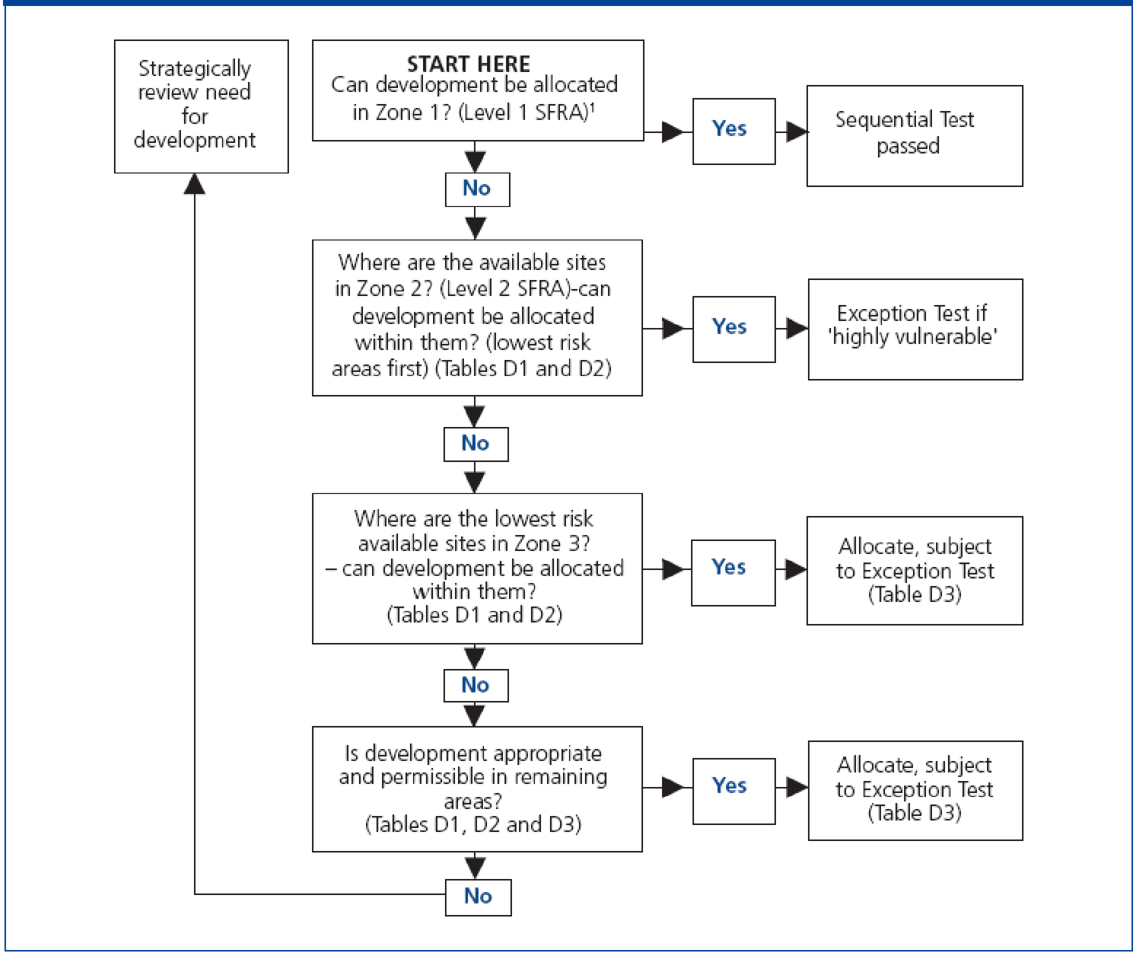
The Level 1 SFRA mapping provides the tools for the Sequential Test to be undertaken. This is achieved by presenting information to identify the variation in flood risk across the administrative area and allowing an area-wide comparison of future development sites with respect to flood risk considerations.

7.3 Guidance

The following flow diagram (Figure 7-2) is taken from the PPS25 Practice Guide and illustrates how the Sequential test should be undertaken. The full process is described in Chapter 4 of the PPS25 Practice Guide (2008).

Figure 7-2: Application of the Sequential Test (from Figure 4.1 of PPS25 Development and Flood Risk Practice Guide, 2008)

Figure 4.1 Application of the Sequential Test at the Local level for LDD preparation



Note

1 Other sources of flooding need to be considered in Flood Zone 1

Additional Guidance

The sequence of steps presented below, coupled with Figure 7-2, provides a guide for the application of the Sequential Test and, where necessary, that the requirement for the application of the Exception Test is clearly identified.

Recommended stages for application of the Sequential Test:

1. The developments (i.e. housing, hospitals, industrial etc) that need to be accommodated should be assigned a vulnerability classification in accordance with Table D.2 "Flood Risk Vulnerability Classification" in PPS25;
2. The Flood Zone classification of all development sites should be determined based on a review of the Environment Agency Flood Zones and the Flood Zones presented in this Strategic Flood Risk Assessment. This should consider the effects of climate change on Flood Zone definition for the design life of any development that the site may be suitable for, i.e.:

- 75 years – up to 2085 for commercial / industrial developments; and
- 100 years – up to 2110 for residential developments

3. In the first instance the 'highly vulnerable' developments should be located in those sites identified as being within Flood Zone 1. If the 'highly vulnerable developments' cannot be located in Flood Zone 1, because the identified sites are unsuitable or there are insufficient sites in Flood Zone 1 then sites in Flood Zone 2 can be considered but will be subject to the Exception Test. According to PPS25 'highly vulnerable' uses would not be permitted in Flood Zone 3.
4. Once all 'highly vulnerable' developments have been allocated to a development site, Thurrock BC can consider development types defined as 'more vulnerable'. In the first instance 'more vulnerable' development should be located in any unallocated sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate the 'more vulnerable' development types, sites in Flood Zone 3a can be considered but will require the application of the Exception Test. When allocating in Flood Zone 3a the hazard rating of the site, as defined in the Level 2 SFRA, must also be considered with development being preferentially steered to those sites of least hazard. Evidence to support parts 'a' and 'b' of the Exception Test should be established before 'part c' is tackled. 'More vulnerable' developments are not permitted in Flood Zone 3b.
5. Once all 'more vulnerable' developments have been allocated to a development site, Thurrock BC can consider those development types defined as 'less vulnerable' which can be located in any remaining unallocated sites in Flood Zones 1, 2 or 3a. Again, sites with the highest hazard rating should be avoided wherever possible. 'Less vulnerable' development types are not permitted in Flood Zone 3b.
6. 'Essential infrastructure' developments should also be preferentially located in the lowest flood risk zones, however this type of development can be located in Flood Zones 3a and 3b subject to the Exception Test being passed. Where these types of developments are required in Flood Zones 3a or 3b, evidence to support parts 'a' and 'b' of the Exception Test should be established before part 'c' is tackled.
7. Water compatible development typically has the least flood risk constraints and it is therefore recommended to consider these types of development last when allocating development sites.
8. For decisions made through stages 4 to 7 it will also be necessary to consider the risks posed to the site from other flood sources.

8 Guidance on Applying the PPS25 Exception Test

8.1 Why is there an Exception Test?

The aim of the Sequential Test is to steer all development towards areas of lowest risk. However, PPS25 recognises that in some exceptional circumstances, it may not be possible to locate development in areas of low or appropriate flood risk with respect to the vulnerability classification of the development. Where the Sequential Test has been carried out and it is shown that there are no reasonably available sites in lower flood risk areas, the Exception Test will then be required in some circumstances.

Through the application of the Exception Test any additional wider sustainability benefits resulting from development can be taken into account in order to demonstrate that the benefits for development of a site outweigh the flood risks to the development and its occupants.

8.2 What is the Exception Test?

The Exception Test is a series of three criteria as shown below, all of which must be satisfied for development in a flood risk area to be considered acceptable. For the Exception Test to be passed:

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA. For this criteria to be passed, the site/broad area must be shown to positively contribute to the aims and objectives of the Sustainability Appraisal. Where this is not the case, it must be considered whether the use of planning conditions or S106 agreements could make it do so. If neither of these are possible, the site is not deemed to pass part 'a' and the allocation should be refused;

b) The development should be on developable previously developed land or, if not, it must be demonstrated there is no such alternative land available; and

c) A Flood Risk Assessment (FRA) must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall. At the level of strategic planning the SFRA must be used in order to assess the potential feasibility of providing flood risk management measures for site allocations/broad development locations.

All three parts of this test must be satisfied in order for the development to be considered appropriate in terms of flood risk. There must be robust evidence in support of every part of the test.

This report is intended as a Level 1 SFRA to inform the application of the Sequential Test. Further detail required to inform the Exception Test is provided in the accompanying Level 2 SFRA.

9 Flood Risk Management

9.1 Flood Defences

Flood defences are typically engineered structures designed to limit the impact of flooding. The National Flood and Coastal Defence Database (NFCDD) is compiled by the Environment Agency and provides information on natural and man-made defences. Figure 10 shows the location of NFCDD defences throughout the study area and identifies the design life and the authority responsible for maintenance of the defences.

The Environment Agency Flood Zone maps define the extent of flooding without considering the presence of defences. The reason for this approach is to make an allowance for residual flood risk in the event of a failure or breach/blockage/overtopping of the flood defences. This conservative approach raises the awareness of flood risk in defended areas and helps to ensure that is it not discounted as part of development but is managed appropriately.

Flood defences are typically designed and constructed to protect people and property from a given magnitude of flood. This is referred to as the design standard and may vary depending on the age of the structure, the monetary value attributed to the people and property it is designed to serve and the scale of works necessary to construct the defence. For new defences, these issues and others are balanced through a cost benefit analysis to determine if investment in defence schemes can be justified.

9.1.1 Current

The NFCDD includes a range of tidal and fluvial flood defences within the Thurrock study area. The tidal flood defences in Thurrock are mainly raised reinforced concrete walls, steel walls, or earth embankments which are recorded as providing protection up to a 1 in 1000 year tidal flood event. Due to the complex industrial use along the riverside, provision for access, pipelines and cables is often incorporated into the design. The Environment Agency stated that the defence height along the Thurrock 'coastline' varies between 6.9m AOD and 7.2m AOD (Appendix B).

Along the River Mardyke there are approximately 10km of maintained channels, including the channels in close proximity to the Mardyke sluice and Stifford gauging station. These provide protection up to the 1 in 20 year fluvial flood event and are maintained by the Environment Agency.

A number of other small watercourse channels are also recorded in the NFCDD as providing protection from fluvial flooding. These include natural earth and vegetated channels associated with Manor Way Creek, Fobbing Creek, and Stanford Brook from Mucking Creek to Stanford-le-Hope.

As shown in Figure 10, the Environment Agency is responsible for maintaining almost all of the defences within Thurrock. The few privately owned defences include the raised defence at the pumping station at Aveley Marsh in Purfleet, a culverted channel owned by Network Rail north of Tilbury, and an earth embankment in Fobbing Marsh, which is not officially classified as a flood defence.

Outfalls and Pumping Stations

Whilst the lower reaches of the River Mardyke and Stanford Brook are protected from direct tidal inundation, tides can still affect the fluvial flood levels in these areas. In these locations outfalls are flapped or pumped to prevent tidal inflow according to fluvial and tidal action; during high tide the flaps are closed and water is stored within the channel, at low tide the flaps are open enabling the river water to drain. Therefore, during larger tides there is more tide locking and when this occurs with high river flow it is possible for channel capacity to be exceeded causing flooding.

Unless further channel storage is provided, anticipated increase in sea levels will result in more tide locking and therefore an increased occurrence of flooding in these areas.

9.1.2 Future

South Essex Catchment Flood Management Plan

The South Essex CFMP summarises fluvial improvement projects planned to further reduce flood risk. Projects planned within the Thurrock area include the following and are projected for 2008 – 2011.

- Improvements to West Thurrock Main Sewer to cope with increased discharges due to increased residential development in the area;
- Improvements to the East Dock sewer, Tilbury post-construction work;
- Scarhouse sluice improvement works;
- Stonehouse sluice improvement works;
- Tilbury reservoir compliance works.

Shoreline Management Plan

Thurrock is located within the coastal unit covering the area from the River Mardyke to North Shoebury in the Shoreline Management Plan. As previously mentioned in section 4.5, the current preferred coastal defence policy put forward in this study is to hold the existing line of flood defence.

Thames Estuary 2100

The Thames Estuary 2100 Project is an Environment Agency initiative, which seeks to plan for future flood protection needed for London and the Thames Estuary over the next 100 years. As part of this project a number of preferred management objectives have emerged that are of relevance to Thurrock. For western Thurrock, stretching from the Rainham Marshes to Tilbury, the preferred option is to do more to combat the impact of climate change and therefore keep up with the impact of climate change. For the portion of Thurrock stretching from East Tilbury to Fobbing Marshes, the preferred option is to maintain the current level of protection, accepting that the impact of climate change will result in an increase in flood risk over time in these areas.

Maintaining a standard of protection may require the maintenance of defences or alternatively an increased reliance upon active floodplain management in accordance with PPS25 through relocation of development, application of the Sequential Test and sequential approach, proactive development control procedures and effective emergency planning.

It is clear that the predicted increases in sea level will continue to reduce the standard of protection as time goes by. In light of Thurrock's plans for development and regeneration floodplain management measures such as those described above will play an increasingly important role into the future.

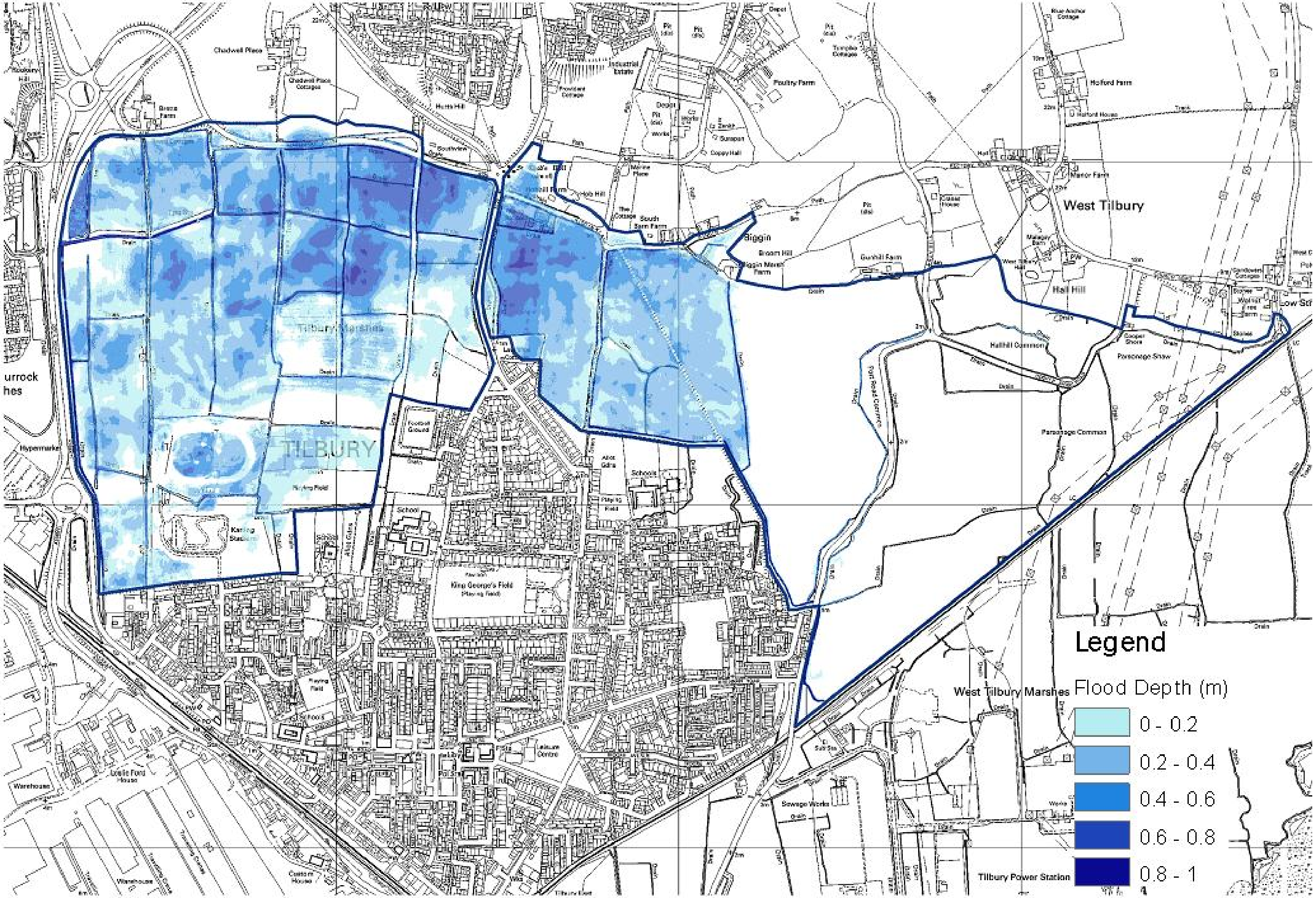
9.2 Flood Storage Area

The area to the north of Tilbury is classified as washlands and has been defined by the Environment Agency as a Flood Storage Area. The area is shown in Figure 9-1. It is also registered under the Reservoirs Act (1975) and will be maintained and operated as a category C Reservoir and Flood Storage Area (FSA) with capacity to store fluvial floodwaters during a 1 in 1000 year event. The Environment

Agency is currently running a scheme to ensure that the FSA is compliant with the Matters of Safety outlined by the Inspecting Engineer under the Reservoirs Act 1975. This involves the raising of embankments along sections of the eastern and western parts of the FSA to ensure that it can withstand a 1 in 1000 year event.

For the purpose of spatial planning, this area is classified as functional floodplain and therefore many types of development will be inappropriate. It is essential that the Environment Agency is consulted before development plans are prepared for sites within this area.

Figure 9-1 Tilbury Flood Storage Area (figure provided by the Environment Agency, modelled 2009)



9.3 Flood Warning

Whilst measures can be put in place to lessen the risk of flooding, it is impossible to eliminate risk completely. Warning people about the impending flooding is therefore one of the most important means of flood management, enabling people to prepare for flooding through taking steps to minimise damage to property and prevent loss of life.

The Environment Agency operates a flood warning service in areas at risk of flooding using a set of four easily recognisable codes, indicating the level of danger associated with the warning.

Flood Watch – Flooding of low-lying land & roads is expected. Be aware, be prepared; Watch out!

Flood Warning – Flooding of homes and businesses is expected. Act now!

Severe Flood Warning – Severe flooding is expected. Extreme danger to life & property. Act now!

All Clear – There are no flood watches or warnings currently in force for this area.

In Thurrock, the flood warnings are disseminated through the media using local television and radio stations. There is also an emergency Floodline number (0845 988 1188) and a quick dial number for specific areas.

Flood Warning Areas are used to deliver flood warnings and/or severe flood warnings. Within Thurrock there is one fluvial FWA along the main river catchment of the River Mardyke, and the remainder are tidal located along the Thames Estuaries.

Table 9-2 shows the flood warning areas within the study area along with the approximate lead times, and an indication of the percentage uptake of the Environment Agency flood warning service. The low level of uptake shown in Table 9-2 is a reflection on the preference for the use of local media services in issuing flood information to the residents of Thurrock.

Table 9-2: Flood Warning Areas in Thurrock Borough, extracted from South Essex CFMP, 2008

Floodline Warning Area	Flood Code	Main urban areas covered	Lead time (hrs)	Properties at risk in FWA	Up-Take
Mar Dyke	051FWFEF7C	Aveley, Purfleet	2	105	10.3%
Shellhaven to Purfleet including Tilbury and Dartford Crossing	051FWCDV5B3	Aveley, Purfleet, Grays / W Thurrock Tilbury	6-10	12,920	0.4%

9.4 Emergency Planning

The Flood Plan for Essex, published in June 2006, provides general information on the type of flooding that may affect the county, together with the appropriate responses by Essex County Council Emergency Planning and Core Resilience Team, Essex Police, the Environment Agency, District Councils and Unitary Authorities, one of which is Thurrock BC.

The Flood Plan for Essex is a high level document that provides a generic approach for the county and is of limited use for the emergency planning within the Thurrock borough. Thurrock BC is currently preparing a draft Emergency Flood Plan tailored to the specific risks facing Thurrock. Thurrock BC has recently become responsible for the closure of some local tidal flood gates during times of flood warning and a procedure is being prepared for the closure of these gates. It is noted Thurrock BC is mainly responsible for gates in Grays, and there are a number of additional gates that are privately owned and managed.

The primary responsibility of Thurrock BC would be to provide temporary accommodation to any displaced people until such time that they are in a position to return to their homes or their insurance companies can arrange temporary accommodation for them. This shelter is provided in the form of rest centres, and provides a warm dry place to sleep and basic facilities including shower, food, etc.

The following developments are typically suitable for such use as refuge and/or reception centres:

- Leisure centres;
- Churches;
- Schools; and
- Community Centres.

The nominated rest and reception centres in Thurrock have been identified and presented within Figure 11. This demonstrates that the majority of the nominated locations lie within Flood Zone 1 and are therefore at low risk of flooding. There are two exceptions, which are the Tilbury Leisure Centre and the Gateway Academy, which are within Flood Zone 3. Given the high proportion of development within Flood Zone 3 in Thurrock, it is likely that rest centres will be required within Flood Zone 3. However, the particular suitability of these two locations as rest centres should be reviewed following further assessment of the nature of flooding, which will be undertaken as the Level 2 SFRA.

Figure 11 highlights a lack of emergency rest centres in certain parts of the borough, including Purfleet, West Thurrock and Tilbury. It is recommended that additional rest centres are identified and incorporated into the Emergency Flood Plan for the borough.

In the event of an emergency, it is essential to ensure that those services vital to the rescue operation are not impacted by flood water. PPS25 classifies Emergency dispersal points, police stations, ambulance stations, fire stations, command centres and telecommunication installations that are required to remain operational during a flood event as 'Highly Vulnerable' buildings and these are therefore not permitted to be developed in Flood Zone 3. Hospitals are also vital to the rescue operation, but are classified in PPS25 as 'More Vulnerable' establishments and therefore might be situated within a flood zone, although they should remain accessible and operational. In addition future development control polices should seek to locate other 'More Vulnerable' institutes such as schools, nurseries, residential care homes, children's homes, prisons, hostels and health services in areas of the lowest risk to minimise the potential for flood casualties. Situations may arise in an emergency where the occupants of the above institutions cannot be evacuated (such as prisons) and therefore special consideration should be made when allocating sites for such development types. Individual flood emergency plans will be required for such developments in addition to the overall flood emergency plan produced by Thurrock BC.

A number of educational establishments are identified as lying within Flood Zone 3 and should be taken into particular consideration in the event of an emergency.

9.5 Residual Risk

Residual risk in a generic sense can be defined as 'the remaining risk following the implementation of all risk avoidance, reduction and mitigation measures' (Communities and Local Government, 2007). In the context of flood risk, residual risk refers to the flood risk that remains after flood avoidance and alleviation measures have been put in place. A combination of aging defences and increasing sea levels due to the effects of climate change make residual risk a key consideration in Thurrock. An example of residual flood risk would be a breach of the flood defence walls along the River Thames frontage caused by an open flood gate or the hydrostatic water pressure generated during high tides.

Residual risk management therefore aims to prevent or mitigate the consequences of flooding that can occur despite the presence of flood alleviation measures. The primary tool in achieving residual risk management is the rigorous application of the PPS25 Sequential Test; however some development might still need to be located in areas at risk of flooding and as a result, such developments will require site-specific residual risk management to minimise the consequences of potential flooding, e.g. following a breach or overtopping of local defences.

As part of the Level 2 SFRA, further assessment of the nature of the residual flood risk in the event of flood defence breach has been undertaken. This provides an appreciation of the depth and velocity of flood water and the time between a breach and inundation. This assessment will inform the suitability of locating development within Flood Zones 2 and 3 and enable the identification of appropriate measures to further reduce the residual risk to a development such as adopting a sequential approach within the site, defining appropriate finished floor levels, and ensuring safe access or a safe place of refuge above the flood level.

10 Sustainable Drainage Systems

10.1 Background

Sustainable Drainage Systems (SuDS) are surface water drainage systems developed in accordance with the ideals of sustainable development. The philosophy behind SuDS is to mimic as closely as possible the natural catchment processes prior to development. Wherever possible, SuDS techniques should seek to contribute to each of the three goals identified below, with the preferred solution contributing significantly to each objective. SuDS solutions for specific sites should seek to:

- Reduce flood risk (to the site and neighbouring areas);
- Reduce pollution and improve water quality, and;
- Provide wildlife and landscape benefits.

The SuDS Manual 2007, produced by CIRIA outlines how these goals can be achieved through the implementation of a chain of techniques. Each component adds to the performance of the overall system, whereby techniques are applied right through from site management procedures to consideration of a wider catchment as outlined below:

- **Prevention -** the use of good site design and management measures to reduce run-off and pollution (e.g. reducing impermeable areas, regular pavement sweeping) and encourage rainwater harvesting;
- **Source control** – control of run-off at/near source e.g. rainwater harvesting, green roofs, permeable pavements, soakaways and other infiltration methods;
- **Site control** – water management from several different catchments e.g. route water from roofs and impermeable areas to single infiltration/attenuation point;
- **Regional control** – integrate run-off from multiple sites e.g. use of detention pond or wetland.

Local authorities should encourage the use of SuDS, which are a requirement of Approved Document Part H of the Buildings Regulations. This chapter presents a summary of the SuDS techniques available and a non-specific overview of the types of techniques that may be appropriate for development sites in Thurrock. Further assessment has been undertaken as part of the Thurrock Outline Water Cycle Study which is being prepared for Thurrock BC.

10.2 Why use SuDS?

Traditionally, built developments have used piped drainage systems to manage surface water and convey surface water run-off away from developed areas as quickly as possible. Typically these systems connect to the public sewer system for treatment and/or disposal to local watercourses. Whilst this approach rapidly transfers surface water from developed areas, the alteration of natural drainage processes can potentially impact on downstream areas by increasing flood risk and reducing water quality.

Due to the difficulties associated with upgrading sewer systems it is uncommon for sewer and drainage systems to keep pace with the rate of development/redevelopment and the increasingly stringent drainage discharge restrictions that are being placed upon them. As development continues and/or urban areas expand these systems can become inadequate to deal with the volumes of surface water that is generated, resulting in increased flood risk and/or pollution to watercourses. Allied to this are the implications of climate change and increasing rainfall intensities.

SuDS offer a method for managing surface water on site by maximising the amount of rainwater which is returned to the ground through infiltration techniques and holding back, or attenuating excess surface water on-site, and potentially releasing it into the sewer systems over a longer time period. Infiltration techniques enable the recharging of aquifers which is of importance in Thurrock. A preference for the use of SuDS is highlighted in Planning Policy Statement 25 and its associated Practice Guide and is also a requirement of Approved Document Part H of the Buildings Regulations. Further details regarding water resources available to Thurrock are discussed within the Water Cycle Study Report.

In addition, SuDS offer wider sustainability advantages within Thurrock, such as creating opportunities for landscaping within development sites and incorporating habitats for wildlife as well as encouraging the recharging of aquifers.

10.3 SuDS Techniques

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourses or public sewers etc). Various SuDS techniques are available and they operate under two main principles; infiltration and detention/attenuation.

Infiltration techniques rely on discharges to the ground and therefore their success is dependent on the local ground conditions, such as the permeability of the soils and geology, the groundwater table depth and the importance of underlying aquifers as water resources.

Detention/attenuation techniques result in a reduction in the rate of discharge from the site through storing water on the site. Clearly the volume of water leaving the site will still remain the same and therefore it will be necessary to assess the volume of on-site storage available as well as the impact the storage may have on development proposals and risks to neighbouring properties. The volume of on-site storage required should be calculated through hydrological analysis using industry-approved procedures to ensure that a robust design storage volume is provided.

Due consideration should be given to appropriate SuDS techniques throughout preparation and development of the overall drainage strategy for individual development sites. An investigation into ground conditions will be required in order to determine whether infiltration techniques are feasible or whether attenuation techniques are more appropriate.

During the design process, liaison should take place with Thurrock BC, the Environment Agency and if necessary, Essex and Suffolk and/or Anglian Water to establish a satisfactory design methodology and permitted rate of discharge from the site.

The application of SuDS is not limited to a single technique per site. In fact, the most successful SuDS solutions often utilise a combination of techniques, in order to provide flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be implemented on a strategic scale, for example with a number of sites, contributing to large scale jointly funded and managed scheme. It should be noted that each individual development site must provide storage to offset its own increase in runoff and attenuation cannot be ‘traded’ between developments.

A summary of available techniques and their suitability to meet the three goals of sustainability is provided in Table 10-1 overleaf.

Table 10-1: Summary of SuDS Techniques and their Suitability to meet the Three Goals of Sustainability

Key: ● – highly suitable, ○ - suitable depending on design

Management Train	Component	Description	Water Quantity	Water Quality	Amenity Biodiversity
Source / Prevention	Green roofs	Layer of vegetation or gravel on roof areas providing absorption and storage.	●	●	●
Source / Prevention	Rainwater harvesting	Capturing and reusing rainwater for domestic or irrigation uses.	●	○	○
Source / Prevention	Permeable pavements	Infiltration through the surface into underlying layer.	●	●	○
Source	Filter drains	Drain filled with permeable material with a perforated pipe along the base.	●	●	
Source	Infiltration trenches	Similar to filter drains but allows infiltration through sides and base.	●	●	
Source	Soakaways	Underground structure used for store and infiltration.	●	●	
Source	Bio-retention areas	Vegetated areas used for treating runoff prior to discharge into receiving water or infiltration	●	●	●
Source / Site	Swales	Grassed depressions, provides temporary storage, conveyance, treatment and possibly infiltration.	●	●	○
Site	Sand filters	Provides treatment by filtering runoff through a filter media consisting of sand.	●	●	
Site / Regional	Basins	Dry depressions outside of storm periods, provides temporary attenuation, treatment and possibly infiltration.	●	●	○
Site / Regional	Ponds	Designed to accommodate water at all times, provides attenuation, treatment and enhances site amenity value.	●	●	●
Site / Regional	Wetland	Similar to ponds, but are designed to provide continuous flow through vegetation.	●	●	●

10.4 Where can SuDS be used?

The underlying ground conditions of a development site will determine the most appropriate type of SuDS to be used. These will need to be established through ground investigations carried out on a site-by-site basis. However, an initial assessment of the suitability of SuDS techniques can be carried out on a strategic scale through a review of geological mapping. Tables 10-2 and 10-3 provide a review of the geology in Thurrock.

The Solid and Drift Deposits Geology throughout Thurrock has been determined from analysis of BGS geological mapping at 1:50,000 scale. In the northern part of the Thurrock study area the solid geology is dominated by London Clay, which typically consists of very fine grains and is therefore highly impermeable. In these areas, it would be appropriate to consider using attenuation techniques as part of the drainage systems. Elsewhere, where the solid geology comprises Chalk and Lambeth Group, it may be possible to use a combination of infiltration and attenuation methods.

A large proportion of southern Thurrock, in which most of the broad areas for regeneration are located, is covered by drift deposits of Alluvium. Alluvium deposits are generally created through deposition of material eroded through coastal and fluvial processes, and typically consist of clay, silt, sand and gravel. Alluvium is considered to have variable permeability and therefore infiltration systems may prove feasible in these locations.

In general, the conclusion of the geological mapping review is that attenuation systems are likely to be the most feasible SuDS system throughout the north part of Thurrock. Attenuation and combined attenuation/infiltration systems are considered appropriate for central and southern Thurrock, as displayed in Figure 13. Preventative SuDS should be considered in all areas of the borough. Table 10-4 provides a summary of the types of SuDS that could be considered in each of the Broad Areas for Regeneration in Thurrock.

An Outline Water Cycle Study is currently being prepared for Thurrock. This document provides more detailed assessment and description of the SuDS that could be considered for development areas in Thurrock dependent on the type of housing and development that is envisaged, the vulnerability of groundwater to contamination and the presence of source protection zones (SPZs). Within this report it is noted that of the minor watercourses within Thurrock, Gobions Sewer, Stone House Sewer, East Tilbury Dock Sewer and West Thurrock Sewer, have been identified by the Environment Agency as low-flow channels with no additional capacity to accept surface water runoff. Any future development within the locality of these watercourses will therefore require attenuation to greenfield runoff rates prior to discharging into the sewers.

10.5 Further Information

The above information is intended to provide an introduction to SuDS and broad recommendations as to where techniques may be appropriate. The options available for provision of SuDS is not limited to those presented within this chapter and new techniques will be developed as time progresses. Chapter 15 includes a list of relevant reference material, which contains further detailed information on SuDS, their benefits, limitations and how they can be utilised to maximum effect.

The Outline Water Cycle Study for Thurrock provides useful recommendations regarding the best use of SuDS for development sites in Thurrock and should be used to build upon the introduction provided in this report.

Table10-2: Specific Drift Deposits Geology within Thurrock

Drift Deposit	Permeability	General Characteristics	Locations	SUDs
Alluvium	Variably Permeable	Generally clay with some gravel sand and silt	Found adjacent to the River Thames and within the River Mardyke floodplain	Infiltration and combined infiltration/attenuation systems and attenuation systems e.g. permeable surfaces, sub surface infiltration, basins and ponds, swales and filter strips i.e. a combined system
River Terrace Deposits	Variably Permeable	Variable, generally dominated by sand and gavel	Mid Thurrock, to the north of the alluvium deposits	Infiltration and combined infiltration/attenuation systems and attenuation systems e.g. permeable surfaces, sub surface infiltration, basins and ponds, swales and filter strips i.e. a combined system

Table 10-3: Specific Solid Geology within Thurrock

Solid Geology	Permeability	General Characteristics	Locations	SUDs
London Clay Formation	Impermeable	Clay, Orange brown becoming blue grey with depth, variably silty with thin sand and rare pebble beds. Some siltstone nodules and bands and Selenite Crystals, occasional shell fragments	North Thurrock (to the north of the A13)	Attenuation systems e.g. basins and ponds, green roofs, tanks, rainwater harvesting etc
Chalk	Permeable	White, grey chalk, nodular and soft with flint seams	River Thames and River Mardyke floodplains	Infiltration and combined infiltration/attenuation systems e.g. permeable surfaces, sub surface infiltration, swales and filter strips i.e. a combined system
Thanet Sand & The Lambeth Group	Variably Permeable	Lambeth Group was formerly known as the Woolwich and Reading Formation and consists of mottled clays sands silts with some shelly beds. Thanet sands.	Band running across mid Thurrock,	Infiltration and combined infiltration/attenuation systems and attenuation systems e.g. permeable surfaces, sub surface infiltration, basins and ponds, swales and filter strips i.e. a combined system

Table 10-4: Sustainable Drainage Systems Summary for the Broad Areas for Regeneration in Thurrock

SITE	AQUIFER	SOURCE PROTECTION ZONE	ASSESSMENT FOR USE OF SUDS
Purfleet Urban Area	Major Aquifer	None	It is unlikely there will be any stringent restrictions on the use of SUDs in this area.
Aveley Urban Area	Minor Aquifer	SPZ3 to south of area	There may be some restrictions placed on the amount of infiltration that would be permitted in the south eastern section although with suitable pollution prevention such as hydrocarbon separators, infiltration SuDS should be acceptable
S. Ockendon Urban Area	Minor Aquifer	SPZ2 and 3 to south of site	There may be some restrictions placed on the amount of infiltration that would be permitted in the south of the area although with suitable pollution prevention such as hydrocarbon separators, infiltration SuDS should be acceptable
West Thurrock Urban Area	Minor Aquifer	SPZ 3 covers half of area, SPZ 2 (north eastern corner), SPZ 1 (adjacent to NE boundary)	There will be limitations on the amount of infiltration permitted in the east of the area, although with suitable pollution prevention such as hydrocarbon separators, infiltration SuDS should be acceptable. In the north east area there is likely to be significant restrictions on the type of infiltration SuDS that can be promoted in order to protect the Stifford abstraction for Public Water Supply. It is likely that only clean roof water runoff will be permitted for discharge to ground and there may also be limitations on the industry and other land uses such as garages and petrol stations to accompany residential development. Surface water runoff reduction will be heavily reliant on surface water attenuation.
Grays Urban Area	Major Aquifer	SPZ 3 (west of area), SPZ 2 (north western corner), SPZ 1 (north western corner)	There will be limitations on the amount of infiltration that would be permitted in the west of the area, although with suitable pollution prevention such as hydrocarbon separators, infiltration SuDS should be acceptable. In the north west area there is likely to be significant restrictions on the type of infiltration SuDS that can be promoted in order to protect the Stifford abstraction for Public Water Supply. It is likely that only clean roof water runoff will be permitted for discharge to ground and there may also be limitations on the industry and other land uses such as garages and petrol stations to accompany residential development. Surface water runoff reduction will be heavily reliant on surface water attenuation.
Tilbury Urban Area	Major Aquifer	None	It is unlikely there will be any stringent restrictions on the use of SuDs in this area.

SITE	AQUIFER	SOURCE PROTECTION ZONE	ASSESSMENT FOR USE OF SUDS
Chadwell St Mary Urban Area	Minor Aquifer	SPZ3 overlies north east of the area	There may be some restrictions placed on the amount of infiltration that would be permitted in the north eastern section although with suitable pollution prevention such as hydrocarbon separators, infiltration SuDS should be acceptable
East Tilbury	Minor Aquifer	Area overlies SPZ3, SPZ 2 and SPZ1.	The area is likely to have significant restrictions on the type of infiltration SuDS that can be promoted in order to protect the Linford abstraction for Public Water Supply. It is likely that only clean roof water runoff will be permitted for discharge to ground and there may also be limitations on the industry and other land uses such as garages and petrol stations to accompany residential development. Surface water runoff reduction will be heavily reliant on surface water attenuation.
Villages	Minor Aquifer (South) / Non-Aquifer (North)	None	It is unlikely there will be any stringent restrictions on the use of SuDS in this area.
Stanford-le-Hope and Corringham Urban Area	Minor Aquifer (South) / Non-Aquifer (North)	None	It is unlikely there will be any stringent restrictions on the use of SuDS in this area.
London Gateway	Minor Aquifer (south) / Non-Aquifer (north)	None	It is unlikely there will be any stringent restrictions on the use of SuDS in this area.

11 Broad Areas for Regeneration

Thurrock BC has formulated an overall strategy for the regeneration of Thurrock, called the Regeneration Framework and identified 12 Broad Areas for Regeneration in Thurrock. These Broad Areas for Regeneration are shown in Figure D-1.

The purpose of this Level 1 SFRA is to provide a strategic review of flood risk across Thurrock to inform the strategic spatial planning of Thurrock. This chapter seeks to present the implications of this review for these Broad Areas for Regeneration.

11.1 Flood Zone Mapping

Figures within Appendix D provide an indication of the probability of tidal and fluvial flooding affecting each Broad Regeneration Area. These maps should be used as part of the evidence base when applying the Sequential Test and making decisions about where to locate new development in Thurrock.

11.2 Flood Hazard Rating

11.2.1 Overview

A large proportion of Thurrock lies within the defended floodplain and is therefore shown to be at residual risk of flooding in the Flood Zone maps. In order to enable a sequential approach to planning within the Broad Regeneration Areas and locate development in areas of lowest flood risk first, further information regarding the variation in flood risk is required.

The scope of this Level 1 SFRA has therefore been expanded to include Flood Hazard mapping associated with the fluvial flood risk and the risk resulting from a breach of the tidal flood defences.

11.2.2 Tidal Flood Hazard

Hydrodynamic breach modelling has been undertaken for 21 breach locations along the Thurrock frontage as part of the Level 2 SFRA. The precise breach locations and detailed methodology are included within the Level 2 SFRA report.

As part of the Level 1 SFRA, these models have been run for the following return period events during the present day conditions (i.e. with no consideration for climate change):

- 1 in 200 year tidal breach event for the current day 2009
- 1 in 1000 year tidal breach event for the current day 2009

The derivation of these categories is based on Flood Risks to People FD2320 (DEFRA & EA, 2005), using the following equation:

*Flood Hazard Rating = ((v+0.5)*D) + DF* *Where v = velocity (m/s)*

D = depth (m)

DF = debris factor

The depth and velocity outputs from the 2D hydrodynamic modelling are used in this equation, along with a suitable debris factor. For this SFRA, a precautionary approach has been adopted inline with FD2320; a debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

Table 11-1: Hazard categories based on FD2320, DEFRA & Environment Agency 2005

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

Hazard outputs have been processed for the 1 in 200 year event and 1 in 1000 year events for the present day (2009) and are included in the Figures in Appendix F of this report.

11.2.3 Fluvial Flood Hazard

Flood hazard has been calculated for the River Mardyke and Stanford Brook flood outlines using the same formula applied for the breach assessments described above. For these fluvial systems, the 1 in 100 year event has been used, as this is considered comparable with the 1 in 200 year tidal event. The velocity has been assumed as 0. A debris factor of 0.5 has been used for depths less than and equal to 0.25m, and a debris factor of 1.0 has been used for depths greater than 0.25m.

The hazard rating for the River Mardyke and Stanford Brook has been mapped with the tidal hazard rating resulting from the breach scenarios. Where these overlap, the highest hazard rating at each point in the floodplain has been presented.

11.3 Coarse Assessment

Appendix D presents Flood Zone mapping of each Broad Areas of Regeneration allocated by Thurrock BC and Appendix F presents the mapping of hazard rating in relation to actual fluvial flood risk and residual tidal flood risk. Table 11-2 provides an overview of this coarse assessment for the 12 Broad Areas for Regeneration.

Table 11-2 Coarse Assessment Overview for Broad Regeneration Areas in Thurrock

Area Name	Flood Zone 2	Flood Zone 3a/b	Max Hazard Rating 1 in 1000 yr (2009)	Surface Water Issues	Groundwater	Recorded Sewer Flooding	Artificial Water Features	Passes Sequential Test?	Exception Test Required?
Purfleet Urban Area	✓	✓	Extreme	✓	-	-	×	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
Aveley Urban Area	×	×	×	-	-	-	×	✓	No
S. Ockendon Urban Area	×	×	×	-	-	-	×	✓	No
West Thurrock Urban Area	✓	✓	Extreme	-	-	-	✓	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
Grays Urban Area	✓	✓	Extreme	-	-	✓	✓	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
Stifford Clays / N. Grays	×	×	×	-	-	-	×	✓	No
Tilbury Urban Area	✓	✓	Extreme	-	-	✓	✓	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
Chadwell St Mary Urban Area	×	×	×	-	-	-	×	✓	No
East Tilbury	✓	✓	Significant		-	-	×	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
Villages	×	×	×	✓	-	✓	×	✓	No
Stanford-le-Hope and Corringham Urban Area	✓	✓	Extreme	✓	-	✓	×	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b
London Gateway	✓	✓	Extreme	-	-	-	✓	Further assessment needed	Where it can be demonstrated that there are no reasonably available alternative sites for the proposed development, i.e. it passes the Sequential Test, the Exception Test will be required for: • More Vulnerable development located in Flood Zone 2 • Highly Vulnerable development located in Flood Zone 3a • Essential Infrastructure located in Flood Zone 3a or 3b

11.4 Conclusions

The coarse assessment shows that of the 12 Broad Areas for Regeneration, five are located within Flood Zone 1; Aveley Urban Area, Chadwell St Mary Urban Area, South Ockendon Urban Area, Stifford Clays / North Grays and the Villages in the north of Thurrock. Within these areas, fluvial flood risk and residual tidal flood risk resulting from a breach in the flood defences, are low and are not expected to impact upon the type and design of development that is appropriate. Where development is proposed within these areas, an assessment of surface water runoff pathways should be undertaken as part of a site-specific Flood Risk Assessment (FRA). Steps should be taken to ensure that the development does not increase flood risk elsewhere, and Greenfield runoff rates should be sought from all new developments through the implementation of sustainable drainage systems (SuDS). Further details with respect to the requirements of FRAs and the use of appropriate SuDS are provided in Chapters 7 and 10 respectively.

The remaining Broad Areas for Regeneration are located predominantly within Flood Zone 3a associated with the River Thames. These include East Tilbury, Grays Urban Area, London Gateway, Tilbury Urban Area and West Thurrock Urban Area. It will be necessary to use the Flood Hazard mapping to apply the Sequential Test to individual development sites within these areas to determine whether there are reasonably alternative sites available for the development in areas of lower flood risk.

The Sequential Test undertaken for Thurrock demonstrates the need for development within these areas and therefore it is likely that development will be proposed where there is residual risk of tidal flooding and may require application of the Exception Test. In order to apply the Exception Test, more detailed information is required regarding the nature of flooding in these areas such as flood depths, velocities and time to inundation by floodwaters. A Level 2 SFRA has been prepared to present this information and provide guidance for those sites that will require the Exception Test.

12 Minerals and Waste Development Sites

12.1 Introduction

One of the Development Plan Documents (DPD) that forms Thurrock BC's LDF is the Minerals and Waste DPD which sets out detailed site and development control issues for Minerals and Waste sites within the borough. This SFRA provides part of the evidence base for the Minerals and Waste DPD and assists the Sustainability Appraisal and Strategic Environmental Assessment (SA/SEA) in the evaluation of the Minerals and Waste DPD in relation to flood risk.

Thurrock BC is currently collating suitable sites to be considered for adoption within the Minerals and Waste DPD. Whilst these sites are yet to be adopted, an assessment of the flood risk posed to these sites is a useful resource to add to the evidence base. As a result, a supplementary document has been prepared, providing an assessment of the flood risk to the sites that have been identified in the first stages of the search for sites.

12.2 Policy Context

12.2.1 Background

In the past, Thurrock has been renowned for mineral extraction including clay, aggregates and large quantities of chalk to supply cement industries. Many of these industries are now widely out of use.

In addition, South Essex has historically provided a large number of landfill sites for waste from London and southeast England due to the presence of numerous former quarries within the area. There are therefore a number of current and historic landfill sites within Thurrock and a continued need for more within the wider area.

The following sections provide a summary of regional and local policy in relation to the provision of minerals and waste sites in Thurrock.

12.2.2 Regional Policy

Waste

The RSS East of England Plan highlights key objectives for waste management policies in the area. Policy WM4 states that when developing policies in their Waste LDDs, planning authorities should take responsibility for waste arising in their particular administrative areas. Thurrock should therefore plan for the following quantities of waste, including provision for imported waste from London in agreement with Policy WM3.

Table 12-1 Policies WM3 & WM4 for Thurrock, extracted from East of England Plan, May 2008

ANNUAL TONNAGES OF WASTE (THOUSAND TONNES) TO BE MANAGED			
YEAR	2005/06 – 2010/11	2010/11 – 2015/16	2015/16 – 2020/21
Thurrock (WM4)	540	510	510
Imported from London (WM3)	210	100	-

Minerals

National policy with respect to minerals is to ensure supply is sufficient to meet industry's needs whilst taking full account for the objectives of sustainable development. Whilst the underlying aim is to move towards a more sustainable use of the mineral resource through a reduced reliance on primary aggregates, these primary minerals will still be required. The East of England Plan identifies the presence of sand and gravel resources in Thurrock.

12.2.3 Local Policy

Thurrock BC released a Preferred Options Consultation DPD to inform the Core Strategy & Policies for Control of Development, which forms part of their LDF. The following policies are of relevance to minerals and waste sites:

SO15: *To ensure an adequate supply of minerals by promoting the use of secondary and recycled aggregates; safeguarding sites for their importation; and by safeguarding and identifying resources for future extraction to maintain a landbank of permitted reserves, whilst seeking to minimise the impact on the environment.*

SO16: *To achieve a reduction of waste at source through promotion of the waste hierarchy, whilst securing a sustainable network of waste facilities to provide self-sufficiency for Thurrock waste and a reduction of imported waste into the borough in accordance with regional apportionment.*

12.2.4 National Policy: PPS25 Development and Flood Risk

PPS25 promotes a sequential approach during the planning process in order to ensure that sites are allocated within areas at lowest risk of flooding first. During application of the Sequential Test, the Environment Agency and SFRA flood maps should be used as a basis for measuring flood risk.

Tables D.1 and D.2 of PPS25 identify the types of development appropriate for each Flood Zone. Table 12-2 below develops this and displays the vulnerability classification for the different forms of minerals and waste developments that can be envisaged.

Table 12-2: Vulnerability Classifications for Minerals and Waste Sites (Tables D1, D2, PPS25)

DEVELOPMENT TYPE	VULNERABILITY CLASSIFICATION	ACCEPTABLE FLOOD ZONE
Landfill and hazardous waste facilities	More Vulnerable	Flood Zone 1, 2
Sewage Treatment Plants	Less Vulnerable	Flood Zones 1, 2, 3a
Waste treatment (except landfill and hazardous waste facilities)	Less Vulnerable	Flood Zones 1, 2, 3a
Waste recycling and composting uses (except hazardous waste)	Less Vulnerable	Flood Zones 1, 2, 3a
Minerals working and processing (excluding sand and gravel)	Less Vulnerable	Flood Zones 1, 2, 3a
Sand and gravel	Water Compatible	Flood Zones 1, 2, 3a, 3b
Secondary aggregate re-cycling	Less Vulnerable	Flood Zones 1, 2, 3a
Concrete block manufacture	Less Vulnerable	Flood Zones 1, 2, 3a
Concrete batching plant	Less Vulnerable	Flood Zones 1, 2, 3a
Electricity generating power stations	Essential Infrastructure	Flood Zone 1, 2

The supplementary document provides an appraisal of the sites suggested as potential sites for mineral extraction and/or waste management with respect to flood risk.

12.3 Mineral Extraction and Flood Risk

12.3.1 Tidal / Fluvial Flooding

The spatial strategy for minerals development is primarily driven by geology since minerals can only be worked where they naturally occur. Most deposits of sand and gravel are located within natural river floodplains and as a result, the application of the Sequential Test is not as strict as that for built development. For the purposes of applying the Sequential Test, this type of development is classified as 'water compatible' in Table D.2 of PPS25 and is therefore considered appropriate in areas of flood risk.

Mineral extraction in the floodplain may lead to a reduction in the level of flood risk by providing additional capacity during its operation phase for floodwater storage. Alternatively, structures and buildings required for and associated with mineral extraction procedures can reduce the capacity for storage in the floodplain and may alter the natural flow of floodwater by obstructing flow paths, thereby increasing flood risk in adjacent land. This can be managed by applying the sequential approach within the site to ensure that such structures are located in areas of lowest flood risk, or areas with the lowest influence on flood risk elsewhere.

Site-specific Flood Risk Assessments (FRAs) submitted at the application stage should ensure that sites are designed, worked and restored accordingly. The fact that workings may still result in some increased flood risk elsewhere justifies application of the Sequential Test when considering site allocations through the LDF. However, such workings are classified as Water Compatible development and it is not expected that a Level 2 SFRA will need to be undertaken for such sites. Sequential working and restoration can be designed to reduce flood risk by providing flood storage and attenuation.

12.3.2 Surface Water Flooding

Periods of prolonged rainfall, or intense periods of rainfall over a short duration, can lead to overland flow where rainwater is unable to infiltrate into the ground or enter drainage systems.

One of the main issues with surface water flooding is that relatively small changes to hard surface and surface gradients can cause flooding. As a result, development for minerals sites including the stockpiles and ancillary buildings could lead to more frequent surface water flooding which can cause disruption to the site and surrounding land. Additionally, the use of heavy machinery during the construction and operation phases could reduce the permeability of the site and thereby increase the potential for surface water runoff. It is thought that any problems encountered from surface water flooding are more likely to inconvenience the operator and are unlikely to be significant in assessing the suitability of sites; however the risk of surface water flooding to adjacent sites should be considered.

12.3.3 Groundwater Flooding

Groundwater flooding is described in PPS25 as occurring when water levels in the ground rise above surface elevation, which is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

Minerals workings in most cases excavate below the natural water table, which during periods of heavy rainfall may rise. Mineral workings often operate a pumped system and can therefore interfere with groundwater flow. These issues would be most appropriately addressed in a site-specific FRA at the planning application stage.

12.3.4 Sewer Flooding

Sewer flooding generally results in localised short term flooding caused by intense rainfall events overloading the capacity of sewers. Flooding can also occur as a result of blockage, poor maintenance or structural failure.

Minerals sites are generally located in rural areas remote from settlements, and therefore sewer flooding is not thought to be a large issue with regard to flood risk at proposed minerals sites. However, localised sewer flooding issues should be considered as part of a site-specific FRA.

12.3.5 Flooding from Artificial Sources

There are a number of small lakes and ponds throughout Thurrock, some of which have small embankments to retain water. Where appropriate, any residual risk to proposed sites should be considered as part of a site-specific FRA.

12.4 Waste Management and Flood Risk

Landfill has historically been the most common method of waste management throughout the UK. However, in order to come into line with EU legislation and government targets ways must be found to reduce the current dependence on landfill and move towards more sustainable methods of managing waste. These methods include recycling, composting and energy recovery through various technologies such as anaerobic digestion, combustion or gasification.

12.4.1 Tidal / Fluvial Flooding

A large proportion of Thurrock is at residual risk from tidal flooding from the River Thames, as well as the actual risk of flooding from fluvial sources. It is therefore likely that sites allocated for mineral extraction or waste disposal will be at risk of tidal or fluvial flooding.

PPS25 Table D.2 and Table 12-2 of this report classify landfill sites and waste management facilities for hazardous waste as ‘More Vulnerable’ developments, and are therefore restricted to Flood Zones 1 and 2 (prior to the application of the sequential test). All other minerals and waste sites are classified as ‘Less Vulnerable’ and are considered appropriate in Flood Zones 1, 2 and 3a.

The flooding of landfill and waste management sites could significantly contaminate surface water sources so it is necessary to apply the Sequential Test when locating these sites to ensure that wherever possible opportunities are taken to locate these developments in Flood Zone 1. Any applications made for sites allocated within a flood zone will need to be supported by a site-specific Flood Risk Assessment.

12.4.2 Surface Water Flooding

Waste treatment plants may increase the percentage of impermeable surfaces on the site and therefore increase the risk of flooding from surface water. The risk from this form of flooding is increased at low points in the catchment and should be considered on a site by site basis as part of a site-specific FRA.

12.4.3 Groundwater Flooding

Groundwater flooding is described in PPS25 as occurring when water levels in the ground rise above surface elevation, which is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

The relation of groundwater and potential contamination should be investigated prior to approval of any waste sites.

12.4.4 Sewer Flooding

Sewer flooding generally results in localised short term flooding caused by intense rainfall events overloading the capacity of sewers. Flooding can also occur as a result of blockage, poor maintenance or structural failure. Anglian Water and Essex and Suffolk Water are the statutory water undertakers for wastewater and clean water respectively in the study area which includes all the proposed waste management sites. Any incidents of sewer flooding relevant to the waste sites within Thurrock are included in Figure 9.

12.4.5 Flooding from Artificial Sources

There are a number of small lakes and ponds throughout Thurrock, some of which have small embankments to retain water. Where appropriate, any residual risk to these sites should be considered as part of a site-specific FRA.

13 Site-Specific Flood Risk Assessment Guidance

Site-specific Flood Risk Assessments (FRAs) are required to assess the flood risk posed to proposed developments and to ensure that, where necessary and appropriate, suitable mitigation measures are incorporated. This section presents recommendations for FRAs prepared for submission with planning applications in Thurrock. The guidance presented within this chapter has been based on:

- recommendations presented within Planning Policy Statement 25 and the accompanying Practice Guide;
- a review of local policies contained within Thurrock BC's Site Specific Allocations and Policies Preferred Options DPD (2008), and;
- information provided to enable preparation this Level 1 SFRA.

13.1 When is a Flood Risk Assessment Required?

The Environment Agency provides flood risk standing advice for applicants and agents on their website http://www.environment-agency.gov.uk/research/planning/82587.aspx. This includes information on when a FRA is required and advice on the contents of FRAs for various development types in Flood Zones 1, 2 and 3.

When informing developers of the requirements of a FRA for a development site, consideration should be given to the position of the development relative to flood sources, the vulnerability of the proposed development and its scale.

In the following situations a FRA should always be provided with a planning application:

1. The development site is located in **Flood Zones 2 or 3**;
2. The area of the proposed development site area is 1 hectare or greater in Flood Zone 1. This is to ensure surface water generated by the site is managed in a sustainable manner and does not increase the burden on existing infrastructure and/or flood risk to neighbouring property. Surface water management will also need to be considered as part of the FRA for sites of 1 hectare or greater in Flood Zone 2 and 3;
3. The development site is located in an area known to have experienced flooding problems from any flood source.

13.2 FRA Requirements

The Practice Guide to PPS25 sets out a staged approach to site-specific FRA with the findings from each stage informing both the next level and the site Master Plan, throughout the development process. The staged approach comprises:

- Level 1 Screening Study
- Level 2 Scoping Study
- Level 3 Detailed Study

Table 13-1 Stages of site-specific FRA, PPS25 Practice Guide

FRA Level	Description of Report Content
Level 1 **Screening Study**	The Level 1 FRA is intended to identify any flooding or surface water management issues related to the development site that may require further investigation. The study should be based on readily available existing information, including: • SFRA, • Environment Agency Flood Maps, • Standing Advice The Level 1 FRA will determine the need for a Level 2 or 3 FRA.
Level 2 **Scoping Study**	Where the Level 1 FRA indicates that the site may lie in an area at risk of flooding, or may increase flood risk elsewhere due to runoff, a Level 2 FRA should be carried out. This report will confirm sources of flooding which may affect the site and should include the following; • Appraisal of available and adequacy of existing information; • Qualitative appraisal of the flood risk posed to the site, the potential impact of the development on flood risk on and off the site; • An appraisal of the scope of possible measures to reduce the flood risk to acceptable levels. This Level may identify that sufficient quantitative information is already available to complete a FRA appropriate to the scale and nature of the development.
Level 3 **Detailed Study**	Undertaken if the Level 2 FRA concludes that further quantitative analysis is required in order to assess flood risk issues related to the development site. This Level should include: • Quantitative appraisal of the potential flood risk to the development; • Quantitative appraisal of the potential impact of development on the site under investigation on flood risk on and off the site; • Quantitative demonstration of the effectiveness of any proposed mitigation measures.

At all stages Thurrock BC, and where necessary the Environment Agency, Essex and Suffolk Water and/or Anglian Water, should be consulted to ensure the FRA provides the necessary information to fulfil the requirements for Planning Applications.

13.3 FRA Guidance

The Environment Agency provides flood risk standing advice for applicants and agents on their website http://www.environment-agency.gov.uk/research/planning/82587.aspx which includes a matrix to determine the level of assessment that is required based on Flood Zone classification and development type. Within this matrix are links to FRA Guidance notes and advice for applicants as to which data they will need to purchase from the Environment Agency in order to carry out their FRA.

13.3.1 Risks of Developing in Flood Risk Areas

Developing in flood risk areas can result in significant risk to a development and site users. Issues to consider include the following:

- Failure to consider wider plans prepared by the Environment Agency or other operating authorities may result in a proposed scheme being objected to;
- Failure to identify flood risk issues early in a development project could necessitate redesign of the site to mitigate flood risk;
- Failure to adequately assess all flood risk sources and construct a development that is safe over its lifetime could increase the number of people at risk from flooding and/or increase the risk to existing populations;
- Failure to mitigate the risk arising from development may lead to claims against the developer if an adverse effect can be demonstrated (i.e. flooding didn't occur prior to development) by neighbouring properties/residents;
- Properties may be un-insurable and therefore un-mortgageable if flood risk management is not adequately provided for the lifetime of the development;
- By installing SuDS without arranging for their adoption or maintenance, there is a risk that they will eventually cease to operate as designed and could therefore present a flood risk to the development and/or neighbouring property;
- The restoration of river corridors and natural floodplains can significantly enhance the quality of the built environment whilst reducing flood risk. Such an approach can significantly reduce the developable area of sites or lead to fragmented developments, however positive planning and integration throughout the master planning process should resolve these.

In cases of redevelopment of brownfield sites in the functional floodplain, the advice of the Environment Agency National Development Control Policy team is that the existing building footprint should be considered part of the functional floodplain unless it can be proven that they exclude floodwaters. If the buildings do exclude floodwaters, then solely the area around these buildings will be deemed functional. When undertaking an FRA this matter should be clarified and ideally pre-agreed with the Environment Agency.

13.3.2 Safe Development

Furthermore, the following items should be addressed as part of a FRA in order to demonstrate that proposed developments are 'safe' in line with PPS25. The Environment Agency has specified that the following should be achieved for all development vulnerability types in order to demonstrate safe development:

- Dry access and egress should be provided for all development where possible. Dry escape for residential dwellings should be up to the 1 in 100-year event for fluvial events and 1 in 200 year event for a tidal event, taking into account climate change for the lifetime of the development.
- Finished floor levels should be set at or above the 1 in 100 year plus climate change level (fluvial) and 1 in 200 year plus climate change level (tidal) with a 300mm freeboard allowance.
- Where floodplain compensation is undertaken, the Environment Agency requires that this is provided on a 'Level for Level, Volume for Volume Basis'.
- Flood flow routes should be preserved.
- Flood resilient constructions measures should be incorporated into new developments where required.

It should be noted that the Environment Agency are constantly reviewing their guidance based upon experience, increasing knowledge and the findings of new research and therefore the above criteria are subject to change in the future.

The specific definition of a ‘safe’ development will vary for each individual site, based on location and development vulnerability. The Environment Agency encourages pre-application discussions and it is therefore recommended that developers for individual sites consult with the Environment Agency at an early stage to establish an appropriate definition of ‘safe’ development for their specific site.

14 Where do we go from here?

14.1 Level 1 SFRA

This Level 1 SFRA has drawn on existing information and data to provide a strategic assessment of the flood risk posed to Thurrock from all sources of flooding.

The Level 1 SFRA presents Flood Zone Maps that delineate the Flood Zones outlined in PPS25 as Flood Zone 1, low probability, Flood Zone 2, medium probability, Flood Zone 3a, high probability and Flood Zone 3b, functional floodplain.

Table D.1 of PPS25 provides information on which developments are considered appropriate in each Flood Zone, subject to the application of the Sequential Test and either the Exception Test or a site-specific Flood Risk Assessment (FRA) to demonstrate safety.

Information regarding flood risk has been used to provide a coarse assessment for the Broad Regeneration Areas and the Minerals and Waste sites across Thurrock and to assist with the application of the Sequential Test for these development sites.

14.2 Implications for Policy in Thurrock

In line with flood risk issues and objectives identified by the Environment Agency, it is suggested that the following strategies and considerations are incorporated into Thurrock BC's LDF to strengthen the position of Thurrock BC with respect to flood risk management.

- Ensure the Sequential Test is undertaken for all land allocations. This will ensure that all development is steered towards the areas of lesser flood risk wherever possible and that the vulnerability of proposed developments are appropriate to the defined Flood Zone, thereby reducing the overall flood risk posed to the residents of the borough;
- Site-specific FRAs should be carried out for all developments in Flood Zones 2 and 3; all sites in Flood Zone 1 which are greater than 1.0 ha and all sites that are known to have a critical drainage problem, whatever their size;
- Sustainable Drainage Systems should be included in new developments wherever possible to manage surface water.
- Additional rest centres across the borough should be identified and included in the emerging Flood Emergency Plan for Thurrock.

14.3 Next steps for Thurrock BC

Using the information presented in the Level 1 SFRA, Thurrock BC is now in a position to carry out the Sequential Test with respect to flood risk. This will enable Thurrock BC to identify those areas where further information is required regarding the nature of the flood risk as well as those areas where the Exception Test will need to be applied. These requirements will then be presented and addressed in the Level 2 SFRA.

As part of the Level 2 SFRA, the residual risk resulting from a breach in the flood defences will be assessed to provide information regarding the precise nature of flood risk posed to development sites in

Thurrock. The residual risk behind a flood defence is dependant upon the flood depth, speed of flow of the water, local flow paths, the speed of the onset of flooding, the distance from the defences, the duration of the flood and how water will be removed (Practice Guide, 2008).

14.4 Living Document

This study has been completed in accordance with PPS25 and its accompanying Practice Guide, published in June 2008. The Level 1 SFRA has been developed by building heavily upon existing knowledge with respect to flood risk within the Thurrock study area.

These documents have an intended lifespan of 6-10 years, with Local Development Documents and potential development sites typically revised within 3-6 years. Therefore it should be noted that although up-to date at the time of production, the SFRA has a finite lifespan and should be upgraded or revised as required by the Local Planning Authority.

In summary, it is imperative that the SFRA is adopted as a ‘living’ document and is reviewed regularly in light of emerging policy directives and an improving understanding of flood risk within the borough of Thurrock.

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16 Appendices

Appendix A –Figures

Appendix B – Data/ Contacts Register and Correspondence

Appendix C – Flood Zone Mapping: Broad Areas for Regeneration

Appendix D – Hazard Mapping: Broad Areas for Regeneration

Appendix A: Figures

Appendix B: Data Register and Correspondence

Appendix C: Flood Zone Mapping – Broad Areas for Regeneration

C1	Broad Areas for Regeneration
C2	Purfleet Urban Area: Flood Zones 2009
C3	Purfleet Urban Area: Flood Zones 2109
C4	Aveley Urban Area: Flood Zones 2009
C5	Aveley Urban Area: Flood Zones 2109
C6	South Ockendon Urban Area: Flood Zones 2009
C7	South Ockendon Urban Area: Flood Zones 2109
C8	West Thurrock Urban Area: Flood Zones 2009
C9	West Thurrock Urban Area: Flood Zones 2109
C10	Grays Urban Area: Flood Zones 2009
C11	Grays Urban Area: Flood Zones 2109
C12	Stifford Clays / North Grays: Flood Zones 2009
C13	Stifford Clays / North Grays: Flood Zones 2109
C14	Tilbury Urban Area: Flood Zones 2009
C15	Tilbury Urban Area: Flood Zones 2109
C16	Chadwell St Mary Urban Area: Flood Zones 2009
C17	Chadwell St Mary Urban Area: Flood Zones 2109
C18	East Tilbury: Flood Zones 2009
C19	East Tilbury: Flood Zones 2109
C20	Villages: Flood Zones 2009
C21	Villages: Flood Zones 2109
C22	Stanford-le-Hope and Corringham Urban Area: Flood Zones 2009
C23	Stanford-le-Hope and Corringham Urban Area: Flood Zones 2109
C24	London Gateway: Flood Zones 2009
C25	London Gateway: Flood Zones 2109

Appendix D: Hazard Mapping – Broad Areas for Regeneration

D1 Thurrock Borough: Hazard Rating 200 Year Event (2009)
D2 Thurrock Borough: Hazard Rating 1000 Year Event (2009)

D3 Purfleet Urban Area: Hazard Rating 200 Year Event (2009)
D4 Purfleet Urban Area: Hazard Rating 1000 Year Event (2009)

D5 Aveley Urban Area: Hazard Rating 200 Year Event (2009)
D6 Aveley Urban Area: Hazard Rating 1000 Year Event (2009)

D7 South Ockendon Urban Area: Hazard Rating 200 Year Event (2009)
D8 South Ockendon Urban Area: Hazard Rating 1000 Year Event (2009)

D9 West Thurrock Urban Area: Hazard Rating 200 Year Event (2009)
D10 West Thurrock Urban Area: Hazard Rating 1000 Year Event (2009)

D11 Grays Urban Area: Hazard Rating 200 Year Event (2009)
D12 Grays Urban Area: Hazard Rating 1000 Year Event (2009)

D13 Stifford Clays / North Grays: Hazard Rating 200 Year Event (2009)
D14 Stifford Clays / North Grays: Hazard Rating 1000 Year Event (2009)

D15 Tilbury Urban Area: Hazard Rating 200 Year Event (2009)
D16 Tilbury Urban Area: Hazard Rating 1000 Year Event (2009)

D17 Chadwell St Mary Urban Area: Hazard Rating 200 Year Event (2009)
D18 Chadwell St Mary Urban Area: Hazard Rating 1000 Year Event (2009)

D19 East Tilbury: Hazard Rating 200 Year Event (2009)
D20 East Tilbury: Hazard Rating 1000 Year Event (2009)

D21 Villages: Hazard Rating 200 Year Event (2009)
D22 Villages: Hazard Rating 1000 Year Event (2009)

D23 Stanford-le-Hope and Corringham Urban Area: Hazard Rating 200 Year Event (2009)
D24 Stanford-le-Hope and Corringham Urban Area: Hazard Rating 1000 Year Event (2009)

D25 London Gateway: Hazard Rating 200 Year Event (2009)
D26 London Gateway: Hazard Rating 1000 Year Event (2009)