Braintree District Council, Chelmsford Borough Council, Colchester Borough Council, Maldon District Council

Mid Essex Strategic Flood Risk Assessment

Main Report

October 2007

Prepared for:

Braintree District Council

Chelmsford Borough Council

Colchester

MALDON DISTRICT COUNCIL

Revision Schedule

Mid Essex Strategic Flood Risk Assessment
October 2007

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GLOSSARY

Term	Definition
Actual Risk	The actual risk of flooding to any area is the risk associated with the current local defences. This is expressed, in terms of probability, as the probability that the defence will be overtopped and/or the probability that the defence will suffer a structural failure and the consequences of these scenarios.
Breaching	Failure of a flood defence structure such that the crest of the existing defence is lowered allowing water to pour over or through the defence. This may lead to rapid inundation of the land behind the defence.
Critical Ordinary Watercourse	A watercourse that passes through an intensively developed urban area and at risk from flooding or, a less extensive urban area with some high grade agricultural land and/or environmental assets of international importance requiring protection. The watercourse is only defined as 'critical' for the length that is within the areas outlined above. If however, the length of watercourse is situated out of the areas outlined above, but is considered to have significant impact on the lengths of watercourse within the above areas, it can be designated as critical.
Flood plain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Freeboard	Height of flood defence crest level (or building level) above designed water level.
Hard Flood Defence	Engineered, structural defence often constructed using brick, concrete or metal, e.g. floodwall, sheet piling, or earth embankment with additional engineered toe protection.
Hazard	The potential for something to cause harm, for example a flood, independent of its likelihood of occurring
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, potential development sites and a proposals map.
Overtopping	Passage of floodwater over a defence. May range from wind-driven spray to severe overflowing when flood levels exceed the defence crest level.
Permissive Powers	Powers which may be used, but where there is no statutory duty for them to be used.
Residual Risk	Residual Risk is a term often used in impact and risk assessment across a variety of topics. For this reason, it is also a term that is often inappropriately applied or misused. In a general sense, residual risk is usually taken to refer to that portion of overall risk that remains once risk-aversion measures have been put in place. In a flood risk sense therefore, residual risk can be seen as the risk of flooding that remains after flood defence measures have been implemented.
Risk	The probability or likelihood of an event occurring.
Soft Flood Defence	A non-structural method of flood defence, often a strategic approach such as managed retreat or flood forecasting and warning system.
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 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.

Acronym	Definition
AONB	Area of Outstanding Natural Beauty
CFMP	Catchment Flood Management Plan
COW	Critical Ordinary Watercourse
DCLG	Department of Communities Local Government
DEFRA	Department of Environment, Food and Rural Affairs
DEM	Digital Elevation Model
EA	Environment Agency
EHD	External Hard Drive
FRA	Flood Risk Assessment
GIS	Geographical Information Systems
IDB	Internal Drainage Board
LDD	Local Development Documents
LDF	Local Development Framework
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
NFCDD	National Flood and Coastal Defence Database
NNR	National Nature Reserve
ODPM	Office of the Deputy Prime Minister
PPG25	Planning Policy Guidance Note 25: Development and Flood Risk
PPS25	Planning Policy Statement 25: Development and Flood Risk
RFRA	Regional Flood Risk Assessment
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy
SAC	Special Areas of Conservation
SAR	Synthetic Aperture Radar
SCP	Sustainable Communities Plan
SEA/SA	Strategic Environmental Appraisal / Sustainability Assessment
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
UDP	Unitary Development Plan
WHS	World Heritage Site

1 Introduction

1.1 Background

1.1.1 Since the publication of the Planning and Compulsory Purchase Act 2004 (HMSO, 2004), local authorities have been required to update the existing system of Local, Structure and Unitary Development Plans and replace them with Local Development Frameworks (LDF). LDFs are a portfolio of documents, which collectively deliver the spatial planning strategy for the authority area. Allied with LDFs are Sustainability Appraisals, for which the council is required to produce a Strategic Flood Risk Assessment (SFRA). The SFRA process is essentially an assessment of flood risk issues at a strategic scale undertaken to inform the spatial planning process at a local scale and forms part of the LDF evidence base.

1.1.2 Planning Policy Statement 25: Development and Flood Risk (PPS25) was released in December 2006 (Communities and Local Government, 2006) and supersedes Planning Policy Guidance Note 25: Development and Flood Risk (PPG25). This modification in policy guidance represents a shift from the previous reactive resolution of flooding problems as a result of development to the effective management of flood risk within the planning system. Recent government guidance presented in PPS25 describes the function of SFRAs.

> *"Decision-makers should use the SFRA to inform their knowledge of flooding, refine the information on the Flood Map and determine the variations in flood risk from all sources of flooding across and within their area".* (Communities and Local Government, 2006)

1.1.3 The SFRA will enable a more detailed understanding of the flood risk issues to existing and proposed developments within the individual authorities, allowing a direct input into the strategic planning of the Mid-Essex region through Local Development Frameworks. The current general reference materials for flooding throughout the region are the Environment Agency's Flood Zone Maps.

1.1.4 Spatial Planning documents such as the Draft East of England Plan or Regional Spatial Strategy (RSS14) (East of England Regional Assembly, 2004), and Sustainable Communities Plan (ODPM, 2003a) outlines potential targets for the region with respect to potential residential development (estimated increase of 41,200 dwellings within the SFRA study area by 2021), regeneration, policy and employment. The spatial planning of these must be considered with regard to the current and future risk of flooding from a combination of sources, including tidal inundation, fluvial overspill, storm water management and groundwater. It is therefore vitally important that flood risk is considered at a strategic scale to inform land allocations and future developments within the emerging Local Development Frameworks.

1.1.5 This SFRA is intended to work alongside a similar study conducted in South Essex, therefore giving greater coverage of the county of Essex.

1.2 Scope and Objectives

1.2.1 The SFRA has been undertaken for the Mid Essex Area Liaison group (MEAL), which primarily includes the local councils Chelmsford Borough Council, Colchester Borough Council, Braintree District Council and Maldon District Council.

1.2.2 The SFRA should be regarded as an advisory study informing a suite of policies within each participating authority. The purpose of this SFRA is to:

- Assist the local planning authority (LPA) when defining their appropriate potential development areas and sub-areas (zones) to accord with the principles of PPS25 policies;
- Enable a more detailed understanding of the flood risk issues relating to existing and proposed development;
- Identify areas which are vulnerable to flooding;
- Help identify particular land use types that might need to be restricted in areas vulnerable to flooding;
- Assess the degree of change as a result of climate change through the impact of likely sea level rise and increased peak flood flows though rivers and the storm water drainage system;
- Provide a heightened understanding of flood risk for partners of the MEAL and;
- Inform the planning process to enable integration of flood risk management into the strategic spatial planning of the Mid Essex region.

1.3 Mid Essex SFRA

1.3.1 The local authorities of Mid Essex have identified several development areas within their administrative boundaries, as potential areas for future potential development sites within their preferred options and Local Development Frameworks.

1.3.2 The development areas within each of these local authority areas are principally outlined as:

Braintree

- Bocking;
- Witham
- Braintree; and

- Halstead.

Chelmsford

- Chelmsford Town Centre;
- Broomfield;
- North Chelmsford (north of Springfield);
- Great Leighs; and
- South Woodham Ferrers.

Colchester

- Colchester Town Centre (including North Station, St Botolph's and Garrison);
- North Colchester (includes Cuckoo Farm, Mile End and Severall's);
- East Colchester, Rowhedge Port and Essex University; and
- Stanway

Maldon

- North Heybridge;
- Southminster;
- Totham; and
- Tollesbury

1.3.3 The spatial planning of these areas must be considered with regard to the current and future risk of flooding from a number of sources, including fluvial, tidal, storm water management and groundwater. It is therefore vitally important that flood risk is considered at a strategic scale to inform preferred strategic locations and land allocations and future developments proposed by the emerging Local Development Frameworks.

1.3.4 At the time of writing this document site-specific allocations were in preparation for Chelmsford town centre and core strategies had identified preferred broad locations for growth, therefore pending the finalisation of these, the growth areas were used to identify the flood risks to potential growth and development areas. If on completion of the preferred options there are any allocations that fall outside these growth areas, then the sequential test and potential exception test for these sites will need to be explored at that time.

1.4 SFRA Approach

1.4.1 Development and Flood Risk: A Practice Guide Companion to PPS25 'Living Draft' (Feb 2007) recommends a two-tiered approach to SFRA's:

- A level 1 SFRA, the first stage in the SFRA process, identifies data sources and assesses flood risk using existing data for draft potential development sites. The Level 1 SFRA should enable the Local Authorities to undertake the Sequential Test for their allocation sites.
- A level 2 SFRA, the second phase in the SFRA process, provides a greater level of information and detail on existing and potential development areas within the study area and flood risks, to inform future policies and provide detailed flood risk information.

1.4.2 An Inception Report, completed by Scott Wilson in November 2006, preceded this 'Stage 2' SFRA. The Inception Report located and identified available data and information that would be useful for completion of the SFRA. In addition the report outlined the extents of the study areas, the modelling approach and highlighted various specific flood risk issues within the Mid Essex area that should be covered within the main SFRA report.

1.4.3 The Inception Report stated that the main SFRA study should comprise of two separate components, as requested by the MEAL representatives.

- The first component is a Strategic Flood Risk Assessment covering the whole of the Mid Essex study area. This should be a single, unified report covering all four Districts and should be undertaken without regard to administrative boundaries between the individual Districts. This is in essence a generic (to the wider study area) reference document.
- The second component of the main SFRA should consist of four supporting appendices, one for each of the four MEAL partnership LPAs. These should include certain elements, such as flood mapping outputs and LPA guidance that are specific to that District in addition to specific SuDS information and containing, where specified in the Inception Report, the LPA specific additional information.

1.5 Synopsis

1.5.1 The Inception Report was completed prior to the release of the draft Development and Flood Risk: A Practice Guide Companion to PPS25 'living draft', which made no reference to the level 1 assessment for specific potential development sites. To ensure consistency with future policy these have been included in this report in each of the LPA appendices.

1.5.2 The Inception Report identifies areas of specific interest within the four Districts/Boroughs where more detailed flood risk assessments and studies are required to assist in the application of PPS25. Some of the coastal locations have been subjected to dynamic two-dimensional (2D) hydraulic modelling to determine the pattern of propagation of floodwater flowing through breaches and overtopping of the existing defences. This information has been presented in the relevant local authority appendices.

1.5.3 The SFRA has been structured as follows:

- Main Report: Strategic Flood Risk Assessment
- Annex A: Essex Estuary Management Strategies
- Appendix A: Braintree District Council
- Appendix B: Chelmsford District Council
- Appendix C: Colchester District Council
- Appendix D: Maldon District Council
- The main SFRA report details the processes and methodologies employed in the assessment and mapping of flood risk. It presents information on tidal and fluvial sources, giving an overview of flood risk data and flood pathways throughout the study area.

1.5.4 One of the key deliverables for the SFRA is accurate, high quality mapping of flood risk zones and hazard zones. The relevant inundation flood maps and hazard maps detailing the high, medium and low classifications can be seen in the relevant authority appendices (Appendices A, B, C and D).

Level 1 SFRA

1.5.5 The aim of the Level 1 SFRA, principally a desk based study, is to enable the Local Authorities to apply the Sequential Test. The SFRA aims to facilitate this process by identifying the variation in flood risk across the Borough allowing an area-wide comparison of future development sites with respect to flood risk considerations. This information can also be used to assess how present environmental objectives relating to flooding and defined in the sustainability appraisal can be affected by additional development.

1.5.6 The key development areas within the study area LPA's, outlined in the Inception Report, were investigated with regard to flooding. These are presented in the specific LPA appendices and issues surrounding flooding in these areas discussed.

Level 2 SFRA

1.5.7 Where it can be demonstrated by the Local Planning Authority that the Sequential Test is passed, it will also be necessary in some circumstances for the Council to demonstrate that all three elements of the Exception Test are satisfied.

1.5.8 To assist the Local Authority in the application of the Exception Test, the 'Level 2' SFRA introduces an 'increased scope' taking into account the flood hazard and presence of defences. This information has been assessed within each of the Local Authority specific studies, with hazard mapping presented in each of the specific appendices.

2 SFRA Study Area

2.1 Mid Essex Area

2.1.1 The Mid-Essex region comprises four districts; Maldon, Colchester, Chelmsford and Braintree and lies within the Environment Agency Anglian Region. The region comprises large areas of flat, low lying land, a quarter of which is below sea level. The region has over 160km of coastline most of which is defended from tidal flooding by sea defences. In the last 20 years only 23% of the coastal sea walls in Essex have been raised or improved (Environment Agency, online, year unknown).

2.1.2 The River Crouch forms the southern boundary of the study area, with tidal flows through the lower part of the Crouch Estuary past the towns of Chelmsford and Maldon. The North Sea forms the majority of the eastern boundary of the study area, from the estuary of the River Crouch to the River Colne. Further north of the Colne Estuary, the River Colne forms the eastern boundary. The northern boundary of the study area is defined by the River Stour with the western boundary running to the west of Chelmsford, past Roxwell, Braintree and up to Bumpstead, to the south east of Haverhill. Figure 2-1 below indicates the study area.

2.1.3 There are numerous major rivers within the study area, including the Rivers Can, Chelmer, Brain, Stour, Colne and Crouch and their tributaries.

2.1.4 The estuary systems of the River Crouch, Blackwater and Colne should be regarded as potential sources of tidal flood risk, as should the North Sea on the eastern boundary of the region. The Environment Agency's Flood Zone Maps (Environment Agency, 2006), which indicate the areas of the study region that are at risk from a 1 in 100-year return period flood (fluvial) and 1 in 200 year (tidal) and a 1 in 1,000 year event is shown in Figure 2.

2.1.5 Many of the coastal areas of the study region are defended against flood events by flood defences.

2.1.6 The study area includes the towns of Colchester, Braintree, Halstead, Witham, Heybridge, Burnham-on-Crouch, South Woodham Ferrers, Maldon and Chelmsford. The geographical distribution of these towns can be seen in Figure 2-1, below.

2.1.7 There are no Internal Drainage Boards within the study area. Anglian Water serves the SFRA study area for foul sewerage purposes. Both Essex and Suffolk Water and Anglian Water cover the region with regards freshwater supply and surface water drainage respectively.

2.1.8 Various coastal and estuary conservation designations exist in the estuaries of the River Blackwater and Colne. These range from locally designated areas such as Local Nature Reserves (LNRs), nationally important sites such as Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs) to European sites of importance, e.g. Special Protection Areas (SPAs) and Special Areas of Conservation

(SACs) and internationally important sites such as Ramsar sites. These designations have an important role in nature conservation providing habitats and feeding/breeding grounds for large populations of wildfowl and wader birds. The northern Dedham Vale is also designated an Area of Outstanding Natural Beauty.

FIGURE 2-1 STUDY AREA FOR THE MID ESSEX SFRA

2.1.9 The coastline around Maldon features the large areas of Dengie and Bradwell Marshes, fronted by salt marsh and extensive tidal mudflats. The mouth of the River

Colne at Colchester is fringed with marsh and salt marsh areas, dissected by creeks. In addition, Mersea Island is located within the Colne Estuary.

2.1.10 The geology of the Mid Essex area comprises mudstone in the low-lying. southern and eastern areas. The west and north is underlain by chalk and sandstone (Environment Agency, 2006).

2.2 The Mid Essex Catchments

2.2.1 As mentioned in Section 2.1 above, the major catchments in the study area are the Stour, Colne, Chelmer and Blackwater. Table 2.1 below outlines some of the key statistics of each major river along with their main tributaries.

TABLE 2.1 MAJOR RIVERS IN THE MID ESSEX AREA, THEIR CATCHMENT AREA, SOURCE AND TIDAL LIMIT.

River	Catchment Area (km^2)	Major tributaries	Source	Tidal limit
Stour	862	River Glem, River Box, River Brett	Great Badeley	Downstream of Flatford
Colne	380	Bourne Brook, Toppisford Brook, Layer Brook, Roman River	Great Yeldham	Colchester
Blackwater	313	River Pant, River Brain	Wimbish	Beeleigh
Chelmer	663	River Wid, Stebbing Brook, River Ter, River Can	Thaxted	Beeleigh
Crouch	109.7	Several small, unnamed tributaries	Little Burstead	Battlesbridge
Other Coastal streams	675	Ramsey River, Holland Brook, Catchpole Brook	N/A	N/A

Based on information from the draft North Essex CFMP (Environment Agency, 2006).

2.2.2 As indicated by Table 2.1, the largest main river in the Mid Essex area is the Stour. This river forms the northern border of the study area. As a result, much of the catchment area of this river system outlined within Table 2.1 falls outside of the study area. Similarly, the River Crouch forms the southern boundary of the study area. As a result, much of the catchment area for this river is outside of the study boundary.

2.3 Mid Essex Geology and Hydrogeology

2.3.1 The geology of the study area is dominated by three distinct deposits; London Clay (of Tertiary age), Ice Age clays, sands and gravels and coastal muds and silts (laid down over the last few thousand years). To the northwest of the study area, at the sources of some of the main rivers (including the Stour, Colne and Brain) Chalk is exposed. The study area itself is dominated by mudstone. Chalk generally responds slowly to rainfall, due to it allowing more groundwater storage (albeit depending on the size and amount of fissures within the bedrock). However, the dominance of clays and later deposits in the majority of the study area generally causes the river systems to respond quickly to rainfall (Environment Agency, 2006).

2.3.2 Soils type invariably affects the rate of surface water runoff in a catchment. Deep, loosely packed soils with relatively high volume of air spaces generally retains more rainfall than shallow, dense soils. In the Mid Essex area, the upper areas of the Colne, Stour, Blackwater and Brain are made up of deep chalky clays with the middle and lower areas mainly made up of deep coarse loams and clays. The lower extent of the Chelmer typically consists of seasonally wet clay. The lower extent of the Colne is typified by deep loam soils (Environment Agency, 2006).

2.4 History of Flooding

2.4.1 The Mid Essex area suffered two major flood events in the 20th century, in 1928 and again in 1953. The 1953 flood affected most of eastern England and had significant consequence with surge heights reaching 2.74m at Southend in South Essex and 2.97m at King's Lynn in Norfolk (Met Office, 2006). As a consequence of the event, 307 people lost their lives, a further 30,000 were evacuated and 24,000 properties were destroyed. The overall cost of the disaster is estimated at over £5 billion at current prices.

2.4.2 The 1953 flood event affected the southern part of the North Sea including the majority of the Essex coastline. Despite this having greater effect on areas in South Essex along the Thames Estuary, areas in Mid Essex, such as those along the Roach Estuary, were known to be affected.

2.4.3 The cause of this event was a storm surge that approached the East Anglian coastline on the 31st January 1953. As this surge coincided with a high spring tide, the level of the water experienced was much higher than usual high tide levels. By midnight, Harwich and Maldon had been flooded, with breaches also occurring in the earth embankment flood defences in various locations such as Tollesbury. At Jaywick in Clacton, the sea rose a metre in 15 minutes and 35 people drowned (Met Office, 2006). Major devastation was commonplace along the coast of the east of England following the flood event.

2.4.4 There was also a significant flooding event in the Chelmsford area more recently in October 2000 and October 2001. These events have been recorded in the River Chelmer Flood Risk Study prepared by Black and Veatch 2006. These events were initially assessed by the Environment Agency to have a return period of a 200 year event within the Chelmer catchment (i.e. a chance of 1 in 200 of occurring in any year). Black & Veatch later reassessed this estimate suggesting that the peak flows recorded during these events had a return period in the range 20 to 50 years.

2.4.5 In response to the major flood events, the UK Government initiated the construction of an improved flood defence scheme. Flood defence measures include defence barriers, as well as many kilometres of raised walls in both the upper and lower reaches of the estuary. The loss of life and much of the suffering experienced by residents 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. The result of the high winds experienced as a result of the low-pressure weather system demolished telephone lines within the region, thus removing the main communication link.

3 Flooding and Planning Policy

3.1 Introduction

3.1.1 As a result of the major floods during Easter 1998 and during the autumn and winter of 2000/1, the UK Government placed greater emphasis upon flood risk management. One result was the release of Planning Policy Guidance note (PPG) 25: Development and Flood Risk (PPG25) in 2001, which outlined the Government's policies in terms of development and flood risk.

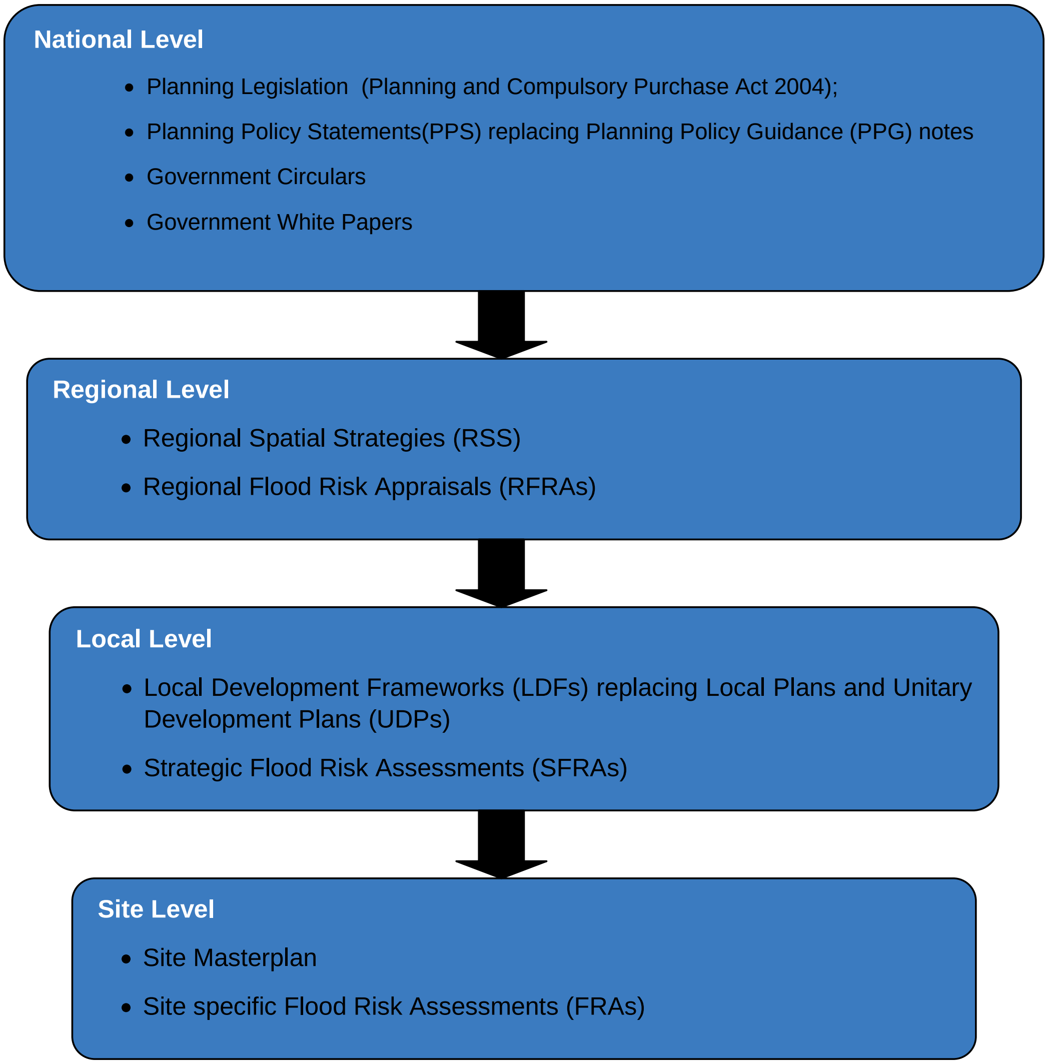
3.1.2 In line with standard Governmental procedures, PPG25 was subject to a three yearly review. The review showed that, whilst the core themes of PPG25 were appropriate and valid, the specific guidance was not comprehensive enough to ensure flood risks were considered early enough within the planning process. The result was the release of Planning Policy Statement (PPS) 25: Development and Flood Risk, initially in consultation phase in December 2005 with the final version being released in December 2006. This has since been accompanied by a draft Practice Guide, released in consultation phase in March 2007 (Communities and Local Government, 2007).

3.1.3 This chapter covers the statutory and non-statutory documents that relate to SFRAs. Firstly, there is an overview of the English planning system followed by an in depth review of PPS25. Subsequent sections examine other relevant statutory and non-statutory policy and guidance relating to flooding at the national, regional and local level.

3.2 Overview of the English Planning System

3.2.1 The English planning system is a hierarchical plan-led system whereby central government determines national policies on different aspects of planning and the rules that govern the operation of the system. The national policies consist of broad guidelines and principles that filter down through regional and local policies to site-specific policies. This system is illustrated in Figure 3-1.

FIGURE 3-1 STRUCTURE OF THE PLANNING SYSTEM



3.2.2 Integrating the previous level's policies with more regional, local or site-specific detail generates each level of policy.

3.2.3 Flood risk is a core issue to be considered when making land use decisions. The challenge of a Strategic Flood Risk Assessment is to develop pragmatic solutions that take account of the various requirements of these policies, and deliver guiding principles to steer future development to the most sustainable locations, avoiding areas of flood risk wherever possible.

3.3 Introduction to Flooding and Planning Policy

3.3.1 PPS25 (Communities and Local Government, 2006) describes flooding from rivers and coastal waters as a:

> '…*natural process that plays an important role in shaping the natural environment*'

3.3.2 However, unmanaged flooding can cause injury or loss of life and damage or destruction to property. The severity of flooding and its associated negative impacts can be intensified as a consequence of previous land use decisions such as location, design and nature of development. In addition, the cumulative effects of climate change could also contribute to the relative severity of flooding events.

3.3.3 PPS25 is explicitly clear that all forms of flooding and their impact on the natural and built environment are a material planning consideration[1]. Planning Policy Statement 1: Delivering Sustainable Development (PPS1, ODPM, 2005) is the Government's flagship planning policy document on how planning should facilitate and promote sustainable patterns of development. This document also advocates the avoidance of flood risk and accommodating the impacts of climate change.

3.3.4 Flooding, from any source, can never be entirely prevented but the severity of impacts can be avoided through good planning and management.

3.4 Statutory National Planning Policy and Guidance

Planning Policy Statement 25: Development and Flood Risk

3.4.1 As explained above, the relevant Planning Policy Statement in terms of managing flood risk that pertains to development is PPS25. PPS25 requires local authorities to take a risk-based approach to flooding in relation to the preparation of development control documents or plans.

3.4.2 This document 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.

3.4.3 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.

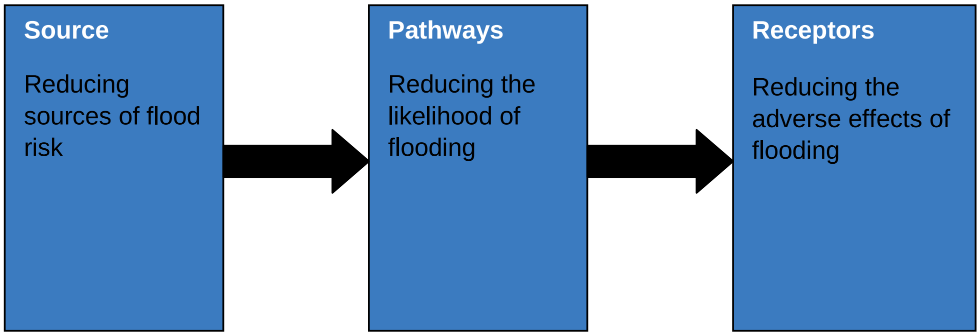
[1] A material planning consideration is a factor that is relevant to a planning application or an appeal. Such factors include density, privacy, cumulative impact, and flooding. Factors not relevant to applications or appeals include loss of view, commercial competition and restrictive covenants. Each application or appeal is judged on its own merits.

Key Planning Objectives

3.4.4 PPS25 identifies means by which Regional Planning Bodies (RPBs) and Local Planning Authorities (LPAs) should prepare and implement strategies that help to deliver sustainable development. These include:

- Appraising risk
  - Identifying land at risk and the degree of risk of flooding from river, sea and other sources in the area;
  - Preparing Regional Flood Risk Assessments (RFRAs) or SFRAs as appropriate;
- Managing risk
  - Framing policies for the location of development which avoid flood risk to people and property where possible, and manage any residual risk and accounting for climate change;
  - Only permitting development in areas of flood risk when there are no reasonably available sites in areas of lower flood risk and benefits of the development outweigh the risks from flooding;
- Reducing risk
  - Safeguarding land from development that is required for current and future flood management eg conveyance and storage of flood water, and flood defences;
  - Reducing flood risk to and from new development through location, layout and design, incorporating sustainable drainage systems (SuDS);
  - Using opportunities offered by new development to reduce the causes and impacts of flooding eg surface water management plans; making the most of the benefits of green infrastructure for flood storage, conveyance and SuDS; re-creating functional floodplain; and setting back defences;
- A partnership approach
- Ensuring spatial planning supports flood risk management policies and plans, River Basin Management Plans and emergency planning.

FIGURE 3-2 SOURCE-PATHWAY-RECEPTOR MODEL



Risk Based Approach

3.4.5 PPS25 advocates a risk-based approach at all levels of planning. This approach utilises the Source-Pathway-Receptor Model to planning for development in areas at risk from flooding. This is illustrated in Figure 3-2.

Flood Risk Assessments

3.4.6 PPS25 explains that SFRAs should be carried out by the LPA to inform the preparation of its Local Development Documents (LDDs), having regard to catchment-wide flooding issues. Thus, the SFRA provides the information, such as aerial photography, flood zone maps provided by the Environment Agency (EA) and the National Flood and Coastal Defence Database (NFCDD), needed to apply the Sequential Test or the Exceptions Test. These tests are risk-based and aim to steer new development to areas at the lowest risk of flooding and will be discussed in the following sections.

The Sequential Test

3.4.7 A sequential risk-based approach to determining the suitability of land for development in flood risk areas should be applied at all levels of the planning process.

3.4.8 PPS25 aims to encourage decision-makers to steer all new development into Flood Zone 1. Where there are no available sites in Flood Zone 1, land allocations or development of any kind should consider reasonably available sites in Flood Zone 2, taking into consideration the flood risk vulnerability of the proposed use and applying the Exception Test where necessary. Only if there are no available sites in Flood Zones 1 or 2 should sites in Flood Zone 3 be considered, again taking into account the flood risk vulnerability of the proposed use and applying the Exception Test where necessary. Within each Flood Zone, decision-makers are expected to steer allocations and developments to those areas of lowest hazard as identified by the SFRA.

3.4.9 Table D.3 illustrates the developments that might be considered to be appropriate in certain flood zones once the Sequential Test has been applied. This table should be referred to in conjunction with Tables D.1 and D.2 of PPS25.

3.4.10 Where Table D.3 indicates an Exception Test is required (i.e. when 'more vulnerable' development and 'essential infrastructure' cannot be located in Zones 1 or 2 and 'highly vulnerable' development cannot be located in Zone 1), the scope of the SFRA will be widened to consider the impact of the flood risk management infrastructure on the frequency, impact, speed of onset, depth and velocity of flooding within the Flood Zones considering a range of flood risk management maintenance scenarios.

The Exception Test

3.4.11 The Exception Test is only appropriate for use when there are large areas of development in Flood Zones 2 and 3, where the Sequential Test alone cannot deliver acceptable sites, but where continuing development is necessary for wider sustainable development reasons. There must be evidence to prove that the Sequential Test has been applied to a particular area to support the outcome.

3.4.12 For the Exception Test to be passed:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA;
- The development should be on developable previously developed land or, if not, it must be demonstrated there is no such alternative land available; and
- A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall.

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.

Development and Flood Risk: A Practice Guide Companion to PPS25 'Living Draft'

3.4.13 This document is due to be published late in 2007 with the consultation process closing in August 2007. However, the document is a living document and a working version is currently available, though only on-line. This copy was made available on 19th February 2007.

3.4.14 The draft supporting Practice Guide provides advice on the practical implementation of PPS25 policy.

Strategic Flood Risk Assessments

3.4.15 With regards to SFRAs the draft guide explains that there are two levels of assessment, Level 1 and Level 2. A Level 1 SFRA should provide sufficient data and information to enable the LPA to apply the Sequential Test to land use allocations and to identify whether the application of the Exception Test will be necessary. The draft guide explains that the Level 1 SFRA should also enable LPAs to:

- Prepare appropriate policies for the management of flood risk within the LDDs;

- Inform the sustainability appraisal so that flood risk is taken account of when considering options and in the preparation of strategic land use policies;
- Identify the level of detail required for site-specific FRAs in particular locations; and
- Enable them to determine the acceptability of flood risk in relation to emergency planning capability.

3.4.16 The Level 2 SFRA corresponds to a more in-depth study of flood risk required to facilitate the application of the Exception Test, and to allow a sequential approach to site allocation within a flood zone i.e. preferentially developing those sites situated in an area of lower hazard within a flood zone.

3.4.17 The draft Practice Guide also explains the full scope of a Level 2 SFRA, the variety of data sources available and the expected outputs of this more detailed analysis.

3.4.18 The draft guide concludes that:

> *'…the SFRA should aim to provide clear guidance on appropriate risk management measures for adoption on sites within Flood Zones 2 and 3 , which are protected from flooding by existing defences, to minimise the extent to which individual developers need to undertake separate studies of the same problem. In some instances improvements to existing flood defences may be required to manage residual flood risks (see Annex G of PPS25). Where such flood defence works are considered, the SFRA should include an appraisal of the extent of any works required to provide or raise the flood defence to an appropriate standard'*

DCLG Circular 04/2006: Town and Country Planning (Flooding) (England) Direction 2007

3.4.19 This document was published in December 2006 and highlights that on 1st October 2006 the Environment Agency was made a statutory consultee on matters relating to flood risk under The Town and Counrty Planning (General Development Procedure) (Amendment) (No. 2) (England) Order 2006. LPAs now have a duty to consult with the Environment Agency on all applications for development in areas of flood risk or where critical drainage problems exist and for developments where the site is larger than 1 hectare, at risk of flooding or not.

3.4.20 In addition, the document details that a LPA must notify the Secretary of State (SoS) of any application for a major development in a flood risk area, where it is minded to grant permission against the advice on flood risk grounds from the Environment Agency. This direction came in to force 1st January 2007.

Planning Policy Statement 1: Delivering Sustainable Development (PPS1)

3.4.21 The application of PPS25 will be closely linked with the application of Planning Policy Statement 1: Delivering Sustainable Development (PPS1) published in February 2005. PPS1 sets out the parameters for planning policy to deliver sustainable development across the planning system. It advocates that local authorities need to take into account the risks of flooding when producing development plan policies. PPS1 emphasises that new development should be avoided in areas that are at risk of flooding and sea level rise, unless such development meets the needs of the wider objectives of sustainable development. Therefore, planning authorities are advised to ensure that developments are 'sustainable, durable and adaptable'.

Consultation - Planning Policy Statement: Planning and Climate Change - Supplement to Planning Policy Statement 1

3.4.22 Planning and Climate Change sets out how spatial planning should contribute to reducing emissions and stabilising climate change (mitigation) and take into account the unavoidable consequences (adaptation).

3.4.23 The document states that climate change in the UK could mean more extreme weather events, including hotter and drier summers, flooding and rising sea levels leading to coastal realignment.

3.4.24 These expected changes will have knock-on effects for land use decisions. The document explains that when deciding which sites and areas are suitable for development and deciding the type and intensity of development, planning authorities should take into account:

> *'…known physical and environmental constraints on the development of land such as sea level rises, flood risk and stability, and take a precautionary approach to increases in risk that could arise as a result of likely changes to the climate'*

Planning Policy Statement 3: Housing (PPS3)

3.4.25 PPS3: Housing was developed in response to recommendations in the Barker Review of Housing Supply in March 2004 (Barker, 2004). A principal aim of the new PPS3 is to underpin the Government's response to the Barker Review of Housing Supply and the necessary step-change in housing delivery, through a new, more responsive approach to land supply at the local level.

3.4.26 The document states that at the local level, LDDs should set out a strategy for the planned location of new housing which contributes to the achievement of sustainable development. LPAs should, working with stakeholders, set out the criteria to be used for identifying broad locations and specific sites taking into account of flood risk.

Planning Policy Guidance 20: Coastal Planning (PPG20)

3.4.27 This guidance note covers planning policy for the coastal areas of England. It sets the general context for policy and identifies planning policies for the coast and policies for development that requires coastal location. Guidance is also given on how these policies should be reflected in development plans.

3.4.28 The document explains that, on the coast, opportunities for development may be limited by physical circumstances, such as risk of flooding, erosion, land instability and by conservation policies. Where the coastal zone is only a small part of the territory of a local planning authority it is reasonable to expect provision of land for housing and employment to be made elsewhere in the district.

3.4.29 In areas at risk of flooding, policy should avoid putting further development at risk. In particular, new development should not generally be permitted in areas that would need expensive engineering works to defend land, which might be inundated by the sea. There is also the need to consider the possibility of such works causing a transfer of risks to other areas. PPG20 highlights the particular risk posed by flooding to low-lying coastal areas.

3.5 Non-Statutory National Planning Documents

Making Space for Water

3.5.1 During 2004, the Department for Environment, Food and Rural Affairs (DEFRA) undertook a consultation exercise, the object of which was to engage a wide range of stakeholders in the debate regarding the future direction of flooding strategy. The consultation document 'Making Space for Water' (DEFRA, 2005) is part of the Governments overall approach to managing future flood risks and sets out the following aim:

3.5.2 'To manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as to:

- Reduce the threat to people and their property; and
- Deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles'

3.5.3 Thus, the aim of the strategy is to balance the main pillars of sustainable development, namely social, economic and environmental factors.

3.5.4 Making Space for Water examines the impact of climate change on flood levels. Experts consider that the primary impacts on flood risk will be from changes in precipitation, extreme sea levels and coastal storms. DEFRA and the Environment Agency will produce revised guidance for use by those implementing flood and coastal erosion risk management measures. The revised guidance, to be finalised by the end of 2006, will ensure that adaptability to climate change through robust and resilient solutions becomes an integral part of all flood and coastal erosion management decisions.

3.5.5 Making Space for Water emphasises the Government's commitment to ensure that a pragmatic approach to reduce flood risk is adopted. However, the paper notes that 10 per cent of England is already within mapped areas of flood risk. Contained within these areas are brownfield sites which policy has identified as a priority for future development. The document asserts that over the past five years 11 per cent of new houses were built in flood risk areas.

3.5.6 The plan advocates the use of European Union (EU) funding streams, such as INTERREG IIIB, to enable local authorities to undertake trans-national projects aimed at advancing knowledge and good practice in flood risk management. The document also encourages integration with water management initiatives, in particular Catchment Flood Management Plans. The document proposes that RSSs and LDFs should take full account of strategic flood risk assessment and incorporates the sequential approach, as set out in PPS25.

3.5.7 At the development control level, the document encourages local planning authorities to follow the existing guidance to require site-specific FRAs. In addition, the use of FRAs as supporting documents to planning applications in areas of flood risk is encouraged. The document proposes that if mitigating measures are shown to be required, they should be fully funded as part of the development.

Sustainable Communities Plan

3.5.8 The Sustainable Communities Plan (SCP, ODPM, 2003a) was launched by the ODPM in February 2003. The plan's main aims include improving the overall quality of housing in England, a step change in housing supply to meet demand and encouraging new growth areas while maintaining and protecting the Green Belt. These objectives are to be achieved with sustainability at the centre to ensure a legacy of improved, liveable communities.

3.5.9 The challenge is to reconcile the SCP's requirement to identify sufficient land for large volumes of new homes whilst ensuring that the sites allocated satisfy sustainability criteria specifically with regard to the avoidance of flood risk.

3.5.10 '*Sustainable Communities in the East of England: Building for the Future*' is the document that covers the districts commissioning this SFRA and will be discussed further in the Regional Planning Policy and Guidance Section.

3.6 Regional Planning Policy and Guidance

Draft East of England Plan

3.6.1 The Draft East of England Plan or Regional Spatial Strategy (RSS, East of England Regional Assembly, 2004) 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.

3.6.2 The Plan plays a significant role in contributing to sustainable development and sets out policies that address the needs of the region and key sub- regions. These policies provide a development framework for the next 15 to 20 years that will influence the quality of life, the character of places and how they function, and will inform future strategies and plans.

3.6.3 The East of England is one of the largest of the English regions with an area of 19,000 square kilometres. It extends from the fringes of London in the south to the North Norfolk coast. The area is generally considered low-lying in character with parts at or below sea level. It is a region of diverse landscape with a rich built environment and is of national heritage importance.

3.6.4 The Plan highlights population growth in the East of England within the last few decades. This has been driven by inward migration from the rest of the UK, principally from London due to job opportunities and low house prices making commuting to London a viable proposition. A key objective of the Plan is to ensure these demands are accommodated in a sustainable manner.

3.6.5 The Plan identifies key drivers of change in the region, which are most likely to influence the scale and location of development within the next 20 – 30 years. They include:

- Social progress, which recognises the needs of everybody;
- Effective protection of the environment;
- Prudent use of natural resources; and
- The maintenance of high and stable levels of economic growth and employment.

3.6.6 Additionally, the Essex and Southend-on-Sea Replacement Structure Plan (Essex County Council, 2001) has set a specific target for new dwellings in the four districts of 27,000 between 2001 and 2011 (sourced from Annex A, Table A.2)

3.6.7 This sub-regional target indicates the intense pressure the East of England is under to provide new housing. Inevitably this pressure for housing will increase the need for land for development and redevelopment. As supplies of Flood Zone 1 land are utilised so the pressure on more marginal land will increase and, unchecked, so will the risk of flooding.

3.6.8 A key objective of the East of England Plan is to minimise the risk of flooding within the region. The Plan states that the coastline is naturally dynamic, with strong natural processes. These processes, principally coastal erosion, can result in increased stress on flood defences. Consequently, climatic change, also a contributor to increasing sea levels, is highlighted as a key issue that will need to be addressed.

3.6.9 Policy Wat4: Development and Flood Risk, aims to defend existing properties from flooding, and where possible locate new development in locations with little or no risk of flooding. The policy states that local development documents (LDDs) should; promote the use of SFRAs to guide development away from floodplains, areas at medium or high risk, or likely to be at risk from flooding in the future, or where development would increase the risk of flooding elsewhere, and include policies to protect floodplains and areas prone to flooding from tidal sources based on EA maps, historical and modelled data and SMP's. These instructions should only be deviated from in exceptional circumstances.

3.6.10 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.

3.6.11 Areas now at risk from flooding will become more vulnerable and there will be new areas at risk. The Plan states that sea levels in the region may be between 22 and 82 centimetres above the current level by 2080. This is expected to have significant impacts on coastal and low-lying areas. Water is likely to become scarcer in the summer months adding to the supply-demand issues already faced in this, the driest of the English regions. The Plan also notes that changes in biodiversity may occur in response to climate change and that climate change is also likely to cause disruption in international trade and the region's vulnerability to this needs to be reduced.

East of England Plan – Secretary of State's (SoS) Proposed Changes: A High Level EERA Briefing

3.6.12 These proposed changes by the SoS to the East of England Plan were published in January 2007.

3.6.13 The changes include a proposed growth in jobs from the Draft Plans original 421,000 to 452,000. In addition, housing provision in the region has been proposed to increase from 478,000 to 508,000. Both these increased targets are stressed to be floor targets rather than ceiling targets and, where possible, should be exceeded.

3.6.14 These increased targets will add further pressure for new land to develop and could increase the need for using more marginal land, at greater risk of flooding.

Regional Planning Guidance 9 for the South East (RPG9)

3.6.15 This document was published in 2001 and since its creation the regions have been re-divided. The East of England is now the region incorporating Braintree, Colchester, Chelmsford and Maldon and the new RSS (draft East of England Plan) will replace this document during 2007. Though RPG9 is the adopted document it carries less weight than the new RSS due to this document's proximity to adoption.

3.7 Sustainable Communities in the East of England: Building for the Future

3.7.1 This document sets out proposals for maintaining and creating sustainable communities in the East of England and is the regional version of the national document, the Sustainable Communities Plan, both of which are non-statutory guidance.

3.7.2 One of the strategic challenges for the region is to address problems of high and rapidly rising house prices. This would indicate a high and increasing level of demand for housing reflected in the fact that household numbers increased by 5.4% between 1996-2001 while supply for the same period only increased by 4.6%. The problems of added development pressure on land at risk from flooding have already been discussed previously.

3.7.3 Another strategic challenge the document foresees is that of managing development with the increased threat of rising sea levels for coastal and low lying areas.

3.7.4 The SCP identifies development in the East of England as a national priority. The Plan recognises the following factors as key tools to support regeneration in the area:

- Location within close proximity to London;
- The strategic location of major transport links to the continent;
- One of the largest concentrations of brown field sites in the country; and
- Creation of an opportunity for 232,000 new jobs and 128,500 homes between 2001-2016.

3.7.5 The Plan reiterates that the development of sustainable communities and regenerating existing areas will be avoided in unsustainable locations in terms of flood risk. The plan states 'development proposals will be subject to flood risk assessment in consultation with the Environment Agency'. Furthermore, the Plan suggests that development will be concentrated on brownfield land and protected by flood defence infrastructure.

3.8 Sub-Regional Planning Policy and Guidance

The Essex and Southend-on-Sea Replacement Structure Plan

3.8.1 The Essex and Southend-on-Sea Replacement Structure Plan has been prepared jointly by Essex County Council and Southend-on-Sea Borough Council and was adopted by both authorities in April 2001 and covers the period to 2011. This document will be superseded by the East of England Plan, when it is adopted.

3.8.2 The adopted Plan forms part of the statutory development plan for the combined areas of the four authorities. The Plan provides strategic guidance for land use planning decisions for example, new housing, employment land, town centres, transport, and conserving the environment. This will underpin the Shoreline Management Plan.

3.8.3 A key objective of the Structure Plan is to:

- 'Protect, conserve and enhance the special landscape nature conservation, and heritage qualities of the undeveloped coastline;
- Prevent new development in coastal areas being at risk from flooding, erosion and land instability; and

- Balance and reconcile interests in sensitive coastal areas' (Essex County Council, 2001).

3.8.4 The Plan recognises the importance of maintaining or enhancing the water quality of coastal waters and inland watercourses. It is advised that new development, redevelopment, and land raising can have significant implications for flood risk. The Plan considers that new development within river or coastal floodplains may increase the risk of flooding.

3.8.5 Policy NR12 advises on the protection of water resources, and suggests that:

3.8.6 'Development will only be permitted where:

1. *Adequate water resources can be provided within the plan period without a materially adverse effect on the environment;*
2. *There would not be a risk to existing water resources, including the flow and water quality of underground or surface water, or existing abstraction;*
3. *Such development would not be at direct risk from tidal or fluvial flooding or likely to increase the risk of flooding elsewhere;*
4. *There would be no materially adverse effect upon fisheries, nature conservation, archaeological remains, landscape and recreation in river and canal corridors, coastal margins and other waterside areas'* (Essex County Council, 2001).

3.8.7 The Essex and Southend on Sea Structure Plan states that the natural resources of the coast should be protected as they make a major contribution to the overall environmental quality of the area. The Coastal Protection Belt aims to protect the rural and underdeveloped coastline from development. Policy CC1 advocates that stringent restrictions are placed on development in rural and the underdeveloped coastline.

3.8.8 Erosion is considered a dominant physical process, occurring in over 90% of the Essex and Southend on Sea coastline, and affects both existing saltmarsh and landform. The Plan states that a significant proportion of the coastline is low-lying in character. Furthermore, the Plan suggests that extensive areas are at risk from flooding, particularly areas below or at sea level. Therefore, the Plan advises development should not occur in areas at risk from flooding. Policy CC2 states that *'...particularly where existing flood defences properly maintained would not provide an acceptable standard of safety over the lifetime of the proposed development, or where the construction of new coastal defences would be required'* (Essex County Council, 2001).

3.8.9 DEFRA has overall responsibility for flood defence and protection in England. The protection of human life and existing property and the conservation of natural habitats is a core aim of coastal protection and flood defence works. Planning permission is not required for improvements to existing flood defence works, but is required for new works. Policy CC3 states that the:

'…construction of new or replacement flood defence and coast protection works may be permitted provided they are essential: -

1. *To protect human life and existing property; and*
2. *To conserve irreplaceable natural habitats'* (Essex County Council, 2001).

3.8.10 The Plan supports development in previously developed areas along the coast and not on the undeveloped coastline. Policy CC4 states that *'Development requiring a coastal location should be sited within the already developed areas of the coast defined in adopted local plans, particularly where this can promote urban regeneration and the conservation of areas of special architectural and historic interest, providing that where development is acceptable in locational terms, its bulk and scale must be compatible with the special character of the coast'* (Essex County Council, 2001).

Draft North Essex Catchment Flood Management Plan (CFMP)

3.8.11 This document will be a high level strategic plan published by the Environment Agency that will look to assess how flood risks might change and be managed over the next 50 to 100 years. The Scoping Report published in August 2005 outlined current understandings of flood risk in the North Essex CFMP area. It provided a broad understanding of flooding processes and how these may change in the future.

3.8.12 The final CFMP has been released in draft format (Environment Agency, 2006). Results from this draft CFMP have been incorporated in this SFRA.

Shoreline Management Plans (SMP)

3.8.13 A SMP provides a large-scale assessment of the risks associated with coastal evolution and presents a policy framework to address these risks to people and the developed, historic and natural environment in a sustainable manner. In doing so, a SMP is a high-level document that forms an important part of the DEFRA strategy for flood and coastal defence (DEFRA, 2001).

3.8.14 Typically, SMPs cover both the coastal and estuarine components of a region. However, due to the complexities of the aquatic and marine systems around Mid Essex, the SMP for this region concentrates solely on the shoreline and does not include any of the estuarine systems. Such estuaries (e.g. the Crouch and Roach, Blackwater, Colne and Stour) are covered by the Essex Estuarine Strategies, detailed below. According to the Essex Estuarine Strategies website (Environment Agency, et al, 2006) the publication dates for the 'round 2' SMPs is still to be decided but is likely to be in the near future.

Essex Estuarine Strategies, 2008

3.8.15 The Environment Agency has commissioned the development of long-term flood management plans for each estuary operating under the generic Essex Estuaries Strategies: the Roach and Crouch, Blackwater and Colne, the Stour and Orwell, and

Hamford Water. These flood management strategies are being developed on an estuary-by-estuary basis starting with the Roach and Crouch and ending with Hamford Water.

3.8.16 It is worth noting that some of the completed strategies are likely to have taken the old climate change levels as specified in PPG25 into account. It is likely that the strategies yet to be completed should therefore include the new climate change levels as specified in PPS25.

3.8.17 Each of the individual estuary strategies has similar generic flood management policies. These are Hold the Line, Advance the Line, Managed Realignment and No Active Intervention (Environment Agency et al. 2006). Of these methods, the one with the greatest potential to affect development proposals within Mid Essex is the Managed Realignment. This essentially involves placement of a new alleviation structure on the landward side of the existing structure. In addition, it can include either a partial or complete removal of the existing structure, thus increasing the flood risk to the newly created hinterland. These Managed Realignment areas have been made available for analysis as part of this SFRA as a GIS layer.

3.8.18 With sea levels expected to rise over the next 100 years, and with areas of land behind the current defences several metres lower than the normal high water in the estuary, steps must be taken to ensure that the response to changes in the risk of flooding is appropriate. The production of a flood management strategy will enable management of potential impacts that natural change will bring and also allow opportunities associated with such change to be identified at a strategic level.

Roach and Crouch Flood Management Strategy (R&CFMS)

3.8.19 The R&CFMS is one of the management plans operating under the generic Essex Estuarine Strategies. It was developed in several stages. Firstly the flood risk strategy objectives and flood management options were defined through a series of consultation exercises. Following this a short list of flood management options was appraised. Such management options included holding the line, managed realignment, advancing the line and no intervention. From these, a preferred flood management strategy was produced.

3.8.20 For the first 5 years the R&CFMS indicates very little required change with some small sections of realignment possible. Generally, holding the line will be sufficient.

3.8.21 After 50 years, the R&CFMS foresees the vast majority of the area as requiring potential realignment following detailed studies. There is also a small area of managed realignment but it is clear that holding the line is not considered a sufficient option (Environment Agency, et al. 2006).

3.8.22 However, the outcomes of the FMS are not definitive and are only intended to provide an indication of potential locations and measures.

Blackwater and Colne Flood Management Strategy (B&CFMS)

3.8.23 The B&CFMS has been prepared in the same fashion as the R&CFMS. However, the Draft Preferred Strategy has not been published. The outcomes of the Flood Management Strategy are, as above, not definitive and are only intended to provide an indication of potential locations and measures. This management strategy will outline the preferred flood management options in a similar method to the R&CFMS (Environment Agency, et al. 2006).

3.8.24 The Environment Agency has not published the FMSs for the other two Essex Estuaries (Stour and Orwell and Hamford Water) at the time of writing.

Water Framework Directive in the Anglian River Basin District

3.8.25 The Water Framework Directive was introduced by the European Commission (EC) in 2000 and applies to all EC Member States. It primarily aims to ensure that the quality of all waters is of 'Good ecological status' by 2015 (UK TAG, 2006). In addition to this, the directive is aiming to reduce the effects of floods and droughts. It was transposed into UK law in 2003, at which time the various River Basin Districts were derived. The Mid Essex area falls within the Anglian River Basin District, stretching from Lincolnshire in the north, Northamptonshire in the west, Essex in the south with the East Anglian coastline forming the eastern border (the area itself is similar to the Environment Agency's Anglian administrative boundary).

3.8.26 As part of the WFD process, River Basin Management Plans will be undertaken for each River Basin District. These plans will be produced in 2009 and will be subsequently subjected to three-yearly reviews.

4 Data Collection and Sources

4.1 Introduction

4.1.1 There was a wide variety of data available for the SFRA, as identified by the Inception Report undertaken by Scott Wilson in the autumn of 2006.

4.1.2 Further details of the data used in this assessment, how it has been used and the source/provider of the information are presented in Table A-1 in Annex 2. Additional tables are provided in the appendices detailing the data used to address the specific issues of individual authorities.

4.1.3 The data has been grouped into categories relating to its primary use in the production of the SFRA.

4.1.4 The majority of the data was provided by the following organisations:

- Environment Agency
- Maldon District Council
- Chelmsford Borough Council
- Colchester Borough Council
- Braintree District Council
- Anglian Water

4.2 Topographic Data

4.2.1 Topographic data used in the SFRA consists of LiDAR (Light Detection and Ranging) and SAR (Synthetic Aperture Radar) data, provided by the Environment Agency.

4.2.2 The LiDAR dataset provided approximately 95% of the Mid Essex area, which can be seen in Figure A-1. Further details on how the LiDAR provides elevation data, along with its accuracy, can be seen in Annex 2. SAR data is less accurate than LiDAR and was available for the entire Mid Essex area.

4.2.3 The data made available for this study also included helicopter flown LiDAR data of the flood defences along the various watercourses.

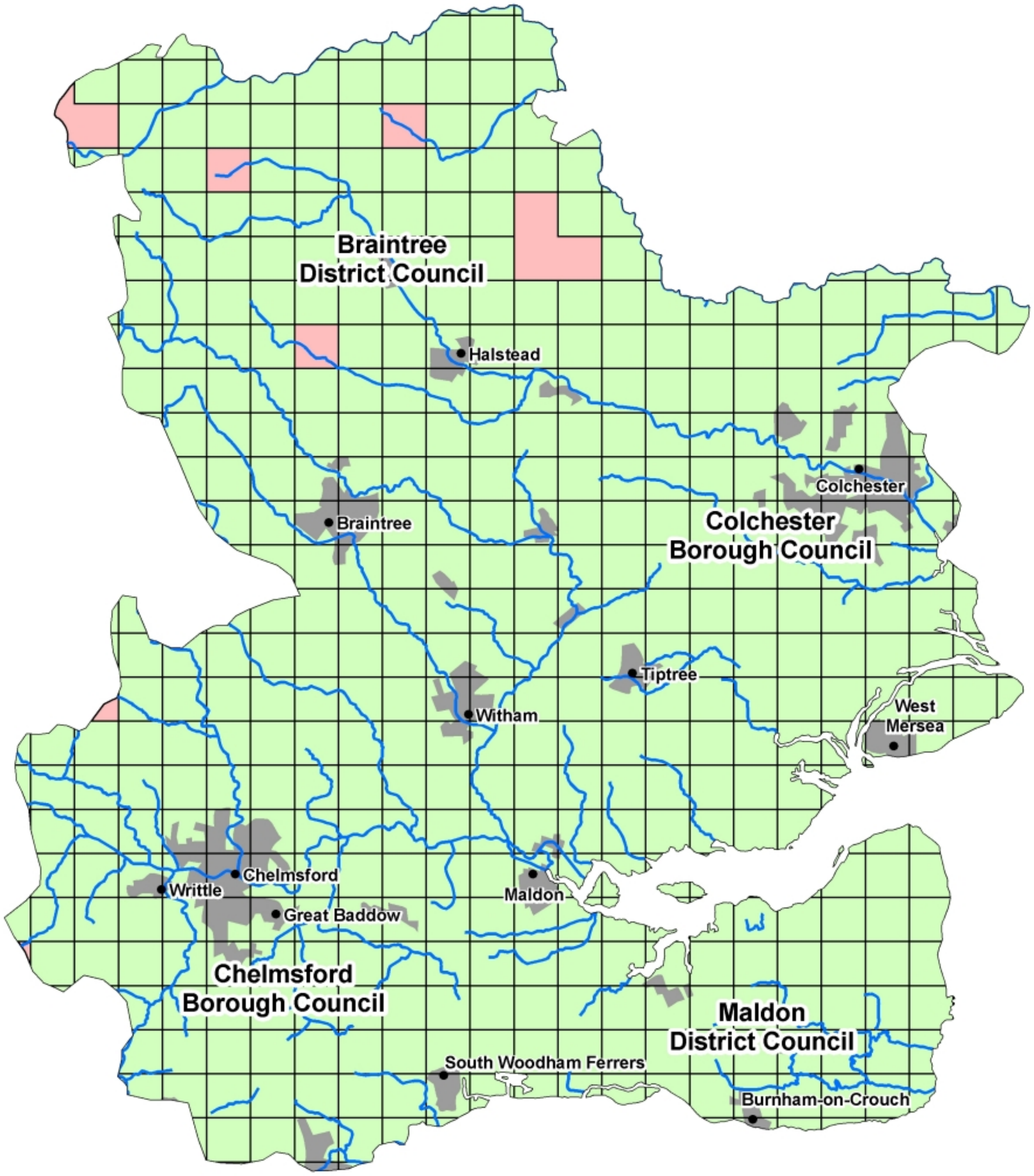
4.2.4 Due to the greater accuracy of the LiDAR data, this was used wherever possible for the generation of the Digital Elevation Model (DEM) on which hydraulic modelling was undertaken. However in areas where LiDAR data were not available the SAR data was used to fill in the gaps in the LiDAR data.

4.2.5 Areas for which no LiDAR data were available (for areas in which hydraulic models were required) are located in the north of the study area, within Braintree DC. The methodology used for generation of the DEM is presented in Chapter 6, with additional details on the LiDAR data itself outlined in Annex 2.

4.2.6 LiDAR data only provide surface levels for reflective objects. Therefore an important exercise was to identify areas where bridges, culverts and/or other major floodwater pathways existed. This was done by reviewing Ordnance Survey maps for the area. Where bridges and/or structures that could significantly influence local flooding were identified, the DEM was manually adjusted during the model construction, to accurately represent the flow paths available to floodwater. This results in a more accurate flood model.

4.2.7 Ordnance Survey 1:50,000 and 1:2,500 base mapping was used, in Geographical Information System (GIS) format for the presentation of flood zones and hazard zones throughout the Mid Essex study area.

FIGURE 4-1 – LIDAR COVERAGE IN THE MID ESSEX REGION



4.3 Flood Defences

4.3.1 GIS layers provided by the Environment Agency included 1:10,000 mapping of defences and defended areas within the Mid Essex area.

Tidal Defences

4.3.2 The nature of tidal flood defences at the breach locations were determined through the use of the DEM, the National Flood and Coastal Defence Database (NFCDD) and knowledge of local Environment Agency flood defence officers.

4.3.3 Querying the DEM identified the locations of flood defences. The defence type (earth embankment or hard defence) was determined from a review of high-resolution aerial photography (supplied in a digital format). Reference was also made to the NFCDD and/or drawings supplied by the Environment Agency that include details of the tidal defences.

4.3.4 In addition to the digital data provided by the Environment Agency, two sea defence reports were made available, the Essex Sea Wall Strategy, undertaken by the Environment Agency and Halcrow in 1997 and a Sea Defence Survey, undertaken by Mott McDonald in 1999.

4.3.5 Whilst the information on tidal defences is substantially complete, it is considered that there are significant gaps in the data on the condition of defences and that this should be addressed in any future assessments. Most notably more detailed condition surveys would be required for flood defences, in particular privately owned defences.

Fluvial Defences

4.3.6 Information available regarding fluvial defences within Mid Essex is not as extensive as information pertaining to tidal defences. However, information was obtained from the NFCDD as well as various reports, flood studies and discussions with the Environment Agency.

4.3.7 In general, within the tidal extents of the main watercourses (the Blackwater, Colne and Crouch), tidal defences dominate. Upstream of the tidal extents, many of the main watercourses flow through rural areas and are undefended as flooding will not result in damage to buildings or put people at risk. However, flow control structures such as mills, weirs and gates are present and offer some protection against flooding from fluvial sources. Other fluvial defence measures include embankments and levees, and various storage facilities such as Abberton Reservoir. The flood storage area appraisal undertaken as part of the Chelmsford subsidiary report investigated the potential for future fluvial defence via the use of upstream storage areas on the major watercourses in Chelmsford.

4.3.8 The level of protection offered by the fluvial defences varies throughout the region although in general is to the 1 in 100 year return period standard. This standard is typically exceeded within tidal extents where tidal flooding presents a greater flood risk. As such, tidal protection typically offers protection against a level of water not realistically reached following fluvial events.

Drainage

4.3.9 Due to the low-lying nature of the Mid Essex region, local drainage can be a key contributor to local flooding problems. However, as indicated by the Stage 1 Inception Report, with the exception of draft drainage databases for Maldon District Council and Chelmsford Borough Council, there is little drainage specific flood information available for the Mid Essex region.

4.3.10 The development of a more formal, integrated flood related drainage database would aid the strategic assessment of flooding within Mid Essex. Such a database could be an extension of the aforementioned databases already in existence and would build up greater knowledge of drainage related flood issues throughout the study area. In particular, creating a robust database is likely to aid the identification of areas susceptible to drainage problems in and around Mid Essex.

Flood History

4.3.11 There is limited historical flood information available for the Mid Essex region. The Stage 1 Inception Report outlined that Maldon District and Chelmsford Borough Councils have developed basic databases outlining previous flood events. These including locations, dates along with some anecdotal information such as the nature of the problem. Both of these databases primarily include events during the winter of 2000/ 2001.

4.3.12 As with the drainage issues outlined in Section 4.3.4 above, a more robust flooding database can help LAs and flood risk assessors to identify potential flooding hotspots. In addition to identifying any potential flooding hotspots, the database should include a method or reason for inundation, depths, locations and extents of water. This will aid any potential mitigation measures that could be applied to reduce the risk of flooding, i.e. more regular drain clearance or maintenance. In addition, it could aid LAs and developers to either avoid developing in flood prone areas or design a development with due regard to potential flooding. An example of this could be designing a development to include car parking, garden or landscaping area within the flood prone area.

4.4 Flood Risk

Environment Agency Flood Zone Maps

4.4.1 The Environment Agency has provided GIS layers presenting Flood Zones 2 and 3 for the Mid Essex area. The maps present the Flood zones for areas at risk of flooding from tidal sources (Thames Estuary, North Sea etc) and for rivers throughout Mid Essex.

4.4.2 The flood maps have been generated by a combination of techniques. Areas at risk from tidal flooding have been identified by extrapolation of extreme tide level over the ground surface until the corresponding ground level is reached. Consequently anything below the extreme tide level is considered to be within a Flood Zone. This approach does not take into account the presence or effect of defences, flood routes as a result of topography, or the volume of water available for flooding as a result of the tidal cycle. These maps (Environment Agency Flood Zone maps) do not take into account or make any allowances for climate change.

4.4.3 Flood Zones for fluvial river systems have been estimated in a similar manner. Flood levels have also been extrapolated across the ground surface to define the flood envelope, however, the flood envelope has also been refined with the results of section 105 hydraulic modelling and/or observations.

4.4.4 Whilst this source of data does not present a completely accurate estimate of flooding for tidal and fluvial sources throughout Mid Essex, it provides comprehensive coverage of the area and was the best available at the outset of the SFRA.

4.4.5 Additional data provided by the Environment Agency also included flood warning and flood watch areas.

Flood Risk Reports

4.4.6 Several other reports have been provided by the Environment Agency and stakeholders, relating to flood risk in the Mid Essex area. These include:

- Strategic Flood Risk Assessments from neighbouring areas;
- Various flood risk assessments undertaken within the region, e.g. at Bradwell Wind Farm, Timberyard in Heybridge Basin; and
- Catchment Flood Management Plan (CFMP) for the Eastern Area and North Essex and Shoreline Management Plans (SMP), currently in draft or scoping phase (as outlined in Section 3.2).

4.5 Extreme Water Level/Tides Information

4.5.1 The extreme sea water levels associated with tidal flood events along the Essex coastline vary throughout the study area and consequently are specific to each breach location. The extreme sea water levels for the breach locations along the coastline are based on information obtained from the Draft '*Report on Extreme Tide Levels: Anglian Region, Central and Eastern Area'* (Royal Haskoning, 2007) obtained from the Environment Agency.

4.5.2 Extreme flood levels for the Rivers Roach and Crouch were obtained from the Roach and Crouch Flood Management study.

4.5.3 Where these reports did not address the return periods required for this study, the data was extrapolated or interpolated to provide the levels. Further details of this approach are presented in Chapter 6 (Methodology). For areas where no detailed information on sea level rise was provided, sea level rise was assumed to be as outlined in Table B.1 in PPS25 (see below – part of Table B.1 PPS25):

TABLE 4-1 PPS25 RECOMMENDED CONTINGENCY ALLOWANCES FOR NET SEA LEVEL RISE

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

4.5.4 Information provided by the UK Climate Impacts Programme (UKCIP) indicates that relative sea level rise in the Mid Essex area to rise by approximately 70 – 80 cms by the 2080s (Hulme, et al. 2002). These figures are calculated using a high (predicted worst case) emissions scenario. Hulme et al, 2002 also outline the predicted increase in storm surge levels, which have the potential to rise in the south east of England by up to 1.4m for an event with a return period of 50 years (2% annual probability of occurrence).

4.6 Planning Documents

Statutory Planning Documents

4.6.1 Documents for preparation of emerging statutory policy

4.6.2 Several Statutory planning documents were available for this study, including information and draft reports currently being used in the preparation of Local Development Documents (LDDs).

4.6.3 Existing statutory planning document

4.6.4 Data provided by the stakeholder councils largely took the form of reports including various Local Plans and their associated maps. Each of these documents is at a different stage in the planning process, with some approaching the end of their useful life, and others informing emerging policy.

4.6.5 Due to the differing ages of the plans their content varies depending on the guidance and best practice available at the time of their production. Therefore, the information presented in them is outdated, as the development sites outlined may have already been allocated and/or in development or operation. In addition, policies may no longer be adequate, especially where Local Plans were prepared prior to the release of PPG25 in 2001. Section 3 presents details of the planning documents reviewed for the SFRA.

Non-Statutory Planning Documents

4.6.6 Several non-statutory planning documents were also reviewed in the preparation of the SFRA. These present the Government's and/or local government aspirations in several areas that may impact on flood risk in the future, such as Making Space for Water and Sustainable Communities. Supplementary planning documents include the SPG on Chelmer and Can-side sites, adopted with Environment Agency input.

4.7 Commentary on data gaps

4.7.1 The purpose of an SFRA is to present information for all sources of flooding. However, gaps in the data include information on secondary and tertiary sources of flooding such as groundwater and surcharged drainage. Although these are not likely to pose a significant risk (compared to flooding from tidal sources), they can potentially be very disruptive. More comprehensive information would be required to assess the impacts of secondary and tertiary flooding in Mid Essex.

4.7.2 Even where data was largely available, there are some gaps, for example:

- Condition assessment of private flood defences;
- No records of past incidence of flooding, or incomplete records of flooding;
- No records of groundwater flooding;
- Lack of flood level and extent information on smaller watercourses that are not classified as "main" river.

4.7.3 It is a recommendation of this SFRA to update local records regarding these data and information gaps. By providing information relating to the above discrepancies, it will ensure lower level flood risk assessments (e.g. site specific assessments) are completed more quickly and to a greater level of detail.

5 Flood Sources, Mechanisms and Defences

5.1 Background

5.1.1 The area of Mid Essex is extremely large, with coastal, fluvial and estuary systems, including a wide distribution of creeks and marsh areas, posing a wide range of flood risks. Within this SFRA a broad scale approach was required to focus on the flood risks with the largest possible consequences.

5.1.2 Much of the Mid Essex area is low-lying and the area includes the alluvial marshlands in Mersey and Mersey Island, and the valleys of the Rivers Crouch, Blackwater, Chelmer, Stour and Colne. There are also relatively expansive areas of salt marshes adjacent to the Blackwater and on Dengie and Blackwell marshes.

5.1.3 Large sections of Mid Essex are protected from tidal flooding by embankments, hard defences and movable barriers. Such barriers include the Colne Barrier on the River Colne.

5.2 Flood sources in Mid Essex

5.2.1 The following sections give details of the specific flood sources for the study area of Mid Essex. These range from tidal sources from the North Sea to fluvial sources from the major river systems, (e.g. the River Crouch, see below), as well as flooding from groundwater.

North Sea

5.2.2 The eastern boundary of Mid Essex is formed by the land/sea interface from the mouth of the River Crouch in the south to the mouth of the River Stour in the north. This area is generally low-lying and fairly undeveloped in comparison to the more inland areas of Mid Essex. Tidal flooding is the main source along this boundary, which forms an exposed but defended coastline.

5.2.3 Tidal information for the North Sea in the Mid Essex area is available from the Admiralty Tide Tables (UKHO, 2006). The reported mean high water spring tide at Clacton-on-Sea is +1.5m OD and reported mean low water spring tide is –1.9m OD. These figures indicate a tidal range of 3.4m under normal conditions but do not account for waves or storm surge[2], which can increase the water level significantly. To the north of the study area, in Felixstowe, Suffolk, the tidal range is 4m. To the south of the study area, at Sheerness, the tidal range is 5.2m.

5.2.4 The defences along this stretch of coastline consist of a combination of large earth embankments and hard defences. The overall condition of these defences is classified as 'good condition in need of maintenance', however the protection standard (e.g. able to protect from flooding from a 1 in 1,000 year event) of these defences is

[2] The rise of the sea along the coast as a result of winds associated with a storm

poor. Specific defence surveys for this area estimate the average standard of defences to be approximately 1 in 5 years. This is well below the Environment Agency required standard of 1 in 200 years for developed areas.

River Crouch System

5.2.5 The River Crouch extends from its source in Little Burstead to the east of Battlesbridge (near South Woodham Ferrers). At this location, it becomes tidal and forms part of the Crouch Estuary.

5.2.6 The River Crouch is identified by the Environment Agency flood risk map as having extensive fluvial floodplains, with a 'high probability' of flooding or classified as a 'functional floodplain'. These classifications correspond to a 1 in 20 or greater annual probability of fluvial flooding and 'land where water has to flow or be stored in times of flood'. These areas are fairly sparsely populated areas in comparison to areas in the south of the region.

5.2.7 The Roach and Crouch Estuary Management Plan (Environment Agency, 2005, currently in draft), outlines the management strategy for the Crouch as well as the Roach (located to the south of the Crouch and included as part of the South Essex SFRA) estuaries. The plan recognises the need for managed retreat in order for the areas of salt marsh to increase, thus dissipating some of the energy from wave action. This is outlined as a particularly relevant management strategy in order to combat the effects of sea level rise that is likely to render the already eroding hard sea defences in the region inadequate in the near future.

5.2.8 The defences along the course of the River Crouch are formed through a mixture of hard defences, embankments and culverted watercourses of overall good condition but in some places in need of maintenance.

River Stour System

5.2.9 The River Stour forms part of the boundary between Essex and Suffolk. It extends from its source in Cambridgeshire and flows south then east where it becomes an estuary at Manningtree before meeting the North Sea at Harwich Harbour, between Harwich and Felixstowe, Suffolk.

5.2.10 The majority of the River Stour, including its tidal reaches, are located outside of the study area between Tendring DC and Suffolk. However, there are some flood risk areas in the north of Braintree BC that are sourced from the Stour.

River Chelmer System (including the Can and Wid tributaries)

5.2.11 The Chelmer flows from its source in Thaxted, Essex, to the north of Chelmsford. From here it flows south, through the town of Chelmsford before joining the River Blackwater to the west of Maldon at Beeleigh. East (downstream) of this location the now converged Chelmer and Blackwater form the Blackwater Estuary and are influenced by tidal action of the North Sea.

5.2.12 Since the Environment Agency Flood Zone map was revised in 2006, the lower reaches of the Chelmer are identified by the Environment Agency as having extensive areas at risk from a 'high probability' of fluvial flooding (or a 1 in 100 or greater annual probability) of fluvial flooding. Many of these areas fall within Chelmsford town centre itself. The upper reaches of the Chelmer have less extensive areas at risk from flooding.

River Colne

5.2.13 The River Colne extends from its source at Great Yeldham in Braintree and flows east, past Halstead and into Colchester, where the tidal limit of the Colne is at East Mill Sluice towards the east of the town. The Colne then flows south as the Colne Estuary and meets the North Sea between Mersea Island and Brightlingsea.

5.2.14 As the river flows through the centre of Colchester, there are fairly extensive areas within the town that are, according to the Environment Agency's Flood Maps, at a 'high probability' of fluvial flooding. However, many of these areas are protected by flood defences, such as the Colne Barrier at Wivenhoe (see Section 5.3, below). Due to the low lying and marshy nature of the banks of the lower Colne Estuary, such as Mersea Island, there are extensive areas in these locations that are at significant risk of flooding. The upper reaches of the Colne have a significantly reduced floodplain.

River Blackwater

5.2.15 The River Blackwater is sourced at Wimbish in Essex. From here it flows southeast, past Braintree, then flows south past Witham, forming part of the border between Braintree DC and Colchester BC. It continues south until it converges with the River Chelmer at Beeleigh to the west of Maldon. From here, it flows east as an estuarine system into the North Sea.

5.2.16 As with many of the other river systems in Mid Essex, the downstream areas of the river and estuary contain significant areas outlined by the Environment Agency's Flood Maps as being at 'high probability' of fluvial flooding. Such areas include parts of Maldon and the Heybridge Basin. Further upstream, the areas at risk of flooding reduce, however, some towns and villages are still at risk from a significant event, such as Keveldon, Coggeshall, Bocking and Bradwell.

5.3 Flood Defences in Mid Essex

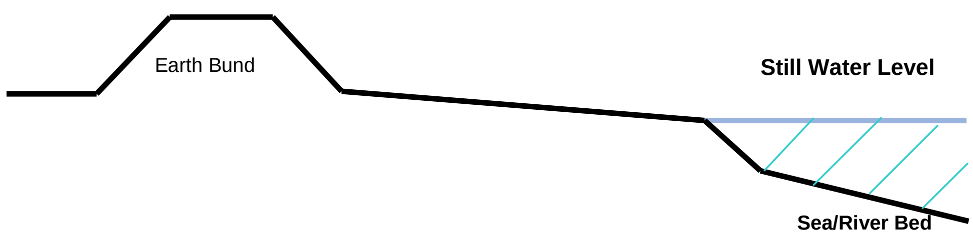
5.3.1 There are a variety of flood defence mechanisms throughout Mid Essex. These defences range from engineered and built defences including sea walls and tidal barriers, embankments and sluices to non-engineered solutions such as flood warning and evacuation procedures.

Earth Bunds (Earth Embankments)

5.3.2 The majority of the defences along the Mid Essex coastline consist of earth bunds, also known as earth embankments. Typically, these structures protect an area from flooding by providing a mass of earth, which raises the surrounding land level preventing inundation from a specific direction. The crest of a bund is typically flat and a minimum of 3m wide. Wider bunds have a reduced risk of breaching. Side slopes down from the crest to the natural level of the land have a gradient of 1 in 3 as a maximum, but the actual slope depends on the material used to construct the bund.

5.3.3 Bunds are constructed from mass fill material, the majority is usually earth, but other bulk fill material, such as aggregates, may be used to form the core. As indicated by the Essex Shoreline Management Plan (Mouchel, 1997), the majority of the earth embankments along the Mid Essex coastline are constructed using clay (presumably on account of its low permeability). Bunds may be reinforced with piles, concrete retaining wall structures, or sheet pile walls driven through the crest, to provide structural stability, additional resistance to breaching and to raise the level of protection. In these situations the failure is significantly different. Therefore for breach analysis, reinforced earth bunds are classified as hard defences.

FIGURE 5-1 TYPICAL CROSS SECTION OF EARTH BUND



5.3.4 Bunds are typically covered with grass to prevent erosion. Where bunds may be subject to high flow velocities or wave action the bund may have a revetment on its watercourse face or rock armour to prevent scour and erosion. Bunds may be placed directly along the watercourse edge or setback and can often be used further inland to limit possible flood extents.

5.3.5 Earth bunds in Mid Essex are a common defence structure along the North Sea and other coastal zones local to the study area (e.g. Suffolk, South Essex and the Thames Estuary). They often incorporate revetments (see Section 5.2.2 below) and extra toe protection from scour and erosion.

Plate 5-1 A grassed earth bund example along the North Sea coastline

Revetment

5.3.6 Revetments are armouring placed along embankments or natural channel banks to prevent erosion and scour from wave action and/or high flow velocities. The armouring may be constructed from a wide range of materials including concrete, Essex blocks (small rectangular blocks), or rock armouring. The Essex SMP identifies that there are fairly extensive lengths of revetments along the Mid Essex coastline.

Plate 5-2 Essex block revetment on an earth bund with additional rock armour toe protection providing greater stability at the toe of the structure, reducing undercutting and erosion.

River walls

5.3.7 River walls (also known as seawalls when used along open coastline) are protective walls built along the river bank/shoreline. They provide protection from high water levels and heavy wave action.

5.3.8 The majority of walls are constructed from steel reinforced concrete but can also be constructed from timber and sheet pile wall. Walls can vary in shape and style depending upon the requirements of the location.

Plate 5-3 River walls. The wall has an overhang to deflect wave action and has paved aprons at the base to provide further protection against scour.

Plate 5-4 Example of sheet pile wall as a primary flood defence

Plate 5-5 Example of sheet pile wall as a secondary flood defence

Floodgates

5.3.9 Where access is required through the flood defences, floodgates may be constructed. These are normally operated manually, and consist of a gate that is generally watertight with an appropriate crest height to prevent overtopping. The Environment Agency is generally responsible for floodgates, and is responsible for issuing tidal flood warnings and ensuring the floodgates are closed as necessary. In some places local agreements exist between the council and private landowners regarding floodgate operation.

Plate 5-6 Open floodgates in Essex allowing access to and from the sea wall

Culverts

5.3.10 Culverts are covered channels where flow passes through or under an obstruction (embankments, roads, railway lines, etc.) They are often constructed of a rectangular (also know as box) or circular channel section made from concrete. Culverts can be idealised as a large pipe where flow is rarely enough to fill the cross section.

5.3.11 Culverts are used as a means of controlling watercourse flow and function as a flood defence structure along fluvial watercourses. Culverted channels are often constructed with tide flaps at their discharge point to avoid surcharges and backflow during high tides.

5.3.12 Culverts are commonly found in Mid Essex on smaller ordinary watercourses and drains on the marsh areas of Dengie, Bradwell and Mersey supporting surface water drainage systems.

Plate 5-7 Culverts in a fluvial system. Note: the two smaller culverts are source from surface water drains

Plate 5-8 Culvert through a flood defence wall. Outlet is fitted with a non-return flap to prevent backwater effects during high tide events

Tidal Barriers

5.3.13 Barriers function as a flood defence structure through various mechanisms of rising, falling or rotating and may be automated or manually operated. The very nature of the defence is to provide a 'barrier' to the storm surge or extreme high tides, effectively blocking the influx of water into the channel and protecting the adjacent lands from inundation of floodwater.

5.3.14 There is only one flood defence barrier within the study area. It is located at the tidal limit of the River Colne at Wivenhoe. It protects areas upstream, in particular Colchester, from flooding caused by tidal surges. The barrier is 8m high and 130m wide, with a navigation opening of 30m. The main mechanism consists of two metre gates that operate in a similar method to those used as locks on canals and rivers. The barrier limits upstream water levels to 3.1m AOD (Colchester BC, 2003).

Flood Warning

5.3.15 The Environment Agency has general supervisory and other statutory responsibilities to flood defence in the Mid Essex region, including permissive powers for the maintenance and upkeep of river channels and flood defence structures and flood warning procedures.

5.3.16 The Environment Agency is responsible for issuing flood warnings in the Mid Essex region. This warning system only applies to flooding from tidal or fluvial sources. It does not generally include other sources of flooding such as from groundwater or surcharging drains. Flood warning systems are based on meteorological reports and forecasts including the use of radar imagery to track storms and rainfall intensities, as well as using data from the national tide gauge network. The resulting warnings are issued via local radio, the Internet as well as direct dial telephone messages to subscribed users as well as other local measures. As indicated by the flood events in 1953, it is important to have a robust system of communication in place to ensure that those in danger can receive warnings should one method of communication be removed.

5.3.17 The degree of advance warning that can be provided is critical to the amount of action that can be taken to prevent damage. However the ability to provide a minimum of 2 hours - the standard currently used in England and Wales for river flooding - can vary considerably. This variability in the amount of warning time available can be due to the geography and geology of an area, the intensity of the rainfall and the type of weather systems causing the rain. For example, in the South East of England, winter fluvial flooding is typically easier to forecast as it is sourced from rainfall from frontal weather systems. Summer fluvial flooding can be more difficult to forecast as it may be more flashy, sourced from high intensity storms (Crooks et al., 2001). Allied with this reduced predictability is a reduced warning time.

5.3.18 Flooding on the coast is usually the result of a combination of high tides, storm surges and waves. High tides are predictable years in advance, but on their own seldom cause flooding, it is typically when high tides are combined with storm surges that flooding is more likely to occur. Storm surges are caused by atmospheric conditions and wind action and are usually accompanied by strong winds that cause severe waves. In the case of flooding from the sea forecasting systems are required in order to provide predictions of sea level and wave height. An example of this is the Storm Tide Forecasting System (STFS), undertaken by the Metrological Office and Defra. The STFS forms a pivotal role in coastal flood warning systems by providing the Environment Agency with their forecasts of storm surge levels, wave activity and coastal flooding. Potential tidal flooding is forecasted by firstly linking to a network of over 40 tidal gauges around the UK. The gauges relevant to the East Coast are located from Wick, Scotland in the north to Southend at the mouth of the Thames Estuary in the south. This tidal gauging network information is then fed into a computer model along with wind and pressure fields to predict tidal surge levels.

5.3.19 The role of flood warnings in flood risk and residual risk reduction can be either a stand-alone measure or in combination with built defences. Flood warning as a stand-alone measure can reduce the consequences of flooding to properties by enabling reactive action to protect life and reduce the effect of flooding on property. Flood warning in combination with built defences can protect life and reduce damage in the event of the defence level being exceeded by the severity of the flood. In the case of much of Mid Essex this could take the form of a breach in the tidal defences.

5.3.20 The need for flood warnings in defended areas, such as Mid Essex, is particularly important, as the consequence of flooding in areas where people's perception of flood risk is low can be significant. In such cases flood warning needs to work closely with local authority emergency planning to ensure that potential evacuation routes exist and to start contingency plans when a flood event is forecast. The difficulties of issuing effective warnings of possible defence failure poses a significant challenge and in some cases it will not be practical to provide a reliable or timely flood warning service to an area because of the rapidity or unpredictable nature of flooding.

5.4 Future Flood Risk Management in Mid Essex

5.4.1 There are two main studies in the Mid Essex region that outline flood risk management over the next 50 years. These studies are the Essex SMP and the Essex Estuarine Strategies.

5.4.2 The Essex Estuarine Strategies (EES) were partly borne out of the Essex SMP undertaken in 1997 (Mouchel, 1997). The SMP concluded that further monitoring studies and investigations were needed to update the policies and management options outlined within it. One result of the SMP review period is to produce the EES, which aims to minimise future pressures on the existing flood management structures within Mid Essex. Such pressures include the inevitable degradation of flood defences over time, the threat of global climate change and rising sea levels (Environment Agency, et al. 2006). The EES have been divided according to the constituent estuarine systems in Mid Essex (e.g. Roach and Crouch, Blackwater and Colne and Stour and Orwell). Each estuarine system then has a flood management strategy that supports the long-term objectives of providing effective flood management in line with responding to the pressures outlined above.

5.4.3 At the time of writing, only the Roach and Crouch estuary has a management strategy produced for it. The Blackwater and Colne management strategy is outlined to finish in the autumn/winter of 2007 with the Stour and Orwell strategy due later in the same year.

5.4.4 The Roach and Crouch Management Strategy has outlined various available flood management options, including No Intervention, Hold the Line, Managed Realignment and Advance the Line. Each of these options has been considered for each compartment within the Roach and Crouch study area and then applied to the various compartments for the first five years and after 50 years (from 2006). The River Crouch forms the southern boundary of the Mid Essex study area. Therefore, it is the northern banks of the river that pertain to the study area. The five-year strategy outlines that the preferred management option for the majority of the coastline and riverbank is to Hold the Line. There are some areas of the frontage that may require managed realignment following more detailed study. These areas are located to the west of North Fambridge, behind Bridgemarsh Island and to the east of Bridgemarsh Island. These management strategies can be seen in Figure A-1 in Annex A. For the 50-year scenario, the majority of the frontage has been categorised as either possibly requiring realignment following further study or Hold the Line. Figure A-2 in Annex A outlines this strategy.

5.5 Flood Mechanisms in Mid Essex

5.5.1 The SFRA Inception Report identified that the main focus of the SFRA should be on breaching, as these events are likely to have the greatest consequence. Table 6-2 gives an overview of the sources of flood risk and an indication of the scale of consequence associated with such an event. This identifies the greatest consequence arising from overtopping or breaching of defences during extreme events. The terms for scale of consequence are broadly based on the number of dwellings an event might impact. The following scale, developed by Scott Wilson from previous flood risk experience in the Thames gateway area, has been used:

- Very large = 100+ houses/buildings
- Large = 50-100 houses/buildings
- Medium = 10-50 houses/ buildings
- Small = 1-10 houses/ buildings

5.5.2 This section describes the main flooding mechanisms throughout Mid Essex, providing a background for the flood risk analysis later in the subsequent Appendices.

Overtopping

5.5.3 Overtopping occurs when water passes over a flood defence. Low levels of overtopping may arise even when the defence crest level is higher than the water cycle, due to the action of winds, waves and spray. Higher levels of overtopping occur when water levels exceed the defence level and overflowing is occurring.

5.5.4 When flow exceeds the capacity of the channel to convey that flow, the water in that channel will rise until the point is reached where the banks of the channel are overtopped. Water will then spill over the channel banks and onto adjoining land. With an upland river the adjoining land is its natural floodplain, which will generally be of limited extent and fairly well defined. In a lowland river where the gradient flattens the floodplain can be much wider (i.e. Mersea marshes). Flood defences and urban development can significantly alter the natural flow paths within the floodplain area and affect the dispersion of floodwater.

5.5.5 The area of Mid Essex is predominantly flat low-lying land with small areas of high relief in the north and west. Marshland features heavily in this region including the Mersea Marshes, Dengie Flats and Clements Marsh on the banks of the River Roach.

5.5.6 Flood defences are usually designed with a degree of 'freeboard', the height by which the crest level of the defence exceeds the design flood level, to allow for wave action, wear, subsidence etc. Main river and tidal embankments are designed to have a constant freeboard above their design level so, in theory, when they are overtopped the overflow should be small in volume and of uniform depth along the full length of the defence embankment, occurring during the highest water levels at the peak of the tide/flood. In reality the freeboard varies from point to point due to the natural subsidence of defences over time, and water heights can be exacerbated by wave action. Even so, in the event of overtopping, an embankment acts like a weir limiting the rate of flow and volume over the embankment and limiting flooding velocities and volume to the immediate area. There is however no guarantee that any defence freeboard will remain for the lifetime of the development.

5.5.7 Overtopping from a fluvial source will be limited as there is a limit to the quantity of water held in the channel. As the water level in the river rises above the crest height of the defence overtopping will occur and water will spill out onto the surrounding land. This will act to lower the level of the water in the channel and the water level in the fluvial channel may recede below the height of the defences. Inundation can however be widespread and damage considerable. In tidal conditions this mechanism does not exist. The source of water is far more considerable. An extreme tide may well overtop any sea defences. Once this level has been reached overtopping will continue until the tide recedes below the level of the defences. Again, this can cause a considerable amount of inundation and damage.

Breaching

5.5.8 Breaching of flood embankments is one of the main causes of major flooding in lowland areas. Breaches can occur in any situation where there is a defence with a raised crest height above adjacent land levels.

5.5.9 An earth embankment may be breached as a result of overtopping, which weakens the structure through erosion, eventually creating a breach in the defences. Breaches in tidal and fluvial embankments are more likely during high water level events including extreme tides or periods of high river flow. A fluvial breach in an embankment will result in the dispersal of floodwater from the channel resulting in a lowering of the water levels and flow through the breach. However with tidal embankments the level of water flow driving through the breach will remain unaffected by the volume flowing through the breach.

5.5.10 The time taken for a breach to be sealed can have a major effect on the extent and depth of flooding. This is discussed in more detail in Section 7.4. In addition to the flood risk associated with a breach event, there is an implied flood hazard. The highest hazard exists in the period immediately following a breach, and usually, but not necessarily, in the areas closest to the breach. Floodwater flowing through a breach will be of high velocity and volume, dissipating rapidly across large low-lying areas, and possibly affecting evacuation routes. Flooding as a result of a breach in defences, either from fluvial or tidal sources, can be life threatening with far reaching consequences.

Breach Locations

5.5.11 The risk of flooding from breaches in flood defences was recognised by the Inception Report. Consequently the Inception Report specified that the SFRA should consider the risk to the Mid Essex area from breaches in local flood defences. To assist in this assessment the participating boroughs were asked to contribute specific breach locations they considered important for assessment. These are located such that they represent places of known weakness or vulnerability in the existing defences, or in locations where a breach would be expected to have the greatest consequence.

5.5.12 The breach locations specified by the participating boroughs are presented in Table 5-1, below. The breach or hazard mapping deliverables are presented in the relevant LPA Appendices A-D.

TABLE 5-1 BREACH LOCATIONS

Number	Breach location	Ordnance Survey Grid Reference
1	Colchester: Ballast Quay	042 213
2	Colchester: Waldergraves Farm	043 131
3	Maldon: Maylandsea Marina	907 029
4	Maldon: Burnham-on-Crouch	951 956
5	Chelmsford: Woodham – Clementsgreen Creek	820 967
6	Maldon: Bradwell Waterside – Power Station	001 090
7	Maldon: – Heybridge Basin	873 068
8	EA proposed	011 134
9	EA proposed	857 074

Mechanical or Structural Failure

5.5.13 Flooding may result from the failure of engineering installations such as tidal barriers, land drainage pumps, sluice gates and floodgates.

5.5.14 Structural failure in the context of this section is also taken to include the failure of hard defences along the Mid Essex coastline. Hard defences may fail through the slow deterioration of structural components such as the rusting of sheet piling, erosion of concrete reinforcement and toe protection or the failure of ground anchors. Such deterioration is often difficult to detect, so that failure when it occurs is often sudden and unexpected. Failure is more likely when the structure is under maximum stress, such as during extreme tides, when pressures on the structure are at its most extreme.

5.5.15 The risks associated with flooding of this type are difficult to quantify. The Environment Agency regularly monitors the condition of EA owned flood defences in Mid Essex, and has a rolling five-year programme for maintenance of flood defences, however, maintenance is usually carried out under a priority scale. The EA work under permissive powers under the Water Resources Act 1991 and Land Drainage Byelaws, and do not guarantee that defences would be maintained every five years. Flooding resulting from mechanical failure has been considered in this SFRA in the context of barrier failure during extreme tides in the North Sea, at the major flood barriers/ structures of Mid Essex.

5.6 Localised Flooding

Surface Water

5.6.1 Localised flooding can occur as a result of severe storms, which are localised in extent and duration. The intensity of the rainfall in urban areas can create runoff volumes that temporarily exceed the natural or urbanised sewer and drainage capacities, creating 'flash' flooding, referred to in this document as Surface Water Flooding.

5.6.2 Surface water is the overflow from any urban runoff and from sewer systems when the rainfall intensity exceeds the capacity for the drainage systems. This will become a more common occurrence in the future, due to climate change and an increase in the number and intensity of convective storms. It is now fairly widely accepted that one of the main effects of climate change in the South East will be a higher intensity rainfall and more frequent winter storms, which will increase the risk of flooding from surface water.

5.6.3 In lowland areas such as Mid Essex, the topography results in dispersal over a wide area. Local flooding of this kind is often exacerbated by deficiencies in the local surface water drainage system, temporary blockages or saturated ground conditions. These can often be remedied through reactive management once they have been identified in a flooding event.

Groundwater

5.6.4 There is a risk of groundwater flooding in the Mid Essex region. Groundwater flooding usually occurs following a prolonged period of low intensity rainfall and although there are no records of significant groundwater flooding in the region, it is still a possibility. The future risk from this source is more uncertain than surface water as the climate change predictions indicate that although sea levels will rise, thus possibly raising groundwater levels, overall summer rainfall will decrease, therefore having a long-term effect of lowering the groundwater levels. However, long periods of wet weather, such as those experienced in the autumn and winter of 2000/01 are predicted to increase: these are the type of weather patterns that can cause groundwater flooding to occur.

5.6.5 There is limited information on groundwater flooding in the Mid Essex area. However, the draft North Essex CFMP outlines that some of the soils in the lower lying areas of Mid Essex (in particular areas of the Chelmer catchment) are characterised by seasonally wet clays. Therefore, these could be susceptible to groundwater flooding following prolonged rainfall as described above. In addition, dry valleys that are potentially susceptible to groundwater flooding should be assessed. Due to a lack in available data, these are currently difficult to assess but should be considered in future reviews of this SFRA.

Data availability

5.6.6 PPS25 states that through the application of the Sequential Test, all sources of flooding must be investigated, including surface water and groundwater sources. Records for surface water, groundwater and other historic flooding events from the participating authorities in Mid Essex have therefore been included in the relevant appendices. However, due to the unpredictability of this type of flooding, data collection is generally of a sporadic nature, and flood risk relating to surface and ground water should be addressed at a localised site-specific scale through the flood risk assessment process.

5.6.7 The data sets included in the appendices are not comprehensive and of little constructive use on a strategic scale. The Environment Agency hopes to identify areas prone to groundwater flooding. If surface water and groundwater flooding are to be considered on a strategic scale in future, local authorities, water companies and the Environment Agency need to consider improved methods for consistent and comprehensive data collection relating to these flooding sources.

6 Methodology

This chapter presents the methodologies used in developing the flood outline, maximum flood depth and hazard zone maps for this SFRA.

6.1 Digital Terrain Map (DTM) Generation

6.1.1 A key component in the modelling process for the SFRA is the representation of topography throughout flood prone regions of the study area. For this purpose, a Digital Terrain Map (DTM) was derived for each of the modelled areas. A DTM is a three-dimensional 'playing field' on which the model simulations are run.

6.1.2 The platform used for the generation of the DTM was the GIS software package MapInfo Professional (version 8.5) and its daughter package Vertical Mapper (version 3.1).

6.1.3 The DTM is primarily based on filtered LiDAR data provided by the Environment Agency. LiDAR (Light Detection And Ranging) is a method of optical remote sensing, similar to the more primitive RADAR (which uses radio waves instead of light). In this case, the LiDAR surveys return data at a horizontal resolution of approximately 2 metres. Filtered LiDAR data represents the "bare earth" elevation with buildings, structures and vegetation removed.

6.1.4 Where LiDAR data was not available, or there were gaps in the LiDAR coverage, SAR (Synthetic Aperture Radar) data was used. Although similar to LiDAR data, SAR data is of lower resolution (approximately 5 metre squares compared to 2 metres for LiDAR). However, it is an ideal source of infilling data where the LiDAR data is lacking.

6.1.5 CMAP data was also used, where applicable, to define ocean and estuary bathymetry. CMAP is a worldwide database of ocean depths, particularly along coastlines and estuarine areas. As both LiDAR and SAR data is not well defined over water, SAR data is extremely useful for defining the bathymetry of the model in these areas.

6.1.6 Using these three sources of data, the best possible complete DTM grid for each study area was obtained.

6.2 Flood Cell Definition

6.2.1 The breach locations were specified through discussions with the MEAL representatives and Environment Agency based on local knowledge of the condition of the defences, the location of future development sites, historical flooding events and the vulnerability of local communities.

6.2.2 Once the DTM grids and breach locations have been obtained, the flood cell for each model must be defined. The flood cell is the geographical extent of the model, the area of the overall DTM that will be used in the model. While it would be possible to run each of the breach models using all of the derived DTM topographical data, it is far more sensible to define a smaller area on which to run each scenario.

6.2.3 Flood cells are typically defined by considering the topography of the area inland of the breach and the peak levels of the tidal events to be tested. MapInfo can be used to show areas of potential flooding by only displaying areas of the DTM that are below the predicted peak inundation levels in the vicinity of the breach, plus a freeboard of several hundred millimetres. Areas of the DTM that are not shown (that is, areas that are well above the tidal levels of interest) do not need to be considered in the model.

6.2.4 Ideally, the entrance the flood cell will be at the breach itself, and inflows into the model will occur at this point. However, where areas of overtopping also occur near the breach, the breach and overtopping and their interactions must be considered within the flood cell. In such situations, the entrance to the flood cell must be situated some way downstream of the breach.

6.2.5 Where the local topography does not clearly define an enclosed flood cell it may be necessary to artificially enclose certain parts of the flood cell. This should only be done for areas that are not near the breach or any important areas of the model, and will typically be outlying or empty areas of the flood cell. For example, estuaries or flat, open fields at the far end of the flood cell. Since the model treats the boundaries of flood cells as 'glass walls' it is vital that any artificial boundaries do not affect levels in the important areas of the flood cell. However, this is typically not an issue in models where the inflows are based on tidal levels rather than a specific volume.

6.2.6 For the SFRA study area, eight flood cells were defined. Each of the nine models has its own flood cell defined, with the exception of the two models in Maldon itself (MA4 and MA5). As the two breach locations are relatively close, and the characteristics of the local system are relatively complicated (overtopping, navigation channels, etc.) the same flood cell was used with different breach locations.

6.2.7 The flood cells for each of the models are shown in the relevant Appendices A-D.

6.2.8 Table 6-1 presents the flood cell references and a brief description of the breach located within each flood cell.

TABLE 6-1 FLOOD CELLS AND THE ASSOCIATED NUMBER OF ANALYSED BREACH/OVERTOPPING EVENTS

Flood Cell	Location of Event	Nature of Event
CH1	Clementsgreen Creek	Breach in existing defences
CO1	Colchester Ballast Quay	Breach of full width of barrier
CO2	Strood Channel	Breach in existing defences
CO3	Waldegraves Farm	Breach in existing defences
MA1	Maylandsea Marina	Breach in existing defences
MA2	Burnham-on-Crouch	Breach in existing defences
MA3	Bradwell Waterside	Breach in existing defences
MA4	Maldon Inland	Breach in existing defences
MA5	Maldon Heybridge Basin	Breach of full width of navigation sluice

6.3 Extreme Water Level Derivation

6.3.1 The extreme sea water levels associated with tidal flood events along the Essex coastline vary throughout the study area and consequently are specific to each breach location. The extreme sea water levels for the breach locations along the coastline are based on information obtained from the Draft '*Report on Extreme Tide Levels: Anglian Region, Central and Eastern Area'* (Royal Haskoning, 2007) obtained from the Environment Agency, which was considered the most relevant data at the time of this study.

Climate Change

6.3.2 Estimates of the effects of climate change on extreme water levels were based on current DEFRA guidelines. These assume a progressive increase in water levels with time. For the East of England, East Midlands, London and Southeast England the increases in peak tidal levels as a result of climate change are predicted as being 4 millimetres per year until 2025, 8.5 millimetres per year from 2025 to 2055, 12 millimetres per year from 2055 to 2085 and 15 millimetres per year 2085 to 2115. As such, using the year 2007 as a basis, 100 years of climate change equates to an increase in peak tidal levels of 1.02 metres (shown in Table 4-1).

6.3.3 The extreme water levels for each breach location simulated in this assessment are presented in Table 6-2.

TABLE 6-2 MAXIMUM SEA WATER LEVELS

Floodcell	1 in 200 year [mAOD]	1 in 200 year + 100 years climate change [mAOD]	1 in 1000 year [mAOD]	1 in 1000 year + 100 years climate change [mAOD]
CH1	4.39	5.41	5.00	6.02
CO1	4.26	5.28	4.49	5.51
CO2/CO3	4.15	5.17	4.51	5.53
MA1/MA4/MA5	4.44	5.46	4.79	5.81
MA2	4.32	5.34	4.67	5.69
MA3	4.24	5.26	4.59	5.61

Tide Curve

6.3.4 It is necessary to superimpose extreme sea levels onto a tidal curve. This enables a model run to accurately estimate the total volume of water flowing through a breach. In general, the sea water level profile during a tidal flood event consists of two components - an astronomical tide and a surge residual. The astronomical tide is assumed to be independent of the meteorological conditions. The tidal curve applied in this study has been obtained by superimposing an astronomical tide on a storm surge residual.

Astronomical Tide

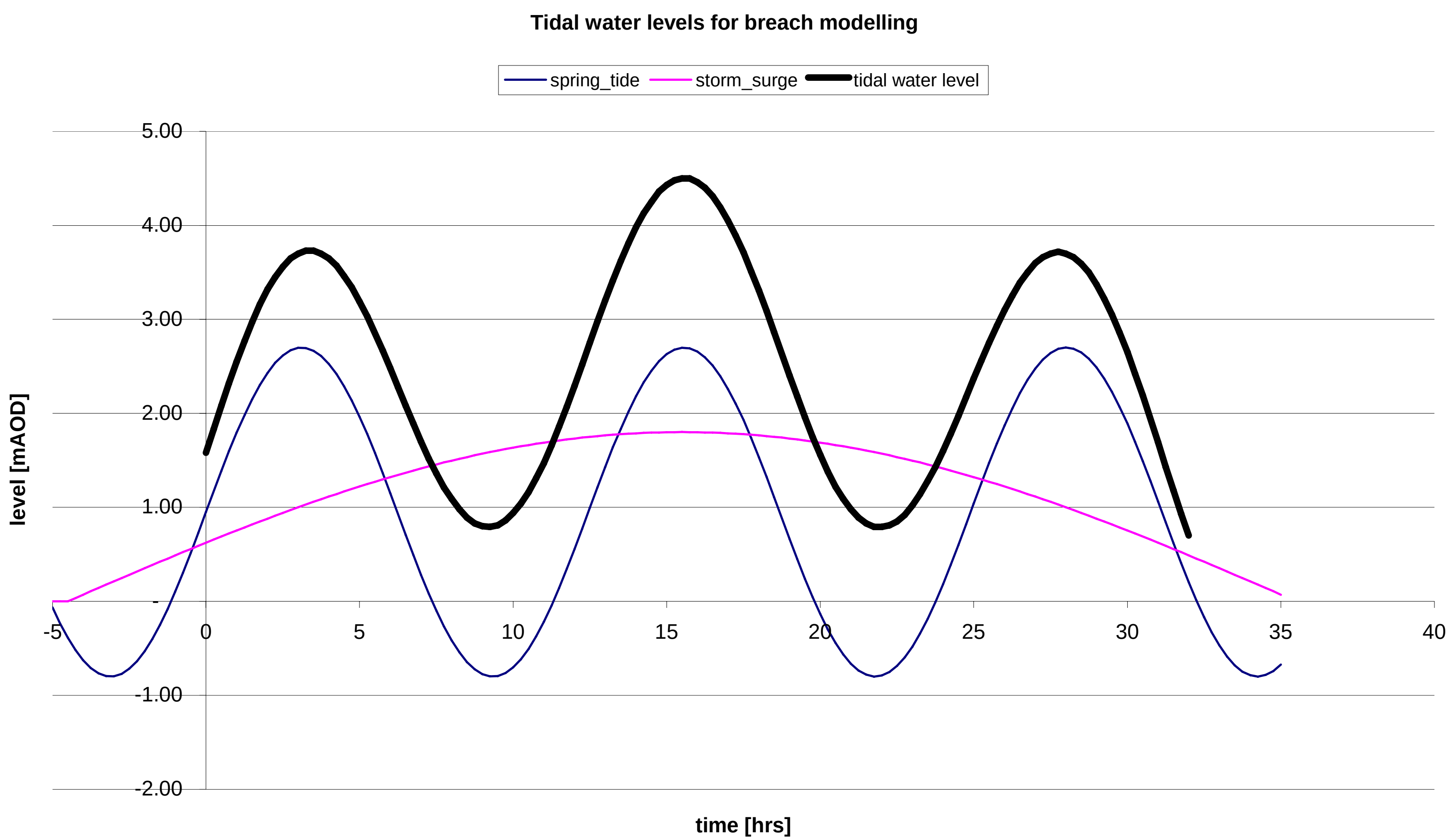
6.3.5 For the astronomical tide the mean spring tide at the breach locations has been used. Mean Spring Tidal Water levels at the breach location were obtained from the Admiralty Tidal Tables (UKHO, 2004).

Storm Surge Profile

6.3.6 The surge component was simulated by a regular half-sinusoidal shaped water level increase. The duration of the surge event was assumed to be 40 hours (equivalent to 1.7 days). The storm surge peaks at the same moment as the second astronomical high tide.

6.3.7 The water levels during a tidal flood event can be found by summing the astronomical tide levels and the storm surge residual. An example of the sea water levels used for the breach modelling analysis is shown in Figure 6-1.

FIGURE 6-1 TIDAL CURVE USED IN ASSESSMENT OF BREACH EVENT



6.4 Breach Modelling

6.4.1 Due to the relatively low-lying nature of the area along the Mid Essex coastline, and the numerous tidal inlets and creeks, tidal flooding is considered to have the largest potential impact from a single flood source. Flood protection for these areas is provided by a combination of man-made and natural flood defences of various types and design standards.

6.4.2 Breaching of these flood defences has the potential to generate the greatest flood risk hazard for this area. To assess flood propagation in events where the flood defences are breached, a hydraulic modelling analysis has been undertaken using the two-dimensional hydraulic modelling software MIKE21-HDFM (version 2007).

6.4.3 This section of the report discusses the methodology that has been applied for the hydraulic modelling analysis of the breach events. The choice of model is discussed, the model schematisation is described and the boundary conditions used are presented.

Model and Software Selection

6.4.4 To achieve the study objectives, the model used to estimate the maximum flood conditions was required to:

- Accommodate the effects of a flood flow (propagation of a flood wave and continuous change of water level);
- Simulate the hydraulics of the flow that breach the flood defences; and
- Generate detailed information on the localised hydraulic conditions over the flooded area in order to evaluate flood hazard.

6.4.5 To investigate the flood conditions resulting from every breach location over the study domain, the two-dimensional (2D) hydraulic modelling software MIKE21-HDFM (MIKE21-Hydrodynamic Flexible Mesh Model, 2007 version) has been used.

6.4.6 MIKE21-HDFM simulates water level variations and flows for depth-averaged unsteady two-dimensional free-surface flows. MIKE21 is specifically oriented towards establishing flow patterns in complex water systems, such as coastal waters, estuaries and floodplains. The MIKE21 hydraulic modelling software is developed by the Danish Hydraulic Institute (DHI) Water and Environment.

6.4.7 MIKE21-HDFM is a new modelling system based on a flexible mesh (FM) approach. The flexible mesh model has the advantage that the resolution of the model can be varied across the model area. The model utilises the numerical solution of two-dimensional shallow water equations.

Model Extent and Resolution

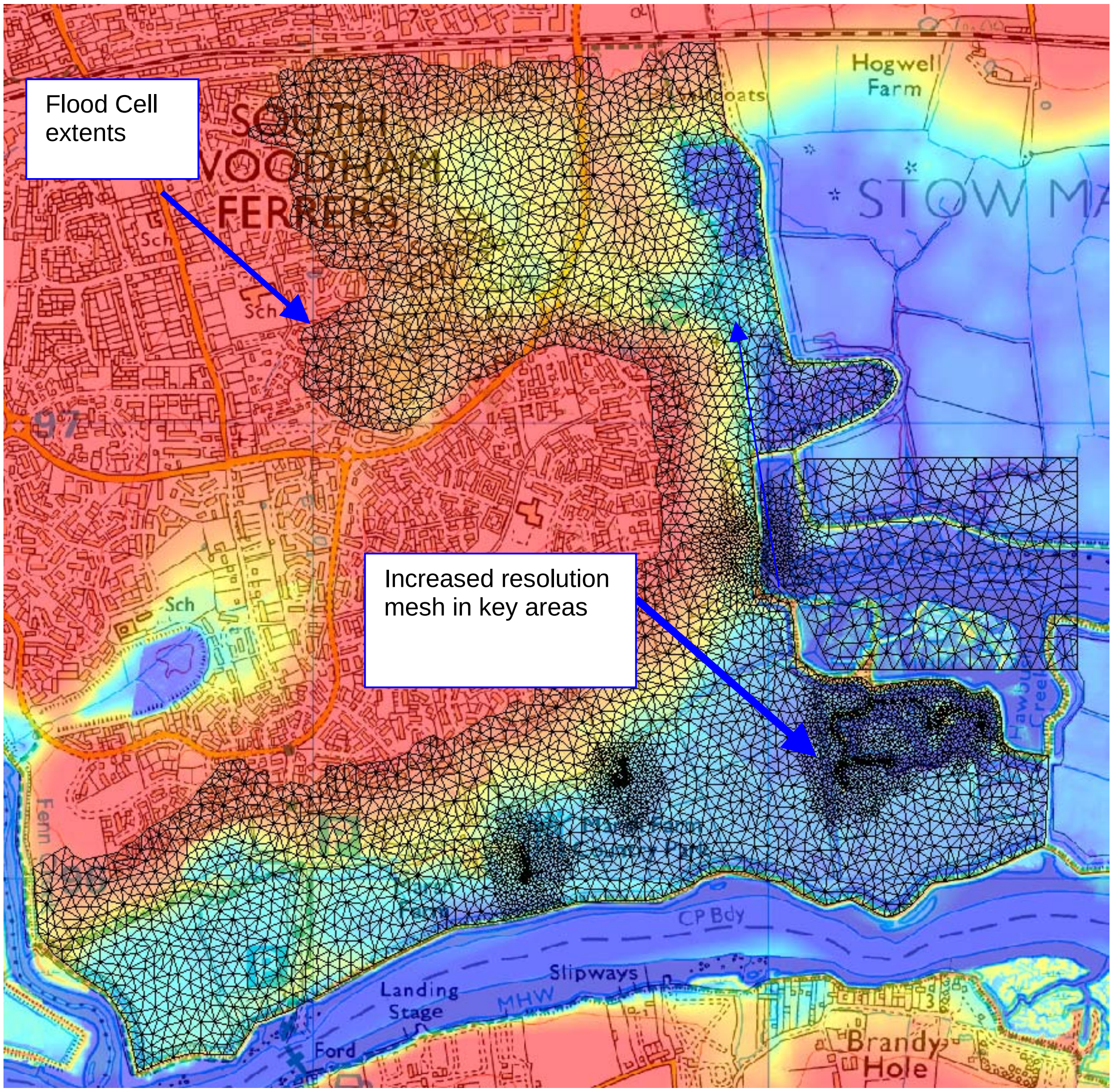
6.4.8 For each flood cell, a MIKE21 flexible mesh model has been developed using the MIKE21 program Mesh Generator (example shown in Figure 6-2). The mesh generator creates a mesh over the flood cell DTM using triangular elements. The element size varies throughout the model domain and depends upon the complexity of floodplain topographic features and/or areas of interest.

6.4.9 Using the flexible mesh module it is possible to generate a highly resolved mesh in areas of particular interest or in areas that are important from a hydrodynamic viewpoint and have a lower resolution in areas that have a lower priority reducing demands on computational resources.

6.4.10 To represent the hydraulics around the breach with a relatively high level of accuracy, a comparatively small element size has been applied in the vicinity of breaches. The breach has been represented by a minimum of four elements. Urban areas and structures within the floodplain have the potential to affect the free flow of floodwater. Embankments, flood defences, significant watercourses and other linear features have been incorporated into the flexible mesh by creating break-lines parallel to the feature.

6.4.11 By adding break lines, the mesh orientation is forced to follow the alignment of the features and the localised elevations of structures are used by the mesh generator. The break lines of linear man-made features were schematised by reference to the DTM, 1:25000 OS maps and high-resolution aerial photographs. The crest levels of linear features, such as secondary flood embankments, road embankments and railway embankments, have been established by interrogation of the DTM. It should be noted that the majority of the features described above have been identified through a desktop analysis only, and have not been verified on the ground. Results from the breach modelling which show strong dependence on barriers should therefore be used with caution.

FIGURE 6-2 EXAMPLE OF MIKE 21 HD FLEXIBLE MESH



Breach Specifications

6.4.12 Breach modelling was undertaken for nine breach/overtopping locations. The flood conditions (i.e. inundation rate, flood extent, depth of flooding) that may be experienced if a flood defence were to breach are a function of the breach dimensions, time required to repair the breach (exposure duration) and tidal conditions. Since it is not possible to set repair time in the modelling software, the breach and tidal details are the two major factors that determine the extent of inundation due to breaching.

6.4.13 Overtopping is simulated, where applicable, 'automatically' in the model when it is run as the levels of the defences and other structures will have been determined by the DTM topography details.

6.4.14 Suitable breach dimensions were determined using the Environment Agency Strategic Flood Risk Assessment (SFRA) Guidance.

6.4.15 The breach width is determined on the location and type of embankment as tabulated in Table 6-3.

TABLE 6-3 BREACH WIDTH CATEGORIES

Location type	Defence type	Breach width (m)
Open coast	Earth bank	200
	Dunes	100
	Hard	50
	Sluice	Sluice width
Estuary	Earth bank	50
	Hard	20
Tidal river	Earth bank	50
	Hard	20
Fluvial river	Earth bank	40
	Hard	20

6.4.16 For each breach location, the type of embankment has been derived from inspection during site visits, aerial photographs, and 1:10000 OS maps. The breach widths applied to these defence types are presented in Table 6-4.

TABLE 6-4 DEFENCE TYPE BREACH WIDTH

Model	Location	Location Type	Defence Type	Breach Width [m]
CH1	Clementsgreen Creek	Tidal river	Earth bank	50
CO1	Colchester Ballast Quay	Sluice	Sluice width	30
CO2	Strood Channel	Estuary	Earth bank	50
CO3	Waldegraves Farm	Estuary	Earth bank	50
MA1	Maylandsea Marina	Tidal river	Earth bank	50
MA2	Burnham-on-Crouch	Tidal river	Hard	20
MA3	Bradwell Waterside	Estuary	Earth bank	50
MA4	Maldon Inland	Tidal river	Earth bank	50
MA5	Maldon Heybridge Basin	Sluice	Sluice width	9

6.4.17 The base levels of the breaches have been set to the lowest elevation of the land directly behind (landward) the flood defence.

6.4.18 In the hydraulic modelling undertaken for this study, the breach in the flood defence was present during the whole flood event (i.e. it is deemed to have occurred prior to the onset of the extreme tidal event) as it is not possible to vary the DTM during the simulation period. This is a conservative assumption.

6.4.19 It is important to note that the current condition of the defences has not been used as a criterion on which to base the breach dimensions. Instead, it has been assumed that over time all defences will be maintained to the required standard, that is the standard they are currently built to. That is, no assessment has been made of the probability of failure.

Boundary Conditions

6.4.20 The MIKE21 breach models require one boundary condition to be defined. This is a time dependent head boundary (HT) at the seaward side of the breach location, which replicates the extreme tide levels/cycle during a tidal flood event.

6.4.21 As previously stated (in Table 6-2) four tidal flood events were analysed for each breach location. The tidal flood events analysed were:

- A tidal flood event with a return period of 1 in 200 years (present day);
- A tidal flood event with a return period of 1 in 200 years including the effect of 100 years climate change;
- A tidal flood event with a return period of 1 in 1000 years (present day); and
- A tidal flood event with a return period of 1 in 1000 years including the effect of 100 years climate change.

Hydraulic Roughness

6.4.22 Hydraulic roughness represents the conveyance capacity of the vegetative growth, bed and bank material, channel, sinuosity and structures of the floodplain. Within the MIKE21 model, hydraulic roughness is defined by the dimensionless Manning Number 'N'.

6.4.23 The assigned hydraulic roughness coefficient is based on engineering judgement and available literature (e.g. Chow, 1979).

6.4.24 The applied Manning Number, N, for the study area was set at 24. This represents a common roughness coefficient for seabed and non-urban areas, which forms the majority of each study area.

6.4.25 While it is possible to define individual roughness coefficients to various areas within a MIKE21 model, in this case it was deemed appropriate to simply apply a single roughness to the entire study area.

Model Simulations Undertaken

6.4.26 To investigate the flood conditions throughout the study area, several model simulations were undertaken. A total of 36 model simulations were undertaken for nine breach locations (four simulations per breach, as previously defined).

6.4.27 The model results of the individual model simulations have been processed and are presented in the relevant Appendices for each local authority. Flood extent outlines are presented for all cases. The two cases that include climate change have also had flood depth maps and flood hazard zone maps prepared for all breach locations.

6.5 Definition of Tidal Hazard Categories

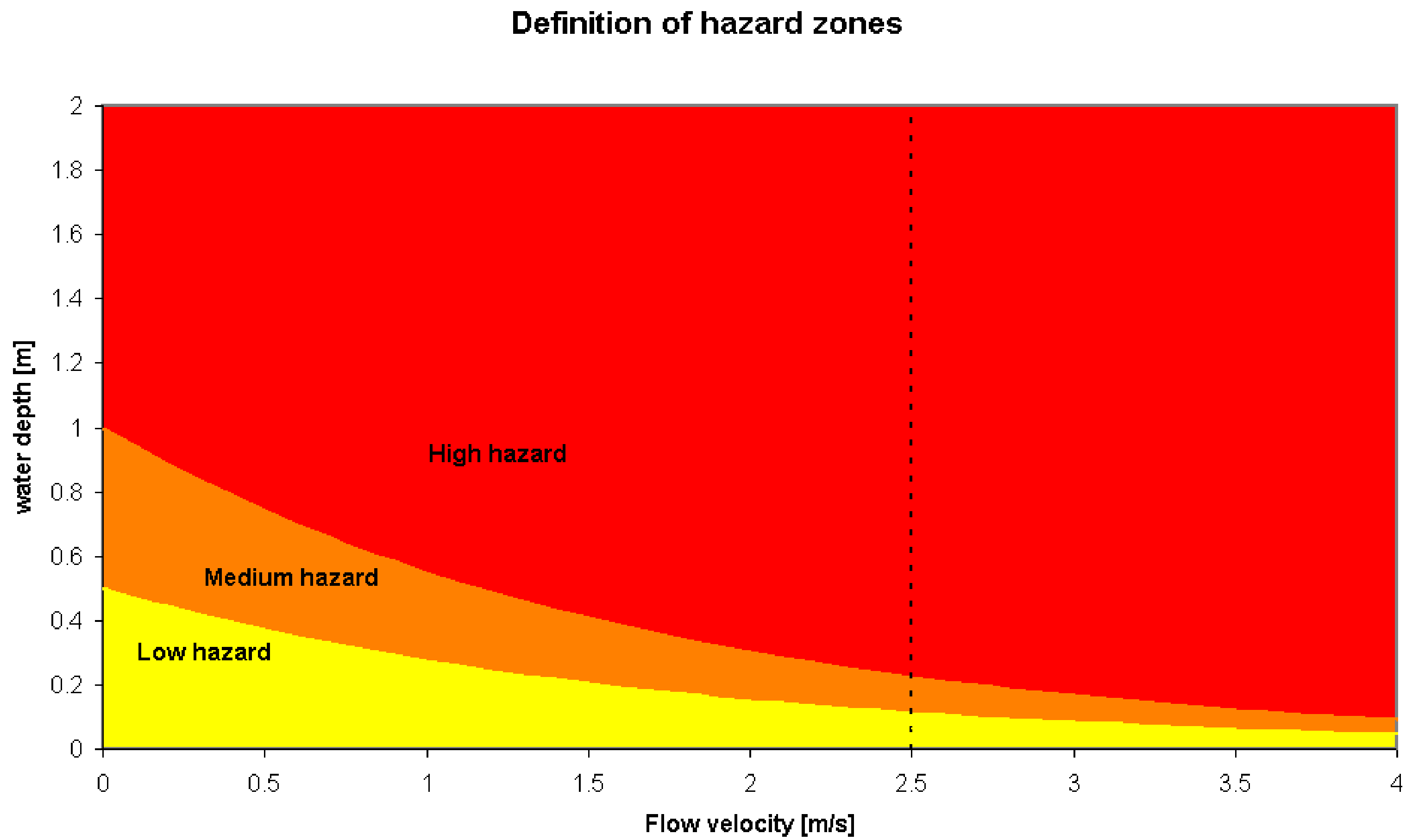
6.5.1 Breach analysis presents data to identify the residual risk of flooding from a failure of local defences. The mapping of flood hazard zone maps within the Mid Essex area) (for the two climate change scenarios) represents an appreciation of the residual risk to provide an additional level of information to local planning authorities allowing them to make more detailed consideration of the sequential test and PPS25 vulnerability classifications within Flood Zone 3.

6.5.2 Flood hazard is a function of both the flood depth and flow velocity. Therefore, to create flood hazard maps, the modelled floodwater depth and flow velocities resulting from each breach model scenario have been assessed.

6.5.3 In most flood events the maximum hazard of a flood at a certain location is not experienced at the peak of the flood but before the maximum floodwater level occurs. This is the point at which the greatest flood depths and velocities typically occur. In order to determine the maximum flood hazard, the hazard level was assessed by using an in-house tool (Hazard Index). This assigns one of three hazard categories (low, medium or high) to each element in the mesh at every time step of the model simulation, then determines the maximum for that element.

6.5.4 The relationship between flood depth and flow velocity and the definition of hazard zones and presented in Figure 6-3. This methodology was originally derived using the DEFRA Flood and Coastal Defence R&D Programme 'Risk to people' FD2321, using velocity and depth variables to determine the appropriate hazard classification. A debris factor has not been included in our methodology as this is difficult to assess on a strategic scale.

FIGURE 6-3 DEFINITIONS OF HAZARD ZONES



7 Flood Mapping and Application

7.1 Introduction

7.1.1 The following section is intended for use in conjunction with the flood zone and hazard mapping presented in the Appendices of this study. Planning guidance indicating what type of development is likely to be appropriate in certain flood zones is presented in Tables D.1, D.2 and D.3 of PPS25 (Communities and Local Government, 2006). These tables can then be viewed in conjunction with the hazard zone mapping for specific areas to inform planning decisions and enable the LPA to apply the sequential approach within a flood zone, as well as between the flood zones.

7.2 Flood Zone Mapping

7.2.1 The current flood zones (2007) were mapped for the main settlement and growth areas for each of the Local Authority areas. These maps present the flood zones 1, 2, 3a and 3b in relation to current levels of flood risk (2007). In addition these areas were also mapped to take into account the climate change recommended by PPS25 for residential development at 100 years (2107). These figures are included in each of the Appendices and should enable the local authorities to undertake the Sequential Test as part of a 'Level 1 SFRA'.

Functional Floodplain

7.2.2 Functional floodplains have the highest probability of flooding of all the Flood Zones defined within Table D.1 of PPS25. As outlined by Table D.1, there are only two appropriate land uses that should be permitted in this zone – water compatible land uses and essential infrastructure. Any planning applications for proposed appropriate development must be accompanied by a site-specific Flood Risk Assessment that proves that the proposed development will not impede flood flows, will not increase flood risk elsewhere and will remain operational in times of flood. In light of the above, it is important that functional floodplain is illustrated by the SFRA in order for the LPAs to consider its location when preparing LDF documents and other strategic documents.

7.2.3 A functional floodplain is defined by Table D.1 in PPS25 as an area of land where water has to flow or be stored at times of flood (Communities and Local Government, 2006). The functional floodplain has an annual probability of flooding of 5% (i.e. from a 1 in 20 year return period event). Table D.1 of PPS25 also classifies functional floodplains as being Flood Zone 3b.

7.2.4 The functional floodplains for fluvial areas (Flood Zone 3b) were derived from the main fluvial models (for the rivers Chelmer, Can and Wid, Colne, Blackwater and Brain) for the 1 in 20 year return period. In addition the fluvial functional floodplain was mapped to include an allowance on climate change by assuming a 20% increase in flows for 100 years of climate change (as recommended by PPS25 Table B.2).

7.2.5 The draft “Practice Guide Companion to PPS25 ‘Living Draft’” outlines that climate change should be considered for allocated development sites over an appropriate time period; for the lifetime of each development. The Environment Agency considers the lifetime of residential development as 100 years and commercial/industrial development as 60 years. The SFRA is intended to assist the LPA with their strategic planning as part of the their LDF process, therefore the emphasis is on residential so 100 years of climate change has been presented for each flood zone.

7.2.6 The tidal areas of the majority of the Mid Essex area are defended to a high standard. As a result, there are limited functional floodplains in these areas. The functional floodplains for the tidal areas (Flood Zone 3b) were derived using the 1 in 20 year water level taking into account the presence of defences. The functional floodplain taking into account climate change (2107) was mapped using the PPS25 climate change increases for 100 years (1.02m outlined in Table 4-1).

7.2.7 Many of the smaller tributaries and streams have not been subjected to detailed modelling. Therefore, they do not have a defined functional floodplain as yet. It should be noted that where Flood Zone 3b has not been identified in the SFRA due to insufficient information (e.g. smaller watercourses). All areas within Flood Zone 3 should be considered as Zone 3b until an appropriate FRA can demonstrate to the Environment Agency that it can be considered as falling within Flood Zone 3a.

7.3 Hazard Zones

7.3.1 To provide a greater level of detail on the variation of fluvial and tidal flood risks an assessment of hazard has been made for the main fluvial rivers and tidal areas for Mid Essex. The scenarios modelled include the 1 in 200 year plus climate change scenario and the 1 in 1000 year plus climate change scenario.

Fluvial Hazard Mapping

7.3.2 The fluvial hazard maps are based on 1 dimensional hydraulic models and as such do not have an associated velocity output; therefore the hazard has been classified as a function of depth, assuming zero velocity. The Hazard categories have been mapped using the “FD2320/TR2 –Flood Risks Assessment Guidance for New Development” depths and associated hazard with an assumed zero velocity as shown in Table 13.1 of that document.

Key (depth of flooding in metres assuming a 0 m/s velocity):

0.30-0.50	**Danger for Some**
0.50-1.50	**Danger for Most**
1.50 +	**Danger for All**

*Taken from Table 13.1 Defra/ EA Flood and Coastal Defence R&D Programme FD2320.

7.3.3 The Rivers Chelmer, Can and Wid were mapped for the Borough of Chelmsford. The Rivers Blackwater, Brain and Colne were mapped for Braintree, Maldon and Colchester.

Tidal Hazard Mapping

7.3.4 The hazard maps, shown in the relevant appendices indicate a breakdown of the PPS25 defined Flood Zone 3 into areas of High, Medium and Low hazard as a result of overtopping and breach scenarios. They were produced using the consequence and risk methodology outlined in Chapter 6.

7.3.5 The 2D breach modelling produces variables for both depth and velocity during the tidal inundation as a result of a breach. The hazard zone methodology on a strategic scale is similar to the Flood Hazard guidance provided in DEFRA/EA R& D publication FD2320/TR2 table. The debris factor cannot be considered on a strategic scale as the source and volume of debris would vary hugely on a spatial basis resulting in ambiguous results.

7.3.6 The tidal flood hazard maps present the results of each breach scenario and include overtopping and breach assessments where relevant. In areas where the existing standard of defence was below the 1 in 200 year water level, the flood cells have modelled overtopping inundation for the 200-year and 1000 year existing scenarios i.e. the actual flood risk that would result at present day defence heights- Actual Risk.

7.3.7 The hazard zone maps have been produced by calculating the depth and velocity of inundation water from particular breach events. It is important to remember that the hazards maps represent the hazard arising from one or more breach scenario in a specific location and will almost certainly vary spatially should the breach location differ. The breach locations were derived during the initial scoping and modelling stages through consultation with the Environment Agency and district councils. The locations were considered in relation to most likely areas to breach as well as greatest potential consequences.

7.3.8 In addition, further issues to be considered whilst using the hazard maps are:

- Not all possible breach locations in each authority area have been considered. The modelling study had to be limited to those locations thought most likely to lead to flood risk for specific growth areas.
- Not all fluvial areas have been mapped for 'hazard', therefore where this has not been possible, hazard should be assessed through site-specific FRA's.
- Breach width and depth, though based on EA guidance, are arbitrary and do not necessarily represent the actual dimensions of a breach in a given location.
- Changes in inundation extent or hazard zone do not vary linearly with changes in breach location so interpolation is not possible.
- The hazard maps from this SFRA do not correspond exactly to Defra/ EA R&D FD2320 as a debris factor has been omitted from the calculations due to the strategic nature of the study.

7.4 Rapid Inundation Zone

7.4.1 The draft "Practice Guide Companion to PPS25 'Living Draft'" identifies a rapid inundation zone as an area at risk from rapid flooding should a flood defence structure be breached or overtopped (Communities and Local Government, 2007). Unsurprisingly, these areas tend to be located close behind the flood defences. In general, the zone of rapid inundation suggests that development should be avoided within the first few hundred metres of the defences because there is a risk to all people exposed to floodwater (Environment Agency Flood and Coastal Defence R&D Programme, 2005). There is an inherent risk to properties in this area from the potential high floodwater velocities following a potential breach event.

7.4.2 As part of the breach and overtopping modelling undertaken as part of this assessment, flood inundation animations have been supplied to the participating authorities and Environment Agency to provide further detail with regards the main flood routes and speed of inundation relating to a particular breach event.

7.4.3 For an SFRA located in a more urbanised location a 500m buffer zone, to include the zone of rapid inundation, is commonly used. The study area for the Mid Essex SFRA included large areas of coastline and river/estuary areas that are largely rural, therefore breach locations were concentrated in more urbanised areas such as Maldon, Colchester, and Chelmsford. The existing breach scenarios provide information in relation to depth, speed and related hazard for the various flood cells in these specific areas.

7.4.4 It is important to consider the probability of a breach event occurring, even in the sparsely populated areas. Therefore in rural areas where breach scenarios were not examined in greater detail, an assumption of 500m (Environment Agency Flood and

Coastal Defence R&D Programme, 2005) for the zone of rapid inundation and associated high hazard would not be overly conservative. Although the local topography and existing defences would need to be considered, the definition of this area for a particular site or masterplan should be identified in a site specific flood risk assessment.

7.5 Using the Hazard Maps

7.5.1 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.

7.5.2 Where it can be demonstrated by the Local Planning Authority that the Sequential Test is passed, it will also be necessary in some circumstances for the Council to demonstrate that all three elements of the Exception Test are satisfied.

7.5.3 It is intended that the hazard maps will provide the Local Planning Authority with an appreciation of the actual flood risks faced in their areas taking into consideration the presence of flood defences.

7.5.4 The hazard maps will inform policies and practices required to ensure development satisfies the requirements of the Exception Test through the detailed consideration of flood hazard. Presenting information such as depth variation for fluvial flood zones, depth and velocity variation including onset of flooding for tidal flood zones.

7.5.5 The tidal hazard maps take into consideration the existing infrastructure, modelling overtopping and potential breach scenarios to identify potential flood hazards to areas behind existing defences.

7.5.6 A number of further considerations in addition to flood hazard should be taken into account when allocating specific areas for development or placing one area ahead of another in terms of suitability for development. Potential evacuation routes, flood warning times and the time to peak flood hazard are some of the additional factors that should be taken into account. Further details are provided in Chapter 9.

8 Residual Risk Management

8.1.1 Residual risk in a generic sense can be defined as being the remaining risk following all risk avoidance, reduction and mitigation measures have been implemented (Communities and Local Government, 2007). In a flood risk context, this residual risk pertains to the flood risk that remains after flood avoidance and alleviation measures have been put in place. Examples of such residual risks include overtopping or breaching of floodwalls or embankments.

8.1.2 Residual risk management therefore aims to prevent or mitigate the consequences of flooding that can occur despite the presence of flood alleviation measures.

8.1.3 Much of the Mid Essex region is protected by various flood defence structures. However, the sizes of these structures have been limited by economic considerations and some are older than other. Therefore there is a risk of overtopping or breach leading to inundation by floodwater. Examples of this have been identified by the breach analysis and flood mapping exercise undertaken as part of this SFRA.

8.1.4 Application of the Sequential Test as part of PPS25 aims to preferentially develop or relocate potential development sites into areas with low flood risk. Where this is not realistically possible, some development sites may be located in higher flood risk areas, such as PPS25 defined Flood Zones 2 and 3. As a result, such developments will require residual risk management to minimise the consequences of potential flooding, e.g. following a breach or overtopping of local defences.

8.1.5 Ensuring properties are defended to an appropriate design standard reduces flood risk. However, further options are also available should the residual risk to a development prove unacceptable. This chapter presents some of the information and options available to understand and manage residual risk.

8.2 Managing Residual Risk

Potential Evacuation and Rescue Routes

8.2.1 In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe. The Environment Agency deem evacuation routes safe if they fall within the white cells of Table 13.1 of the Defra/EA document FD2320 for a 1 in 100/200 year design event as a minimum, and the Environment Agency inform the LPA of the flood risk posed during the extreme event (1 in 1000 year). This allows the LPA to consult with the emergency services over the suitability of the access route. If potential evacuation routes are likely to become inundated so that safe access/egress would not be possible, then the proposed development should be relocated. This may also be the case should the possible evacuation routes be particularly long or across difficult terrain.

8.2.2 A key consideration in relation to the presence and use of evacuation routes is the vulnerability and mobility of those in danger of being inundated. Development for highly vulnerable users e.g. disabled or the elderly should be located away from high-risk areas. The Sequential Test does not however differentiate between the vulnerability of the end users of the site, only the vulnerability of the intended use of the site. A proposed residential development for highly vulnerable end users (elderly, physically impaired etc) will still fall under the 'More Vulnerable' classification in Table D.2 of PPS25 and the Sequential and Exception Tests will apply accordingly. Where development for highly vulnerable end users cannot be avoided, safe and easy evacuation routes are essential.

Time to Peak of Flood Hazard

8.2.3 The time to peak relates to the amount of time it takes for a flood event to reach its maximum level, flow or height. The greater the time to peak, the greater the time available for evacuation. The time to peak can, for residual flooding, be very short. Should a defence structure breach then inundation can be rapid, resulting in a short time to peak for the areas local to the breach. On the other hand, during tidal events, should a breach occur early in the tidal cycle, the time to peak could be a lot slower. Typically, areas immediately adjacent to a breach location will have a lower time to peak than areas setback from the flood defence.

Methods of Managing Residual Flood Risk

8.2.4 The following sub-sections outline various methods available for the management of residual flood risk. The methods outlined will not be appropriate for all development types or all geographical areas. Therefore, they should be considered on a site-by-site basis. In addition, it is important that the use of such techniques do not exacerbate flooding elsewhere within the flood cell oversight.

Recreation, Amenity and Ecology

8.2.5 There are many different ways in which recreation, amenity and ecological improvements can be used to mitigate the residual risk of flooding either by substituting less vulnerable land uses or by attenuating flows or both. They range from the development of parks and open spaces through to river restoration schemes. In addition, they have wider ecological, biodiversity and sustainability benefits.

8.2.6 The basic function of these techniques is increased flood storage and the storage or conveyance of rainwater. Typical measures include various guises of pools, ponds, and ditches. These all can have the added benefit of improving the ecological and amenity value of an area. These features can provide a haven for local wildlife. In addition, they can contribute to a sites amenity value both aesthetically and for recreation by providing attractive areas available for activities such as walking, cycling, water sports or wildlife watching.

Secondary Defences

8.2.7 Secondary defences are those that exist on the dry side of primary defences. Typically, their main function is to reduce the risk of residual flooding following a failure or overtopping of the primary defences.

8.2.8 Secondary defences can relocate floodwaters away from certain areas or reduce the rate of flood inundation following a residual event. Examples of secondary defences include embankments or raised areas behind flood defence walls, raised infrastructure e.g. railways or roads and, on a strategic level, canals, river and drainage networks. The latter are a form of secondary defence as they are able to convey or re-direct water away from flood prone areas even if this is not their primary function.

Land Raising

8.2.9 Land raising can have mixed results when used as a secondary flood alleviation measure. It can be an effective method of reducing flood inundation on certain areas or developments by raising the finished levels above the predicted flood level. However, it can result in the reduction in flood storage volume within the flood cell. As a result, floodwater levels within the remainder of the cell can be increased and flooding can be exacerbated elsewhere within the flood cell. Level for level compensatory storage should be provided where any loss of floodplain storage has occurred as a result of land raising or developing within the floodplain.

8.2.10 Partial land raising can be considered in larger, particularly low lying areas such as marshlands. It may be possible to build up the land in areas adjacent to flood defences in order to provide secondary defences. However, again the developer should pay due regard to the cumulative effects of flooding such as increasing flood risk elsewhere.

Finished Floor Levels

8.2.11 Where developing in flood risk areas is unavoidable, the most common method of mitigating flood risk to people is to ensure habitable floor levels are raised above the maximum flood water level. The Environment Agency require 300mm freeboard for precisely computed flood levels, and 600mm for less precisely computed levels in addition to modelled flood levels when setting finished floor levels. It is also necessary to ensure that roads levels are such that emergency access and evacuation routes are maintained. This can significantly reduce the risk of the proposed development becoming inundated by flooding. As with the land raising option, it is imperative that any assessment takes into consideration the volume of floodwater potentially displaced by such raising.

Flood Resilience

8.2.12 The Association of British Insurers in cooperation with the National Flood Forum has produced published guidance on how homeowners can improve the food resilience of their properties (ABI, 2004). These measures can not only improve properties against flood risk, by reducing the residual risk, but can also improve the insurability of homes in flood risk areas. The guidance identifies the key flood resistant measures as being:

- Replace timber floors with concrete and cover with tiles,
- Replace chipboard/MDF kitchen and bathroom units with plastic equivalents,
- Replace gypsum plaster with more water-resistant material, such as lime plaster or cement render,
- Move service meters, boilers, and electrical points well above likely flood levels, and,
- Put one-way valves into drainage pipes to prevent sewage backing up into the house.

8.2.13 Advice on flood mitigation for homes and businesses is also given in the ODPM's 2003 report, 'Preparing for Floods' (ODPM, 2003b).

Flood Warning and Emergency Procedures

8.2.14 Flood warning and emergency procedures are typically higher-level management strategies. Such procedures typically include information such as warning, evacuation and repair procedures. Documents providing guidance on how to use flood resistance and resilience measures to limit damage caused by flooding, such as 'Improving the Flood Performance of New Buildings, (May 2007) Department for Communities and Local Government: London, can also offer important guidance and should be referred to

8.2.15 When undertaking flood risk assessments for developments within flood risk areas, the local flood warning and emergency response plans should be referred to as a flood damage mitigation method.

8.2.16 Where these procedures already exist they should be updated to include the information generated by this SFRA. Emergency planning maps are provided in each of the supporting appendicies and should be consulted in order to identify places of refuge within each District. This will ensure that emergency plans are appropriate to the conditions expected during a flood event and that local authorities and emergency services are fully aware of the likely conditions and how this may affect their ability to safeguard the local population.

9 Sustainable Drainage systems

9.1 Background

9.1.1 Traditionally, built developments have utilised piped drainage systems to manage storm 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 storm water from developed areas, the alteration of natural drainage processes can potentially impact on downstream areas by increasing flood risk and reducing water quality. Receiving watercourses are therefore much more sensitive to rainfall intensity, volume and catchment land uses after a catchment or areas of a catchment have been developed.

9.1.2 Due to the difficulties associated with updating sewer systems it is uncommon for sewer and drainage systems to keep pace with the rate of development/re-development and the increasingly stringent controls placed on discharges to watercourses. As development progresses and/or urban areas expand these systems become inadequate for the volumes and rates of storm water they receive, resulting in increased flood risk and/or pollution of watercourses. Allied to this are the implications of climate change on rainfall intensities, leading to flashier catchment/site responses and surcharging of piped systems.

9.1.3 In addition, as flood risk has increased in importance within planning policy, a disparity has emerged between the design standard of conventional sewer systems (1 in 30 year) and the typical design standard flood (1 in 100 year). This results in drainage inadequacies for the flood return period developments need to consider, often resulting in potential flood risk from surface water/combined sewer systems.

9.1.4 A sustainable solution to these issues is to reduce the volume and rate of water entering the sewer system and watercourses.

9.2 What are Sustainable Drainage Systems?

9.2.1 Sustainable Drainage Systems (SuDS) are the preferred method for managing the surface water run-off generated by developed sites. The Environment Agency as well as PPS25 (Annex F) and Buildings Regulations (Approved Document Part H) advocate the use of SuDS for surface water runoff. PPS25 notes that regional planning bodies and Local Authorities should promote their use for the management of runoff. SuDS seek to manage surface water as close to its source as possible, mimicking surface water flows arising from the site, prior to the proposed development. Typically this approach involves a move away from piped systems to softer engineering solutions inspired by natural drainage processes.

9.2.2 Discharge rates from a developed area vary depending on the characteristics of the site pre development. If the site was originally Greenfield in nature surface water discharge rates should mimic the Greenfield rate. In accordance with PPS25 peak flow rates of surface water leaving a developed site should be no greater than the rates prior to the proposed development, unless specific off-site arrangements can be made that result in the same net effect. Where possible, efforts should be made to improve the current situation with regard to discharge from the site, particularly in areas known to suffer from surface water inundation.

9.2.3 SuDS should be designed to take into account the surface run-off quantity, rates and also water quality ensuring their effective operation up to and including the 1 in 100 year design standard flood including an increase in peak rainfall of 30% to account for climate change. In addition, these systems must be proven to be effective for the lifetime of the development, 100 years for residential developments and 60 years for commercial (as outlined by PPS25).

9.2.4 Wherever possible, a SuDS technique should seek to contribute to each of the three goals identified below with the favoured system contributing significantly to each objective:

- Reduce flood risk (to the site and neighbouring areas),
- Reduce pollution, and,
- Provide landscape and wildlife benefit.

9.2.5 The goals of SuDS can be achieved by utilising a management plan incorporating a chain of techniques, (as outlined in Interim Code of Practice for Sustainable Drainage Systems 2004), where each component adds to the performance of the whole system:

- Prevention: good site design and upkeep to prevent runoff and pollution (e.g. limited paved areas, regular pavement sweeping)
- Source control: runoff control at/near to source (e.g. rainwater harvesting, green roofs, pervious pavements)
- Site control: water management from a multitude of catchments (e.g. route water from roofs, impermeable paved areas to one infiltration/holding site)
- Regional control: integrate runoff manage from a number of sites (e.g. into a detention pond)

9.2.6 In keeping with the guidance of PPS25 local authorities should encourage the application of SuDS techniques. This chapter presents a summary of the SuDS techniques currently available and a review of the soils and geology of the Mid Essex areas, enabling local authorities to identify where SuDS techniques could be employed in development schemes.

9.2.7 The application of SuDS techniques is not limited to one technique per site. Often a successful SuDS solution will utilise a number of techniques in combination, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS.

Planning

9.2.8 All relevant organisations should meet at an early stage to agree on the most appropriate drainage system for the particular development. These organisations may include the Local Authority, the sewage undertaker, Highways Authority, and the Environment Agency. There are, at present, no legally binding obligations relating to the provision and maintenance of SuDS. However, PPS25 states that:

"where the surface water system is provided solely to serve any particular development, the construction and ongoing maintenance costs should be fully funded by the developer."

9.2.9 The most appropriate agreement is under Section 106 of the Town and Country Planning Act. Under this agreement a SuDS maintenance procedure can be determined.

9.2.10 When a decision has been made regarding a SuDS method, the various organisations involved should agree on a management and responsibility strategy. Problems arise when this has not been decided upon prior to adoption and the SuDS system can fail.

9.3 SuDS Techniques

9.3.1 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 watercourse or public sewer etc). Various SuDS techniques are available, however the techniques operate on two main principles:

- Infiltration
- Attenuation

All systems generally fall into one of two categories, or a combination of the two.

9.3.2 The design of SuDS measures should be undertaken as part of the drainage strategy and design for a development site. A ground investigation will be required to assess the suitability of using infiltration measures, with this information being used to determine the required volume of on-site storage. Hydrological analysis should be undertaken using industry-approved procedures such as the Flood Estimation Handbook to ensure a robust design storage volume is obtained.

9.3.3 During the design process, liaison should take place with the Local Planning Authority, the EA (if the site exceeds 1ha in area or is identified as situated in a critical drainage area), and Anglian Water in order to establish that the design methodology is satisfactory and to also agree on a permitted rate of discharge from the site.

9.4 Infiltration SuDS

9.4.1 Infiltration SuDS discharge surface water directly into the ground and are therefore dependent upon the local ground conditions being suitable for their use, i.e. permeability of soils and geology, the groundwater table depth and the importance of underlying aquifers as water resources etc.

9.4.2 Various infiltration SuDS techniques are available for directing the surface water run-off to ground, (the reader is advised to refer to The SuDS Manual). However, development pressures and a desire to maximise development potential often result in typically small areas available for infiltration systems. These small areas, allied to the rapid rates of run off generation, often require some form of attenuation as part of the infiltration system. The storage may be provided in the sub-base of a permeable surface, within the chamber of a soakaway or as a pond/water feature.

9.4.3 Infiltration measures include the use of permeable surfaces and other systems that are generally located below ground.

9.5 Attenuation SuDS

9.5.1 Should it be found that the ground conditions are not favourable for infiltration techniques, the surface water run-off discharged from a site will need to be attenuated using on-site storage. While this is a SuDS technique that will reduce the rate of discharge from the site, the overall volume will not be minimised using on-site storage alone. An important factor that needs to be taken into consideration when assessing the suitability of on-site storage as part of a proposed development is the volume required and the associated impacts the storage will impose on development proposals and risks to neighbouring properties.

9.5.2 An allowable rate of discharge from the site will need to be agreed with the Environment Agency, Anglian Water, and the Local Planning Authority. This can have significant implications to the proposed development with regards to the large volume of storage that may be required. On-site storage can be constructed both above ground and below ground with the above ground systems usually being the cheaper option on a cost per m^3 of storage basis. It should be noted however that the below ground systems may pose less constraints on the developable area of the site.

On-site storage measures include basins, ponds, and other more engineered forms of storage underground, (the reader is directed to The SuDS Manual for further information regarding SuDS techniques).

9.6 Alternative Forms of Attenuation

9.6.1 In many situations the development of a site may involve proposals that would inhibit the use of basins or ponds as a means of managing the surface water run-off discharged from the site. This may be due to space limitations, economic feasibility, or other issues such as health and safety etc. In these situations it may be appropriate to use a storage option that is viewed as being more 'engineered' than an open basin or pond. Most of these methods involve the provision of storage beneath the ground surface, which may be advantageous with regards to the developable area of the site, however consideration needs to be given to construction methods, maintenance access and to any development that takes place over an underground storage facility. The provision of large volumes of storage underground also has potential cost implications.

9.6.2 Methods for providing alternative attenuation include:

- Deep Shafts
- Geocellular Systems
- Oversized Pipes
- Rainwater Harvesting
- Tanks
- Green Roofs

9.7 Combined Infiltration / Attenuation Systems

9.7.1 In most situations, SuDS systems include both infiltration and storage. Most of the techniques identified above can be used in combination, however dedicated infiltration and attenuation systems include swales and filter strips.

9.7.2 Combined systems often meet all three goals of Sustainable Drainage Systems, whilst also reducing the land take required to accommodate them.

9.8 SuDS Suitability in the Mid Essex Areas

9.8.1 The underlying ground conditions of a development site will often determine the type of SuDS approach to be used at development sites. This will need to be determined through ground investigations carried out on-site, however an initial assessment of the suitability of a site to the use of SuDS can be obtained from a review of the available soils/geological survey of the area.

9.8.2 The types of soils, drift deposits and solid geology that are present in each of the local authority areas are presented in the relevant appendices for the Mid Essex area, and assess their likely suitability to infiltration measures. This is based on a review of:

- The Soil Survey of England and Wales 1993 – 1:250,000 Soils Maps (Sheets 4 & 6), and
- The Geological Survey of Great Britain (England and Wales) 1:50,000 Series Solid and Drift Edition Sheets 207, 176 (1996), 191 (1996) and Sheets 208 & 225 (2001).

The Soils Map Legend was also consulted as part of this assessment.

9.8.3 Each of the Appendices contain a section on SuDS relating the ground conditions found in the specific local authority area in terms of their permeability (impermeable, variably permeable and permeable) and the types of SuDS techniques that may be suitable for a site located on these materials. These definitions are based on a review of available information and our experience and should not supersede site-specific data and ground investigations.

9.8.4 In the design of any drainage system and SuDS approach, consideration should be given to site-specific characteristics and where possible be based on primary data from site investigations. The information presented in the following tables is provided as a guide and should not be used to accept or refuse SuDS techniques.

9.9 Further Information

9.9.1 The above information is intended to provide an introduction to the use of SuDS in the Mid Essex area. The options available for the provision of SuDS is not exhaustive and new techniques are frequently developed. The consideration of utilising SuDS as part of a development will depend on many factors such as the underlying geology and drift layers, the depth of the groundwater table, site slopes, run-off quality, site restrictions, maintenance requirements, economical viability, groundwater protection and ecological considerations. The final drainage scheme and SuDS for a site should consider each of these elements in its design.

9.9.2 The following reference documents provide further information on SuDS, their benefits and limitations and how they can be employed:

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- British Water. 2005. Technical Guidance, Guidance to Proprietary Sustainable Drainage Systems and Components – SuDS. In partnership with the Environment Agency
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- DEFRA/EA. 2005. Preliminary Rainfall Runoff Management for developments, (W5-074/A/TR1)
- National SuDS Working Group. 2004. Interim Code of Practice for Sustainable Drainage Systems. National SuDS Working Group. ISBN 0-86017-904-4.

10 Conclusions and Recommendations

10.1 Summary

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

10.1.2 The SFRA presents Flood Zone Maps that delineated the flood zones outlined in PPS25 as Flood Zone 1, low probability, Flood Zone 2, medium probability and Flood Zone 3a, high probability. In addition, Flood Zone 3b, functional floodplain, has also been mapped. Table D.1 of PPS25 provides information on which developments might be considered to be 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 demonstrating safety.

10.1.3 It is hoped that the further information provided through the hazard maps for both the fluvial and tidal areas, will provide additional information with respect to hazard and flood depths, to provide a better understanding of the spatial variations of flood risk within the Flood Zone 3. This information can then be used to inform the Sequential Test and inform future developers.

10.2 Recommendations

Climate change

10.2.1 This SFRA was completed using the PPS25 climate change recommendations, however during the lifetime of this document it is quite likely that climate change levels may alter. As a result future site-specific flood risk assessments may have to adapt to these changes in line with current guidance in response to changing research into climate change.

A Living Document

10.2.2 The Mid Essex SFRA has been completed in accordance with PPS25 and the current guidance outlined in the draft Development and Flood Risk: A Practice Guide Companion to PPS25 'Living Draft' (Feb 2007). The SFRA has been developed by building heavily upon existing knowledge with respect to flood risk within the study area.

10.2.3 These documents have an intended lifespan of 6-10 years, with local development documents and potential development sites to be 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 potentially be upgraded or revised as required by the local authorities.

10.2.4 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 each of the Local Authority areas.

Local Planning Authority Approach

10.2.5 At the time of writing this document site-specific allocations had only been finalised for Chelmsford, therefore pending the finalisation of the other participating LPA allocations, the development areas were used to identify the flood risks to potential growth and development areas. If on completion of the preferred options there are any allocations that fall outside these growth areas, then the sequential test and potential exception test for these sites will need to be explored at that time.

The following recommendations are made by way of an indication of how to proceed with the SFRA process once the preferred options allocations are finalised:

- The LPAs should apply the Sequential Test to the development potential development sites and identify those sites they consider will be necessary to apply the Exception Test,
- If sites require the Exception Test the LPAs should provide responses to parts 'a' and 'b' of the Exception Test for each of the allocation sites.
- Following completion of the Sequential Test and parts 'a' and 'b' of the Exception test the Environment Agency should be consulted to confirm their acceptance of the LPAs arguments and justification for progressing with sites that require the Exception test. The LPA should then refer future developers to complete an FRA to meet the requirements of part c) of the Exceptions test in line with recommendations set out in PPS25.

Policies

- The LPAs should consider the consequences of including SuDS on development sites and the impact these can have on the developable area. In all cases the LPA should assess allocation sites in relation to geology and local issues to enable completion of the Sustainable Drainage Systems summary in Section 8;
- National and local policies should be reviewed against local flood risk issues and objectives identified by the Environment Agency. This will be discussed with relevance to the districts of Mid Essex in the relevant appendices.

10.2.6 This SFRA recommends various policies pertaining to specific LA areas and associated flood risks (e.g. a stronger SuDS policy for Braintree in view of the surface water related issues in Bocking). These have been included in the relevant Appendices A to D.

10.2.7 Through completion of these recommendations the LPAs will be able to transparently manage flood risk and ensure risk to their development sites and communities, now and in the future are mitigated.

11 References

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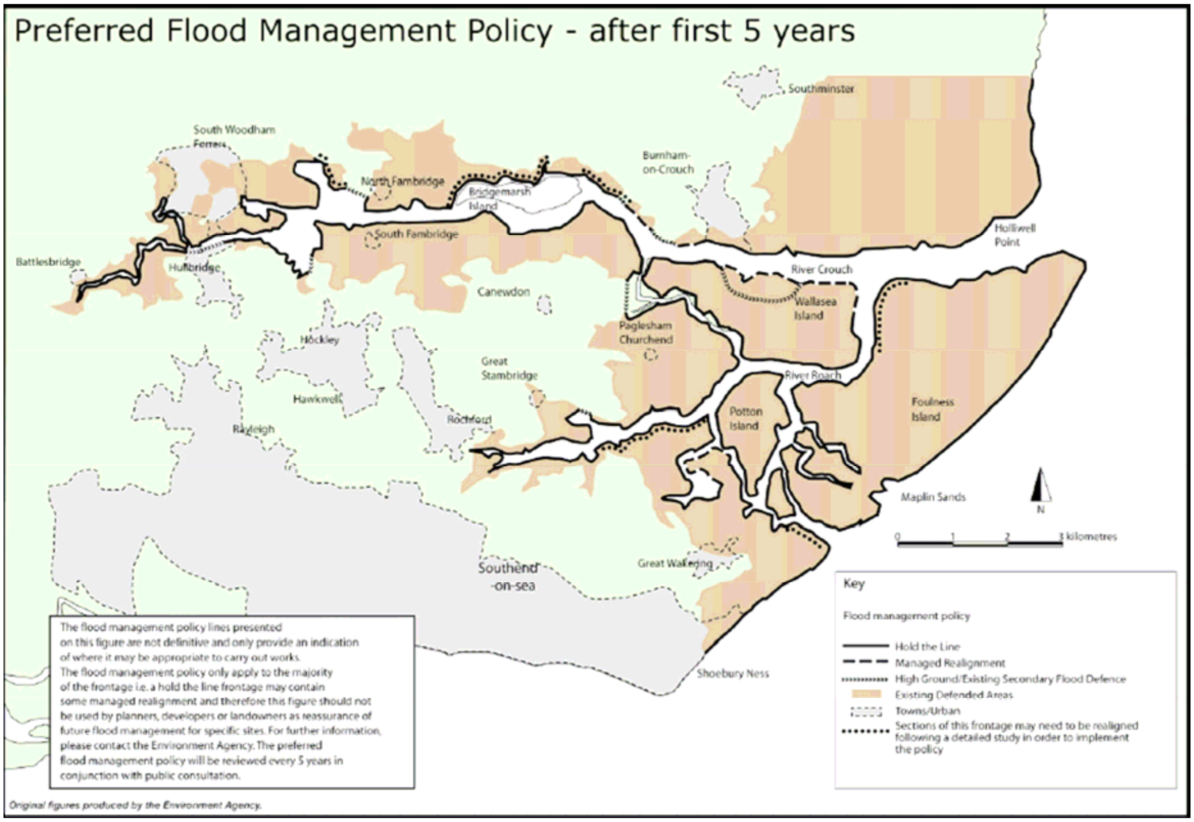
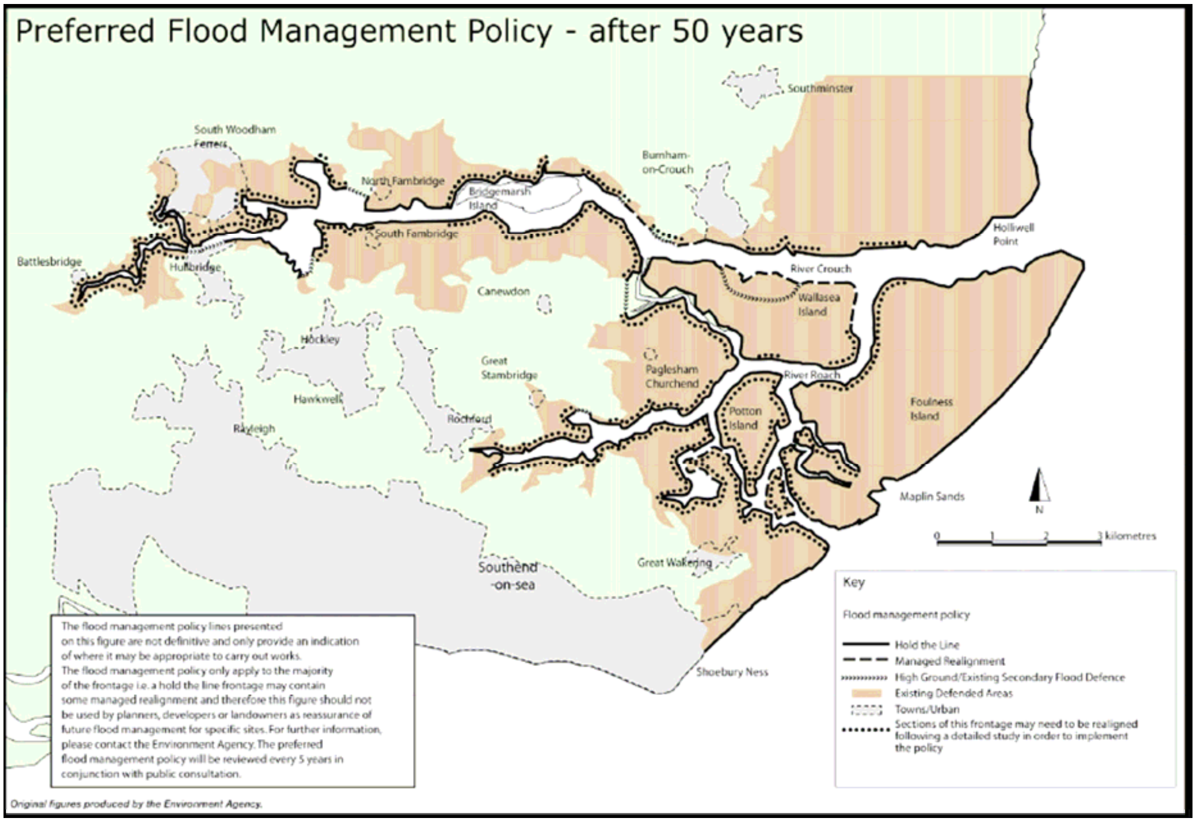
Annex A – Essex Estuary Management Strategies

FIGURE A-1 ESSEX ESTUARINE STRATEGIES, ROACH AND CROUCH FLOOD MANAGEMENT OPTIONS. 5 YEAR SCENARIO



Source: Environment Agency et al. 2006

FIGURE A-2 ESSEX ESTUARINE STRATEGIES, ROACH AND CROUCH FLOOD MANAGEMENT OPTIONS. 50-YEAR SCENARIO



Source: Environment Agency et al. 2006