

Lincoln Policy Area Strategic Flood Risk Assessment

Volume One:
Non-Technical Summary

FINAL REPORT
February 2010

The Lincoln Policy Area Partners

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Purpose

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Executive Summary

This report is a Strategic Flood Risk Assessment (SFRA) for The Lincoln Policy Area. It is a combined Level 1 and Level 2 SFRA that incorporates the requirements of a scoping study SFRA (Level 1) and increased scope SFRA (Level 2). This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25) and updates the previous SFRA published in 2002.

The SFRA constitutes one of a number of planning tools that enables the local authority to select and develop sustainable site allocations away from areas of greatest vulnerability to flooding in Lincoln. The assessment does not focus on specific development sites. The report discusses the broad scale flood risk within the whole policy area, and also focuses in more detail in an extended area of the City of Lincoln including North Hykeham and the Western Growth Corridor (Figure 1-1). This allows for an informed decision to be taken when allocating future development sites. It sets out the procedure to be followed when assessing sites in the future. The SFRA will provide the local planning authorities with the necessary detailed information to make informed decisions when considering development and flood risk issues.

The SFRA is intended to be a “live” document, updated when appropriate to reflect changes in the area and as new information becomes available.

Relevant planning, policy and guidance documents have been taken into account in preparing this SFRA. The documents which have been reviewed include national, regional and local planning legislation, together with Environment Agency policy guidance.

A thorough review of existing information and the construction of new hydraulic models has identified the level of flood risk in the Lincoln Policy Area from fluvial (river flooding).

Consultation has been undertaken with the City of Lincoln Council, the Environment Agency, local Internal Drainage Boards (IDB), British Waterways and Anglian Water to assess the current flood risk from all sources.

The Environment Agency Flood Zone Maps are included in the SFRA. The Flood Zone Maps show indicative flood outlines based on a broadscale assessment of fluvial flood risk only and do not take into account the protection offered by any defences. There are three Flood Zones. Flood Zone 1 classifies areas with a low probability of flooding. Flood Zone 2 (1 in 1000yr) is considered suitable for water-compatible, less vulnerable, more vulnerable and essential infrastructure. Highly vulnerable development is only allowed where the Exception Test is passed. Flood Zone 3 is split in to 2 sections; Zone 3a represents areas with a high probability of flooding (ie 1 in 100yr) and Zone 3b represents the functional floodplain. This is normally defined by the 1 in 20 year flood outline where water is able to spill out of the river channel. In Lincoln 1 in 20 year flows remain in channel except for in specified washland areas designed to hold flood waters.

Hydraulic modelling has been undertaken for the level 2 SFRA within the City of Lincoln to establish more realistic indicative flood outlines in key areas that take into account defences and consider how flood water flows within a floodplain. This modelling (which includes allowances for climate change to 2108) calculates expected depths and velocities of flood water across the floodplain and allows consideration of the flood risk to people and properties. Modelled flood outlines also take in to account the effects of climate change.

The flood scenarios considered in the SFRA are 1 in 100 year with climate change and 1 in 1000 year with climate change annual chance flood events, which may also be expressed as 1%+cc and 0.1%+cc Annual Exceedance Probability (AEP) flood events.

An investigation has been carried out into the effect of defences on flood risk and the risk that remains behind them, for example by failure (due to breach) or overtopping. Purpose built, formal defences have been considered and also other features such as privately owned walls and road and rail embankments, which were not built specifically as flood defences, but which have an impact on the flow of flood water due to their elevated level.

The main flood risk within the Lincoln Policy Area is considered to be from fluvial flooding.

Following major flooding in 1947 and 1958, feasibility studies were undertaken in 1977 to investigate flood risk in Lincoln and possible flood alleviation schemes. As a result, a scheme was implemented, which consisted of two controlled washlands constructed upstream of Lincoln City Centre; one at the confluence of the River Witham and Brant, known as the Witham washlands (5km south of Lincoln), and the other on the River Till (7km to the north-west), which provide a 1 in 100-year level of flood protection. The washlands were created by building shallow embankments across the river valley, with control sluices in the rivers, which allow the amount of water in the washlands to be regulated. Pumping stations aid the final draining of the washlands. The scheme was completed in 1991.

Apart from the control gates at the washlands there are also automated control gates at Stamp End and at the upstream end of Sincil Dyke (Bargate Sluices). All of these control gates are used to keep water levels in Lincoln below critical levels, which were set taking account of existing defence levels. The water level in Lincoln is kept between 4.36m AOD and 5.7m AOD. A set of rules and criteria for the operation of the washlands exists. This is held by the Lincs Washlands Operating Team. The control gates at the washlands are operated manually based on levels and flows from telemetry sites upstream.

The present flood risk within the Lincoln Policy Area has been determined with reference to the Environment Agency's Flood Zone Map (FZM) 2009 and overtopping and breach analysis of the flood defences within the City of Lincoln.

Overtopping and Breach analyses have been undertaken showing the possible depths and hazard mapping has been undertaken (taking into account depth and velocity). Overtopping and Breach analyses have been carried out using JBA's in-house raster based 2-D model JFLOW, to enable the production of maps showing overtopping and breach extent. Maps and GIS layers have been provided.

The flood defence condition has also been summarised (in Volume 2) from information received from the Environment Agency. The condition of flood defences throughout Lincoln ranges from Good to Poor.

2D flood modelling within the 'extended' area of the City of Lincoln (including north Hykeham and the Western Growth corridor) for both the 100 year with climate change and 1000 year with climate change flood scenarios has shown that flood defences will overtop. Breach analysis of flood defences has shown flood water to extend over a large area of the existing low land within the City area. The areas to the Western side of the River Witham in Lincoln are at the greatest risk from flood defence failure.

The SFRA provides guidance relating to future development. It provides advice on any site-specific requirements for a Flood Risk Assessment within the different flood zones, and advises the local authorities on the use of the Exception Test, should the Sequential Test be passed.

Guidance for the local authorities on the future management of development with respect to flood risk has been given, relevant to the different flood zones and possible types of development.

In addition, an outline has been given of requirements for developers for Flood Risk Assessments, with supporting guidance on reducing flood risk and making development safe, including Sustainable Drainage Systems (SuDS) and flood mitigation measures. Advice is also given on environmental improvement opportunities and other issues to consider as part of a development proposal.

The SFRA is presented in four volumes: Volume 1 provides a non-technical summary of the SFRA process and findings, Volume 2 provides a technical summary of methods used to produce the SFRA, Volume 3 provides guidance for those using the SFRA and Volume 4 includes the mapped outputs of the SFRA.

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Abbreviations

AEP	Annual Exceedance Probability
AONB	Area of Outstanding Natural Beauty
CC	Climate Change
CFMP	Catchment Flood Management Plan
DEFRA	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
FRA	Flood Risk Assessment
FZ	Flood Zone
Ha	Hectare
JBA	Jeremy Benn Associates Ltd
LDD	Local Development Document
LDF	Local Development Framework
LPA	Local Planning Authority
m AOD	Metres Above Ordnance Datum
MSfW	Making Space for Water
OS NGR	Ordnance Survey National Grid Reference
PPG25	Planning Policy Guidance Note 25
PPS25	Planning Policy Statement 25
RFRA	Regional Flood Risk Appraisal
SFRA	Strategic Flood Risk Assessment
SSSI	Site of Specific Scientific Interest
SuDS	Sustainable Drainage Systems

Definitions

Annual Exceedance Probability	e.g. 1% AEP	Refer to 'probability'.
Brownfield		Brownfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has previously been developed'. Prior to PPS25, the term 'Brownfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Previously-developed land'. See 'Greenfield'.
Catchment Flood Management Plan	CFMP	A strategic planning tool through which the Environment Agency will seek to work with other key decision-makers within a river catchment to identify and agree policies for sustainable flood risk management.
Compensatory Storage		A floodplain (flood storage) area introduced to compensate for the loss of storage as a result of filling for development purposes.
Core Strategy	CS	This is the strategic vision of an area and is a central pillar of the Local Development Framework, comprising: A Vision, Strategic Objectives, a spatial land use strategy, core policies and a monitoring and implementation framework. The Core Strategy is a Development Plan Document which will determine overall patterns of future development, identifying broad locations where future growth will take place. All other Development Plan Documents should be in broad conformity with the Core Strategy Document The Core Strategy is a mandatory document, and a timetable for production is set out within the Local Development Scheme.
Defended Area		An area offered a degree of protection against flooding through the presence of a flood defence structure.

Development Plan Documents	DPDs	These documents have Development Plan Status and consequently form part of the statutory development plan for the area. A DPD will be subject to an independent examination. Typical documents that will have DPD status include the Core Strategy, Site-specific Allocations of Land, Proposals Map, and Area Actions Plans (where needed).
Environment Agency	EA	An executive non-departmental public body. It's principle aims are to protect and improve the environment and to promote sustainable development.
Exception Test		An integral part of the risk-based approach at the core of PPS25, the Exception Test is designed to allow for those exceptional circumstances when, for wider sustainability reasons, development not entirely compatible with the level of flood risk may be permitted. For the Exception Test to be passed, all three of its components must be fulfilled.
Flood Estimation Handbook	FEH	Provides current methodologies for estimation of flood flows for the UK.
Flood Hazard		A classification system developed by DEFRA/Environment Agency that gives an assessment of the hazard posed by a flood event at a given location. It is defined using the maximum modelled flood depth, velocity and a factor to allow for debris.
Floodplain		Any area of land over which water flows or is stored during a flood event or would flow but for the presence of defences.
Flood Risk Assessment	FRA	A detailed site-based investigation that is undertaken by the developer at planning application stage.
Flood Risk Management		The introduction of mitigation measures (or options) to reduce the risk posed to property and life as a result of flooding. It is not just the application of physical flood defence measures.
Flood Risk Vulnerability Classification		Refer to Section 4.4.
Flood Zone 1	FZ1	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
Flood Zone 2	FZ2	This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year.
Flood Zone 3a	FZ3a	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Flood Zone 3b	FZ3b	This zone comprises land where water has to flow or be stored in times of flood. This is land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood.
Fluvial Flooding		Flooding caused by the overtopping of river or stream banks.
Formal Defence		A flood defence asset that is maintained by the Environment Agency.
Freeboard		A 'safety margin' to account for residual uncertainties in water level prediction and/or structural performance, expressed in mm.

Functional Floodplain		An area of land where water has to flow or be stored in times of (fluvial) flooding.
Greenfield		Greenfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has not previously been developed'. Prior to PPS25 the term 'Greenfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Undeveloped land' See 'Brownfield'.
Informal Defence		A structure that provides a flood defence function, however is not owned nor maintained by the Environment Agency.
Internal Drainage Board	IDB	An Internal Drainage Board is a statutory body which provides flood protection and water level management services
ISIS		1-Dimensional hydraulic modelling software used to demonstrate flow within river channels
JFLOW		Proprietary 2-Dimensional hydraulic modelling software package developed by JBA, which demonstrates overland flow in floodplains
Local Development Framework	LDF	<p>The Local Development Framework is made up of a series of documents that together will form part of the Development Plan. Broadly, Local Development Framework documents fall into two categories:</p> <ul style="list-style-type: none"> - Development Plan Documents - Supplementary Planning Documents.
Local Development Scheme	LDS	A Local Development Scheme is a public statement of the Council programme for the preparation of Local Development Documents which will form the Local Development Framework.
Local Planning Authority	LPA	Local authority with responsibility for determining whether proposed developments are approved or otherwise.
Main River		A watercourse designated as such by DEFRA that is regulated and maintained by the Environment Agency using their permissive powers.
Measure		A deliverable solution that will assist in the effective management (reduction) of risk to property and life as a result of flooding, e.g. flood storage, raised defence, effective development control and preparedness, and flood warning.
Mitigation		The management (reduction) of flood risk.
Option		Refer to 'measure'.
PAG2		Project Appraisal Guidance (PAG) 2 (Strategic Planning) outlines the DEFRA requirements against which the Environment Agency must demonstrate that they are managing flood risk in a strategic (catchment wide) manner.
Probability	e.g. 1%	A measure of the chance that an event will occur. The probability of an event is typically defined as the relative frequency of occurrence of that event, out of all possible events. Probability can

		be expressed as a fraction, percentage or a decimal. For example, the probability of obtaining a six with the shake of a fair die is 1/6, 16% or 0.166. Probability is often expressed with reference to a time period, for example, annual exceedance probability. For example, a 1% AEP event is an event with a 1% chance of occurring or being exceeded in any one year.
Proposals Map		This is an Ordnance Survey based map that spatially illustrates policies and proposals within LDDs. The Proposals Map will show planning policy designations and land allocations identified within DPDs, statutory land use and landscape designations and other land and area based designations. It will form part of the statutory development plan.
Residual Risk		The risk that inherently remains after implementation of a flood mitigation measure (option).
Return Period	e.g. 1 in 100-Year	The expected (mean) time (usually in years) between the exceedance of a particular extreme threshold. Return period is traditionally used to express the frequency of occurrence of an event, although it is often misunderstood as being a probability of occurrence.
Risk		The threat to property and life as a result of flooding, expressed as a function of probability (that an event will occur) and consequence (as a result of the event occurring).
Sequential Flood Risk Test	SFRT	The assessment and 'categorisation' of flood risk on a catchment-wide basis in accordance with PPS25.
Site Specific Allocations Development Plan Document		A mandatory document, the Allocations Development Plan Document is a high priority item for preparation, details of which are provided in the Local Development Scheme. Prepared in conformity with the Core Strategy, once approved, the Allocations Document will identify sites for development as part of the delivery of the overall planning strategy for the area.
Standard of Protection	SoP	The return period to which properties are protected against flooding
Strategic Flood Risk Assessment	SFRA	The assessment of flood risk on a catchment-wide basis for proposed development in a District
Strategic Flood Risk Management	SFRM	Considers the management of flood risk on a catchment-wide basis, the primary objective being to ensure that the recommended flood risk management 'measures' are sustainable and cost effective
Supplementary Planning Documents	SPD	Supplementary Planning Documents, or SPD, support DPDs in that they may cover a range of issues, both thematic and site specific. Examples of SPDs may be design guidance or development briefs. SPDs may expand policy or provide further detail to policies in a DPD. They will not be subject to independent examination.
Sustainable Drainage Systems	SuDS	Current 'best practice' for new development that seeks to minimise the impact upon the localised drainage regime, e.g. through the use of pervious areas within a development to reduce the quantity of runoff from the development.
TUFLOW		2-Dimensional hydraulic modelling software package with links to ISIS, which demonstrates overland flow in floodplains

Uncertainty	A reflection of the (lack of) accuracy or confidence that is considered attributable to a predicted water level or (modelled) flood extent.
Washlands	Areas which are not susceptible to flooding in a 20 year flood event and hence not classified as Flood Zone 3b, but are considered of vital importance as floodplains and should therefore be treated as functional floodplain
Windfall Sites	Sites that become available for development unexpectedly and are not included in a planning authority's development plan as allocated land.

1 Introduction

This section introduces the SFRA and confirms the study format, objectives and key outputs.

1.1 Background

JBA Consulting was commissioned in November 2008 by The City of Lincoln Council, on behalf of the Lincoln Policy Area Partners to undertake a review of the existing Strategic Flood Risk Assessment (SFRA) for the Lincoln Policy Area and update it in accordance with current best practice, Planning Policy Statement 25 Development and Flood Risk (PPS25). The supporting guidance, "Development and Flood Risk: A Practice Guide", The East Midlands Regional Flood Risk Appraisal, the Lincoln Integrated Urban Drainage Pilot Study and the Lincoln Water Cycle Study have also been referred to.

The SFRA will provide the Local Planning Authorities (LPA) with the necessary detailed information to make informed decisions when considering development and flood risk issues. This report provides the information necessary to undertake the sequential tests and exceptions test where appropriate to ensure flood risk issues are afforded appropriate weighting when decisions are made on development, now and in the future.

The SFRA should be treated as a 'dynamic' document that is periodically reviewed as the policy area changes or if further information becomes available to provide a better understanding of flood risk. The SFRA should be updated when changes are made to policies or strategy reports relating to flood risk or if conditions change that impact on the nature of flood risk in the Lincoln Policy Area, for example the presence and characteristics of flood defences, flood defence schemes or significant development in the district. When the Environment Agency Flood Zone outlines are updated, they should be incorporated into the SFRA.

Building on information already available, a Level 1 SFRA has been produced for the Lincoln Policy Area and a Level 2 SFRA has been produced for the City of Lincoln, North Hykeham and the Western Growth Corridor.

1.2 Format of the SFRA and Key Outputs

The Lincoln Policy Area SFRA has been broken down into four separate volumes:

Volume 1: Non - Technical Summary

Volume 2: Technical Summary

Volume 3: Guidance for Planners and Developers

Volume 4: Maps

1.3 Scope and Objectives

The SFRA involves a two step approach to the assessment of flood risk:

- Utilising existing available information, a broad scale assessment of flood risk to identify sites at risk from flooding across the whole Lincoln Policy Area (Level One Assessment of Flood risk); and
- An assessment of flood risk that is based upon more detailed river modelling. This includes consideration of flood risk management measures, such as flood defences, that may be present and the flood risk posed should such defences fail (breach) or be exceeded (overtopped) by extreme flooding (Level Two Assessment of Flood Risk).

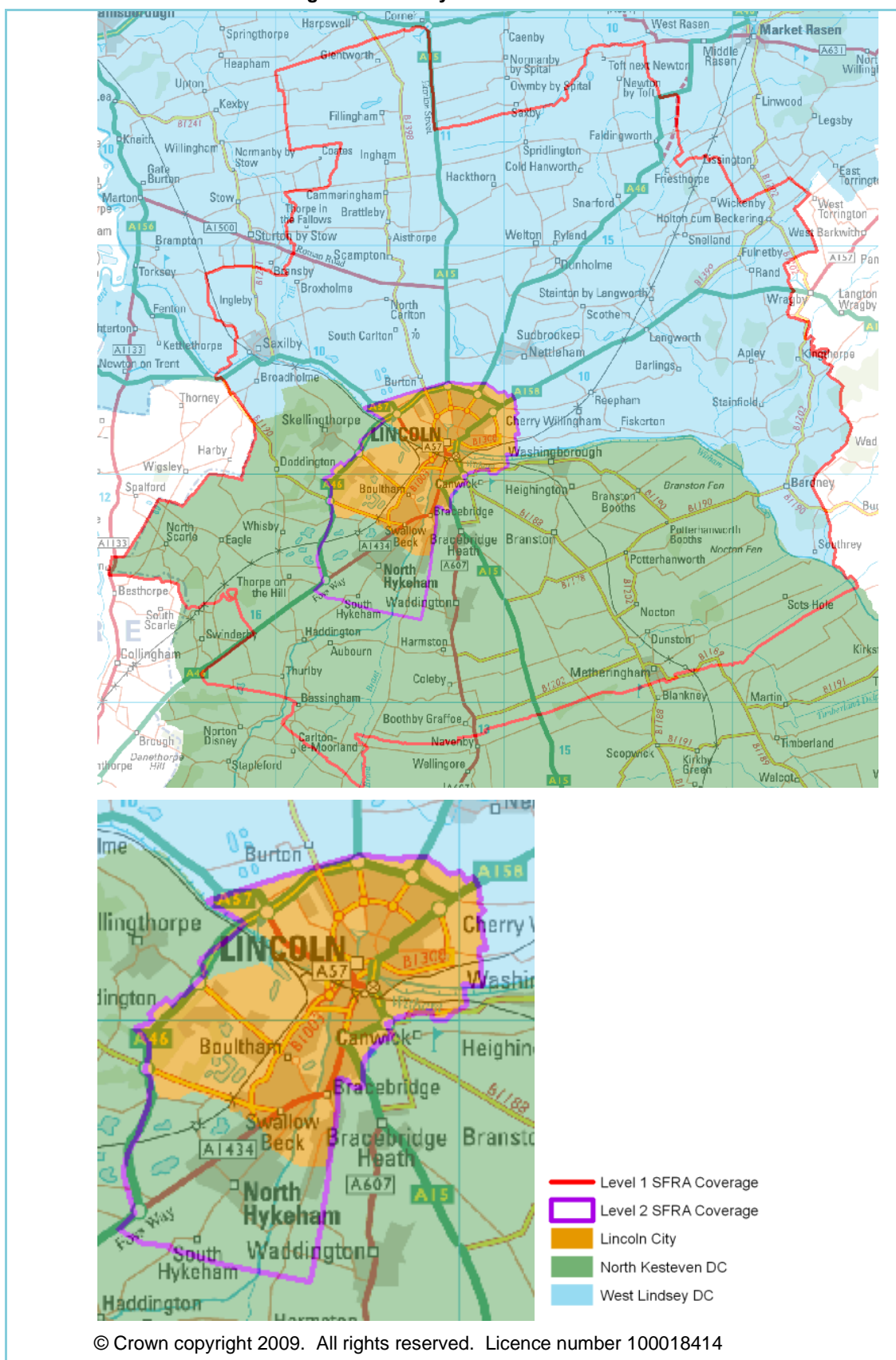
Current Government policy requires local authorities to demonstrate that due regard has been given to the issue of flood risk as part of the planning process. It also requires that flood risk is managed in an effective and sustainable manner and where new development is exceptionally necessary in flood risk areas, the policy aim is to make it safe without increasing flood risk elsewhere. Where possible flood risks should be reduced overall.

The overall objective for this SFRA is to provide sufficient information for the application of the Sequential Test and to identify whether application of the Exception Test is likely to be necessary. It involves a broad scale assessment of flood risk to identify sites at flood risk from fluvial and other sources of flooding, utilising existing available information. In addition to this, the SFRA will allow the LPA's within the Lincoln Policy Area to:

- prepare appropriate policies for the management of flood risk within the policy area;
- inform the sustainability appraisal so that flood risk is taken into account when considering options and in the preparation of strategic land use policies;
- identify the level of detail required for site-specific Flood Risk Assessments (FRA) in particular locations, and
- enable the policy area to determine the acceptability of flood risk in relation to emergency planning capability.

1.4 Policy Area

Figure 1-1: Policy Area



The City of Lincoln is located within a ridge in the Lincolnshire Heights, a north – south limestone ridge, through which the River Witham flows. The River Witham and the River Brant flow north towards Lincoln, with the River Brant joining the River Witham to the south of Lincoln. The River Till joins with the Fosdyke Canal to the north west of Lincoln. The Fosdyke Canal then continues to flow south east towards Lincoln City Centre. The Boultham Catchwater flows towards Lincoln from the west. The Fosdyke and Boultham Catchwater join with the River Witham in the centre of Lincoln. The Sincil Dyke acts as a relief channel for the River Witham in Lincoln. The Sincil Dyke then becomes the South Delph and this and the River Witham flow out of Lincoln in an easterly direction.

The catchment areas for the rivers flowing through Lincoln are primarily large, rural catchments, of 600km² and 200km² for the River Witham and Fosdyke Canal, respectively.

Due to the development of the low-lying areas adjacent to the watercourses, Lincoln is at increasing risk of flooding. Approximately 20% of Lincoln's 100,000 population lives in areas at risk from flooding. High flood risk areas also include the majority of Lincoln's industrial buildings and approximately half of Lincoln's commercial property.

In 1977, following major flooding in 1947 and 1958, feasibility studies were undertaken to investigate flood risk in Lincoln and possible flood alleviation schemes. As a result, a scheme was implemented, which consisted of two controlled washlands constructed upstream of Lincoln City Centre; one at the confluence of the River Witham and Brant, known as the Witham washlands (5km south of Lincoln), and the other on the River Till (7km to the north-west), which provide a 1 in 100-year level of flood protection. The washlands were created by building shallow embankments across the river valley, with control sluices in the rivers, which allow the amount of water in the washlands to be regulated. Pumping stations aid the final draining of the washlands. The scheme was completed in 1991.

1.5 Main Sources of flooding

The main flood risk within the Lincoln Policy Area is from fluvial flooding from the River Witham, River Till and the Fosdyke Canal.

The present flood risk within the Lincoln Policy Area has been determined with reference to the Environment Agency's Flood Zone Map (FZM) 2009 and overtopping and breach analysis of the flood defences within the City of Lincoln.

Flooding from the River Trent has also been considered. The Environment Agency consider the River Trent influence to extend to the western side of the A46 Lincoln Bypass. The Environment Agency Lower Trent Strategy has shown that a breach of the River Trent flood defence at Torksey Lock would allow flows to be concentrated along the Fosdyke canal towards Lincoln, however the A46 Lincoln bypass will form a dam and reduce the effect of flooding in the city as floodplains to the western side of the A46 / Lincoln bypass will accommodate floodwaters. Water will still flow through four openings in the A46 road bridge to reach the eastern side of the bypass, but with flows restricted and water depths of approximately 300mm.

Overtopping and Breach analyses have been undertaken showing the possible flood depths. Hazard mapping has also been undertaken (taking into account depth and velocity). Overtopping and Breach analyses have been carried out using JBA's in-house raster based 2-D model JFLOW, to enable the production of maps showing overtopping and breach extent.

2D flood modelling within the 'extended' area of the City of Lincoln for both the 100 year with climate change and 1000 year with climate change flood scenarios has shown that flood defences will overtop. Breach analysis of flood defences has shown flood water to extend over a large area of the existing low land within the City area.

In some cases within Lincoln it was found that the maximum possible breach outline (derived from the 100 year + cc and 1000 year +cc flooding scenarios) extended beyond flood zones 2 and 3. As a result it is recommended that the local authorities within the policy area restrict development within these areas. It is recommended that the sequential approach be applied to flood zone one in this instance. A flood risk assessment will need to be submitted in accordance with Annex E of PPS 25.

1.6 Other Sources of Flooding

Other sources of flooding can include surface water run off, blocked sewers and groundwater flooding. These sources have been investigated within this SFRA and are detailed further in Volume 4. The maps which are presented in Volume 4 show indicative flooding caused by surface water run off during an extreme (1 in 200 year) rainfall event, assuming sewer networks are full to capacity. The surface water flooding is categorised according to its depth and associated risk. The maps also highlight areas where instances of sewer flooding have been recorded. The maps should be used to inform Flood Risk Assessments

1.7 Updating the SFRA

The SFRA is intended to be a “live” document, updated when appropriate to reflect changes in the area and as new information becomes available. It is recommended that the SFRA is reviewed annually in liaison with the Environment Agency. If changes are required the SFRA should be updated accordingly.

The following areas should be subject to a future review in order to ensure the most up to date information is being used:

- Environment Agency Flood Zones Maps - these are updated periodically by the Environment Agency
- OS Background Mapping - These are updated periodically by Ordnance Survey
- PPS25 Practice Guidance Updates and Flooding Policy - A consultation is currently taking place into proposed amendments to Planning Policy Statement 25 (PPS25). The SFRA should be updated accordingly if the proposed amendments are brought in to force.
- Climate Change Predictions - Predictions for this SFRA are based on current guidance. Any future reviews of the SFRA should consult the Environment Agency to ensure the most up to date predictions are being used.

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2 Approach to the Strategic Flood Risk Assessment

This section contains information on the levels of the SFRA, delineation of flood risk zones, flood risk vulnerability classifications and principles of the sequential and exception tests.

2.1 Overview

A SFRA may be sub-divided into two degrees of detail: Level 1 and Level 2. The assessment approach taken for the Lincoln SFRA is given in the following sections, detailing the requirements at both SFRA levels. The Level 1 SFRA details risk in the whole Lincoln Policy Area and the Level 2 SFRA details risk in the City of Lincoln, North Hykeham and the Western Growth Corridor.

2.2 Level 1 SFRA

A Level 1 SFRA should be sufficiently detailed to allow application of the Sequential Test and to identify whether the Exception Test is likely to be necessary. Existing data is used to make an assessment of flood risk from all sources now and in the future.

2.2.1 Assessment of Current Flood Risk

Flood risk within the Lincoln Policy Area is assessed, categorised and mapped to a level concurrent with the nature and availability of existing data. In general, however, the following key considerations are addressed:

- Identification of known or perceived flood risk areas, including the nature of the flooding problem providing the initial 'filter' for key flood risk issues areas within the SFRA area.
- Review of the current Environment Agency Flood Zone Map and mapping of fluvial flood zones, providing the broad (first pass) definition of High Risk Flood Zone 3.
- Consideration of critical floodplain areas such as washlands and high risk Flood Zone 3b.
- Assessment of non-fluvial flood risk using surface water flooding maps (volume 4).

2.2.2 Delineation of Flood Zones

The most recent revision of the Environment Agency Flood Zone Map has been used to delineate Flood Zones within the whole Lincoln Policy area. The flood zones are precautionary and do not take account of flood defences and, therefore, represent a worst-case extent of flooding. The actual extent of flooding is mitigated by flood defences, both formal and informal along some parts of the River Witham, Fosdyke and Boultham Catchwater. Flood Zone Maps are also limited in that they only consider watercourses with catchments greater than 3 km².

The Environment Agency Flood Zone Maps (with and without climate change) have been produced using broad scale modelling and they do not take into account raised defences. Where raised defences are in place a Flood Risk Assessment will require additional modelling to determine the residual flooding risk to a development.

As more detailed modelling has been undertaken for this SFRA the Flood Zone Maps should be used only where more detailed 1 dimensional or 2 dimensional modelling, including the effects of defences, is not available.

2.2.3 Review Climate Change and Land Use Management Impact

Climate change has the potential to significantly increase the consequences of flooding. Where available, data which allows for the effects of climate change has been included in

the SFRA. Flood Zone Maps with climate change are currently not available. These should be added to the SFRA at a later date when they are available. In the absence of Flood Zone Maps with climate change, an accepted precautionary approach is to use Flood Zone 2 as an approximate outline for Flood Zone 3 with climate change.

2.2.4 Application of the Sequential and Exception Test

Guidance for the future management of development within low (Flood Zone 1), medium (Flood Zone 2) and high (Flood Zone 3) flood risk zones is provided, based on the most accurate flood outlines available. Consideration of the requirements for FRAs, and suitable mitigation measures (such as surface water attenuation and SuDS) has been included to assist both developers and planners.

2.3 Level 2 SFRA

The Level 2 SFRA modelling facilitates the application of the Sequential and Exception Test. It more accurately defines the defended flood outlines and illustrates the variation in risk and hazard within these outlines.

The Level 2 SFRA has been carried out for the extended City of Lincoln area including North Hykeham and the Western Growth Corridor (Figure 1-1).

2.3.1 Defended Outlines

The EA Flood Zone outlines are based on broad scale modelling and do not take into account any defences. A more accurate and useful representation is derived from modelling of defended outlines. Two dimensional JFLOW modelling has been undertaken for this SFRA. This more detailed modelling demonstrates how flood water interacts with features in the floodplain. This modelling has been limited to the City of Lincoln, North Hykeham and the Western Growth Corridor.

It should be noted that in some areas the defended flood outline area created during 2D JFLOW modelling might be larger than the Flood Zone. The modelling for this SFRA to estimate the defended flood outlines uses more accurate techniques than the broad scale modelling of the Flood Zones. In these instances the 2D generated defended outlines should be considered to be more accurate.

2.3.2 Assessment of Residual Risk

Further investigation is undertaken in areas protected by flood defences to allow a risk based approach to strategic planning. Where defences provide a benefit, breach modelling has been undertaken to demonstrate the possible consequences of a defence failure, or 'residual risk'. This is more useful for planning and regeneration purposes. The SFRA examines the probability, depth, velocity and hazard of flooding if defences are breached or overtopped. Overtopping and breach modelling using JFLOW has been carried out in the City of Lincoln, where the defences provide a major benefit to the city and the consequences of breached defences could be severe. The flood risk in terms of a hazard rating is assessed according to the methodology given in DEFRA R&D document FD2320 and clarified in the Supplementary Note published in May 2008.

2.3.3 Variation of Risk within Flood Outlines

The two dimensional modelling provides information on how the flood depth and flood hazard varies across the flood outlines, hence providing guidance on whether the flooding is severe, manageable or insignificant.

2.3.4 Level 2 SFRA Outputs

Within the 'extended' City of Lincoln area flood outlines have been produced using two dimensional JFLOW modelling. This provides a detailed assessment of risk. Modelling has been undertaken for flood defence overtopping and breaching scenarios for two events - 100 year with climate change flood event and 1000 year with climate change flood event. The variation of risk within the outlines is demonstrated in the form of Hazard Mapping.

Guidance is given for future development, with recommendations for site specific Flood Risk Assessments, Drainage Impact Assessments and SuDS.

At this stage there may be locations where departures from the Sequential Test are justified by the need to locate development in medium or higher risk zones or in order to meet the wider aims of sustainable development, and the Exception Test is required.

Where development locations pass parts (a) and (b) of the Exception Test, an assessment must be made as to whether development proposals can pass part (c) of the Exception Test. Recommendations for mitigation methods and emergency planning, reduction of flood risk, and requirements for site-specific FRAs are made. Potential mitigation measures will depend on the proposed end use for the site and defining an acceptable level of residual risk for development proposals.

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3 Integrated Flood Risk with Local Authority Planning

This section contains information and guidance on the key links between Flood Risk Management (FRM) activities and the wider planning system, current relevant National, Regional and Local planning policies, overview of PPS 25: Development and Flood Risk and the Practice Guide and the need for a balanced approach when considering flood risk alongside other key sustainable development factors.

3.1 Introduction

The land use planning process is driven by a whole host of policy guidance on a national, regional and local level. Whilst the majority of these policies are not aimed at mitigating flood risk, there are key links at strategic, tactical and operational levels between land use and spatial planning (Regional and Local Government), and FRM (Flood Risk Management) planning (Environment Agency), which should be considered as part of a planned and integrated approach to delivering sustainable development. The sustainability appraisal will help draw together these links and balance the application of wider social, economic and environmental planning policy and guidance. Flood risk assessment is required at all levels of the planning process and for all major developments in flood risk areas; these play and increasingly important role in assisting effective delivery of key planning objectives.

3.2 Background to Strategic Flood Risk Management Objectives

Historically, the management of flood risk was undertaken in a reactive manner, addressing problems on an as-needed basis in response to flooding events. It was recognised by the Government that this approach was generally not cost effective and often failed to consider individual problem areas within the wider river system.

To address this, the Environment Agency is committed to a rolling programme of flood risk mapping and strategic flood risk management investigations. These include Catchment Flood Management Plans (CFMPs) and Flood Risk Management (PAG2) Strategies within fluvial systems and Shoreline Management Plans (SMPs) within coastal areas.

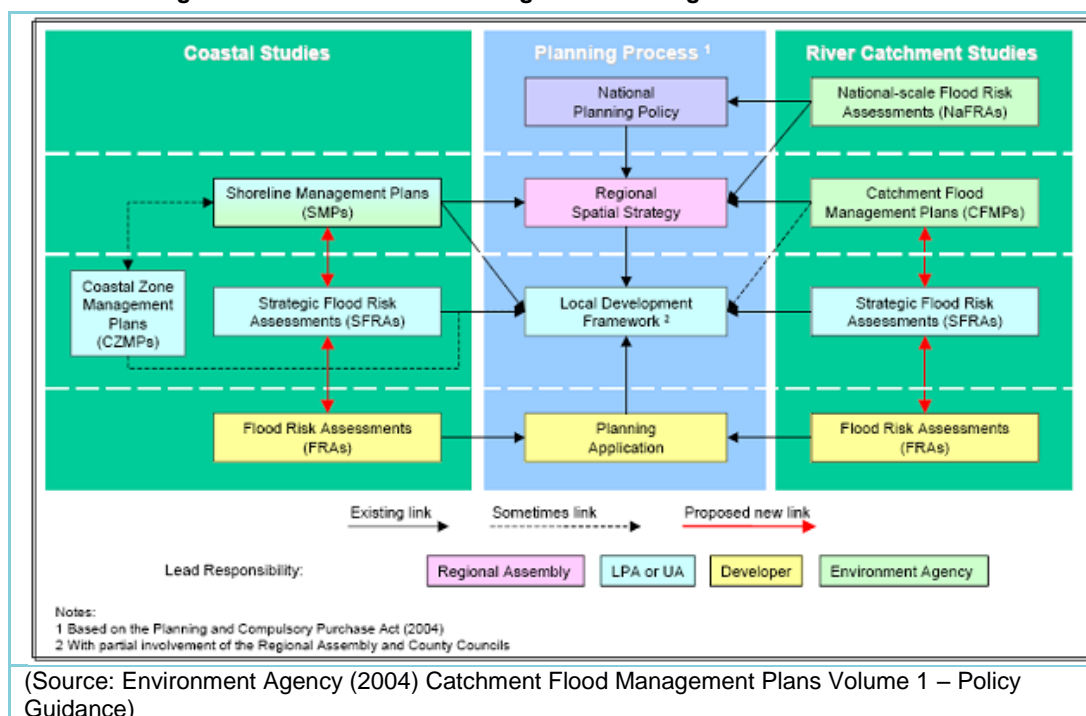
These studies take a catchment-wide approach to flood risk. They identify where flooding is known or perceived to be an existing problem and consider how flooding regimes are likely to alter as a result of climate and land use changes. The studies aim to understand the mechanism of flooding in an area and include assessments of how flooding can be managed in a cost effective and sustainable fashion over the next 50 to 100 years. These investigations also pay particular attention to the environmental implications of flood risk management and seek to provide opportunities for environmental benefit wherever possible.

The importance of influencing both the strategic planning process and development control, by preventing development within flood risk areas is recognised as a key Environment Agency objective. For this reason it is vital that the recommendations of the SFRA are consistent with the long-term strategy for flood risk management in the study area.

3.3 SFRAs and the Planning Process

Figure 3-1 below shows how SFRAs were integrated into the Flood Risk Management and Planning Process.

Figure 3-1: Flood Risk in an Integrated Planning Framework



(Source: Environment Agency (2004) Catchment Flood Management Plans Volume 1 – Policy Guidance)

3.4 National Planning Policy

This SFRA has been prepared in a period during which planning authorities have been implementing the provisions of the Planning and Compulsory Purchase Act 2004 and accompanying planning guidance, including PPS1 Delivering Sustainable Development and PPS12 Local Development Frameworks. This affected all tiers of the planning system and has necessitated major changes at both the regional and local level which will impact on the way in which planned development is approached in the regional strategy and delivered locally.

3.4.1 PPS25 Development and Flood Risk

In December 2006 the Government published PPS25: Development and Flood Risk.

The aim of PPS25 is to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk. The key planning objectives are *that Regional Planning Bodies (RPBs) and Local Planning Authorities (LPAs) should prepare and implement planning strategies that help to deliver sustainable development by:*

- Identifying land at risk and the degree of risk of flooding from river, sea and other sources in their areas;
- Preparing Regional or Strategic Flood Risk Assessments (RFRAs / SFRA) as appropriate, as a freestanding assessment that contributes to the Sustainability Appraisal of their plans;



- Framing policies for the location of development which avoid flood risk to people and property where possible, and manage any residual risk, taking account of the impacts of climate change;
- Only permitting development in areas of flood risk when there are no suitable alternative sites in areas of lower flood risk and the benefits of the development outweigh the risks from flooding;
- Safeguarding land from development that is required for current and future flood management e.g. 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 cause and impacts of flooding e.g. 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;
- Working effectively with the Environment Agency, other operating authorities and other stakeholders to ensure that best use is made of their expertise and information so that plans are effective and decisions on planning applications can be delivered expeditiously; and
- Ensuring spatial planning supports flood risk management policies and plans, River Basin Management Plans and emergency planning.”

In addition to setting out the roles and responsibilities for LPAs and RPBs, PPS25 identifies that landowners also have a primary responsibility for safeguarding their land and other property against natural hazards such as flooding. Those promoting sites for development are also responsible for:

- Demonstrating that it is consistent with PPS25 and Local Development Documents (LDDs);
- Providing a Flood Risk Assessment (FRA) demonstrating whether the proposed development: is likely to be affected by current or future flooding; satisfies the LPA that the development is safe; and identifies management and mitigation measures.

PPS25 also introduces an amendment to Article 10 of The Town and Country Planning (General Development Order) 1995 which makes the Environment Agency a Statutory Consultee on all applications for development in flood risk areas, and those within 20m of a Main River.

The Direction also introduces the requirement for LPAs to notify the Secretary of State where they are minded to approve a planning application contrary to a sustained objection by the Environment Agency.

The introduction of PPS25 enables local authorities to make a direction under Article 4 of the Town and County Planning (General Permitted Development) Order 1995. This will enable Local Authorities to remove permitted development rights where those rights threaten to have a direct, significant and adverse effect on a flood risk area, or its flood defences and their access, or the permeability and management of surface water, or flood risk to occupants.

3.4.2 PPS25 Development and Flood Risk Practice Guide

The Practice Guide to PPS25 was published by the Department for Communities and Local Government (CLG) in June 2008. It provides advice on the practical implementation of PPS25 policy and reflects extensive discussion with local authorities, the Environment Agency and other key stakeholders and practitioners. The guide provides further guidance on the preparation of SFRA's and FRA's, the Sequential and Exception Test, outlines potential mitigation measures e.g. SUDS and risk management techniques.

Local Authority planners and developers are advised to refer to and use PPS25 and the practice guide in conjunction with the further advice contained within this report.

3.4.3 PPS25 Current Consultation of Proposed Amendments

A consultation is currently taking place into proposed amendments to Planning Policy Statement 25 (PPS25). The current consultation period closes in November 2009 and a summary of responses to the consultation is due to be published in December 2009 by the Communities and Local Government Department. The proposed amendments are confined to Tables D.1 and D.2 in Annex D of PPS25. They relate to the application of policy to critical infrastructure and to the identification of the 'functional floodplain'

3.4.4 Other Planning Policy Statements

PPS1 *Delivering Sustainable Development* published in February 2005 sets out the overarching planning policies for the delivery of sustainable development across the planning system and sets the tone for other planning policy statements. PPS1 explicitly states that development plan policies should take account of flooding, including flood risk. It proposes that new development in areas at risk from flooding should be avoided. Planning authorities are also advised to ensure that developments are "sustainable, durable and adaptable" including taking into account natural hazards such as flooding.

PPS1 also places an emphasis on 'spatial planning' in contrast to the more rigid 'land use planning' approach which it supersedes. Planning authorities will still produce site specific allocations and a proposals map as LDDs, but their Core Strategy will be more strategic and visionary in content and will take into account the desirability of achieving integrated and mixed use development and will consider a broader range of community needs than in the past. With regard to flood risk, it will be important for the Core Strategies and accompanying Supplementary Planning Documents to recognise the contribution that non-structural measures can make to flood management.

Planning Policy Statement: Planning and Climate Change, a supplement to PPS1, published in December 2007, sets out how the Government expects the planning system to address climate change. It explains that there is a compelling scientific consensus that human activity is changing the world's climate. The evidence that climate change is happening, and that man-made emissions are its main cause, is strong. The Intergovernmental Panel on Climate Change highlights that we are already experiencing the effects of climate change and if these changes deepen and intensify, as they are predicted to do without the right responses locally and globally, we will see even more extreme impacts.

One of the predicted impacts of climate change is more intense periods of rainfall and consequent flooding. The PPS1 supplement requires Regional Spatial Strategies and Local Development Frameworks to shape sustainable communities that are resilient to such effects. A key objective of the planning system being to secure new development and shape places that minimise vulnerability and provide resilience to climate change in ways that are consistent with social cohesion and inclusion. Accordingly new development should be planned to minimise future vulnerability in a changing climate. The SFRA incorporating Sequential and Exception Test information is essential in meeting the objectives of the PPS1 supplement Planning and Climate Change.

Whilst not directly relevant to the development of an SFRA, it is important to recognise that the exercise takes place within the context of other planning policy guidance and statements, some of which also require sequential testing of site allocations and development proposals. PPS3 (Housing), emerging PPS4 (Planning for Sustainable Economic Development) and PPS6 (Planning for Town Centres) are intrinsic within the planning process and, therefore, an understanding of the constraints faced as a result of this additional policy guidance is required.

3.5 Regional Planning Policy

3.5.1 Regional Spatial Strategy

The Government published The East Midlands Plan (The Regional Spatial Strategy) in March 2009. The Plan sets out the broad development strategy for the Region. It covers topics such as housing, economic development, transport, the environment and regeneration. Flood risk is referred to in the Core Area policies as well as many of the Sub Area and Thematic or Specific Topic Based Area Policies.

3.5.2 Single Integrated Regional Strategy for the East Midlands

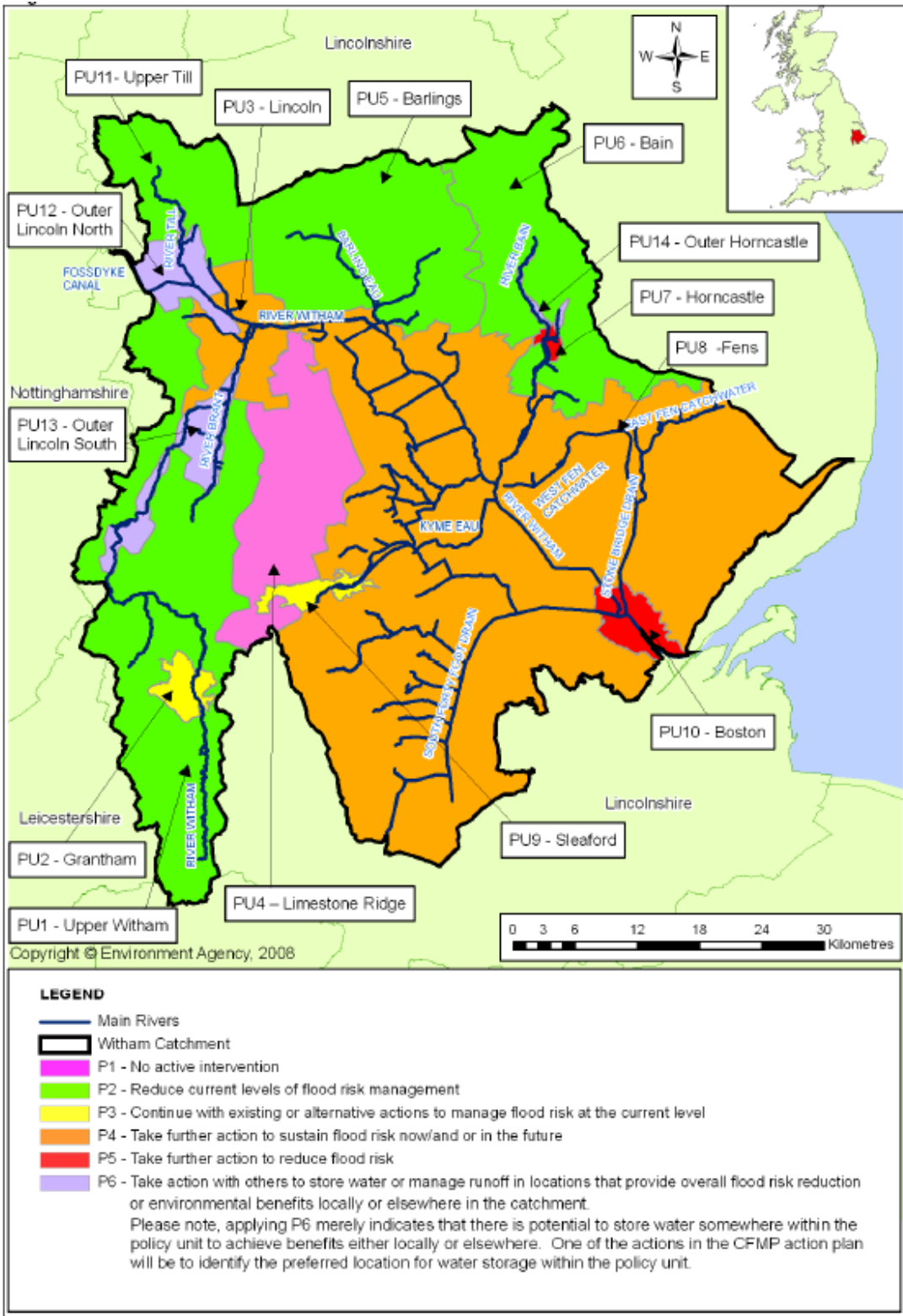
The Government's Sub-National Review of Economic Development and Regeneration (SNR) was published in summer 2007, and it identified a number of changes and new responsibilities for the Regional Development Agencies (RDAs), namely planning, transport and housing. RDAs will be responsible for developing the Single integrated Regional Strategy, and this document will bring together the climate change and other sustainable development elements of the current individual regional strategies for economic development, spatial planning, housing and transport. Further information is available from the East Midlands Development Agency.

3.5.3 River Witham Catchment Flood Management Plan

Catchment Flood Management Plans set out the Environment Agency's preferred plan for sustainable flood risk management over the next 50–100 years.

The River Witham CFMP covers the Lincoln Policy Area. The CFMP divides its coverage into 14 Policy Units, for each it recommends a policy for the management of future flood risk.

Figure 3-2: Coverage of the river Witham CFMP



Several of the CFMP's policy units fall within the Lincoln SFRA policy area. The CFMP recommends a policy for future flood risk management of each policy unit as detailed in Table 3-1.

Table 3-1: CFMP Policy Units and Policy Recommendations for within the SFRA area

Policy Unit	Area	Policy Recommendation
Policy Unit 1	Upper Witham	Reduce existing flood risk management actions (accepting that flood risk will increase with time).
Policy Unit 3	Lincoln	Take further action to sustain the current level of flood risk into the future (responding to the potential increase in risk from urban development, land use change and climate change).
Policy Unit 4	Limestone Ridge	No active intervention (including flood warning and maintenance). Continue to monitor and advise.
Policy Unit 8	Fens	Take further action to sustain the current level of flood risk into the future (responding to the potential increase in risk from urban development, land use change and climate change).
Policy Unit 12	Outer Lincoln North	Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.
Policy Unit 13	Outer Lincoln South	Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment.

Potential Implications of the CFMP

An assessment of each policy unit is made in the CFMP based on a broad understanding of catchment dynamics. This understanding coupled with detailed hydraulic models determines how each policy unit responds to flooding now and in the future. Several different policies for each policy unit are considered in the CFMP. For each policy unit one policy is allocated based on how well it meets the catchment objectives set out in the CFMP (detailed in Table 3-1)

Upper Witham Policy Unit

This policy unit covers some of the urban areas of Lincoln, the Lincoln Washlands and surrounding rural areas. The CFMP recommends that the current levels of flood risk management should be reduced due to the current low risk of flooding.

Lincoln Policy Unit

This policy unit covers the urban areas of the City of Lincoln, North Hykeham, and Skellingthorpe. The unit includes the River Witham, Fosdyke Canal and Boultham Catchwater. Defences within this policy unit provide Lincoln with a 1 per cent (100 year) standard of protection. With the effects of future climate change it is expected that there will be a greater risk of flood defences being overtopped and an exceedance in the capacity of Washlands. The CFMP recommends that further action is taken to sustain flood risk now and / or in the future. The CFMP details that the storage capacity of the upstream Lincoln Washlands should be increased. As a consequence two separate policy units were created - Outer Lincoln North and Outer Lincoln South. The CFMP also recommends that there is an opportunity to limit future flood risk by preventing inappropriate development in the floodplain.

Limestone Ridge Policy Unit

This policy unit covers areas to the east of Lincoln, primarily a rural area. There are no flood defences within this policy unit and no flood risk management activities are currently

undertaken by the EA. The CFMP recommends that no active intervention is undertaken as the flood risk is not forecast to increase with the effects of future climate change.

Fens Policy Unit

This policy unit comprises of the low lying Fens between Lincoln and Boston. The Fens area is heavily defended. Over the next 100 years flood risk is expected to increase as a result of climate change. The CFMP recommends that further action is taken to sustain flood risk now and / or in the future.

Outer Lincoln North Policy Unit

This policy unit comprises of land adjacent to the Fosdyke Canal and River Till, downstream of, and including the Till Washland. The area is mainly rural. The till washland within this unit is used to help protect Lincoln. The CFMP recommends to take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment. Although the flood risk within the policy unit is low, the CFMP details that the effects of climate change will increase flood risk in Lincoln. By adopting this policy the CFMP states that the flood risk within Lincoln will be maintained. It is suggested that the storage capacity of the Washlands is increased.

Outer Lincoln South Policy Unit

This policy unit comprises of rural land adjacent to the river Witham and River Brant and includes washland areas. The CFMP recommends to take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment. Although the flood risk within the policy unit is low, the CFMP details that the effects of climate change will increase flood risk in Lincoln. By adopting this policy the CFMP states that the flood risk within Lincoln will be maintained. It is suggested that the storage capacity of the Washlands is increased.

Summary

The CFMP details that flooding will increase due to climate change. Several different policies are recommended, these are: have no active intervention, reduce flood risk management, take further action to sustain the current level of flood risk and take further action to reduce flood risk in the future. Flood modelling as part of this SFRA has taken into account the effects of climate change, and thus demonstrates where flooding is likely to increase in the future.

3.6 Local Planning Policy and other Significant Documents

3.6.1 The Emerging Local Development Frameworks

The Central Lincolnshire Joint Planning Committee was established in October 2009 involving The City of Lincoln Council, North Kesteven District Council, West Lindsey District Council and Lincolnshire County Council. The Joint Committee will be delivering a Joint Core Strategy covering the Central Lincolnshire Housing Market Area together with other development plan documents that will be set out a joint local development scheme yet to be developed

3.6.2 Lincoln Water Cycle Study

The East Midlands Regional Plan identified Lincoln as a growth area and identifies that the local authorities should make provision for over 28,000 new dwellings by 2026. It was identified that this growth may be limited due to an inadequate water cycle infrastructure. A Water Cycle Study is currently being undertaken to develop a strategic approach to the provision of water cycle infrastructure, hence allowing for sustainable future growth.

The objectives of the study are to:

- Define the current situation and note key issues relating to elements of the water cycle infrastructure;
- Consider how implementation of extant planning permissions would impact on the infrastructure; and
- Identify requirements and phasing for new water cycle infrastructure to meet the target growth numbers over the plan period.

Elements of the water cycle study considered included water resources, water supply, foul sewerage, sewage treatment, surface water drainage and fluvial systems.

A stage 1 - outline Water Cycle Study was completed in June 2008 with the following conclusions:

Table 3-2: Conclusions of the Lincoln Water Cycle Study

A better indication of the number and location of dwellings in major urban growth areas and in rural settlements will have to be determined.
Water resources will have to be supplemented, as currently being planned by Anglian Water.
New water supply trunk mains will be required, possibly to all three major urban growth areas.
New foul sewerage outfalls will be required from the NEQ and the SEQ, and possibly from the WGC (depending on the number of dwellings finally agreed).
Improvements to existing sewerage networks should be considered, where appropriate, in conjunction with the provision of new outfall sewers (e.g. to relieve flooding in the Stamp End area, Bracebridge Heath, etc). Hydraulic models may be required.
Some phased extensions to STWs will be required, depending on the numbers of dwellings in the various locations. Options exist for the major urban growth areas, including extensions at Canwick, North Hykeham, South Hykeham and Skellingthorpe STWs.
Some extensions may be required at STWs serving “villages” and some land purchases may be necessary (again, depending on final numbers of dwellings agreed).
Consideration will have to be given to the contents of the CFMP, in particular to the flood risk management policies e.g. to the strategic options for attenuation of surface water (at the NEQ and the SEQ).
Appropriate SUDS techniques should be used, depending on the geology and soil conditions of individual sites.
Long-term planning of flood defences should take into account the latest advice on impacts of Climate Change (as currently defined in PPS25).
Significant contributions from developers need to be defined.

Source: Lincoln Water Cycle Study

The Stage 2-Detailed Strategy Water Cycle Study is expected to be completed by May 2010 and will build on the work of the Outline Water Cycle Strategy to produce a comprehensive and achievable water infrastructure plan that can be put in place alongside development.

3.6.3 Lincoln Integrated Urban Drainage Study

Defra identified the need for a more integrated approach to urban flooding due to the complexities of the many interacting mechanisms and wide range of stakeholders at the local level. Lincoln was successful in being selected as one of fifteen pilot studies and the

Lincoln Integrated Urban Drainage Group (LIUD) examined the barriers to, and possible ways to solve urban drainage problems where there is an interaction between more than one organisation / body responsible for the issue.

The pilot studies had several objectives to:

- Integrate and, where appropriate, renew drainage and flood risk data to improve knowledge of flooding;
- Gain a better understanding of how a range of flood risk sources interact;
- Improve co-ordination between a range of Partners to identify strategic drainage issues to guide and inform future development in the Greater Lincoln Urban Area;
- Provide a tool to lever developer contributions to improve, provide and maintain additional flood management and drainage assets; and
- Establish the key benefits of an integrated approach and report best practice; identify any recommendations for further action or legislation and communicate these with wider stakeholders and Defra/DCLG as appropriate

The study identified five case study sites across the City of Lincoln where the causes, responsibilities and potential solutions for an integrated urban drainage approach could be found. An outcome of the study has been the establishment of the “Lincoln Drainage Group (LDG)” and the publication of a “Good Drainage Guide” for use by developers. This will ensure that all parties continue to work together in the future. The findings of the study provided Defra with an insight into drainage problems faced in urban areas to inform future policy making.

3.6.4 Adjacent SFRA's

North Kesteven District Council and West Lindsey District Council both of which border the City of Lincoln and fall within the Lincoln Policy Area have published separate SFRA's. These should be reviewed when assessing the potential flood risk within the Policy Area.

3.7 Policy and Procedural Recommendations

It is recommended that Council policy is reviewed taking account of PPS25 and the SFRA, to ensure appropriate allocation of development sites and implementation of development control. Policies should be put in place which:

- Seek to protect the functional floodplain (Flood Zone 3b) from development
- Direct vulnerable development away from areas susceptible to flooding
- Ensure new development is safe, with safe access and egress routes for pedestrians and emergency vehicles
- Ensure new development does not have an adverse impact on flood risk elsewhere
- Promote the use of Sustainable Urban Drainage (SuDS) within new developments
- Seek to adopt above ground SuDS as public open space and amenity areas, given appropriate developer contributions via Section 106 Agreements. These contributions should be “ring fenced” specifically for the on-going maintenance of the SuDS facilities
- Seek developer contributions via Section 106 Agreements or CIL where appropriate towards any proposed flood risk management facilities which will provide a direct benefit to their development proposals

- In areas where the 100 year plus climate change and 1000 plus climate change maximum possible breach extent (generated from 2D modelling) is greater than the extent of Flood Zone 3 (100 year) and / or Flood Zone 2 (1000 year) it is recommended that the LPA create a policy restricting development in these areas. This is further outlined in Figure Figure 4-3

Several procedural recommendations are made within the SFRA which clarify and go beyond the current requirements of the EA Standing Advice. These are discussed below:

- Additional modelling may required to map flood zones relating to un-mapped watercourses, if simple mitigation measures are deemed inappropriate. The Environment Agency and IDB's should be contacted for advice and whether additional modelling is required. It is recommended that a FRA is provided for sites within 20m of an un-mapped watercourse which includes hydraulic modelling to delineate as a minimum the 100 year and 100 year with climate change flood outlines and levels. It is important that consideration is given to any historical flooding at a development site.
- The Environment Agency is currently a statutory planning consultee on all applications for development in Flood Zones 2 and 3, other than minor development, and for sites of more than 1 hectare in Flood Zone 1. This does not address the problem of the cumulative impact of minor development. This may cause problem within the City area if not addressed. Also, the Flood Zones relate only to fluvial flooding therefore the flood risk from other sources is not addressed.
- Where proposed developments are designed with surface water outfall connections to soakaways, ditches, rivers or unadopted drainage systems, the Environment Agency are not always consulted in terms of surface water run-off calculations. Connection to an Anglian Water sewer would automatically require the preparation of surface water run-off calculations. Referral of all development applications to local IDB's (where the development falls within the IDB area) is recommended where the surface water drainage outfall connections are not directly to an adopted sewer.
- With all applications, it should be demonstrated that proposed developments are not at risk of flooding and that developments do not increase flood risk elsewhere. The surface water drainage from proposed developments should be designed such that peak run-off rates and volumes are attenuated in accordance with the current EA Standing Advice. On small developments, where restriction to very low peak flows makes attenuation impractical, porous / permeable surfaces should be used wherever possible and appropriate.
- Planning conditions should be imposed to require the construction of any flood mitigation or surface water attenuation proposals prior to occupations and to put in place appropriate measures to minimise silt run-off and pollution of watercourses and groundwater during construction.
- Porous / permeable surfacing such as gravel drives should be used wherever possible and appropriate. Even on relatively impermeable ground there is some potential for infiltration and permeable surfaces can be combined with attenuation and a drainage outfall.
- Removal of Permitted Development Rights is justified where development threatens to have a direct, significant and adverse effect on a flood risk, flood defences or management of surface water.

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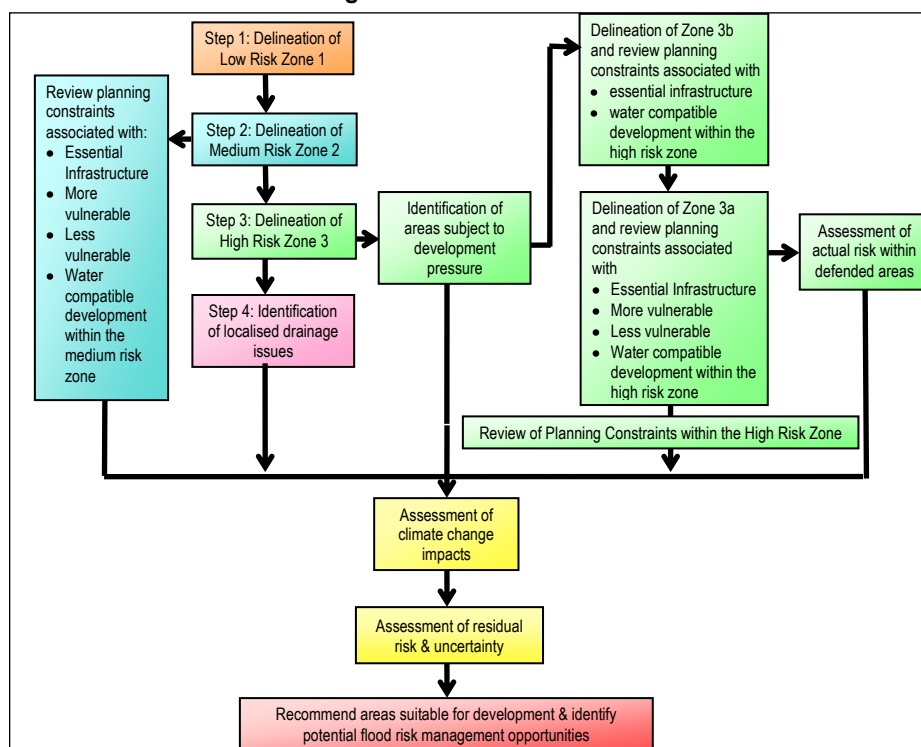
4 The SFRA Process

This section contains information and guidance on: levels of the SFRA, delineation of flood risk zones, flood risk vulnerability classifications, principles of the sequential and exception tests, management decisions and actions and flood risk indicators.

4.1 Overview of the SFRA Process

The SFRA is a planning tool that can be used to inform the spatial planning process in relation to flood risk issues. This process is shown in Figure 4-1 and discussed in more detail below.

Figure 4-1: The SFRA Process



It is the Environment Agency's view, in line with PPS25, that new development should be located in the lowest flood risk areas (i.e. in Flood Zone 1) wherever possible. If there are no reasonably appropriate Flood Zone 1 sites, allocations should be made in Flood Zone 2 first, considering flood risk vulnerability of land uses. Only where there are no reasonably available sites in Flood Zones 1 or 2 should Flood Zone 3 allocations be made. In order to demonstrate that there are no lower risk sites available the Sequential Test needs to be carried out. The information provided in the SFRA will allow the LPA to carry out the Sequential Test.

Only on completion of the Sequential Test should the Exception Test be used to justify allocations or developments in high risk areas where the need to develop is considered exceptional.

The SFRA deliverables are a report and suite of maps to allow the sequential testing to take place thereby informing the LDF process.

Within defended floodplains, the Sequential Test requires a more detailed assessment of probability and consequences. Risk is defined as a function of both probability of an event

occurring and the consequence should that event take place and is dependent on the vulnerability of the intended land use.

To assess risk, it is necessary to model the consequence of overtopping and breaches of defences, in 1% (100 year) and 0.1% (1000 year) probability events. Generally, the worst case scenario will coincide with a failure of the defences, where they are present, at the peak of the flood event. To this end, a two dimensional inundation model (which has the ability to predict depth and velocity) of the defended area is required to examine the impact of either a breach failure or overtopping during the design event.

4.2 Sequential Test – PPS25

PPS25 provides the basis for the sequential approach; it recommends that LPAs use a risk based approach to development planning and specifies the need for undertaking SFRA's in Annex E.

When allocating or approving land for development in flood risk areas, those responsible for making development decisions are expected to demonstrate that there are no suitable alternative development sites located in lower flood risk areas.

The methodology introduces a Sequential Test that is core to the SFRA process. The basis of the test is classification into high (Flood Zone 3), medium (Flood Zone 2) and low (Flood Zone 1) flood risk derived from Environment Agency flood zone maps.

For the purposes of the SFRA, the more detailed 2D modelling which takes in to account the effects of climate change and flood defences can be used to more accurately and usefully demonstrate how flood water interacts with features on the flood plain.

Where defences provide a benefit, breach modelling (including the effects of climate change) has been undertaken to investigate the possible consequences of a defence failure.

Authorities within the Policy Area will be required to prioritise the allocation of land for development in ascending order from Low Risk to High Risk, including the subdivisions of Flood Zone 3 (3a and 3b), if necessary. The Environment Agency is a specific consultation body on certain Local Development Documents and is a statutory planning consultee. The Environment Agency must be consulted on all development applications allocated with medium and high risk zones and for any development on land exceeding 1 hectare outside Flood Zones 2 and 3. In these circumstances, the Environment Agency will require the LPA to demonstrate that there are no reasonable alternatives in lower flood risk zones that are available for development. Where appropriate, the Exception Test is to be applied. Local IDB's should also be consulted where developments fall within an IDB boundary.

4.3 The Exception Test

Where departures from the Sequential Test are justified by the need to locate development in Flood Zones 2 or 3, it is necessary to apply the Exception Test. PPS25 acknowledges that flood risk is one of many issues (including transport, housing, economic growth, natural resources, regeneration and the management of other hazards) which need to be considered in spatial planning.

PPS25 explains where and for what type of development the Exception Test needs to be applied. In some situations, for certain types of development, it is not appropriate to use the Exception Test to justify development; for example, development which is highly vulnerable to flooding cannot be justified within Flood Zone 3 through the use of the Exception Test. The situations where it is necessary and appropriate to apply the Exception Test are outlined below.

Where the Exception Test is required, it should be applied as soon as possible to all Local Development Document (LDD) allocations for development and all planning applications other than for minor development. All three elements of the Exception Test have to be

passed before development is allocated or permitted. For the Exception Test to be passed:

- *It must be demonstrated that the development provides wider sustainability benefits to the local community that outweigh flood risk, informed by an SFRA, where one has been prepared. If the Development Plan Document (DPD) has reached the 'submission' stage – see Figure 4 of PPS12: Local Development Frameworks – the benefits of the development should contribute to sustainability;*
- *The development should be on developable previously developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable, previously developed land; and*
- *A Flood Risk Assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

PPS25 (paragraphs D11 and D12) states that the Exception Test 'should be applied to LDD site allocations for development and used to draft criteria-based policies against which to consider planning applications. Where the Exception Test has been applied in LDD allocations or in criteria-based policies, the local planning authority should include policies in its LDDs to ensure that the developer's FRA satisfies criterion c). The Environment Agency and other appropriate operating authorities, such as Internal Drainage Boards, should be consulted on the drafting of any policy intended to apply the Exception Test at a local level.'

Compliance 'with each part of the Exception Test should be demonstrated in an open and transparent way.' Table 4-2 summarises the applicability of the Exception Test for different development sites; for example, housing allocations are classified as 'more vulnerable' and employment allocations are 'less vulnerable'.

4.4 Flood Risk Vulnerability Classification

In PPS25 different types of development are divided into five flood risk vulnerability classifications (see Table 4-1):

Table 4-1: Flood Risk Vulnerability Classification

Essential Infrastructure	<ul style="list-style-type: none"> • Essential transport infrastructure and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	<ul style="list-style-type: none"> • Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations and emergency dispersal points. • Basement dwellings, caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More Vulnerable	<ul style="list-style-type: none"> • Hospitals, residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwellings, student halls of residence, drinking establishments, nightclubs, hotels and sites used for holiday or short-let caravans and camping. • Non-residential uses for health services, nurseries and education. • Landfill and waste management facilities for hazardous waste.
Less Vulnerable	<ul style="list-style-type: none"> • Buildings used for shops, financial, professional and other services, restaurants and cafes, offices, industry, storage and distribution, and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities), minerals working and processing (except for sand and gravel). • Water treatment plants and sewage treatment plants (if adequate pollution control measures are in place).

Water-Compatible Development	<ul style="list-style-type: none"> • Flood control infrastructure, water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves, navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation. • Essential sleeping or residential accommodation for staff required by uses in this category, subject to a warning and evacuation plan.
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Notes:

-This classification is based partly on DEFRA/Environment Agency research on Flood Risks to People (FD2321/TR2) and also on the need of some uses to keep functioning during flooding.

-Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

-The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

Source: PPS25 Table D2

Table 4-2: Flood Risk Vulnerability and Flood Zone Compatibility

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

Key:

- ✓ Development is appropriate
✗ Development should not be permitted

Source: PPS25 Table D3

4.5 PPS25 - Proposed Amendments

A consultation is currently taking place into proposed amendments to Planning Policy Statement 25 (PPS25). The current consultation period closes in November 2009 and a summary of responses to the consultation is due to be published in December 2009 by the Communities and Local Government Department. The proposed amendments are confined to Tables D.1 and D.2 in Annex D of PPS25. They relate to the application of policy to critical infrastructure and to the identification of the 'functional floodplain'.

Figure 4-2: The Sequential and Exception Tests (General Principles)

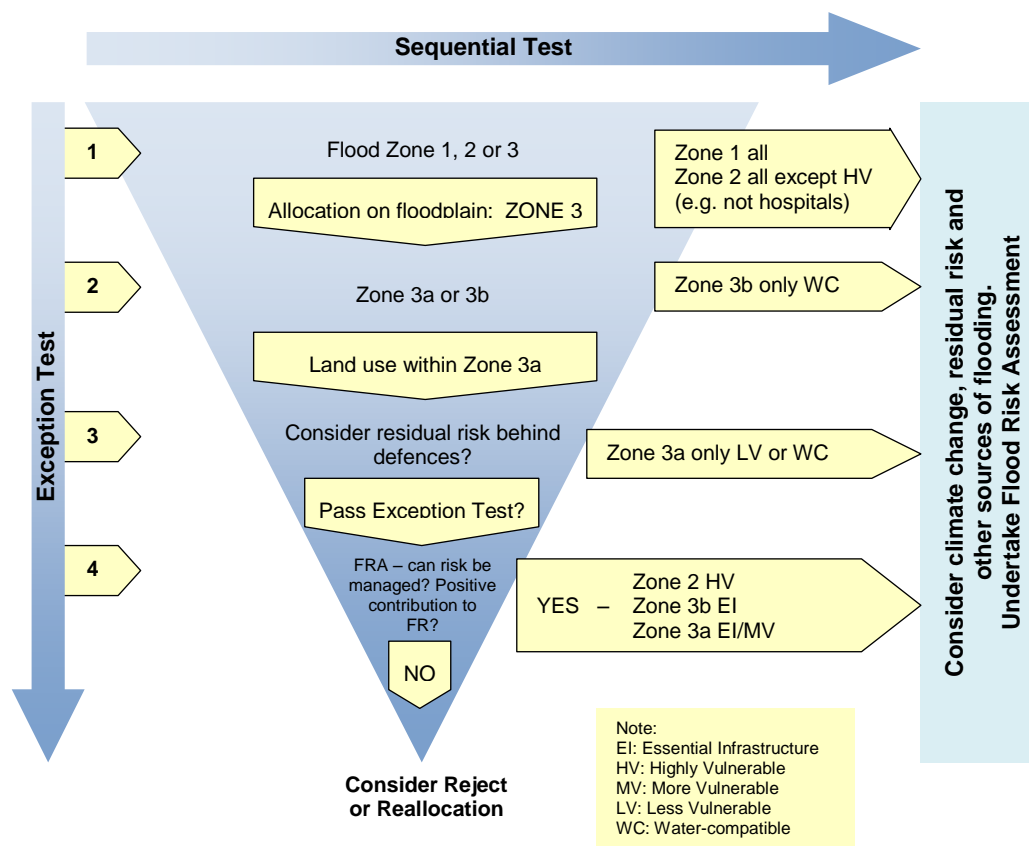
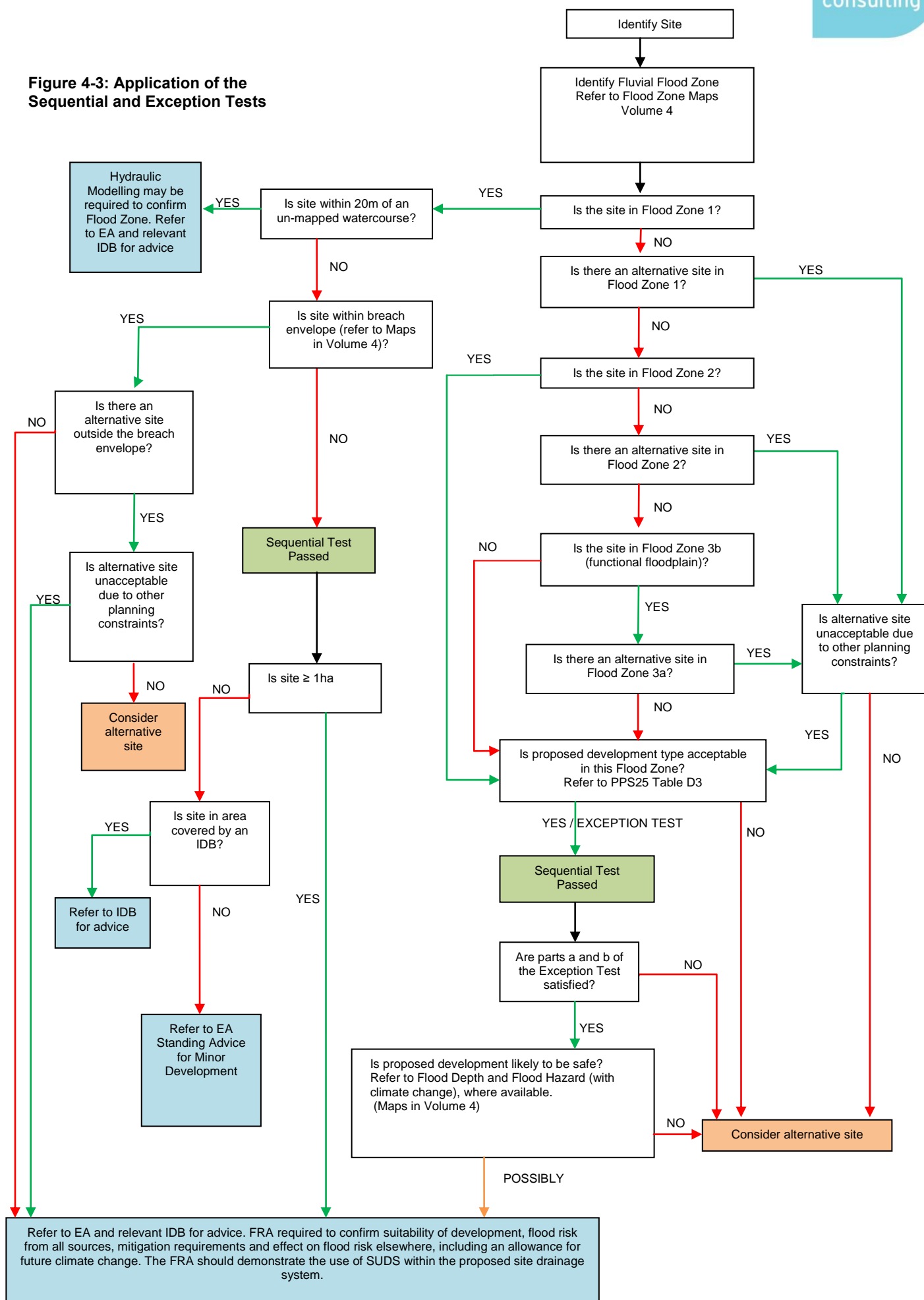


Figure 4-3: Application of the Sequential and Exception Tests



4.6 Flood Zone 3a – High Probability

PPS25 states that water-compatible and less vulnerable developments are permitted in this Flood Zone, following testing within the sequential process. According to PPS25, highly vulnerable development is not permitted. Essential infrastructure and more vulnerable development need to pass the Exception Test, while essential infrastructure should be designed and constructed to remain operational and safe for users in times of flood.

According to PPS25, developers and local authorities should address the following policy aims:

- Reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of SuDS.
- Relocate existing development to land in zones with a lower probability of flooding.
- Create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Therefore a presumption for further development in existing floodplains is not supported by PPS25, and any future SFRA should review existing areas to see if relocation is a spatially sustainable strategy.

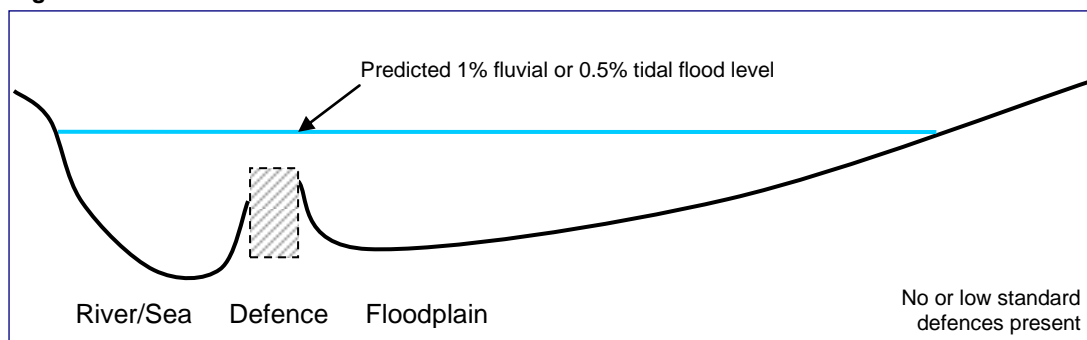
Regeneration of land or change in land use behind existing defended areas in the high risk zone will require a more detailed assessment of the flood risk (i.e. whether the scale of flood risk is worth taking, and how sustainable and effective the mitigation measures would be [i.e. whether the risk could be managed]). Where, due to wider sustainable development reasons there are no other suitable sites available in lower risk zones, an assessment of the risk within Flood Zone 3 is required. Annex G in PPS25 deals with managing residual flood risk. Maps showing the variation in flood depth and hazard across Flood Zone 3 for areas where 2 dimensional modelling has been carried out can be found in volume 4.

Flood Zone 3a should not be used for development where suitable alternative sites exist in Flood Zones 1 or 2. Paragraph G2 of PPS25 states that following application of the Sequential Test and Exception Test for development in Flood Zone 3a, a clear examination of the residual flood risks should be made and development:

‘Should not normally be permitted where flood defences, properly maintained and in combination with agreed warning and evacuation arrangements, would not provide an acceptable standard of safety taking into account climate change.’

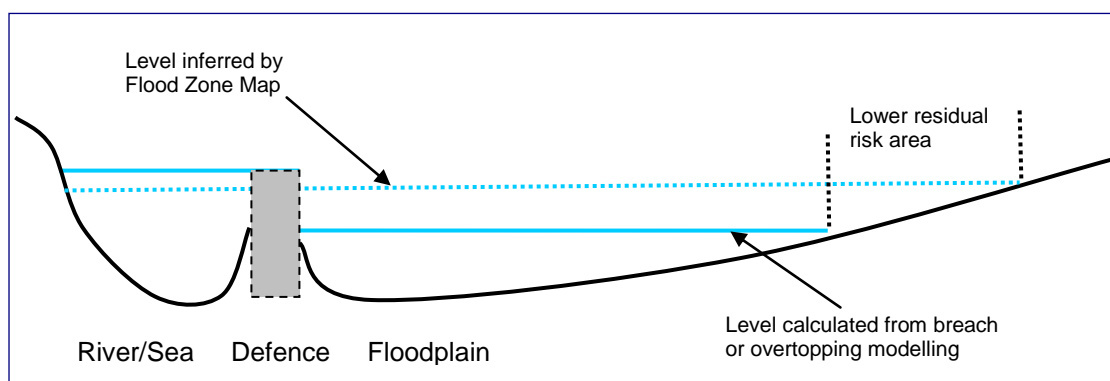
In the context of this discussion, an undefended area (Figure 4-4) of floodplain under fluvial flood risk is considered to be an area where the water level for a fluvial flood event will be similar to that of the river. These areas may be entirely undefended, or if defences are present, they are discontinuous or constructed to a low standard. In these areas guidance provided in Section 4.6.1 (undefended areas) will be most relevant in assessing sustainability and determining mitigation requirements.

Figure 4-4: Illustration of the undefended scenario under fluvial and/or tidal flood risk



A defended area is considered to be an area of floodplain where the defences will result in a water level for the fluvial flood event that is considerably lower than the source river. This means the defences substantially (but not necessarily completely) mitigate the flood risk associated with the 100 year fluvial flood event. These areas will be defended to a minimum standard promoted by DEFRA, but not always necessarily to the 100 fluvial standards. In these areas guidance provided in Section 4.6.2 (defended areas) will be most relevant in assessing sustainability and determining mitigation requirements. Areas which are defended are highlighted in this report.

Figure 4-5: Illustration of the defended scenario and residual flood risk behind fluvial/tidal defences



4.6.1 Undefended Areas – Flood Risk Mitigation

The Sequential Test should first be applied to assess reasonably alternative locations suitable for the proposed development at a lower probability of flood risk. If this proves unsuccessful the Exception Test may be required.

The Sequential Test should then be applied within the development location area, and it is considered appropriate to direct more vulnerable land uses to parts of the location at a lesser probability and lower residual risk of flooding. The lower floors of buildings in areas at both medium and high probability of flooding should seek to develop water-compatible and less vulnerable uses, including car parks or other public areas.

Within undefended or poorly defended Flood Zone 3a areas, floor levels for housing developments should, as a minimum, be situated above the acceptable standard of safety with sufficient freeboard to allow for uncertainties in flood level prediction and climate change.

Housing developments (more vulnerable development) should provide a minimum habitable space floor level above the estimated 100 year (for fluvial flooding) water level with the addition of allowances for modelling uncertainty and climate change (i.e. freeboard). This may be achieved by providing car parking or other public areas at ground floor level.

Employment development (less vulnerable development) should provide a similar standard of flood defence as housing developments. Within undefended or poorly defended Flood Zone 3a areas, employment development should remain dry during the 100 year fluvial flood event, with sufficient freeboard to account for uncertainties in flood level prediction and climate change. Developers will need to carefully consider the commercial viability of developing in these areas. In exceptional circumstances, where there is significant planning justification for development and the provision of this standard of defence is not feasible, a greater acceptance of flood risk may be permitted for less vulnerable development in areas of high probability of flooding with the focus on providing safety to occupants, flood proofing and designing buildings to minimise flood damage.

Flood resilient construction may be considered in circumstances where there is a low probability of limited shallow depth water entry and buildings are not subjected to severe floodwater inundation depths. This type of construction is designed to reduce the consequences of flooding (the probability of flood occurrence remains unchanged) and facilitate recovery from the effects sooner than conventional buildings.

This may be achieved 'through the use of water-resistant materials for floors, walls and fixtures and the positioning of electrical controls, cables and appliances at a higher than normal level and flood resistant construction to either reduce the amount of water or prevent entry of water into a building where resistant techniques are used. PPs25 Annex E and G state that a means of safe access and egress in times of flooding must be provided so that at a minimum, emergency services and their vehicles are able to evacuate people, especially when considering those that are more vulnerable and/or with restricted mobility.

Whilst the basic level of protection afforded to residential and commercial development is the same, it is clear that approaches to how residual risk is managed may differ between these two types of developments. For residential development residual risk is a societal issue, for which a presumption of avoidance and removal is appropriate. Hence a significant freeboard should be incorporated into housing development floor levels, whereas for a commercial property the end user and insurer can assess and transfer this residual risk as appropriate. Therefore commercial and employment uses have a suitably different approach to the management of the residual risk, above that provided by the basic mitigation works. The onus would be on the specific local authority to determine whether these risks are acceptable, in conjunction with advice from the Environment Agency.

For a development to proceed, it must also be shown that it will not increase flood risk elsewhere through a loss of storage or conveyance. Flood risk must be reduced or kept at current levels.

4.6.2 Defended Areas – Flood Risk Mitigation

Within defended areas, residual flood risk is primarily associated with overtopping and/or breach of defences (and localised flooding associated with drainage systems in some locations). These risks are related to the likelihood (standard of protection and structural integrity of defences) and the consequences of flooding.

The likelihood of overtopping can be estimated by comparison of modelled water levels (where available) and defence crest levels. An indication of the likelihood of defence breach can be gained by reviewing the flood defence condition data held within the National Flood and Coastal Defence Database (NFCDD), and by more detailed surveys and investigations. The consequences of defence overtopping or breach failure can be estimated using flood inundation modelling and mapping.

For the extended City of Lincoln Area defences are present on the River Witham, Fosdyke Canal and the Boultham Catchwater. The flood defences provide a significant benefit to the city.

For a development to proceed, it must also be shown that it will not increase flood risk elsewhere through a loss of storage or conveyance. Flood risk must be reduced or kept at current levels.

The feasibility of any proposed mitigation measures which might be introduced to address any residual flood risk may be assessed in accordance with the guidance established in Volume 3.

A site-specific FRA should be undertaken at the planning application stage to facilitate the delineation and definition of the 100 year fluvial flood outline and level including an allowance for the future effects of climate change.

4.6.3 Public Safety

For all Flood Zone 3a potential development locations consideration must be given to residual risks and the risk to public safety associated with access and egress from properties.

Development should not be sited where these risks would unduly threaten public safety and/or the structural integrity of buildings and infrastructure. Consideration of the depth of flooding, flow velocity, rate of inundation and safe access / egress is required to assess these risks.

Reference should be made to Hazard maps where available.

4.7 Flood Zone 3b – The Functional Floodplain

PPS25 states that only water-compatible uses are permissible in Flood Zone 3b. Essential Infrastructure can be permitted after the Exception Test is passed.

According to PPS25, developers and local authorities should aim to:

- Reduce overall level of flood risk in the area through the layout and form of the development and the appropriate application of SuDS.
- Relocate existing development to land with a lower probability of flooding.
-

In addition, according to PPS25, essential infrastructure should:

- Remain operational and safe for users in times of flood.
- Result in no net loss of floodplain storage.
- Not impede water flows.
- Not increase flood risk elsewhere.

Other than water-compatible and essential infrastructure (subject to the Exception Test), Flood Zone 3b should not be used for development except for access road purposes. In this case, the roadway should be kept to the narrowest width possible and crossing the watercourse at 90 degrees to the direction the watercourse flows.

4.8 Flood Zone 2 – Medium Probability

Flood Zone 2 is considered suitable for water-compatible, less vulnerable, more vulnerable and essential infrastructure. Highly vulnerable development is only allowed where the Exception Test is passed.

In this zone, developers and the local authority should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of SuDS.

Where development is implemented, floor levels should be situated, as a minimum, above the 100 year fluvial flood level with sufficient freeboard to account for inherent uncertainties with respect to flood level prediction and potential climate change scenarios.

A site-specific FRA should be undertaken at the planning application stage to facilitate the delineation and definition of the 100 year fluvial flood outline and level including the future effects of climate change.

4.9 Flood Zone 1 – Low Probability

In accordance with PPS25, all development (essential infrastructure, highly vulnerable, more vulnerable, less vulnerable and water-compatible development) is permissible in Flood Zone 1.

Development proposals on sites comprising one hectare or more will require a FRA in accordance with PPS25.

A FRA should be provided for all developments, regardless of size, in areas where a known flooding problem has been identified, to ensure that the proposed development does not result in a worsening of existing flooding conditions. The FRA should include details of drainage proposals, including SuDS, that will mitigate against any increased run-off rates and volumes from the proposed development.

Due to the limitations of the scope of the SFRA, flood outlines have not been produced for smaller watercourses. Therefore a FRA should be provided for all proposed developments, regardless of size, within 20m of any watercourse, to determine the associated flood risk.

Ideally the LPA should work closely with the Environment Agency, sewerage undertakers, highway authority and developers to enable surface water runoff to be controlled as near to the source as possible. For Greenfield developments, the aim is not to increase runoff from the undeveloped situation and for Brownfield re-developments, to reduce existing runoff rates. Wherever possible, this should be achieved through the implementation of a sustainable drainage or flow retention system, constructed within the boundaries of the development site.

The effectiveness of a flow management scheme within a single site is heavily limited by site constraints including (but not limited to) topography, geology (soil permeability), development density, adoption issues and available area. The design, construction and ongoing maintenance regime of such a scheme must be carefully defined at an early stage, and a clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential. In these areas a FRA will be required that demonstrates that the proposed development will not adversely affect existing flooding conditions either alone or in combination with other development.

Prior to making a planning application, discussions should be held with the Environment Agency, the Local Planning Authority and Anglian Water to ascertain the specific nature and most appropriate means of managing the flood risk.

The integration of drainage management is highlighted within the DEFRA strategy for flood risk management in England, detailed within the consultation document 'Making Space for Water'. The strategy aims to achieve better overall management of surface water drainage through better co-ordination between the different bodies.

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5 Existing Flood Risk Data

This section contains information and guidance on the data used in this assessment, including flood zones, flood defences, modelling and background information

5.1 Data Collection

Table 5-1 lists the data that was made available/obtained for the Lincoln SFRA. A critical phase in the project delivery is the collection and review of existing information. This data comprises of known or perceived flood risk issues within the district, development pressures and constraints and current policy governing development within flood risk affected areas. The majority of this data has been recorded and included in the GIS data layers used to undertake the assessment.

Table 5-1: Data availability for use in the Lincoln SFRA

Data Type	Use within SFRA
OS 10k Basemap	Flood Risk Mapping
OS Mastermap	Flood Risk Mapping
Flood Zone Map	Initial Flood Zone delineation
Main river map	Flood Risk Mapping
National Flood and Coastal Defence Database (NFCDD) data	Locate defended and undefended locations
LiDAR Digital Elevation Model	Flood Risk Mapping
Breach and Overtopping Hydrographs	Flood Risk Mapping
River Witham Catchment Flood Management Plan	Background information
The East Midlands Plan	Background information, flood risk
Lincoln Water Cycle Study (Stage 1- Outline Study)	Background information, flood risk
Lincoln Integrated Urban Drainage Study	Background information, flood risk
Surface Water Flooding Maps	Flood Risk Mapping

5.2 Flood Zone Map

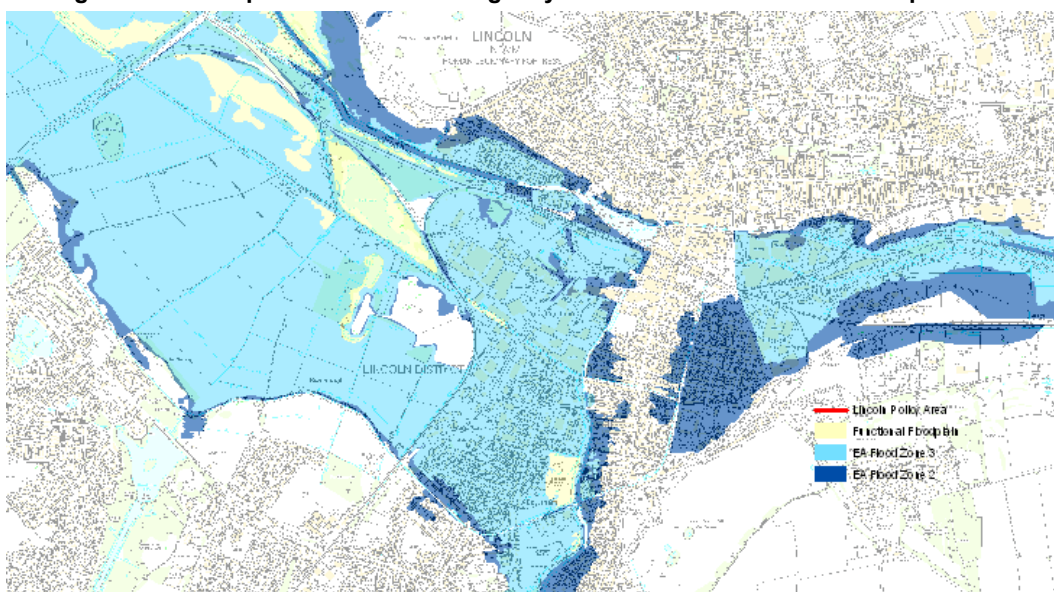
The Environment Agency Flood Zone Map shows the areas at risk from extreme events from river flooding. The Flood Zone maps were prepared using a methodology based on the national digital terrain model (NEXTMap), derived river flows (Flood Estimation Handbook (FEH)) and two dimensional flood routing. The theoretically derived Flood Zone extents have been adjusted in some locations where the results are inconsistent with historical flooding extents, more detailed flood mapping studies are available or where there are known errors in the digital terrain model.

The Environment Agency Flood Zone maps are precautionary in that they do not take account of flood defences and, therefore, represent a worst-case extent of flooding. The actual extent of flooding within the Lincoln Policy Area is mitigated to some degree by flood defences along the River Witham, Fosdyke Canal and Boultham Catchwater. It should be noted that the Flood Zone Maps (without climate change) are based on broadscale modelling and only cover watercourses with catchments greater than 3 km² in size, therefore flood risk associated with smaller watercourses is not shown. The most

recent revision of the Environment Agency Flood Zone Map has been used to delineate Flood Zones in the Lincoln Policy Area and the **full maps are included in Volume 4**.

Flood Zone Maps including the expected future effects of climate change are not currently available, however it is expected that the extent of the Flood Zone outlines will increase over time. A comparison is shown below of the current extents of Flood Zone 3 and the expected approximate outline of Flood Zone 3 in the future (based on the current Flood Zone 2 outline). When the Flood Zone Maps with climate change are available they should be added to this SFRA.

Figure 5-1: Example of Environment Agency Flood Zone Two and Three Map



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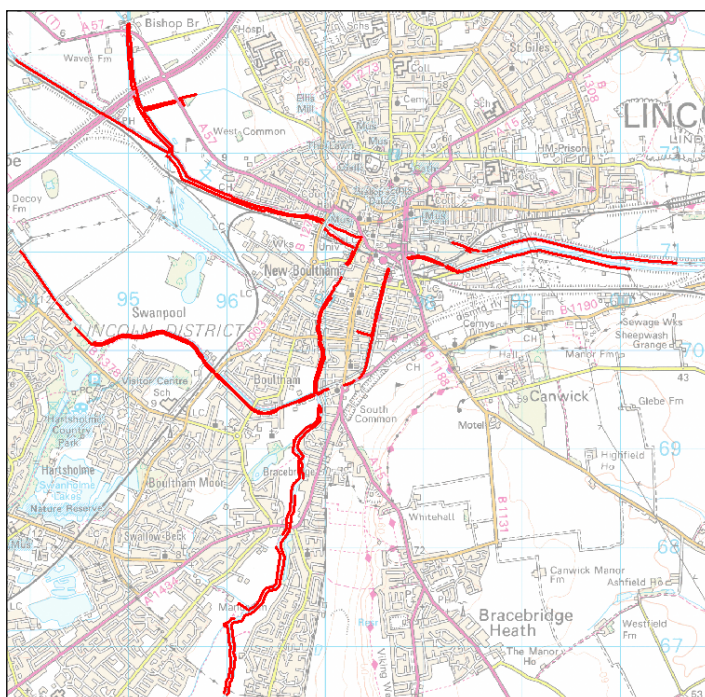
5.3 Flood Defences

As discussed in the previous section, the Environment Agency Flood Zone Maps do not take account of the presence of flood defences. PPS25 states that defended areas (i.e. those areas that are protected to some degree against flooding by the presence of a formalised flood defence) are still at risk of flooding, and therefore sites within these areas must be assessed with respect to the adequacy of the defences.

An extract from the Environment Agency's National Flood and Coastal Defence Database (NFCDD) has been supplied and provides information about existing defences in the area, as well as categorising them by type and providing information on who owns and maintains them (see Vol 2). All of the formal flood defences present in Lincoln are man made and have been constructed to a design standard return period of 1 in 100 years (1% AEP). Defences are maintained and inspected regularly by the Environment Agency.

Internal Drainage Board (IDB) maintained watercourses assist in the removal of storm water from low lying areas behind Environment Agency maintained flood defences on the River Witham and the Fossdyke Canal. Pumping stations operated by the IDB's aid in removing this water, and thus reducing flood risk.

Figure 5-2: Flood defence locations

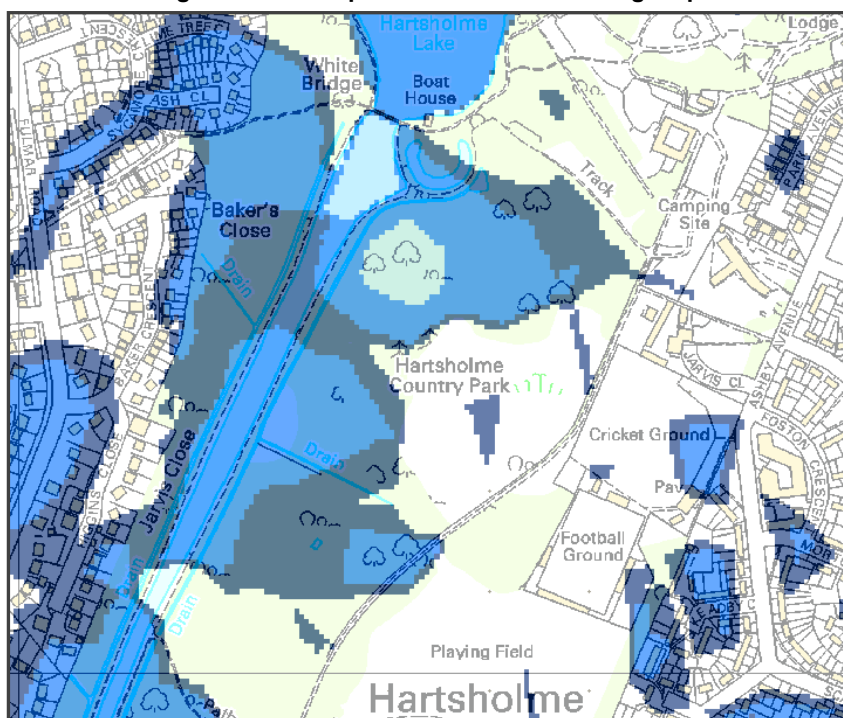


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5.4 Non Fluvial Flood Risk

The following is an example map showing flood risk in Lincoln from sources other than fluvial flooding. Other sources of flooding include groundwater, possible overland flow during extreme rainfall and flooding from surcharged under-capacity or blocked sewers. The full maps are included in Volume 4.

Figure 5-3: Example surface water flooding map



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5.5 Topographical Data

The essential dataset required for flood modelling and mapping is a Digital Elevation Model (DEM). The DEM used for this SFRA was LiDAR data which was supplied by the Environment Agency.

5.6 History of Flooding

Several notable instances of fluvial flooding have occurred in the River Witham catchment during the past 100 years

Table 5-2: Historical Flooding

Date	Flooding Details
March 1947	Flooding of Lincoln from the River Witham
July 1958	of Lincoln and surrounding areas from the River Witham, Fosdyke Canal, River Brant and River Till due to the failure of defences
December 1960	Flooding at Hykeham due to failure of defences
February 1977	Flooding in Lincoln from Heighington Beck, River Witham and River Brant
April 1981	Flooding in Lincoln, Cherry Willingham, Fiskerton, Stainfield, Langworth, Bullington, Fulsby from Barlings Eau and River Witham due to defences overtopping.
October 1993	Flooding in Swinethorpe, Cherry Willingham, Fiskerton, Sudbrooke, Scothern, Snarford, Stainford, Langworth, Friesthorpe from Barlings Eau, Boultham Catchwater Drain and the River Witham due to defences overtopping
November 2000	Flooding in Langworth from local beck. Flooding at several rural locations around Lincoln from the River Witham and River Till. Defences did not fail. Lincoln Washland scheme operated for the first time.
Summer 2007	Flooding in Lincoln and the surrounding area as a result of intense rainfall. Defences in Lincoln did not fail. Washlands to the North and South of the City were opened and reached 15 per cent full (Witham Reservoir) and 85 per cent full (Till reservoir), providing protection for Lincoln.
January 2008	Washlands partially filled providing protection for Lincoln

5.7 Limitations of Background Information

The data used in the SFRA is limited in some aspects and it is important that these limitations are considered.

The Environment Agency's Flood Zone maps are based on generalised river modelling only and are limited by way of not including all minor watercourse floodplains or the effects of any defences. The Flood Zone maps are produced from a national mapping project and provide flood zone mapping from the points where river catchments reach an area of 3km². Therefore, for any site (including those below 1ha) adjacent to an unmapped

watercourse, a site-specific FRA will be required to establish the true floodplain extent and flood risk to the development site.

Where there is no reference to localised flooding issues at a site, this does not necessarily mean that there are none; records may not have been available to inform this SFRA.

Limitations of the existing river modelling studies used in the report should be acknowledged due to the nature of flood risk mapping, estimation of catchments and hydrology. Watercourse surveys, changes since the studies, new developments, additional structures and constraints, seasonal variations in the roughness of watercourse channels due to growth of vegetation and maintenance of the channel will all have an effect on the flood risk.

Limitations associated with the use of LiDAR data must be acknowledged. LiDAR is more accurate on flat ground, but the degree of accuracy decreases substantially for vegetated and built up areas. Inaccuracies are reduced by a process of filtering. It is essential to cross reference against surveyed level information where this is available and against Ordnance Survey and site visits to allow for flow routes under bridges or embankments which would not be picked up by the aerial surveys.

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6 Level 1 Assessment of Flood Risk within the Policy Area

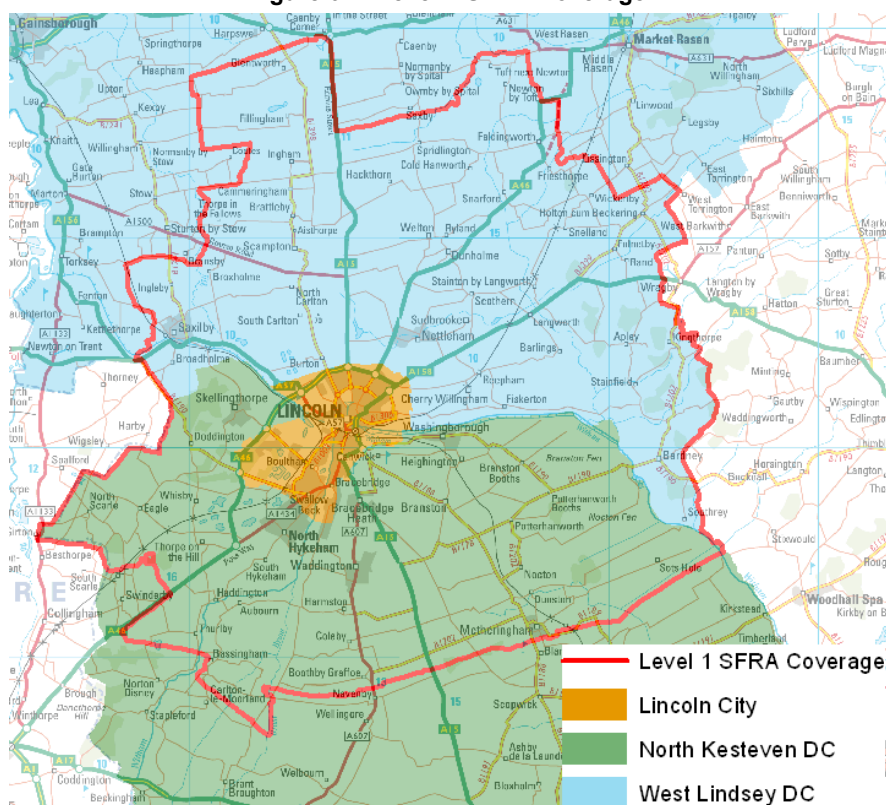
This section contains information and guidance on flood risk issues within the Lincoln Policy Area. The SFRA has been divided into two degrees of detail: Level 1 and Level 2. This section focuses upon the Level 1 assessment of flood risk covering the whole Policy Area

6.1 Introduction

A two stage approach has been taken to this SFRA. A Level 1 assessment of flood risk has focused on the whole of the Lincoln Policy Area and a Level 2 assessment of flood risk has focused on the extended City of Lincoln Area.

The Level 1 assessment of flood risk utilises existing data to make an assessment of flood risk from all sources now and in the future.

Figure 6-1: Level 1 SFRA Coverage



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6.2 Level 1 Flood Risk Mapping

The Environment Agency Flood Zone Maps are a good starting point when considering flood risk in a particular area. The Flood Zone Maps should be used primarily to enable the sequential test to be carried out, firstly in avoiding inappropriate development and then secondly, to seek compatibility between development vulnerability and flood zones as required in Table D3 of PPS 25.

The following maps (contained in Volume 4) have been produced as part of the SFRA in order to delineate the flood zone outlines and establish, in key areas, the variation of risk within the flood outlines:

- **Flood Zone Maps:** These are provided for the whole of the Lincoln Policy Area. They include the latest Environment Agency Flood Zone 3 (100 year) and Flood Zone 2 (1000 year) outlines, which have been generated using broad scale modelling techniques and do not include the effect of any defences. They should be used as the starting point for application of the Sequential and Exception Tests for all areas within the Lincoln Policy Area.
- **Flood Defence Locations:** These are provided for the Lincoln Policy area and display the coverage of key flood defences.

6.3 Condition of flood Defences

The condition of existing flood defences is an important consideration for local authority planners when allocating new development. PPS 25 considers that defended areas (i.e. those areas that are protected to some degree against flooding by the presence of a formalised flood defence) are still at risk of flooding, and therefore sites within these areas must be assessed with respect to the adequacy of the defences.

The location and condition of all flood defences is provided by the Environment Agency via the National Fluvial and Coastal Defence Database (NFCDD).

The condition of existing defences is provided in the form of a 'rating' (1 to 5), and is a reflection of any signs of 'obvious' structural problems. The condition rating is determined on the basis of visual inspection, focussing on obvious signs of structural defect (e.g. slippage, cracking, poor maintenance), designed to inform the maintenance programme. A summary of the NFCDD condition rating allocations is shown in

Table 6-1 below.

Table 6-1: NFCDD Condition Ratings for Flood Defences

Condition Rating	Condition	Condition Description
1	Very Good	Fully serviceable.
2	Good	Minor defects.
3	Fair	Some cause for concern. Requires careful monitoring.
4	Poor	Structurally unsound now or in the future.
5	Very Poor	Completely failed and derelict.

The condition of existing flood defences and whether they will continue to be maintained and/or improved in the future, is an issue than needs to be considered as part of the risk based sequential approach and in the light of this, whether proposed land allocations are appropriate and sustainable. In addition, detailed FRAs will need to explore the condition of defences thoroughly, especially where these defences are informal and contain a wide variation of condition grades. ***A detailed description of Flood Defences in Lincoln is contained within Volume 2: Technical Document***

7 Level 2 Assessment of Flood Risk within the City Area

This section contains information and guidance on flood risk issues within the City of Lincoln area. The SFRA has been divided into two degrees of detail: Level 1 and Level 2. This section focuses upon the Level 2 assessment of flood risk covering the city

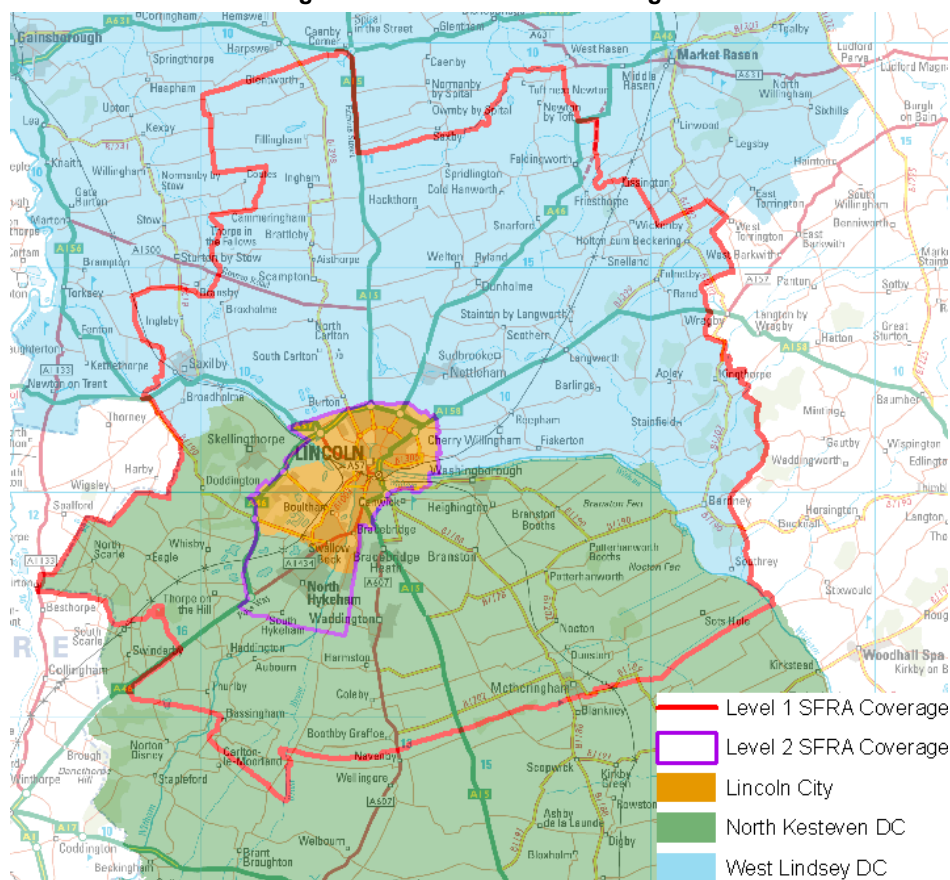
7.1 Introduction

The Level 2 assessment of flood risk goes beyond the existing Environment Agency Flood Map by providing more detailed modelling of breaching and overtopping along watercourses within Lincoln.

This modelling gives the likely degree of flood hazard (in terms of flood depths, velocity and Flood Hazard Rating) within the Flood Zone areas. For planning purposes, this derives a delineation of residual risk that can be used by the local authority and developers to inform on the nature of the flood hazard and possible application of the Exception Test.

For the Lincoln SFRA, JBA has carried out detailed hydraulic modelling to identify the residual risk. A two dimensional hydraulic model of water courses within Lincoln has been used together with LiDAR digital elevation data. The 2-D model (JFLOW) for flood defence breaching and flood defence overtopping provides results and direct output of the variation of the flood risk.

Figure 7-1: Level 2 SFRA Coverage



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7.2 Hydraulic Modelling Requirements

The City of Lincoln Council has specified that:

- An assessment of flood defence breaching be carried out for a 1% AEP (plus climate change) fluvial flood and a 0.1% AEP fluvial flood (plus climate change); And
- An assessment of flood defence overtopping be carried out for a 1% fluvial flood (with climate change) and a 0.1% AEP fluvial flood (with climate change).

The Environment Agency have supplied JBA with breach and overtopping hydrographs for specified locations (See Volume 2: Technical summary) within Lincoln for the purpose of this SFRA. The supplied hydrographs were used to undertake further 2D modelling as outlined in the following sections.

7.3 Level 2 Flood Risk Mapping

The consideration of actual flood risk factors (such as flood depth) is required to gain a greater understanding of the varying degree of flood risk. As outlined in section 6.2 the Environment Agency Flood Zone Maps are a good starting point when considering flood risk in a particular area; however the following maps should be used along side the EA Flood Zone Map to enhance this understanding:

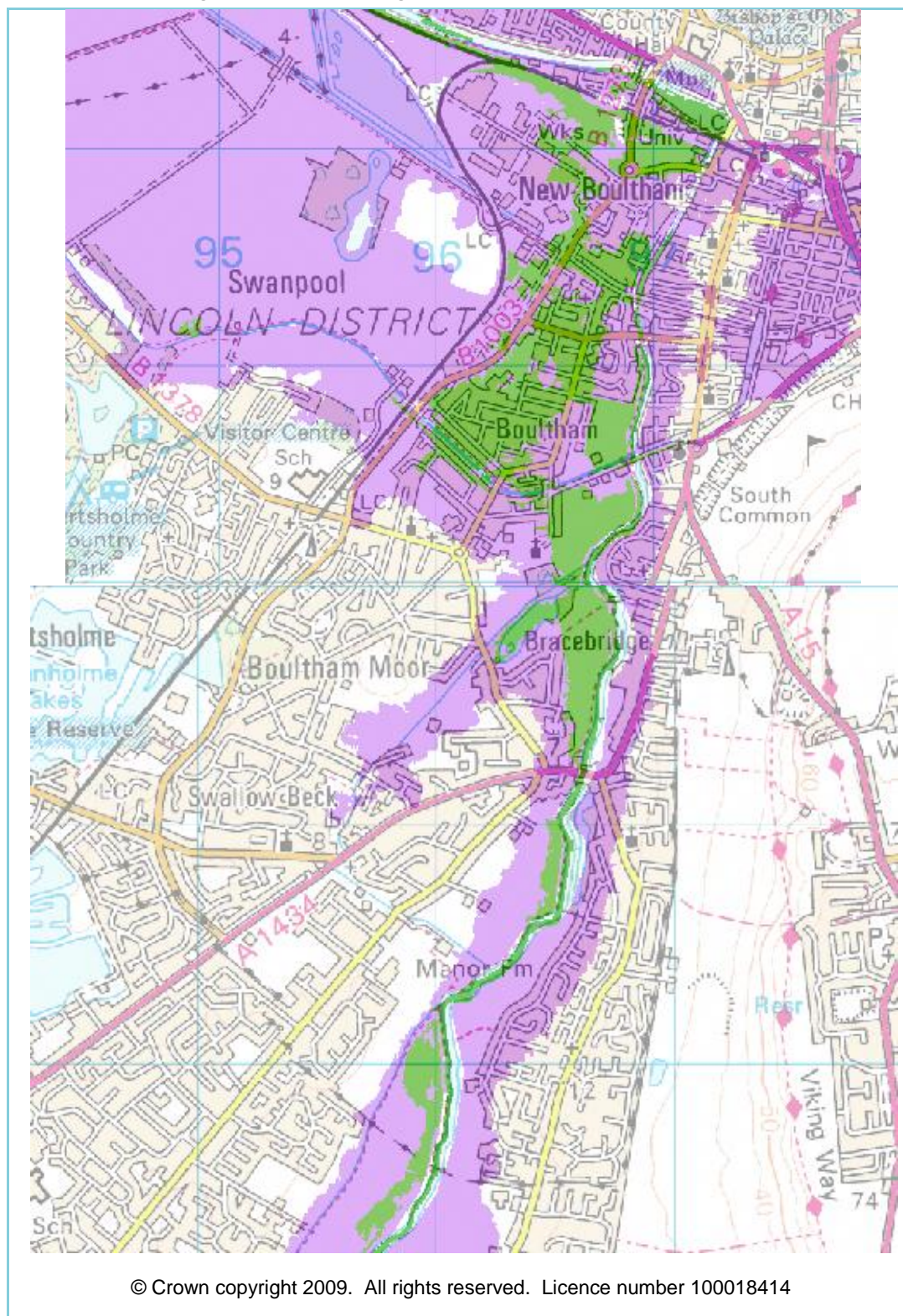
- **Overtopping Flood Depth Maps:** The maps are provided for flood defence overtopping within the City of Lincoln area. The maps are based on two dimensional modelling and show the variation in flood depth during the 100 year (with climate change taken into account) and 1000 year (with climate change taken into account) flood scenarios.
- **Breach Flood Depth Maps:** The maps are provided for flood defence breaching within the City of Lincoln area. The maps are based on two dimensional modelling and show the variation in flood depth during the 100 year (with climate change taken into account) and 1000 year (with climate change taken into account) flood scenarios. Although each breach scenario was run individually, a maximum possible breach extent has been presented in this report. This shows all areas which could be at risk from a breach / failure of a flood defence structure rather than the effect of a single breach.
- **Overtopping Flood Hazard Maps:** The maps are provided for flood defence overtopping within the City of Lincoln area. The maps are based on two dimensional modelling and show the variation in flood hazard during the 100 year (with climate change taken into account) and 1000 year (with climate change taken into account) flood scenarios. The hazard rating is dependent on flood depth and velocity and has been calculated according to the methodology given in the DEFRA report FD2320. Four hazard categories are displayed – very low hazard, danger for some, danger for most and danger for all.
- **Breach Flood Hazard Map:** The maps are provided for flood defence breaching within the City of Lincoln area. The maps are based on two dimensional modelling and show the variation in flood hazard during the 100 year (with climate change taken into account) and 1000 year (with climate change taken into account) flood scenarios. The hazard rating is dependent on flood depth and velocity and has been calculated according to the methodology given in the DEFRA report FD2320. Four hazard categories are displayed – very low hazard, danger for some, danger for most and danger for all.

7.4 Overtopping and Breaching Flood Extent - 100 year with climate change scenario

The following example map display the extent of flooding as a result of flood defence overtopping (green outline) and flood defence breaching (purple outline) within the City of Lincoln. Both Flood defence overtopping and breaching maps are included in Volume 4.

The maps are intended to help inform the Sequential and Exception Tests, in particular to gain an understanding of flooding with the future effects of climate change taken into account.

Figure 7-2: Overtopping and Breach Flood Extent

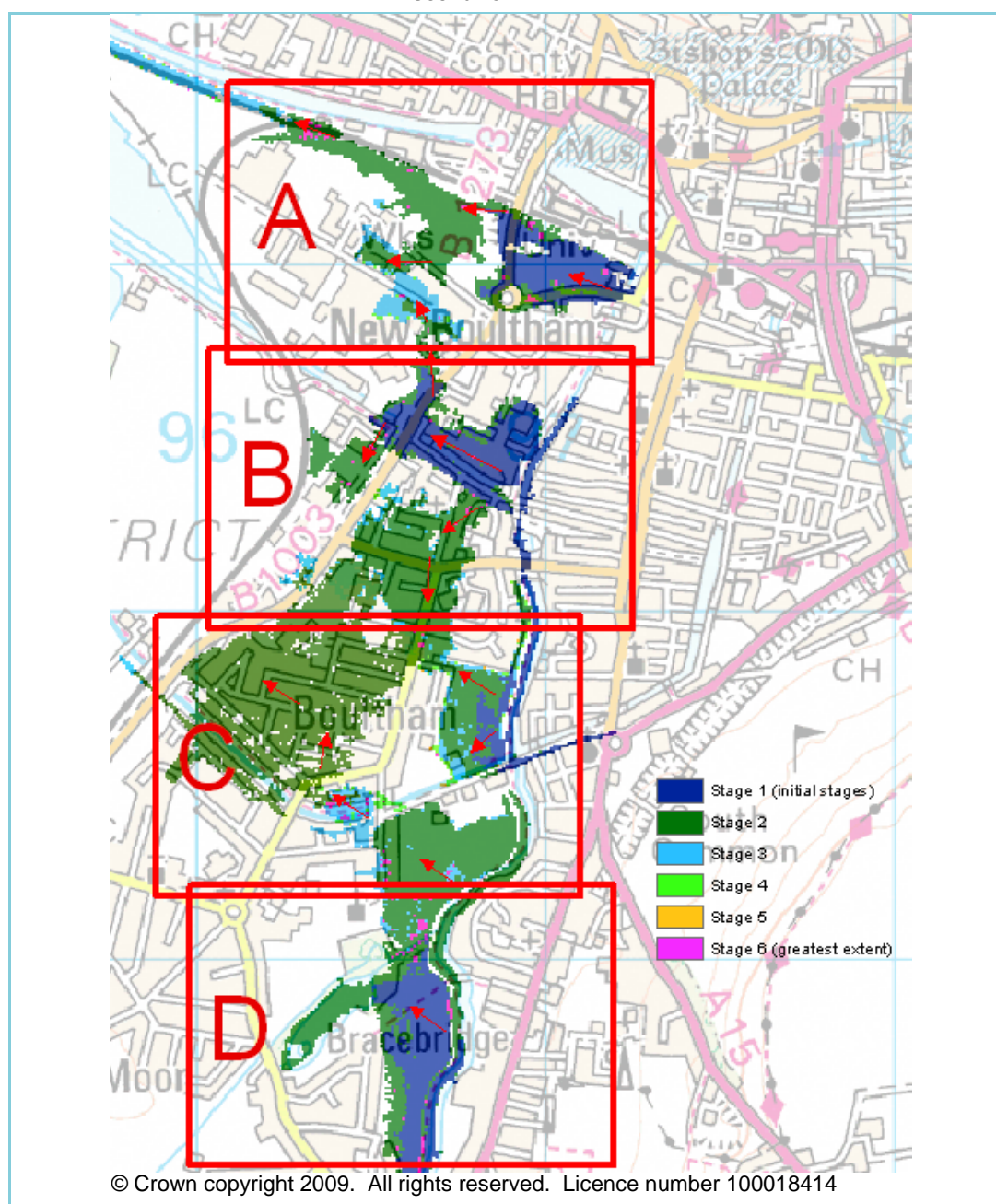


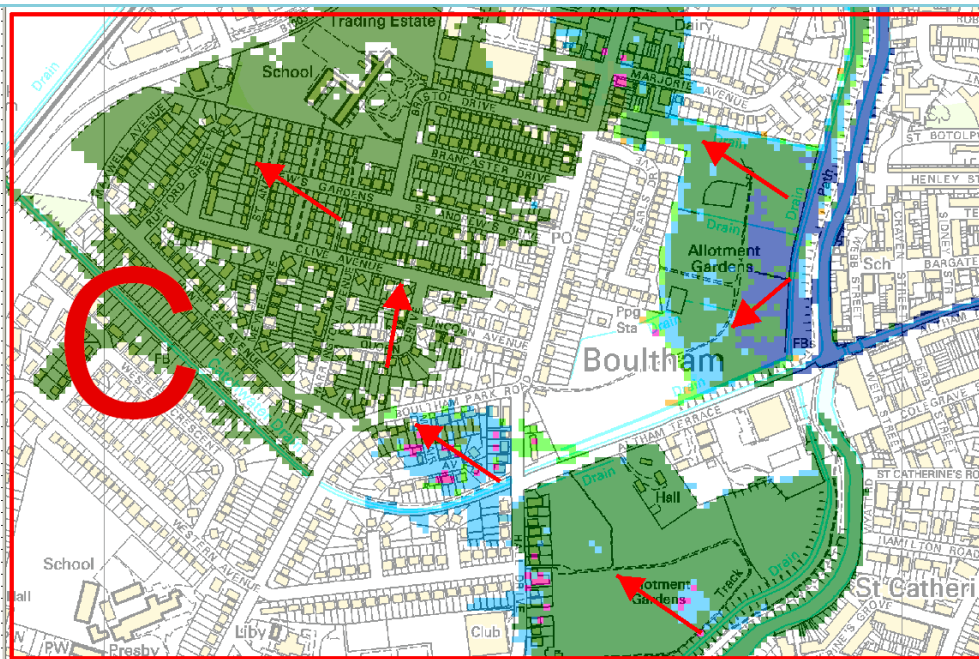
7.5 Overtopping Flood Onset - 100 year with climate change scenario

The following maps visually describe how a flood, as a result of overtopping from the river Witham, Fosdyke and Boultham Catchwater develops. The maps indicate flow routes across the floodplain and will help users gain an understanding of how flood waters interact with the floodplain. They do not show any time scales as this would depend on the intensity of flooding.

The following map combines modelled overtopping outlines from the River Witham, Fosdyke and Boultham Catchwater. Individual outlines can be found in Volume 4.

Figure 7-3: Progression of flooding due to overtopping during the 100 year with climate change scenario

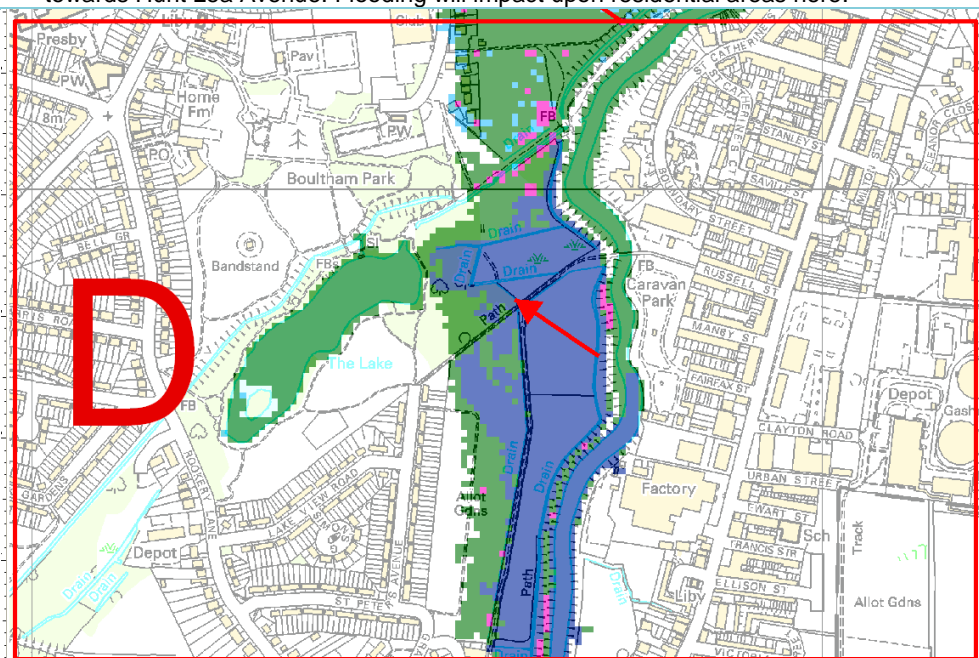




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Vicinity of:

- **Boultham, Altham Terrace, Earls Drive:** Overtopping of the Witham will result in the flooding of Allotment gardens adjacent to Earls Drive. Earls Drive itself is raised above the flood risk area, however a flow route exists to the north towards Marjorie Avenue conveying flows towards Bristol Drive. A further flow route exists across Hall Road conveying flows towards Hunt Lea Avenue. Flooding will impact upon residential areas here.



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Vicinity of:

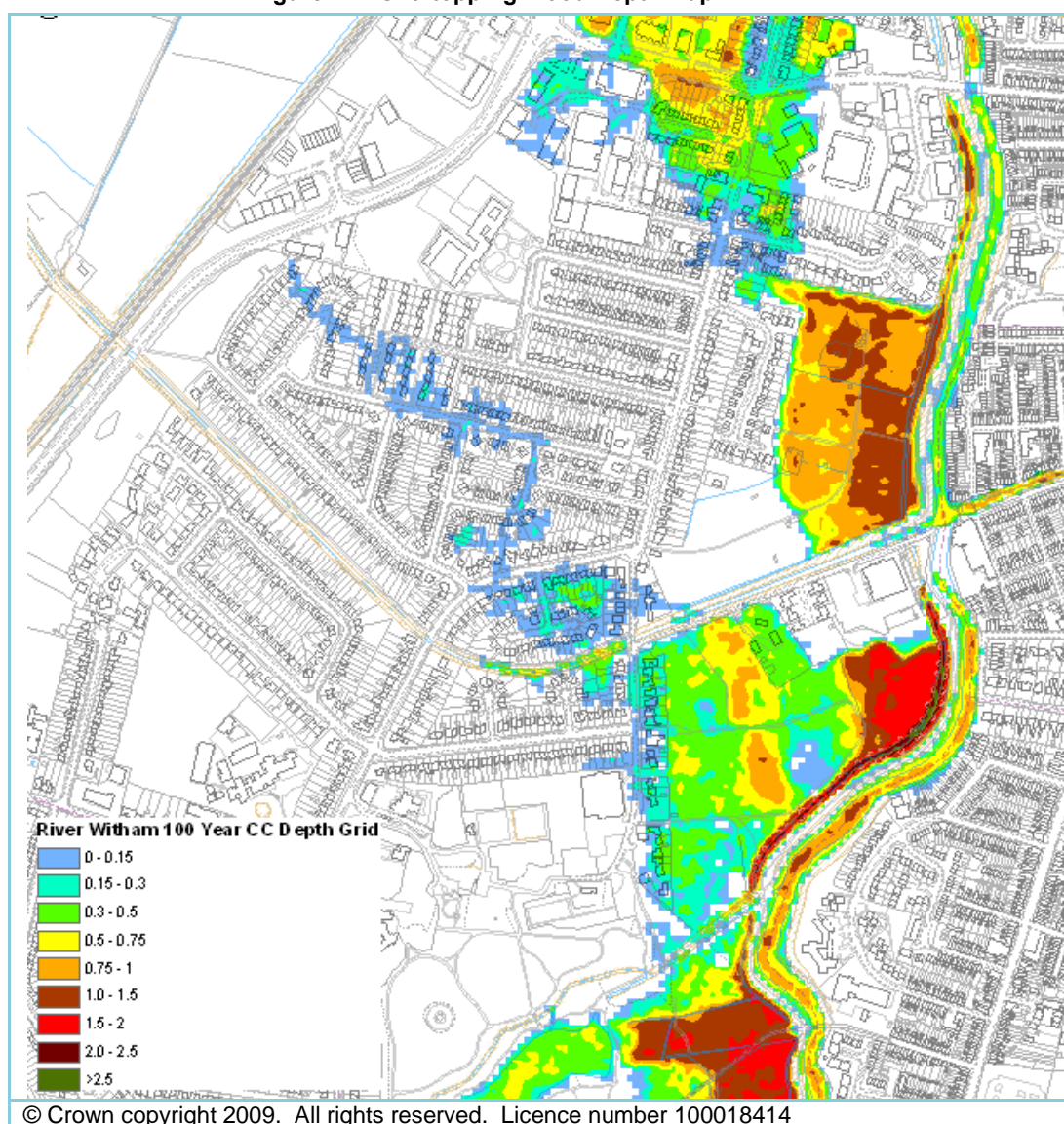
- **Boultham Park:** Overtopping of the West Bank results in the flooding of parkland area.

7.6 Depth Maps

The following maps are examples of flood depth maps which are contained within Volume 4. These maps have been created using 2D modelling. Flood depth maps have been created for both the 100 year with climate change and the 1000 year with climate change scenarios. These maps are intended to inform the sequential and exception tests, in particular to understanding future flood effects as a result of climate change and where flood depths are unacceptable or manageable.

7.6.1 Overtopping Flood Depth

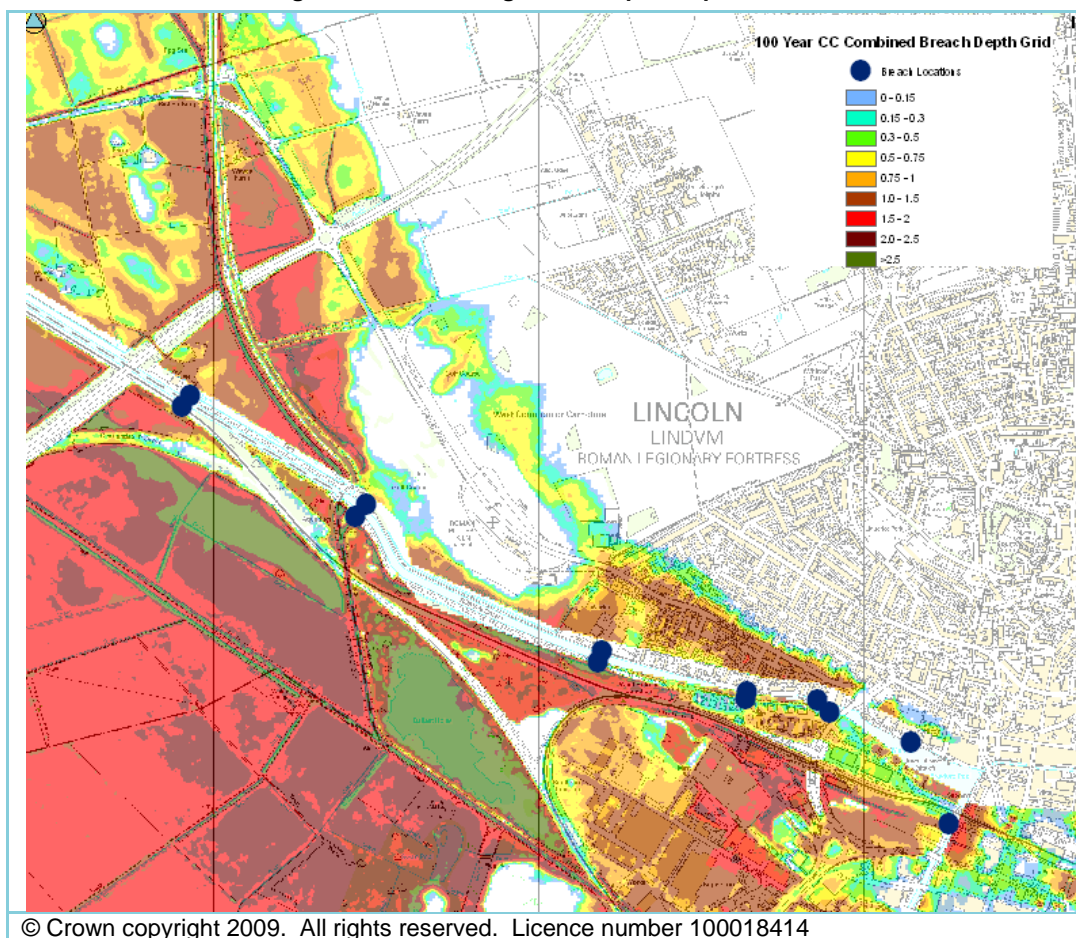
Figure 7-4: Overtopping Flood Depth Map



7.6.2 Breaching Flood Depth

These maps have been produced by 2D modelling for both the 100yr with climate change and the 1000yr with climate change flooding scenarios. These maps demonstrate the effects of failure of the flood defences. It has been decided to display a maximum possible breach outline for Lincoln. Although it is unlikely that all defences would breach simultaneously the outline shows the worst case depth as a result of any breach occurring at one time.

Figure 7-5: Breaching Flood Depth Map

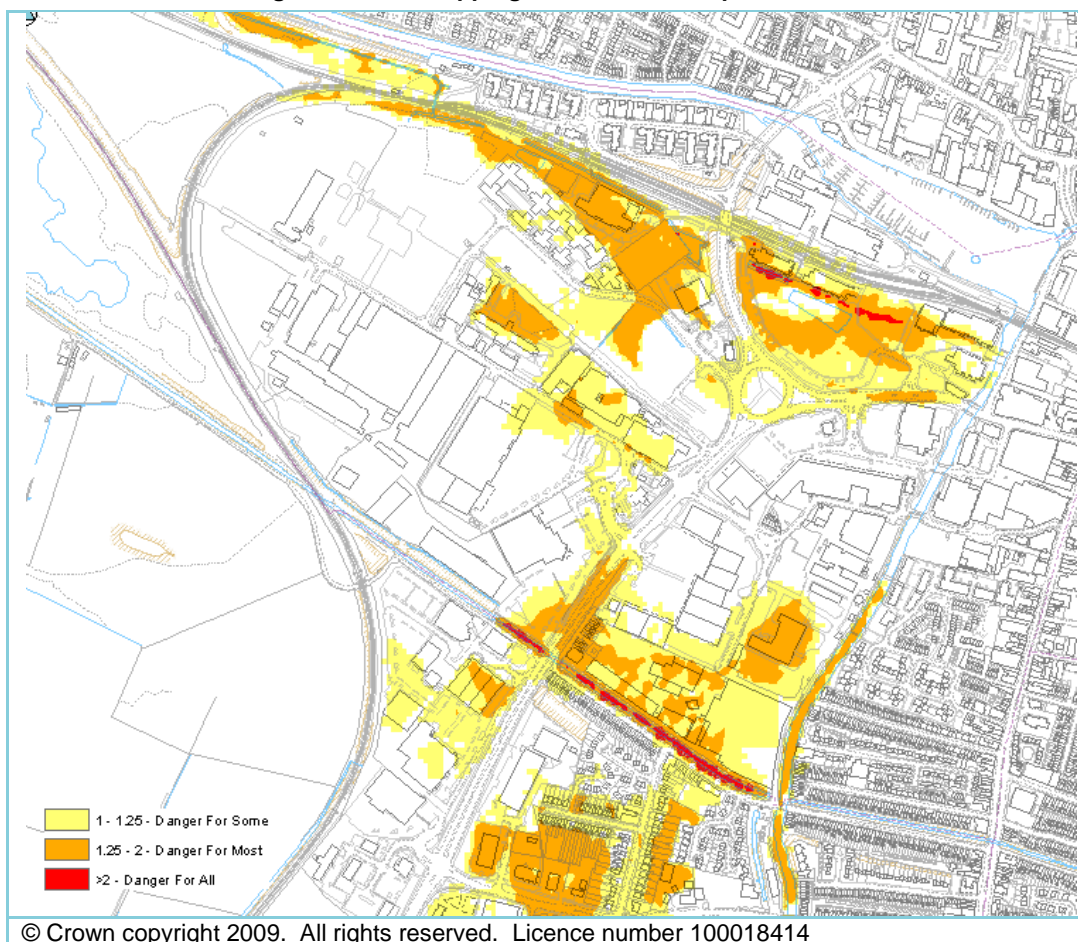


7.7 Flood Hazard Maps

The following maps are examples of flood hazard maps which are contained within Volume 4. These maps have been created using 2D modelling and have been produced in accordance with the current DEFRA guidance report FD3230. Flood hazard maps have been created for both the 100 year with climate change and the 1000 year with climate change scenarios. The hazard rating takes into account the depth of flooding and the speed or velocity of the flow. These maps are intended to inform the sequential and exception tests, in particular to understanding future flood effects as a result of climate change.

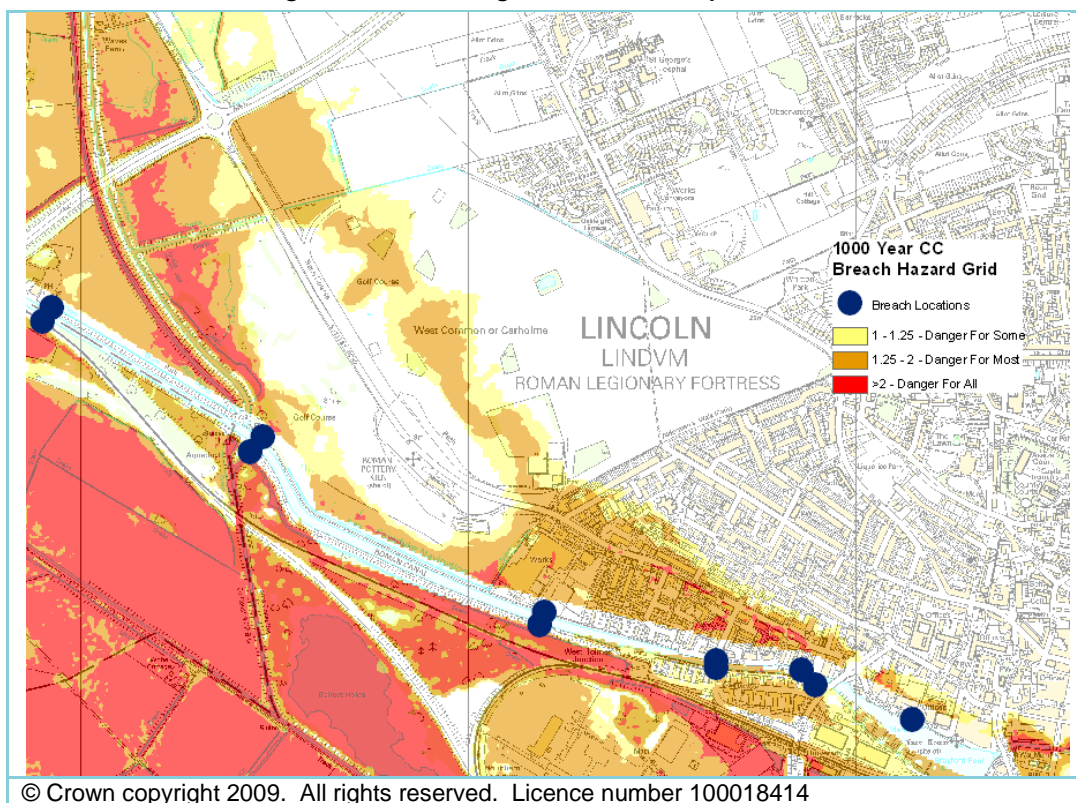
7.7.1 Overtopping Flood Hazard

Figure 7-6: Overtopping Flood Hazard Map



7.7.2 Breaching Flood Hazard

Figure 7-7: Breaching Flood Hazard Map



7.8 Developments within the Breach Outline but Outside the Flood Zone Map

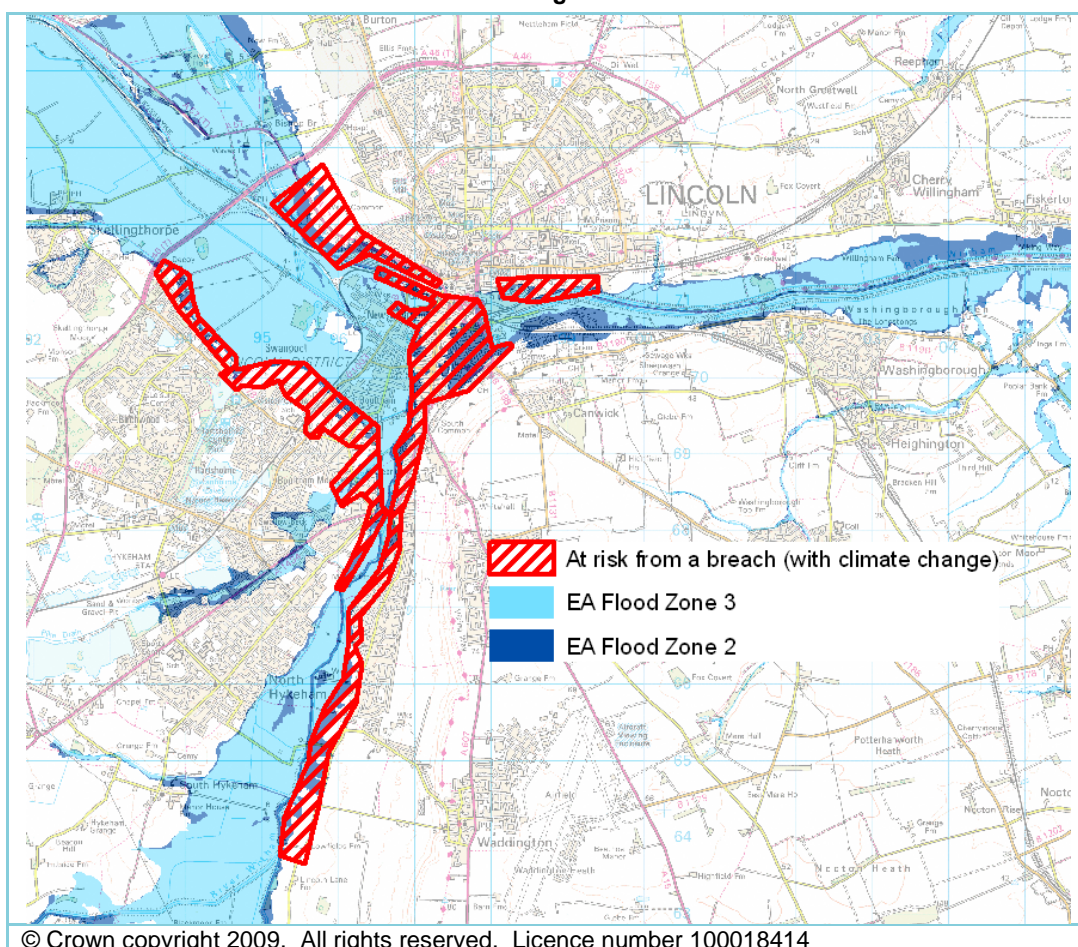
In some cases within Lincoln it was found that the maximum possible breach outline (derived from the 100 year + cc and 1000 year +cc flooding scenarios) extended beyond flood zones 2 and 3 (

Figure 7-8). As a result it is recommended that the local authorities within the policy area restrict development within these areas. It is recommended that the sequential approach be applied to flood zone one in this instance. A flood risk assessment will need to be submitted in accordance with Annex E of PPS 25.

The areas shown to be outside the EA flood zones but at risk from a breach in

Figure 7-8 should only be used as a guide. In all cases the Breach flood extent maps contained in volume 4 should be referred to. These maps show in detail the extent of flooding from a breach.

Figure 7-8: Areas which fall outside the EA flood zone but which may be effected from a breach of the flood defence with future climate change taken in to consideration



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8 Summary of Flood Risk and Recommendations

8.1 Summary of Flood Risk

A thorough review of existing information and new more detailed flood modelling work has identified the level of flood risk within the Lincoln Policy Area. This is summarised below:

Table 8-1: Summary of Flood Risk within the policy area

Source of Flooding	Potential			Comments
	High	Med	Low	
Fluvial Flooding (Rivers)	X			Fluvial flood risk is high within the policy area. The urban areas of Lincoln have significant flood protection. With the effects of climate change the flood defences will be overtopped above the 100 year with climate change scenario causing significant flooding to South Western areas of the city. A breach / failure of a flood defence would have a significant effect on the city and would cause widespread flooding.
Pluvial Flooding (Drainage)		X		It is expected that during moderate rainfall events the drainage system capacity is likely to be exceeded in some areas and further development in these areas will exacerbate this problem.
Surface Water Run-off		X		The overall risk to the district remains moderate due to the topography. Surface Water flood maps have been provided in Volume 4 detailing the effects of a 1 in 200 year chance rainfall event assuming all sewer systems are full to capacity. The flood outlines which have been provided highlight areas where water could collect and thus highlights the need for further consideration during development planning
Groundwater			X	The risk of groundwater flooding is low

8.2 SFRA Recommendations

- Council policy should be reviewed taking account of PPS25 and this SFRA, to ensure appropriate allocation of development sites and implementation of development control.
- Functional floodplain areas (Flood Zone 3b) should be protected from development where possible (See Maps volume 4)
- Developers and planners should follow the guidance set out in this SFRA in order to ensure new developments are safe, away from areas susceptible to flooding and that they do not have an adverse impact on flood risk elsewhere. All developments should have safe access and egress routes for pedestrians and emergency vehicles.
- The use of Sustainable Urban Drainage (SuDS) within new developments should be promoted

- Seek to adopt above ground SuDS as public open space and amenity areas, given appropriate developer contributions via Section 106 Agreements. These contributions should be “ring fenced” specifically for the on-going maintenance of the SuDS facilities
- Seek developer contributions via Section 106 Agreements or CIL where appropriate towards any proposed flood risk management facilities which will provide a direct benefit to their development proposals
- In areas where the 100 year plus climate change and 1000 plus climate change maximum possible breach extent (generated from 2D modelling) is greater than the extent of Flood Zone 3 (100 year) and / or Flood Zone 2 (1000 year) it is recommended that the LPA create a policy restricting development in these areas. This is further outlined in Figure Figure 4-3
- Additional modelling may required to map flood zones relating to un-mapped watercourses, if simple mitigation measures are deemed inappropriate. The Environment Agency and IDB's should be contacted for advice and whether additional modelling is required. It is recommended that a FRA is provided for sites within 20m of an un-mapped watercourse which includes hydraulic modelling to delineate as a minimum the 100 year and 100 year with climate change flood outlines and levels. It is important that consideration is given to any historical flooding at a development site.
- The Environment Agency is currently a statutory planning consultee on all applications for development in Flood Zones 2 and 3, other than minor development, and for sites of more than 1 hectare in Flood Zone 1. This does not address the problem of the cumulative impact of minor development. This may cause problems within the City area if not addressed. Also, the Flood Zones relate only to fluvial flooding therefore the flood risk from other sources such as surface water flooding is not addressed.
- Where proposed developments are designed with surface water outfall connections to soakaways, ditches, rivers or unadopted drainage systems, the Environment Agency are not always consulted in terms of surface water run-off calculations. Connection to an Anglian Water sewer would automatically require the preparation of surface water run-off calculations. Referral of all development applications to local IDB's is recommended where the surface water drainage outfall connections are not directly to an adopted sewer.
- With all applications, it should be demonstrated that proposed developments are not at risk of flooding and that developments do not increase flood risk elsewhere. The surface water drainage from proposed developments should be designed such that peak run-off rates and volumes are attenuated in accordance with the current EA Standing Advice. On small developments, where restriction to very low peak flows makes attenuation impractical, porous / permeable surfaces should be used wherever possible and appropriate.
- Planning conditions should be imposed to require the construction of any flood mitigation or surface water attenuation proposals prior to occupations and to put in place appropriate measures to minimise silt run-off and pollution of watercourses and groundwater during construction.
- Removal of Permitted Development Rights is justified where development threatens to have a direct, significant and adverse effect on a flood risk, flood defences or management of surface water.



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