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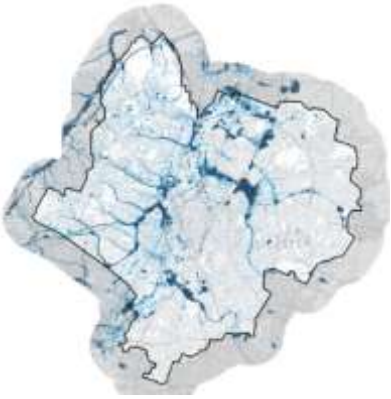
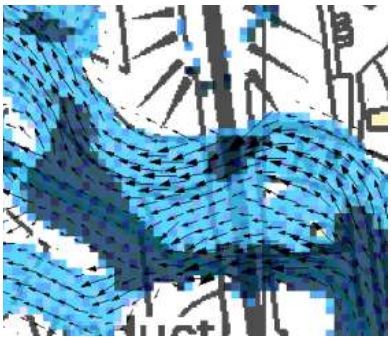
LEICESTER CITY COUNCIL

LEVEL 2 STRATEGIC FLOOD RISK ASSESSMENT

FINAL REPORT

FEBRUARY 2012





PREPARED FOR:

Leicester
City Council

Revision Schedule

Level 2 Strategic Flood Risk Assessment
February 2012

REVISION SCHEDULE					
Rev	**Date**	**Details**	**Prepared by**	**Reviewed by**	**Approved by**
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Abbreviations

ACRONYM	DEFINITION
AEP	Annual Exceedence Probability
AONB	Area of Outstanding Natural Beauty
AStGWF	Area Susceptible to Ground Water Flooding
AStSWF	Area Susceptible to Surface Water Flooding
BW	British Waterways
CFMP	Catchment Flood Management Plan
DEM	Digital Elevation Model
DPD	Development Plan Documents
EA	Environment Agency
EP	English Partnerships
FMfSW	Flood Map for Surface Water
FRA	Flood Risk Assessment
GIS	Geographical Information Systems
GWV	Groundwater Vulnerability
HFM	Historic Flood Maps
IDB	Internal Drainage Board
LDDs	Local Development Documents
LDF	Local Development Framework
LDS	Local Development Scheme
LCC	Leicester City Council
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
ODPM	Office of the Deputy Prime Minister
OPSI	Office of Public Sector Information
PCPA	Planning and Compulsory Purchase Act 2004
PPS25	Planning Policy Statement 25: Development and Flood Risk
RFRA	Regional Flood Risk Assessment
RPG	Regional Planning Guidance
RSS	Regional Spatial Strategy
SAR	Synthetic Aperture Radar
SA	Sustainability Assessment
SFRA	Strategic Flood Risk Assessment
SPG	Supplementary Planning Guidance
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
STW	Seven Trent Water

Glossary

TERM	DEFINITION
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Aquiclude	The term used to describe a solid, impermeable area underlying or overlying an aquifer.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Climate Change	Both natural and human actions causing long term variations in global temperature and weather patterns.
Culvert	A channel or pipe that carries water below the level of the ground.
Digital Elevation Model	A 3D representation of a terrain's surface.
Flood Defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood Storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone 1	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or tidal flooding in any year (<0.1%).
Flood Zone 2	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 tidal flooding (0.5% – 0.1%) in any year.
Flood Zone 3a	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	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone (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, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).
Fluvial Flooding	Flooding by a river or a watercourse.
Geographical Information Systems	A computer system designed for capturing, storing, manipulating, managing, analysing and displaying data which is geographically referenced.

TERM	DEFINITION
Glacio-fluvial deposits	A term used to define the material moved by glaciers and the subsequent sorting and deposition of this material by rivers and streams following the melting of glacial ice. Deposits are commonly stratified (i.e. layered).
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
hydrogeology	The characterisation of an aquifer based on the study of the flow path of water within and through an aquifer
Internal Drainage Board	Independent bodies with responsibility of ordinary watercourses within a specified district.
Inundation	Flooding.
Light Detection and Ranging	Optical remote sensing technology which can measure the distance to, or other properties of an object by illuminating it with light.
Local Development Framework	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Local Planning Authority	Body that is responsible for controlling planning and development through the planning system.
Main River	All watercourses shown as such on the statutory main river maps held by the Environment Agency and the Department of Environment, Food and Rural Affairs, and can include any structure or appliance for controlling or regulating flow of water into, in or out of the channel. The Environment Agency has permissive powers to carry out works of maintenance and improvement on these rivers.
Mitigation Measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Pitt Review	Sir Michael Pitt undertook an independent review of the Summer 2007 flood events. The full title of the document is 'The Pitt Review: Lessons learned from the 2007 floods'.
Pluvial Flooding	Flooding caused by water flowing over the ground surface that has not entered a natural drainage channel or storm water management system.
Risk	The combination of probability and consequence of an event occurring.
Sequential Testing	A risk based approach in to assessing flood risk, which gives priority in ascending order of flood risk, i.e. lowest risk first.
Sewer Flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Source Protection Zone	Areas that surround designated boreholes which take into account the local geology and soil vulnerability.

TERM	DEFINITION
Stakeholder	A person or organisation that has an interest in, or affected by the decisions made within a site.
Strata	Layer of rock or soil with internally consistent characteristics that distinguishes it from contiguous layers. Each layer is generally one of a number of parallel layers that lie one upon another, laid down by natural forces.
Superficial Deposits	A reference to geological deposits typically of the Quaternary age. These recent unconsolidated sediments may include stream channel and floodplain deposits, beach sands, talus gravels and glacial drift and moraine.
Sustainability Appraisal	A process used to identify if policies, strategies or plans promote sustainable development and further used for improving policies. It is a requirement for Regional Spatial Strategies under the Planning and Compulsory Purchase Act 2004.
Sustainable Drainage System (SuDS)	Drainage methods designed to mimic the natural system. Where practicable should be used in preference to traditional piped drainage systems.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
Synthetic Aperture Radar	A form of radar that uses relative motion between an antenna and its target region to provide distinctive long-term coherent-signal variations that are used to produce high resolution imaging across broad areas.
X% Annual Exceedence Probability (AEP) event	Percentage annual exceedence probability (AEP) of occurrence in any one year. For example, a 1 in 200 annual probability event has a 0.5% AEP of occurring in any year.
X% AEP Design Standard	Flood defence that is designed for to protect against a X% AEP event. In events more severe than this the defence would be expected to fail or to allow flooding. For example, defences may be constructed to a standard of protection of 1% AEP.

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1 Introduction

1.1.1 In December 2010, URS Scott Wilson Ltd was commissioned to undertake a three-part project for Leicester City Council, summarised below:

- **PART 1:** A Phase 1 and Phase 2 Surface Water Management Plan (SWMP) study. This will include hydrological and hydraulic modelling to show areas at risk of fluvial flooding from ordinary watercourses and pluvial flooding for the Leicester Principle Urban Area and produce outputs including recommending "hotspots" for more detailed study.
- **PART 2:** Provision of a complete Strategic Flood Risk Assessment (SFRA) to PPS25 Level 2 using, where possible, data produced in Part 1 for Leicester. This will require collating the data produced in Part 1 alongside Environment Agency main river data and providing further information on specific potential development sites such as Flood Risk Assessment requirements and outline recommendations for planning policy initiatives.
- **PART 3:** Produce coupled sewer/river and floodplain models for some of the most at risk hotspots identified in Part 1. From the modelling, potential interventions to resolve flooding issues will be investigated.

1.1.2 In January 2011, LCC requested that a Preliminary Flood Risk Assessment (PFRA) be prepared as an additional part of the commission to make use of data gathered and outputs produced from the other parts of the study.

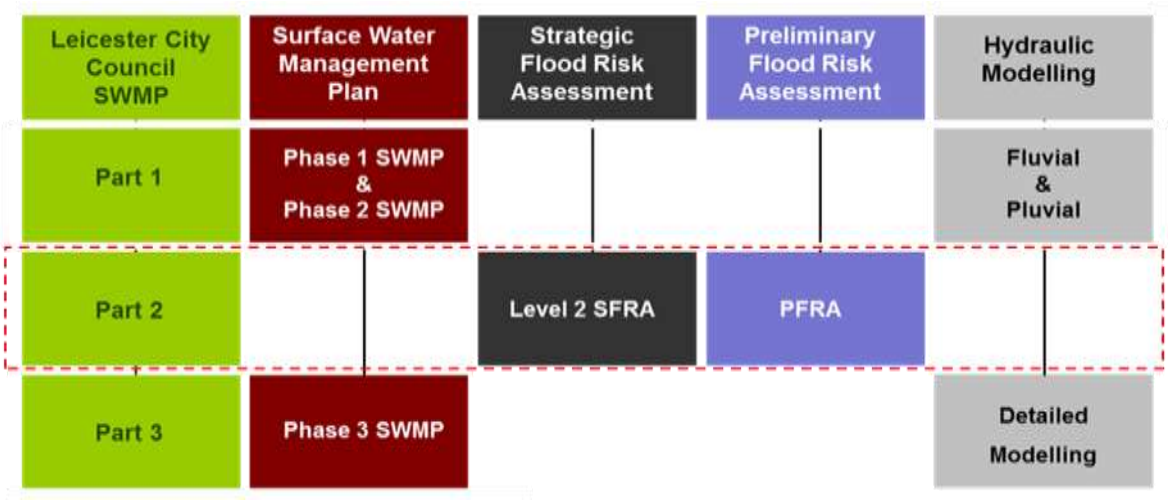

Figure 1-1: Leicester SWMP Project Layout

1.1.3 This report fulfils Part 2 of the study (excluding the PFRA) and also draws upon some of the analyses undertaken for Parts 1 and 3.

1.2 Planning Context

1.2.1 The Planning and Compulsory Purchase Act 2004 (PCPA) requires Local Planning Authorities (LPAs) to produce Local Development Frameworks (LDFs) to replace the system of Local, Structure and Unitary Development Plans. LDFs are a portfolio of Local Development Documents (LDDs) that collectively deliver the spatial planning strategy for the Local Authority area. Local Development Schemes (LDS) set out the timetable for the production of LDDs. The PCPA requires LDDs to undergo a Sustainability Appraisal (SA), which assists LPAs in ensuring their policies fulfil the principles of sustainability.

1.2.2 The Localism Bill (2010-2011) is due to be reviewed at the Reporting Stage in the House of Lords. If the Localism Bill is brought into common law it devolves power from the central government back to individual councils. This Bill would allow local councils to have more control over local planning policy including policies on development and flood risk.

1.2.3 This Level 2 SFRA has been developed taking into account the requirements of PPS25. PPS25 is due to be superseded by the National Planning Policy Framework (NPPF) which sets out the government's requirements for the planning system. The NPPF consists of a framework within which local people and accountable councils can produce local and neighbourhood plans that reflect the needs and priorities of their communities. The principals of PPS25 will, however, still form part of the new NPPF which was submitted to parliament on 25th July 2011.

1.2.4 Planning Policy Statement 25: Development and Flood Risk (PPS25, 2010) emphasises the active role that LPAs should have in ensuring that flood risk is considered in strategic land use planning. PPS25 indicates that LPAs should ensure the most appropriate use of land to minimise flood risk, where necessary substituting land uses so that development which is categorised as the most vulnerable to flooding is located in the lowest risk areas. In addition, LPAs should take opportunities to reduce flood risk where possible.

1.2.5 PPS25 encourages LPAs to undertake a Strategic Flood Risk Assessment (SFRA) for their administrative area. The SFRA should draw together all sources of flood risk to the area including fluvial, pluvial, groundwater, coastal and sewer flooding as well as the risk from artificial sources and failure of reservoir dams, canal embankments and pumping stations. SFRAs are one of the documents to be used as the evidence base for strategic land use planning decisions as part of the LDF and they provide the opportunity to recommend local policies/assess flood risk issues specific to the area. They are also a component of the Sustainability Appraisal (SA) process and should be used in the review of LDDs or in their production.

1.2.6 Leicester City Council (LCC) held a public consultation on the "Issues and Options" for the Core Strategy in autumn 2007. Informal public consultation on an emerging Core Strategy took place in summer 2008. Based on the findings from the public and informal consultations, the Council prepared a Core Strategy Submission Document. The document was submitted to the Secretary of States for Communities and Local Government in December 2009 for an Examination in Public by a Planning Inspector. After receiving formal approval from the Planning Inspector, LCC adopted the LDF Core Strategy at its Full Council meeting in November 2010.

1.2.7 The Core Strategy contains policies for development in Leicester up to 2026, including proposals for the spatial distribution and the Council's preferred strategic sites. Those policies which are relevant to flood risk and green infrastructure are described below.

- **CS Policy 2: Addressing Climate Change and Flood Risk** states that all development should be directed to locations with the least impact on flooding and water resources and should include mitigation measures to reduce the effect of flood waters. Brownfield and greenfield development should both also take into account climate change.
- **CS Policy 13: Green Network** discusses the council's strategy for maintaining and enhancing the quality of the local green network. This involves safeguarding and where possible improving or expanding the current green network. New development should take into account local qualitative and quantitative green space deficiencies and green spaces should not be removed unless they can be replaced or appropriately substituted elsewhere.
- **CS Policy 17: Biodiversity** describes the council's expectations for development to maintain, enhance and strengthen connections for wildlife. A potential impact of development would require ecological surveys and assessment. Careful consideration should be given to find a suitable location for the development and if this is not possible then adequate mitigation will be required. Compensation measures to offset an impact on biodiversity may also be required.

1.2.8 The whole of Leicestershire is part of the Three Cities and Three Counties (6Cs) area which was granted the status of a New Growth Point in 2006. The aim of this New Growth Point status is to deliver 163,000 homes by 2026. In order to meet these growth aspirations (Leicester has a need for over 20,000 new homes within 20 years) and local employment targets, there is need for development beyond the Leicester City Local Authority Boundary. Consequently a number of urban extensions and major potential development areas beyond the City boundary are currently being considered / and or developed.

1.2.9 In the Leicester Core Strategy, the Principal Urban Area of Leicester is the City plus the hydrologically linked surrounding built up area in Leicestershire. Much of what is commonly perceived as part of Leicester lies within the neighbouring authorities of Charnwood, Melton, Harborough, Oadby & Wigston, Blaby and Hinckley & Bosworth. It is therefore important to be aware of the interrelationship of growth both within and on the edge, and outside, of the City boundary and consequently the special spatial relationship Leicester shares with its neighbours, and the progress made by other relevant neighbouring Local Authorities in developing their spatial planning strategies. In terms of proposed development beyond the City boundary, at this stage the most relevant neighbouring spatial planning strategies are:

- Leicestershire County Council and Leicester City Council – The Councils published a Waste Development Framework Pre Submission Site Allocation Policies document in February 2011;
- Leicestershire County Council and Leicester City Council– The Councils produced a Minerals Development Framework and Waste Development Framework Core Strategy and Development Control Policies in October 2009;
- Harborough District Council- The Council published a Core Strategy for 2006-2026 in late 2010 and are set to submit their Core Strategy for examination by April 2011;

- Blaby District Council- The Council consulted on a Core Strategy Alternatives Options Paper in November 2008 and are currently progressing the Core Strategy;
- Oadby and Wigston Borough Council- The Borough Council formally adopted the Core Strategy on 28th September 2010; and
- Charnwood Borough Council- The most recent Core Strategy consultation document the 'Charnwood 2026: Planning for Our Next Generation', which was published and subject to consultation in late 2008. The Council are currently progressing the Core Strategy.

1.3 SFRA Overview

1.3.1 The PPS25[1] Practice Guide[2] recommends that SFRAs are completed in two consecutive stages:

- Level 1 SFRA; and
- Level 2 SFRA.

1.3.2 In 2002, JBA Consulting was commissioned by LCC to undertake a Level 1 SFRA within the City boundary in partnership with the Environment Agency.

1.3.3 The Final Level 1 SFRA was published in February 2004 and the recommendations that were made have been used to inform the Councils' LDF Sustainability Appraisals, whilst formulating the policies and proposals laid out in the Core Strategy (November 2010).

1.3.4 The Level 2 SFRA assesses the flood risk to the whole City and brings the best available flood risk information to one place. This Level 2 SFRA also assesses specific flood risks to Strategic Regeneration Areas (SRAs) and potential major development sites around Leicester identified by LCC. The report also makes recommendations on policy and on more detailed site specific flood risk assessments (FRAs) for each site.

1.4 Aims and Objectives of the Level 2 SFRA

1.4.1 The principal aim of this Level 2 SFRA is to provide sufficient information to facilitate application of the PPS25 Sequential and Exception Tests. Information provided in this Level 2 SFRA will therefore inform decisions regarding the suitability of LCC's potential strategic growth sites that have been put forward for development.

1.4.2 In accordance with the PPS25 Practice Guide, the Level 2 SFRA will fulfil the following objectives for the whole of Leicester City, the specified Strategic Regeneration Areas (SRAs) and the potential major development sites and urban extensions around Leicester:

- An appraisal of the current condition of flood defence infrastructure and of likely future flood management policy with regard to its maintenance and upgrade.
- An appraisal of the probability and consequences of overtopping or failure of flood risk management infrastructure, including an appropriate allowance for climate change.
- Definition and mapping of functional floodplain in locations where this is required.

[1] Department for Communities and Local Government (2006) *'Planning Policy Statement 25: Development and Flood Risk',* TSO: London.
[2] Department for Communities and Local Government (2009) 'Planning Policy Statement 25: Development and Flood Risk Practice Guide', TSO: London.

- Maps showing the distribution of flood risk across all flood zones from all sources of flooding taking climate change into account.
- Guidance on sequential approach within development sites and on Exception Test for sites.
- Guidance on the preparation of flood risk assessments for sites of varying risk across the flood zones, including information about the use of sustainable drainage techniques.
- Meaningful recommendations to inform policy, development control and technical issues.

1.4.3 In addition to the requirements of the PPS25 Practice Guide, LCC requested that the following are also considered:

- Flood Warning Systems;
- SuDS applicability; and
- Hazard mapping.

SFRA Position Statement – February 2012
The Leicester City SFRA has been completed in accordance with PPS25 and the current guidance outlined in the Development and Flood Risk: A Practice Guide Companion to PPS25 (December 2009). The SFRA has been developed by building heavily upon existing knowledge with respect to flood risk within the study area. These documents have an intended lifespan of 6-10 years. Therefore it should be noted that although up-to date at the time of production, the SFRA has a finite lifespan and should potentially be upgraded or revised as required by the local authorities. As a result, it is recommended that the SFRA be adopted as a “Living” document and should be reviewed regularly and, if necessary, updated with new flood risk or planning policy data.

2 Level 2 SFRA Study Area

2.1 Overview

2.1.1 The Level 2 SFRA study area covers the Leicester City administrative area including Strategic Regeneration Areas and identified potential major development sites around Leicester. The administrative boundary, specific sites within the Strategic Regeneration Area (which includes other areas within the City boundary) and potential major development sites around Leicester are shown in Figure 2-1.

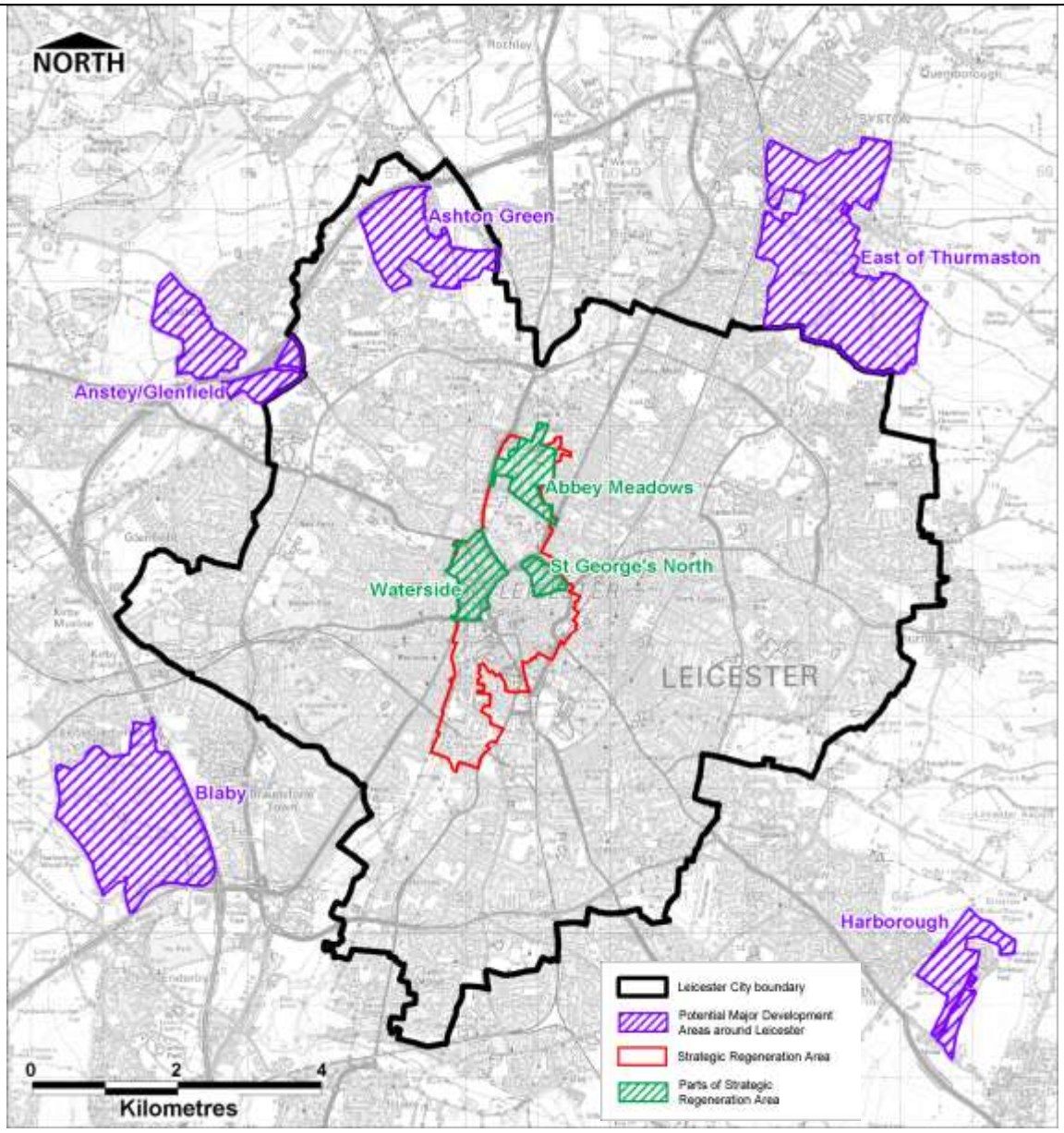

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Figure 2-1: Leicester Level 2 SFRA Study Area

2.2 Leicester City

2.2.1 The Leicester City administrative area is characterised by dense urban concentrations; few distinct settlements exist due to the compact urban nature of the City. The Leicester City Core Strategy[3] divides the City into three categories: Inner Areas, Outer Estate Areas and Suburbs.

2.2.2 The Inner Areas includes the predominantly Council built neighbourhoods and Victorian terraced private housing which stretch from the edges of the City Centre. The Outer Estate Areas consist of mainly large scale 20th century council built housing areas on or near the edges of the City whilst the Suburbs consist mainly of larger private housing with gardens. As previously stated, the Strategic Regeneration Area and potential major development sites around Leicester are shown in Figure 2-1.

2.3 Strategic Regeneration within Leicester City

2.3.1 The Leicester City Council Core Strategy (adopted by the Council in November 2010) sets out the vision, objectives and spatial strategy for the City. Part of the strategy includes a Strategic Regeneration Area (Core Strategy policy 4) which will be:

> *"…the focus of major housing development and physical change to provide the impetus for economic, environmental and social investment and provide benefits for existing communities".*

2.3.2 The following specific parts within the Strategic Regeneration Area have been identified by LCC as requiring assessment as part of the Level 2 SFRA. More details for each are given in the site assessment tables in Section 5.

Strategic Regeneration Area: Abbey Meadows Science and Technology Park

2.3.3 Abbey Meadows is located towards the north of the City centre and falls within the Strategic Regeneration Area of LCC. It is a key area for delivering economic growth in the City and is identified in the Core Strategy (Policy CS4) to attract new jobs in science and technology and related knowledge-intensive business. The intension is to link with the City's two Universities, retaining graduates and building a skills and knowledge base for Leicester's economy.

2.3.4 The canal and riverside location presents potential flood risks that need to be managed effectively to ensure sustainable development.

Strategic Regeneration Area: Waterside

The Waterside area connects existing communities with the City Centre and the riverside and canal. The Leicester Core Strategy (2010) indicates that the Council's aspiration for this area is to develop the Waterside as an attractive, high quality, residential-led, mixed neighbourhood and City leisure attraction, focusing on water, which enhances the riverside, the canal and its ecology, improves connectivity to adjoining areas and reduces the severance effect of the Central Ring Road.

2.3.5 Consequently, the canal and riverside location presents potential flood risks that need to be managed effectively to ensure sustainable development.

[3] LCC 2010. Leicester City Core Strategy. http://www.leicester.gov.uk/corestrategy

Strategic Regeneration Area: St George's North New Community

2.3.6 St. George's North lies to the north of Humberstone Road, just within the ring road. The Leicester Core Strategy (2010) indicates that the St Georges North area has the potential for mixed use regeneration, linking St. Matthew's estate and the City Centre. The area to the north of Humberstone Road provides opportunities for major leisure facilities in locations that will generate activity on key routes.

Strategic Regeneration Area: Remainder of City

2.3.7 In addition to the remainder of the City, other specific parts of the Strategic Regeneration Area referred to in Core Strategy policy 4 include:

- **The New Business Quarter (NBQ):** An area in the vicinity of the Leicester railway station that has been identified as key for providing office based employment and economic growth in the City. The strategy aims to concentrate major office development in the area to promote a critical mass of offices which in turn will attract investment into Leicester.

  Historical flood records and surface water modelling indicate that the area may be at risk of flooding from surface water, drainage and the sewer network. Therefore, new development needs to be managed effectively to ensure flood risk is not made worse to the area or elsewhere.

- **St. George's South:** An area lying to the south Humberstone Road, a key transportation route linking the area to the City Centre. St. George's South has the potential to encourage small scale offices and workplaces that can support cultural and leisure attractions and City Centre living. To support this regeneration and any new residential development, improved public open space and access to education and health care provision will be required.

  Historical flood records and surface water modelling indicate that the area may be at risk of significant flooding from surface water, drainage and the sewer network with some high hazard areas identified. Therefore, new development needs to be managed effectively to ensure flood risk is not made worse to the area or elsewhere.

- **St. John's**: The area of St. John's has been identified as providing the opportunity for mixed use development – especially where improved access and connectivity can be achieved between Abbey Park, Waterside, the City Centre, and existing communities. Development should ensure that viable employment uses are protected.

2.3.8 There are up to 1000 new dwellings (together with significant non-residential development) allocated for the SRA and, with historical and future flood risks identified, it is important to ensure that flood risk is not increased and is managed effectively. More information on the flood risks associated with the wider SRA including recommendations for SuDS and site specific FRAs is presented in Section 5.

2.4 Potential Major Development Sites around Leicester

2.4.1 The following potential major development sites located around Leicester may have an impact on flood risk in Leicester City. An assessment of potential flood risk to and from these major development sites is presented in Appendix D and the sites are considered further in the Leicester SWMP.

New Lubbesthorpe

2.4.2 The New Lubbesthorpe potential major development site falls within the administrative area of Blaby District Council (BDC). Within the Blaby Core Strategy Submission document (published July 2009), Policy 3 (Sustainable Urban Extension) allocates land west of the M1 at Lubbesthorpe as a mixed-use development. Development potential includes housing, employment, education, health care facilities, improved transport links and provision of green infrastructure.

2.4.3 A joint Level 1 SFRA was undertaken for Blaby, Hinckley & Bosworth and Oadby & Wigston Borough Councils in 2007. The SFRA and a review of OS mapping identified four undefended tributaries of Lubbesthorpe Brook; one in the south, south east, east and north eastern areas of the site. Since the SFRA, the Environment Agency have produced a draft model of Lubbesthorpe Brook to improve the available flood risk information and to inform development decisions. Until the final model is complete and results are available, existing information shows that the majority of the New Lubbesthorpe potential major development site is located within Flood Zone 1 and no initial records of historical flooding have been identified.

2.4.4 The SFRA identifies that the site may potentially be at risk from surface water runoff and groundwater flooding due to the presence of wet clay/silty soil comprising low infiltration potential, underlain by limestone/shale. Draft pluvial modelling has confirmed that some areas of the New Lubbesthorpe potential major development site are at risk of shallow and deep surface water flooding (see Appendix D). This will therefore be a key consideration in the undertaking of this study, with particular emphasis on the implications for surface water flooding and the applicability of SUDS.

East of Thurmaston

2.4.5 The East of Thurmaston potential major development site falls within the administrative area of Charnwood Borough Council (CBC). The Charnwood Core Strategy Preferred Options document (published 2006) Draft Core Policy 3 (Development Strategy for South Charnwood) sets out a spatial strategy for South Charnwood, which incorporates the East of Thurmaston potential major development site. The policy identifies the potential for new homes, employment land and a comprehensively planned green infrastructure network on the East of Thurmaston area.

2.4.6 In the most recent Core Strategy consultation document the 'Charnwood 2026: Planning for Our Next Generation' document (published and subject to consultation in late 2008), a number of alternative directions for sustainable urban extensions to the Principal Urban Area of Leicester were set out. One of two preferred options for growth was East of Thurmaston and north of Hamilton. Development potential includes housing, employment, education, health care facilities, improved transport links and provision of green infrastructure.

2.4.7 The Level 1 SFRA identified Barkby Brook (Main River) in the northern region of the site, Thurmaston Parish Dyke (Ordinary Watercourse) in the north east, Melton Brook in the south (enmained immediately downstream of the site), and an unnamed tributary of Melton Brook flowing south west through the site. All these watercourses are tributaries of the River Soar. The SFRA identified historical flooding on Barkby Brook.

2.4.8 The SFRA identifies the limitations of using Thurmaston Dyke as a method of surface water runoff disposal due to flooding problems downstream. Thurmaston Parish Dyke has been modelled as part of the SWMP and SFRA process for LCC and shows some flood risk (see Appendix D).

Harborough

2.4.9 The Harborough potential major development site falls within the administrative area of Harborough District Council (HDC). There is no new development proposed for the area within the Harborough Core Strategy Publication Version document (published October 2010). However, it is likely that any major development would include residential, employment, transport infrastructure and community related facilities.

2.4.10 Scott Wilson undertook the Level 1 SFRA in 2009, which identified a minor watercourse running along the south eastern side of Chestnut Drive at the site boundary. A tributary of Wash Brook is also located in the north western region of the site (Wash Brook has been assessed and modelled as part of the SWMP). The site is shown to be located entirely within Flood Zone 1.

2.4.11 A sewage treatment works is located at the north eastern edge of the site. BGS geological maps illustrate that the site is largely underlain by Diamicton[4], with small areas of sand and gravel. The northern region of the site is underlain by an Environment Agency designated Principal Aquifer[5].

South of Anstey / North of Glenfield

2.4.12 The Anstey / Glenfield potential major development site falls within the administrative area of Charnwood Borough Council (CBC). Within the Charnwood Core Strategy Preferred Options document (published 2006), there is no new development proposed for South Anstey. However, in the most recent Core Strategy consultation document the 'Charnwood 2026: Planning for Our Next Generation', which was published and subject to consultation in late 2008, a number of alternative broad directions for growth that the Council has considered for major development to the Principal Urban Area of Leicester and were set out. One of these alternative options for growth was Alternative Option E: North of Glenfield/South of Anstey.

2.4.13 In the area to the south of Anstey, the Charnwood Borough Council Level 1 SFRA identified that the area drains south eastwards towards Rothley Brook and a tributary from the west. A second tributary originating from the north-west is located in the northern part of the area.

2.4.14 North of Glenfield, the Charnwood Borough Council Level 1 SFRA identifies that the area drains north westwards to Rothley Brook. This drainage path however appears to be intercepted by the

[4] BGS (2011) **Rock Classification Scheme** Diamicton - Poorly-sorted sediment with wide clast size range, clasts >50vol% from pre-existing siliceous rocks. May be rudaceous, arenaceous or argillaceous grade. http://www.bgs.ac.uk/bgsrcs/rcs_details.cfm?code=DMTN.
[5] Environment Agency. 2011. Aquifers. http://www.environment-agency.gov.uk/homeandleisure/117020.aspx

A46. A review of OS mapping illustrates a tributary of Rothley Brook originating to the north west of Leicester Frith Farm.

2.4.15 The SFRA identified historical flooding on Rothley Brook and the River Soar.

2.5 Green Infrastructure Planning in Leicester

2.5.1 As requested by Planning Policy Guidance 17: Planning for Open Space, Sport and Recreation (PPG17), LCC produced an Open Space Strategy[6] to form the evidence base for the LDF Core Strategy. A Green Space Strategy[7] was then created which recommended that a Green Space Supplementary Planning Document[8] (SPD) be produced.

2.5.2 The LCC adopted Core Strategy defines Green Infrastructure (GI) as "networks of multifunctional green space which sit within and contribute to the high quality natural and built environment". In July 2010 the 6C's Growth Point Green Infrastructure Strategy was launched which has a long term vision for protecting, enhancing and extending networks of green spaces and natural elements in and around Nottingham, Derby and Leicester. The 6C's supports development which will contribute to a robust green infrastructure network that will both assist attracting future investment and achieve multi-purpose public benefits for residents and visitors.

2.5.3 LCC are currently undertaking work to produce a Green Infrastructure Strategy for the City of Leicester. Whilst the main body of work has an emphasis on biodiversity and regeneration opportunities, LCC have identified that there are also opportunities to link to other functions, in particular, the potential to reduce flood risk by "making space for water" and to assist with sustainable flood risk management in the future. Green Infrastructure also has the potential to help the City achieve the 'good ecological status' requirements of the European Union Water Framework Directive (EU WFD).

2.5.4 Four main strategic GI assets have been identified at city scale by 6Cs (2009b), these are:

1. **Soar Strategic River Corridor** - the corridor broadly follows the Soar Valley and Grand Union Canal through Leicester. Habitat features directly associated with the River Soar and Grand Union Canal include floodplain grazing marsh, lowland mixed deciduous woodland (including wet woodland), lowland meadows, rivers and streams, reedbed, eutrophic standing water, and lowland fen, e.g. Loughborough Big Meadow; wet grassland in the Cossington area. Other green areas within the corridor include Watermead Country Park; Abbey Park and Great Central Way Sustrans route; and currently designated major Green Wedges to the north and south of Leicester.

   In terms of delivering GI benefits, there are clear opportunities to manage flood risk through appropriate land management, and in association manage biodiversity through river corridor habitat management, creation, restoration and extension in all key habitat types. The river floodplain and Cossington Meadows have been identified as being particularly important in these respects.

   There are also opportunities to improve access and movement for example by linking existing green spaces to one another and to Strategic GI assets such as the River Soar,

[6] http://www.leicester.gov.uk/your-council-services/ep/planning/plansandguidance/ldf/ldfevidence-base/openspacestudy
[7] http://www.leicester.gov.uk/your-council-services/lc/parks-green-spaces/greenspace-strategy/
[8] http://www.leicester.gov.uk/your-council-services/ep/planning/plansandguidance/ldf/spd/green-space-spd/

Grand Union Canal and Watermead Country Park. Identification of pluvial flow routes in the SWMP could be used to inform the routing of these linkages. Similarly, opportunities to enhance the character and distinctiveness of the landscape could be informed by mapping of surface water flow routes and ponding areas and strategic placement of SUDS, while conservation of old willow pollards along watercourses through improved management and increasing tree cover through planting of wet woodlands would have concurrent benefits for amenity and flood management.

2. **Soar Floodplain in Southwest Leicester** - this area provides opportunities for jointly managing flood risk, enhancing the character and distinctiveness of the landscape and creating, restoring and extending habitat types including wet woodland, fens, reedbed and opportunities for creating (buffer strips), restoring and managing rivers and streams. This area could connect with proposed city-scale Corridors (e.g. proposed greenway linking Leicester and Lutterworth) as well as the River Soar, River Sence and the Grand Union Canal. As well as being in an area with high potential for delivering combined multiple public benefits through GI provision/enhancement, it could bridge a gap in the provision of accessible natural greenspace sites of varying sizes on the doorstep of communities including south west Leicester, Narborough, and Blaby, and also within 2 – 10 km of broader range of communities. It could provide opportunities to enhance the character and distinctiveness of the landscape and to manage flood risk.

3. **North West Leicester Urban Fringe** - an area which provides opportunities for GI and flood risk management by creating, restoring and extending lowland mixed deciduous woodland, acid grassland and lowland meadows. As well as being in an area with high potential for delivering combined multiple public benefits through GI provision / enhancement, it could bridge a gap in the provision of accessible natural greenspace sites of varying sizes on the doorstep of communities including north-west Leicester, Thurcaston, and Cropston, and also within 2 – 10 km of a broader range of communities. This area could connect with a proposed City-Scale GI Corridor (e.g. proposed greenway linking north-west Leicester, Anstey and Loughborough) and provide opportunities to enhance the character and distinctiveness of the landscape. It could provide opportunities to enhance the management, presentation, accessibility and interpretation of historic environment assets (e.g. Rothley historic village) and would offer opportunities to manage flood risk. The Stepping Stones Project GI Delivery Plan includes this area as part of its intervention areas, describing it as ‘a priority area for increasing community access to the high quality greenspace within and outside the Stepping Stones Project area, particularly to the National Forest’. It describes ‘opportunities to improve the area’s currently limited ecological resource through biodiversity enhancements including linkages to high quality resources’.

4. **South East Leicester Urban Fringe** - an area which provides opportunities for enhanced flood management by creating, restoring and extending habitat types including lowland mixed deciduous woodland and dry meadows. This area could bridge a gap in the provision of accessible natural greenspace sites of varying sizes on the doorstep of communities including south east Leicester, Great Glen, and Newton Harcourt, and also within 2 – 10 km of a broader range of communities. This area could connect with a proposed City-Scale GI Corridor (e.g. proposed greenway linking south east Leicester and

Market Harborough) as well as the River Sence and Grand Union Canal. It could provide opportunities to enhance the character and distinctiveness of the landscape.

2.5.5 As part of the Leicester SWMP, existing areas of open space and green infrastructure will be identified that could help to alleviate and manage flood risk across the City. The SWMP process will also work closely with authors of the developing Green Infrastructure Strategy to identify areas where new open spaces and green infrastructure could benefit both flood risk management and improve access, biodiversity and recreation across the City.

2.5.6 However, there are also opportunities where the Level 2 SFRA can be used to identify potential green infrastructure and open space that may provide flood risk benefits to the SRAs and other potential major development sites around Leicester. For example, where possible this Level 2 SFRA will provide recommendations and guidance that will inform how SuDs can be incorporated into new development to alleviate flood risk. It is acknowledged that there is pressure for space in developments, so the SFRA will aim to guide developers to make use of multi-beneficial SuDs which reduce flood risk and improve water quality whilst providing biodiversity and amenity open spaces to improve GI. Subsequent functions of the SuDs may be improvements in water quality, biodiversity and runoff from new developments. Further information on how GI and SuDS can be used to mutual benefit is given in Section 6.6.

2.6 A Flood Risk Overview for Leicester City

2.6.1 Leicester City is at risk from a variety of sources of flooding and there are significant areas of flood risk within the Leicester City administrative area. A more detailed description of different flood sources in relation to the SFRA is presented in the remainder of Section 2.6. The dominant sources include flooding from rivers, the land (surface water) and sewers. Pluvial modelling and modelling of the ordinary watercourses for the Leicester SWMP has identified hotspots of flood risk within Leicester City.

2.6.2 The Leicester Principal Urban Area (PUA) has several Statutory Main Rivers flowing through it. The principal Main River is the River Soar, which has several tributaries including the River Sense, Saffron Brook, Braunstone Brook, Evington Brook and Willow Brook. The main sources of information on flooding from these Main Rivers are from the EA and include:

- EA Flood Map; and
- Leicester City Strategic Flood Risk Mapping (SFRM) study.

2.6.3 Several ordinary watercourses have caused flooding in the past and some records exist for these incidents. The main consequences appear to be flooding to roads and gardens, but properties have also been affected. Ordinary watercourses that are known to have flooded include Portwey Brook, Ethel Brook, Gilroes Brook, Hol Brook and Wash Brook. The Leicester SWMP has examined these watercourses in more detail to assess the future potential risks of flooding.

Flood Risk History

2.6.4 Historical flooding to Leicester has been assessed using flood records collected from a variety of data sources many of which are discussed further in the LCC PFRA. Records of over 700 historical flood events and flooding hotspots were collected across LCC's administrative area.

From the total number of historical incidents recorded by LCC, it appears that the June 1993 event was one of the most significant.

2.6.5 These flood events came from a range of flood sources including blocked drains and gullies, sewers, ordinary watercourses and surface water flooding. In many cases the source of flooding was unknown or not recorded. Of the historical records reviewed, nearly 400 have some description of the flood source. However, over 300 records are unclear with regards to the flood source or impact.

2.6.6 Table 2-1 provides a summary of the consequences of the recorded floods where the information was available.

Table 2-1: Summary of recorded historic flooding incidents in Leicester

Flood Event		Source of Flooding	Consequences of Flooding
1968	July	Main rivers, ordinary watercourses, surface water, sewerage, blocked drains and gullies, ponding	Flooded roads, footpaths, gardens, property (cellars, basements, garages, ~1800 houses), commercial property (shops, factories, hotels etc)
1983	May	Surface water, sewer, possible groundwater	Flooded roads, footpaths, gardens, property (cellars, basements)
	September		
1984	March	Surface water, ponding, ordinary watercourse flooding, sewer, possible groundwater	Flooded roads, footpaths, gardens, property (cellars, basements, garages, houses)
	July		
	November		
1985	April	Surface water, ponding, blocked drains and gullies, blockage in ordinary watercourse	Mainly flooded roads and footpaths. Car park affected, property (cellars and gardens), commercial property (shop)
	May		
	December		
1986	August	Blocked drains and gullies, blockages on ordinary watercourses	Mainly flooded roads and footpaths.
1987	April	Surface water, blocked drains and gullies	Mainly flooded roads and footpaths.
	June	Surface water, ponding, ordinary watercourse flooding, sewer, possible groundwater	Flooded roads, footpaths, gardens, property (cellars, basements, garages, houses), commercial property (pub, factory)
1988	January	Surface water	1 property and school (or grounds) affected
1989	May	Surface water, sewer, ordinary watercourse	Mainly flooded roads and footpaths, driveways, commercial property (shop)
	November	Surface water, ponding, ordinary watercourse flooding, sewer, possible groundwater	Flooded roads, footpaths, gardens, property (cellars, basements, garages, houses), commercial property (hotels and industrial units)
1992	September	Surface water, sewer, ordinary watercourse	Flooded roads, footpaths, gardens, property (houses)
1993	June	Surface water, ponding, ordinary watercourse flooding, sewer, possible groundwater	Flooded roads, footpaths, gardens, property (cellars, basements, garages, ~71 houses), commercial property (shops, sports centre, hotels and industrial units)

Table 2-1: Summary of recorded historic flooding incidents in Leicester

Flood Event		Source of Flooding	Consequences of Flooding
1996	August	Surface water, sewer, ordinary watercourse	Flooded roads, footpaths, gardens, property (cellars, basements)
1998	January	Surface water, sewer, ordinary watercourse	Flooded roads, footpaths, gardens, property (houses), school
	October		
2002	January	Surface water, ponding, blocked drains and gullies, blockage in ordinary watercourse	Flooded roads, footpaths, gardens, property (houses)
	July		
	September		
2004	August	Surface water, blocked drains and gullies	Flooded roads, footpaths, gardens, property (houses)
	October		
2008	June	Surface water, blocked drains and gullies	Mainly flooded roads and footpaths.
	December		
2009	April	Surface water, ponding, blocked drains and gullies, blockage in ordinary watercourse	Mainly flooded roads and footpaths, driveways, property (houses), commercial property (Hotel)
	July		
	November		
2010	July	Surface water, blocked drains and gullies	Mainly flooded roads and footpaths.

Significant Flood Event

Flooding from Rivers

2.6.7 The EA's Flood Map and outputs from existing SFRM hydraulic models have been used to map Flood Zone 2, Flood Zone 3a and Flood Zone 3b (functional floodplain) and show extensive flood risk to areas of Leicester along Main River corridors.

2.6.8 Leicester City falls within the 'Upper Soar and Upper Anker' sub-region of the River Trent Catchment Flood Management Plan (CFMP) which confirms that parts of Leicester are at high risk of flooding and between 2,000 and 5,000 properties are considered to be at risk during a 1% AEP (1 in 100 year) fluvial flood event.

2.6.9 A suite of maps showing the best available information relating to fluvial flood risk is included in Appendix B. The fluvial Flood Zones show the distribution of flood risk throughout the study area and are derived from a mixture of detailed hydraulic river models and, where such data is unavailable, broadscale national modelling datasets. The plans present flood risk information against potential future development areas.

2.6.10 The River Soar flows through the centre of Leicester and presents the greatest fluvial flood risk to the study area. Though generally, the existing pattern of urban development is rolled back from the River Soar floodplain, areas of the City are located within Flood Zones 2 and 3 such as parts of Westcotes, Aylestone, Abbey Park, Humberstone, Belgrave, Spinney Hill, North Evington, Rushey Mead and Knighton (See Appendix B).

2.6.11 The Leicester SFRM study for the River Soar and its surrounding tributaries further classifies flood risk into hazard bands and shows that for all return periods the majority of high hazards are contained within the banks of the River Soar. However there are some areas at risk of high

hazard within Leicester City particularly around the Waterside and Abbey meadows SRA's where during the 100 year and 100 year (plus climate change) event, areas such as Marjorie Street, Corporation Street, Repton Street, Dunton Street, Tudor Road and Abbey Gate are subjected to a high hazard risk (see mapping in Sections 5.1).

2.6.12 For a definition of hazard mapping and further information see Section 4.10.

Flooding from Groundwater

2.6.13 Based on the current hydrogeological conceptual understanding, there is potential for groundwater flooding in the LCC administrative area. Across much of the central, southern and northern districts of the Leicester City superficial deposits form a small perched aquifer over the bedrock aquiclude. In addition, the localised Valley Deposits and possibly the Glacio-fluvial deposits will behave as aquifers in localised areas. A number of potential groundwater flooding mechanisms have been identified. Of significance are those flooding mechanisms associated with the superficial aquifers and their hydraulic continuity with surface water courses.

2.6.14 The BGS has produced a data set showing areas susceptible to groundwater flooding on the basis of geological and hydrogeological conditions. The map indicates that susceptibility to groundwater flooding is very high to high in some areas where Alluvium and River Terrace Deposits are present at surface; along the course of the River Soar, and its flood plain, and along the course of the spring fed tributaries flowing from the east and the west, though the Leicester City administrative area. Areas of higher susceptibility within the City include Humberstone, areas around Abbey Park and Belgrave. The Area Susceptible to Ground Water Flooding map (AStGWF) is shown in Appendix B. Properties at most risk are those with basements / cellars.

2.6.15 No groundwater flooding incidents within the study area have been reported to the EA or LCC. It is possible that some historical incidents are groundwater flooding events or related to water table rise or spring flows. However, there is insufficient information from the data to distinguish groundwater flooding from pluvial or fluvial flooding events.

2.6.16 Although it is thought that groundwater flooding has occurred in the past, there is no local information available which provides evidence on future groundwater flood risk across Leicester and groundwater rebound is not believed to be an issue in the county.

2.6.17 Further information regarding groundwater flooding in Leicester City can be found in the Leicester City Council SWMP.

Flooding from Land

2.6.18 Surface water ponds in low lying, flat areas and, consequently, the areas at risk of deep surface water flooding during the 0.5% AEP event are generally confined to river valleys (particularly the River Soar) and drainage ditches, and at locations where there are field drains. Areas at risk of shallow surface water flooding cover a larger area and are less confined to aforementioned topographic features.

2.6.19 There is a number of reported historic surface water flooding events within Leicester City (see Table 2-1). These are generally caused by a combination of factors such as direct runoff and inadequate or blocked drainage systems. Types of drainage systems identified as being

contributing factors to surface water flood events within the study area include highway drains, stormwater drains and combined sewers.

2.6.20 The pluvial modelling results from the SWMP have been used to define Critical Drainage Areas (CDAs) and flooding hotspots throughout Leicester and it has shown that extensive areas within Leicester are potentially susceptible to pluvial flooding and shows that a significant number of properties are at risk from different depth bands (See Figure 2-2).

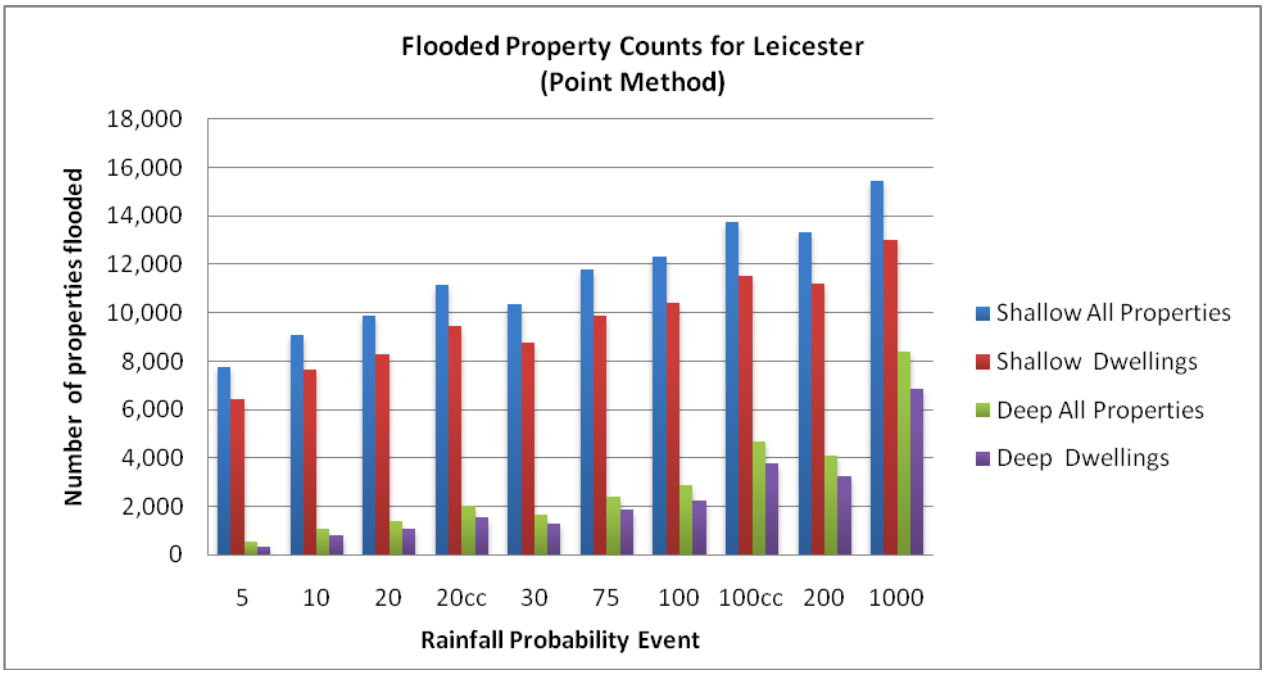


Figure 2-2: Flooded Property Counts for Leicester from Pluvial Modelling

Flooding from Sewers

2.6.21 Severn Trent Water (STW) are the statutory water undertakers within the study area and are responsible for the public sewer systems, which include surface water, foul and combined sewers. The DG5 Register for Leicester includes flooding from surface water (643 events) and foul water (636 events) and both internal flooding (66 events) and external flooding (100 events). A map of Historical Sewer Flooding is presented in Appendix B. Further information on the flooding from sewers and how this information has been used to support this SFRA is provided in Section 4.7.

Flooding from Reservoirs, Canals and Other Artificial Sources

2.6.22 Reservoir flooding is considered to be a residual risk occurring as a result of an impounding structure being overwhelmed and/or experiencing dam/embankment failure. The latter is rare but can happen suddenly and catastrophically resulting in rapidly flowing, deep water that can cause significant threat to life and major property damage downstream.

2.6.23 The residual risk (see 2.6.28) of flooding from reservoirs also includes temporary water retaining structures such as flood relief/storage basins, that could hold a significant volume of water (approximately greater than 25,000 m^3 above normal ground level). There are several notable flood storage reservoirs in Leicester (examples include the Dakyn Road basin on Bushby Brook, the Knighton Park basins on Wash Brook and the Braunstone Park basins on Braunstone Brook) and the Environment Agency has undertaken broad-scale modelling to assess the potential risk of failure for these reservoirs at the point of being at full capacity.

2.6.24 The broad-scale modelling shows that large areas of the City, following the Braunstone Brook, Wash Brook and Bushby Brook/Saffron Brook watercourse corridors could be at risk of reservoir flooding. The reservoir flood mapping is available directly from the Environment Agency on their website[9]. Further information on how the broad-scale reservoir flooding information has been used for this study can be found in section 4.8.

2.6.25 Flood risk posed by canals is at present largely un-quantified. Canals and river navigations are considered to be self maintaining controlled water bodies using various lock by-passes and weirs passing and controlling excess feeds. Incorrect use of lock gate sluices can drain pounds upstream and overwhelm pounds downstream leading to loss of water over the banks. Flood risk is however deemed to be minimal unless overtopped/submerged during storm conditions or following embankment failure.

2.6.26 The Grand Union Canal passes through Leicester and, in may instances, combines with the River Soar. There are few instances where the canal is embanked or artificially raised above surrounding ground levels. The canal passes through the Core Strategy Strategic Regeneration Area and along the Belgrave area before rejoining with a navigable reach of the River Soar and passing out of the north of the City.

2.6.27 Records from British Waterways have recorded one instance of a canal structure breach within Leicester (see historical flood record map in Appendix B). A failure of the Freemans Meadow weir, lock and sluice system was recorded in 1986, however, there is no information relating to whether flooding occurred to the surrounding area, or the consequences of this flooding.

Residual Risk

2.6.28 Residual risk is the risk that remains after all risk avoidance, reduction and mitigation measures (e.g., flood defences) have been implemented. Whilst flood risk management infrastructure, including flood defences and flood storage areas, offer significant benefits to people and property by reducing the frequency and likelihood of flooding, the risk is not removed completely.

2.6.29 Due to the spatial variation of flood risk management infrastructure located throughout Leicester City the residual flood risk varies. The EA have produced Areas Benefiting from Defences (ABD) outlines as part of the flood map for main rivers in Leicester. These areas are all subject to a residual risk of flooding as a result of overtopping or breach in the flood risk management. Other residual risks include the risk of reservoir inundation (see paragraph 2.6.22), canal breach (see paragraph 2.6.25).

[9] http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=458500.0&y=304500.0&topic=reservoir&ep=map&scale=7&location=Leicester, City of Leicester&lang=_e&layerGroups=default&textonly=off#x=458009&y=304619&lg=1,&scale=8

Critical Drainage Areas

2.6.30 Where surface water flooding has been identified, the area contributing to that flooding (including overland flow routes, underground drainage networks and watercourse catchments) is termed a Critical Drainage Area.

2.6.31 As part of the Leicester SWMP, 18 Critical Drainage Areas (CDAs) have been identified for the City using the pluvial modelling results, the sewer network plans, topography and flooding hazard (see Table 2-2 and Figure 2-3). Within each CDA, one or more Local Flood Risk Zones, or flooding hotspots, has been identified based on numbers of properties flooded and to what depth and hazard.

Table 2-2: CDAs and LFRZs / Hotspots Identified for Leicester

CDA	Flooding Hotspots
E_01 (Troon Way)	Troon Way
E_02 (Belgrave)	Belgrave Road
E_03 (Northfields)	Northfield
E_04 (Humberstone)	Forest Road
E_05 (City Centre)	Black Friars
E_06 (Station)	Nedham Street
E_07 (North Evington)	Eggington Street North Evington Colchester Road Green Lane Road
E_08 (Royal Infirmary)	Leicester Royal Infirmary
E_09 (Clarendon Park)	Oakland Road
E_10 (University)	
E_11 (Aylestone Park)	Aylestone Road
W_01 (Stocking Farm)	Redhill Way Abbey Lane
W_02 (Beaumont Leys)	Lomond Crescent
W_03 (Gorse Hill City Farm)	Alderman Richard Hallam
W_04 (Gilroes Cemetry)	Bonchurch Street
W_05 (New Found Pool)	Dane Hills Tudor Road
W_06 (Western Park)	Narborough Road North Westcoates Park
W_07 (Westcotes)	
Other Areas	The Circle Leicester General Hospital Frith Hospital

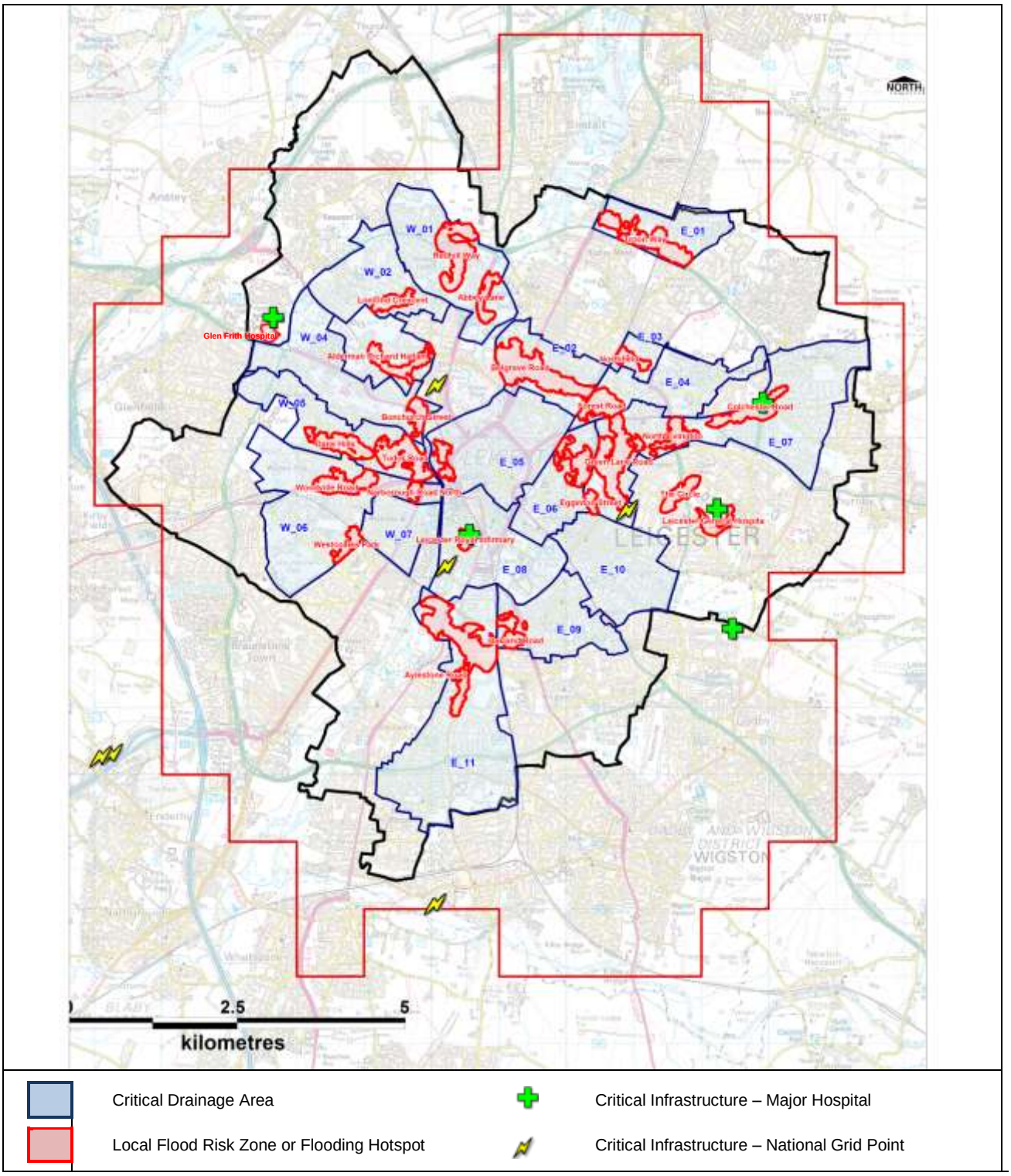


Figure 2-3: CDAs and Flooding Hotspots Identified for Leicester

Position Statement – February 2012 **Critical Drainage Areas**
Critical Drainage Areas were defined as part of the Leicester SWMP in August 2011. These are subject to change as the SWMP and local flood risk strategy continue to develop as living documents in Leicester. It should be noted that the methodology to define these CDA's is different from the CDA's as defined in the direction of flooding within PPS25/GDPO.

3 Sequential Approach to Site Allocation

3.1 Development Vulnerability

3.1.1 In order to determine the suitability of land for development in flood risk areas, the vulnerability of the proposed development must first be established. Flood Risk Vulnerability Classifications, as defined in Table D.2 of PPS25, are shown in Table 3-1.

Table 3-1: Flood Risk Vulnerability Classification

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind Turbines.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non–residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water-Compatible	• 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). • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

3.2 Flood Zone Definition

3.2.1 Flood Zones for Leicester were provided by the Environment Agency. In addition, the Environment Agency provided detailed hydraulic modelling outputs for the River Soar and a number of tributaries (Leicester City Strategic Flood Risk Mapping project).

Flood Zone 1

3.2.2 Flood Zone 1 comprises land assessed as having a less than 0.1% AEP (1 in 1000 annual probability) of river or tidal flooding in any year (low probability). All uses of land for development are considered appropriate in this zone.

3.2.3 A site-specific FRA concentrating on surface water runoff will also be required for any major development within Flood Zone 1 which exceeds 1 ha, illustrating consideration of surface water management options.

Flood Zone 2

3.2.4 Flood Zone 2 identifies the extent of flooding in a 0.1% AEP event, ignoring any formal flood defences.

3.2.5 As defined in Table 3-1 'Water-Compatible', 'Less Vulnerable', 'More Vulnerable' and 'Essential Infrastructure' land uses are considered appropriate in this Flood Zone. Subject to the application of the Sequential Test, 'Highly Vulnerable' uses are only appropriate in this zone if the Exception Test is also passed. All development proposals in this zone should be accompanied by a detailed site specific FRA.

3.2.6 Policy aims of Flood Zone 2 are such that developers and LPAs 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 sustainable drainage techniques (i.e. SuDS).

Flood Zone 3a

3.2.7 Flood Zone 3a identifies the extent of flooding in a 1% AEP (100 year) event, ignoring any formal flood defences, OR the extent of the 1% AEP event including formal flood defences if greater. This Flood Zone also includes the extent of any formal flood storage areas.

3.2.8 As defined in Table 3-1, 'Water-Compatible' and 'Less Vulnerable' land uses are appropriate in this zone. 'Highly Vulnerable' land uses should not be permitted in this zone. 'More Vulnerable' and 'Essential Infrastructure' uses should only be permitted in this zone if the Exception Test is passed. 'Essential Infrastructure' permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood. All development proposals in this zone should be accompanied by a detailed site specific FRA.

3.2.9 Policy aims of Flood Zone 3a are such that developers and LPAs should seek opportunities to:

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

Flood Zone 3b – Functional Floodplain

3.2.10 Flood Zone 3b comprises land where water has to flow or be stored in times of flood with 5% AEP (1 in 20 annual probability) or greater of river flooding in any year or is designed to flood in an extreme flood (0.1% AEP), or at another probability to be agreed between the LPA and the Environment Agency.

3.2.11 As defined in Table 3-1 only the 'Water-Compatible' and 'Essential Infrastructure' land uses should be permitted in this zone. Any permitted development within Flood Zone 3b should be designed and constructed to:

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

3.2.12 'Essential Infrastructure' in this zone should also pass the Exception Test. All development proposals in this zone should be accompanied by a detailed site specific FRA.

3.2.13 Policy aims in Flood Zone 3b are such that developers and Councils 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 sustainable drainage techniques (i.e. SuDS); and
- Relocate existing development to land with a lower probability of flooding.

Flood Zone 3b – a definition for Leicester

3.2.14 Within Leicester, it is recommended that Flood Zone 3b for the River Soar and its main river tributaries be defined using detailed modelled outputs from the Environment Agency River Soar and River Soar Tributaries hydraulic models. Where available, the 5% AEP results should be used. For all cases, the 'defended' model results should be used to define Flood Zone 3b.

3.2.15 Modelling of eight ordinary watercourses has been undertaken for the Leicester SWMP and SFRA. It is recommended that the 5% AEP results from these models be used to define Flood Zone 3b along the following watercourses:

- Hol Brook
- Queens Road Brook
- Portwey Brook
- Gilroes Brook
- Wash Brook
- Ethel Brook
- Western Park Brook
- Thurmaston Parish Dyke

3.2.16 In addition, it is understood that the Environment Agency have created a draft model of Lubbesthorpe Brook. When this has been finalised, it is recommended that the results from the 5% AEP event are used to define Flood Zone 3b along Lubbesthorpe Brook.

3.2.17 A map of Flood Zone 3b for Leicester is provided in Appendix B.

3.3 Development Vulnerability & Flood Zone Compatibility

3.3.1 Table 3-2 replicates Table D.3 from Annex D of PPS25, and illustrates a matrix of 'Flood Risk Vulnerability' of a proposed development against 'Flood Zone Compatibility'.

Table 3-2: Flood Risk Vulnerability and Flood Zone 'Compatibility'

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

✓ Development is appropriate × Development should not be permitted

3.4 The Sequential Test

3.4.1 The Sequential Test is a simple decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to areas at higher risk. Where new development is necessary in high flood risk areas, it should be directed to sites with the lowest probability of flooding and the flood vulnerability of the intended use should be matched to the flood risk of the site, e.g. higher vulnerability uses located on parts of the site at lowest probability of flooding. The Sequential Test should be applied before moving onto the Exception Test.

3.5 The Exception Test

3.5.1 Development is only permissible in areas at risk of flooding where it can be demonstrated that there are no reasonably available sites in areas of lower risk and that the benefits outweigh the risks from flooding. As such, the development must pass the Exception Test (applied by the LPA using evidence supplied by either the Level 2 SFRA or a site specific FRA), which is a method of managing flood risk while still allowing necessary development to occur.

3.5.2 Where there are no reasonably available sites in Flood Zone 1, decision makers should consider reasonably available sites in Flood Zone 2 taking into account the flood risk vulnerability of land uses and applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zone 1 or Flood Zone 2 should decision makers consider sites in Flood Zone 3, taking into account flood risk vulnerability and applying the Exception Test if required.

3.5.3 'More Vulnerable' land uses within Flood Zone 3a and 'highly vulnerable' land uses within Flood Zone 2 should only be permitted if an Exception Test has been passed.

3.5.4 Therefore the undertaking of the Exception Test will be required for any proposed residential development within Flood Zone 3a as shown in Table 3-1 and Table 3-2.

3.5.5 PPS25 states that for the Exception Test to be passed, three main criteria must be satisfied in order for the development to be considered acceptable:

> ***"Part A -*** *It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by an SFRA where one has been prepared. If the DPD has reached the 'submission' stage the benefits of the development should contribute to the Core Strategy's Sustainability Appraisal.*
>
> ***Part B –*** *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.*
>
> ***Part C -*** *A FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible will reduce the flood risk overall."*

3.5.6 For successful application it is important that the arguments presented for justification through the Exception Test are in line with policies set out in Local Plans and the LDF, supported by reference to other national planning and sustainability policies, such as development of greenfield sites.

3.5.7 LCC will need to provide evidence that ***Part A*** and ***Part B*** of the Exception Test can be satisfied; the evidence base for which should be partly informed by the Level 1 SFRA, LPA Sequential Testing and this Level 2 SFRA. This Level 2 SFRA also aims to provide some information relating to Part C of the Exception Test for the assessed sites. However, developers will be required to undertake a site specific FRA for each individual site within these wider strategic development areas to fully satisfy the requirements of Part C.

3.6 Thresholds for Application of Sequential Test and Exception Test

3.6.1 PPS25 provides guidance on the scale and vulnerability of development where a site specific FRA may be required[10]. PPS25 requires that a FRA is undertaken for all major residential developments with a site area greater than 0.5ha or greater than 10 dwellings and for non residential developments of greater than 1ha. In these instances the sequential test and, if necessary, the exception test should be also applied (see Sections 3.4 and 3.5).

3.6.2 For minor developments, i.e. those smaller than those identified within section 3.6.1, the application of the sequential test and exception test should be applied on a site by site basis based on the circumstances of the individual sites. However, as a guideline it is recommended that the sequential approach is applied to smaller developments that are discrete and separate from existing/surrounding development – for example, a new build house in the grounds of an existing house (i.e., one that will be sold on the open market). PPS25 guidance states that the sequential test need not be applied for minor developments that are attached to existing developments. Minor development within PPS25 is defined as;

[10] Department for Communities and Local Government (2006) *'Planning Policy Statement 25: Development and Flood Risk',* TSO: London, Page 9, Para 27.

- Minor non–residential extensions: Industrial/Commercial/Leisure etc. extensions with a footprint less than 250 m^2.
- Alterations: development that does not increase the size of buildings eg alterations to external appearance.
- 'Householder' development: eg sheds, garages, games rooms etc. within the curtilage of the existing dwelling in addition to physical extensions to the existing dwelling itself. This definition EXCLUDES any proposed development that would create a separate dwelling within the curtilage of the existing dwelling eg subdivision of houses into flats.

3.6.3 For the change of use of a development it is not essential to undertake the sequential test or exception test.

3.7 Additional Guidance

3.7.1 Additional guidance for the application of the Sequential Test by LPAs[11] is provided on the Environment Agency website. Furthermore the PPS25 Practice Guide provides additional guidance on the application of the Sequential Test, including guidance on the following aspects:

- Availability of alternative sites (paragraph 4.19 and 4.25);
- Regeneration areas (paragraph 4.38);
- Renewable energy projects (paragraph 4.39);
- Redevelopment of an existing single property (paragraph 4.40); and
- Change of use development (paragraph 4.42).

3.8 National Planning Policy Framework

3.8.1 In July 2011, a consultation on the draft National Planning Policy Framework (NPPF) was released. The NPPF is designed to replace existing national planning policy and aims to produce one clear, tightly focused document, setting out national priorities only where necessary to do so.

3.8.2 Following the ethos of PPS25, the NPPF aims to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk or where development is necessary, making it safe without increasing flood risk elsewhere. Like PPS25, the NPPF also requires that a the local spatial planning process must be supported by SFRAs and that policies are developed to manage flood risk, taking account of advice from the Environment Agency.

3.8.3 Similarly, it is proposed that the NPPF takes its lead from PPS25 and requires that a sequential, risk-based approach (including the sequential test and, where necessary, the exception test) to the location of development is applied to avoid flood risk to people and property and that residual risks are appropriately managed taking into account the effects of climate change.

[11] http://www.environment-agency.gov.uk/research/planning/82584.aspx

3.8.4

SFRA Position Statement – February 2012
The Leicester City SFRA has been completed in accordance with PPS25 and the current guidance outlined in the Development and Flood Risk: However, the proposed National Planning Policy Framework is due to replace Planning Policy Statements (including PPS25). The current draft of the NPPF following the same aims, objectives and ethos to managing development and flood risk. Therefore, the outputs of this study, based on PPS25, are expected to remain relevant when the NPPF comes into force. However, it recommended that the Level 2 SFRA for Leicester is reviewed when the NPPF is released to ensure that it remains relevant and applicable to Leicester.

4 Level 2 SFRA Methodology

4.1 Overview

4.1.1 As outlined in Section 1.4, the main purpose of the Level 2 SFRA is to increase the detail and level of information presented as part of the Level 1 SFRA and to provide sufficient evidence for the application of the Exception Test, if necessary. This information is presented in concise, tabular format summarising flood risk information and making recommendations for the future development of Leicester City, the Strategic Regeneration Area and other potential major development around Leicester.

4.2 Stakeholders

4.2.1 The key stakeholders that were contacted to provide data/information for the SFRA were:

- Leicester City Council;
- Environment Agency (Midlands Region);
- Severn Trent Water;
- British Waterways;
- Network Rail; and
- British Geological Survey.

4.3 Information/Data Collected

4.3.1 A large quantity of data was collected for the SWMP and SFRA. A full list of data is included in Appendix A. Key datasets are summarised below:

Environment Agency Data

4.3.2 The following data was obtained directly from the Environment Agency (Midlands region):

- Leicester City Strategic Flood Risk Mapping (SFRM) Study[12];
- Lubbesthorpe Brook hydraulic modelling and flood alleviation study report (draft);
- Aquifer typology;
- Indicative Flood Risk Areas;
- Local Resilience Forum Emergency Plans;
- Rain gaugings;
- National Flood and Coastal Defence Database (NFCDD); and
- Historic Flooding.

[12] JBA. 2010. Leicester City Strategic Flood Risk Mapping (SFRM) Study. Environment Agency.

4.3.3 The following standard Environment Agency datasets were obtained from LCC (via the Environment Agency Geostore):

- Areas Susceptible to Surface Water Flooding;
- Flood Map for Surface Water (1 in 30 and 1 in 200 year);
- Detailed River Network;
- Flood Map;
- Historic Flood Map;
- Historic Landfill;
- National Receptors Database; and
- Areas Susceptible to Groundwater Flooding.

Leicester City Council Data/Information

4.3.4 In addition to the Environment Agency datasets provided by the Council, the following data was obtained from LCC:

- Ordnance Survey (OS) maps (Mastermap, Streetview, 1:10,000, 1:50,000 and 1:250,000 scale);
- Brook Levels;
- Flood retention basins;
- Green infrastructure data;
- LiDAR data; and
- Level 1 SFRA.

Severn Trent Water

4.3.5 Severn Trent Water (ST) provided a large number of datasets for use in the SFRA and SWMP, including:

- Sewer flooding records (DG5);
- Return Period Analysis Plans;
- Sewer Flooding Capital Programme;
- Asset Records;
- Spatial Units; and
- Waste Water Treatment Works.

British Waterways

4.3.6 British Waterways provided information relating the Grand Union Canal through the study area, including details of culverts, locks, breach and overtopping and weirs.

Network Rail

4.3.7 Network Rail were consulted regarding rail drainage and assets that may affect ordinary watercourse and surface water flooding in Leicester as part of the Leicester SWMP.

Data Review

4.3.8 All of the received data has been registered on receipt and its accuracy and relevance reviewed to assess a confidence level for contribution to this Level 2 SFRA (Table 4-1). Where possible, the information/data was obtained in GIS format, or the raw data was manipulated into this format for use within the study. Details of all collected data are presented in Appendix A.

Table 4-1: Method for qualitative confidence ranking of data received

Relevance \ Accuracy	1	2	3
1	Very good	Good	Average
2	Good	Average	Poor
3	Average	Poor	Very Poor

4.3.9 Under PPS25, the risk of flooding from all sources must be considered, including flooding from rivers, land, groundwater, sewers and artificial sources (flooding from the sea is not an issue for the study area). Our methodology for the appraisal of flood risk from all sources is outlined below.

4.4 Flooding from Rivers

4.4.1 Flooding from rivers can occur as a result of the channel capacity being exceeded, a blockage occurring or as a result of culverted sections surcharging.

4.4.2 As discussed in Section 2.6, Leicester has been subject to flooding from various watercourses in past. Existing flood risk data shows that there is a significant risk of flooding from rivers to parts of Leicester (see mapping in Appendix B).

4.4.3 Three main data sources have been used to identify the risk of fluvial (river) flooding at each of the sites:

- Environment Agency Flood Map;
- LCC SWMP Ordinary Watercourse Flood maps; and
- Leicester City Strategic Flood Risk Mapping (SFRM) study.

4.4.4 The Environment Agency's Flood Map and outputs from existing hydraulic models have been used to map Flood Zones 2, 3a and 3b (functional floodplain) (see Appendix B). It should be

noted that, although most of the watercourses in Leicester are historically documented in terms of flood risk, and have been addressed as part of the EA strategic flood risk mapping programme and the LCC SWMP ordinary watercourse modelling, there are some smaller watercourses that have little or no flood risk information associated with them.

4.4.5 As described in Section 3.2, the functional floodplain floods frequently and therefore development within these areas is discouraged. Where available, the functional floodplain was defined using the 5% annual probability (1 in 20 year) event from Environment Agency river model outputs (SFRM2) and the LCC SWMP Ordinary Watercourse modelling (see Functional Floodplain map in Appendix B). Where there is no information available for the functional floodplain for a watercourse in Leicester it is recommended that the outputs from the EA broad scale flood map for FZ3a are used as a proxy until such time that the data is refined.

4.4.6 The Environment Agency National Flood Coastal Defence Database (NFCDD) has been used to identify the presence of flood defences and the associated standard of protection (SoP) for each site.

4.4.7 For each of the specific areas assessed as part of this study, maps showing the spatial distribution of the fluvial flood risk are presented in Section 5. Where applicable, detailed hazard mapping that allows planners and developers to apply the PPS25 sequential approach within a site has been provided. This can inform site layout and phasing, the vulnerability of proposed development and potential mitigation measures that can be incorporated into the site.

4.5 Flooding from the Land

4.5.1 The Pitt Review into the 2007 flood events identified the importance in quantifying the risk of flooding from land, or 'surface water' flooding. In response to the Pitt Review, the Environment Agency released Areas Susceptible to Surface Water Flooding (ASTSWF) Maps in 2008/9. The ASTSWF Maps were the first attempt (1st generation) at quantifying surface water flood risk on a national scale.

4.5.2 The Environment Agency's Flood Map for Surface Water (FMfSW) was released in 2010 and is the second generation of national surface water modelling. The FMfSW gives an indication of the broad areas likely to be at risk of surface water flooding. The Maps build upon the 1st generation data as they consider more storm events and the influence of both buildings and the sewer system. The FMfSW picks out natural drainage channels, rivers, low areas in floodplains, and flow paths between buildings. The maps only indicate flooding caused by local rainfall and do not show flooding that occurs from overflowing watercourses, drainage systems or public sewers caused by catchment-wide rainfall events or river flow.

4.5.3 There are known limitations to both the ASTSWF and FMfSW datasets. Due to the simplistic modelling techniques used in deriving the maps, they are not suitable for identifying whether an individual property will flood. In locations where surface water flooding is strongly influenced by topography, the maps may be suitable for identifying where properties are in areas at risk of flooding.

4.5.4 Though the FMfSW is the most up-to-date dataset, there may be instances where the ASTSWF dataset is more appropriate:

- Local sewer capacity is able to drain less than 6mm/hr; and

- Areas are very flat and longer storm durations are more likely to cause flooding than shorter durations.

4.5.5 As part of the Leicester SWMP, detailed direct rainfall (surface water or pluvial) hydraulic modelling has been undertaken using best practice techniques. The pluvial modelling is a further improvement on the 2nd generation FMfSW, as it includes a greater level of detail and resolution. The draft pluvial flooding map is presented in Appendix B. Details of the methodology adopted for the pluvial modelling are included in the Leicester SWMP.

4.5.6 Based on the outputs of the pluvial modelling, LCC will develop policies to manage and mitigate the associated flood risk (where feasible). Perhaps one of the most relevant uses for the pluvial modelling results is in planning and fulfilling the requirements of PPS25. In particular, the use of the "deep" flood maps can identify areas where future development should be either stepped back or that appropriate mitigation measures are taken. The maps can also identify flood flow routes and can inform planners whether a development may impede a flood flow route.

4.5.7 A summary of the suggested use for each mapped output from the pluvial modelling and advice for spatial and emergency planners is provided in Table 4-2.

Table 4-2: Pluvial Modelled Return Periods and Suggested Use in Planning Process

Modelled Return Period	Suggested Use
1 in 5 and 1 in 10 probability of rainfall event occurring in any given year (20% AEP and 10% AEP)	The 20% and 10% events are useful to demonstrate areas where frequent flooding could occur. For example, the events can inform highways maintenance and flood response plans by identifying which roads could flood frequently. The 5% can be used as a useful comparator against the fluvial functional floodplain by showing what areas of the City may be at risk from pluvial flooding during such an event. An identical event including climate change is also available. Since 1980, with the introduction of Sewers for Adoption, Severn Trent Water sewers are required to be designed to accommodate 3.3% AEP rainfall event or less. However, many of the sewers in Leicester were built pre-1980 and as such, are likely to have a lower capacity. This layer identifies areas that are prone to regular flooding. Deep flooded areas under these return periods can inform planners of areas that flood frequently. As stated above the pluvial modelling for Leicester has been undertaken at the strategic scale. Therefore until detailed local information is available to clarify flood risk careful consideration should be given to allocated development in these areas especially with regards to the existing and proposed capacity of the drainage network. It is suggested that development proposals for these areas follow the sequential approach encouraged in PPS25 and that sustainable drainage systems are incorporated in to the development. Liaison with the LCC flood risk management officers and key stakeholders such as the EA and STW are encouraged to agree mitigation measures and sustainable drainage proposals.
1 in 20 probability of rainfall event occurring in any given year (5% AEP)	
1 in 30 probability of rainfall event occurring in any given year (3.3% AEP)	
1 in 75 probability of rainfall event occurring in any given year (1.3% AEP)	In areas where the likelihood of deep flooding is 1 in 75 years or greater insurers may not guarantee to provide cover to property should it be affected by flooding. This GIS layer should be used to inform spatial planning as if property can not be guaranteed

Table 4-2: Pluvial Modelled Return Periods and Suggested Use in Planning Process

Modelled Return Period	Suggested Use
	insurance, the development may not be viable. Therefore until detailed local information is available to clarify flood risk careful consideration should be given to allocated development in these areas. Mitigation measures should be proposed to reduce the impact of flood risk to the development and the surrounding areas and increase the viability of the site. Liaison with the LCC flood risk management officers and key stakeholders such as the EA and STW are encouraged to agree mitigation measures and sustainable drainage proposals.
1 in 100 probability of rainfall event occurring in any given year (1% AEP)	Can be overlaid with Environment Agency Flood Zone 3 GIS layer to show areas at risk under the same event from both sources. Can be used to advise planning teams. PPS25 requires that the impact of climate change is fully assessed. Reference should be made to this flood outline by the spatial planning teams to assess the sustainability of developments. For flooded areas classified as deep under these return periods it is suggested that spatial planners follow a similar approach to that encouraged under PPS25 to Flood Zone 3. This will include following the sequential approach, requesting detailed site specific FRAs and adopting appropriate mitigation measures including sustainable drainage techniques. Liaison with the LCC flood risk management officers and key stakeholders such as the EA and STW are encouraged to agree mitigation measures and sustainable drainage proposals.
1 in 100 probability of rainfall event occurring in any given year (1% AEP) plus 30% climate change	
1 in 200 probability of rainfall event occurring in any given year (0.5% AEP)	To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding. Can also be used to assess areas at significant risk where large scale joint/partnered mitigation projects can be undertaken. For flooded areas classified as deep under these return periods it is suggested that spatial planners follow a similar approach to that encouraged under PPS25 to Flood Zone 3. This will include following the sequential approach, requesting detailed site specific FRAs and adopting appropriate mitigation measures including sustainable drainage techniques. Liaison with the LCC flood risk management officers and key stakeholders such as the EA and STW are encouraged to agree mitigation measures and sustainable drainage proposals.
1 in 1000 probability of rainfall event occurring in any given year (0.5% AEP)	To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding. It is recommended that spatial planners use this GIS layer to assess proposed access and egress routes to major developments. It is also suggested that the sequential approach to highly vulnerable development and critical infrastructure proposals, as classified under PPS25, should be adopted. Therefore until more detailed local information becomes available, and appropriate mitigation measures have been agreed development should be steered away from deep flooded areas. Liaison with the LCC flood risk management officers and key stakeholders such as the EA and STW are encouraged to agree mitigation measures and sustainable drainage proposals.

4.5.8 The risk of flooding from surface water was assessed for each area using the pluvial modelling results and a plan showing the spatial distribution of the risk for each site is included in Section 5. During the assessment, the pluvial modelling results were cross-checked against the AStSWF and FMfSW datasets to identify any significant differences.

4.6 Flooding from Groundwater

4.6.1 The Environment Agency released the Areas Susceptible to Groundwater Flooding (AStGWF) dataset to LPAs in March 2011. The AStGWF is a strategic scale map showing groundwater flood areas on a 1km square grid. The dataset was developed by the Environment Agency specifically for Lead Local Flood Authorities for use in Preliminary Flood Risk Assessments (PFRAs).

4.6.2 The AStGWF dataset is based on British Geological Society (BGS) data covering consolidated aquifers and superficial deposits. This data has used the top two susceptibility bands of the British Geological Society (BGS) 1:50,000 Groundwater Flooding Susceptibility Map and thus covers consolidated aquifers (sandstone etc, termed 'clearwater' in the data attributes) and superficial deposits.

4.6.3 It does not take account of the risk of groundwater flooding as a result of groundwater rebound. The dataset identifies the proportion of each 1km grid square where geological and hydrogeological conditions show that groundwater may emerge. It does not identify the likelihood of groundwater flooding occurring.

4.6.4 The susceptible areas are represented by one of four area categories (listed below) showing the percentage of each 1km^2 that is susceptible to groundwater emergence.

- < 25%;
- >= 25% <50%;
- >= 50% <75%; and
- >= 75%.

4.6.5 The AStGWF map of Leicester is presented in Appendix B.

4.6.6 An intermediate assessment of groundwater flooding susceptibility has been undertaken as part of the Surface Water Management Plan phase of the project. The report is included in Appendix C. The report includes maps and plans showing BGS historic flood incidents and BGS groundwater flooding susceptibility data. Areas classed as having ‘Very High’ or ‘High’ susceptibility have been identified. Areas where infiltration SUDS are likely to be appropriate have also been identified using BGS datasets as they have areas where a more detailed assessment will be required.

4.6.7 The available datasets have been used to qualitatively determine the risk of groundwater flooding at each Level 2 SFRA site and to identify the suitability of infiltration SUDS.

4.7 Flooding from Sewers

4.7.1 In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and waste water known as 'combined sewers'. Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity. Due to the potential for sewer flooding in urbanised areas, the data that utility companies hold on the public sewer network can be of high importance in identifying possible flood sources for an area.

4.7.2 Much of the sewer network in Leicester dates back to Victorian times and sections of the network are of unknown capacity and condition. More recent sewers are likely to have been designed to the guidelines in "Sewers for Adoption" (WRC, 2006). These sewers tend to have a design standard of up to the 1 in 30 year storm event (equating to approximately a 1 in 5 year flood flow), although in many cases, it is thought that this design standard is not achieved, especially in privately owned systems.

4.7.3 Severn Trent Water (STW) are keen to participate in flood risk management in Leicester and have agreed to share with LCC certain datasets that can assist in identifying flood sources in the city, one of which was the DG5 register of sewer flooding (terms and conditions apply due to the potentially sensitive information contained in the datasets which may mean that some data cannot be shared publicly).

4.7.4 In order to fulfil statutory commitments set by OFWAT, water companies must maintain verifiable records of sewer flooding, which is achieved through their DG5 registers. Water companies are required to record flooding arising from public foul, combined or surface water sewers and identify where properties have suffered internal or external flooding. The DG5 register does not however indicate areas or properties at risk of future flooding.

4.7.5 DG5 registers from Severn Trent Water were analysed to investigate the occurrence of sewer flooding incidents across Leicester. As highlighted in section 2.6.21, sewer flooding has been recorded at numerous locations in the study area. This includes both surface water (643 events) and foul water (636 events) and both internal (66 events) and external flooding (100). A map of the DG5 records is presented in Appendix B.

4.7.6 It is important to note that the DG5 register indicates areas reported to STW that have experienced flooding in the past (typically the last 10 years) as a result of insufficient hydraulic capacity in the sewer network. The flood records provided could be misleading as they may not be a complete and accurate record of flood events in the study area as some minor flooding incidents may go unreported, particularly if no property is affected by internal flooding.

4.7.7 Furthermore, maintenance work may have been undertaken by STW since the flooding incident(s) occurred. Sewer flooding models provide a much more detailed and useful appreciation of the risk posed. However much of this work is not yet publicly available due to commercially sensitive issues or the Data Protection Act (1998).

4.7.8 Until more detailed and suitable data becomes available, LCC, the EA and STW have agreed to continue to liaise to determine how sewer flooding data can best be used to inform flood risk management in Leicester.

4.8 Flooding from Reservoirs, Canals and Other Artificial Sources

4.8.1 The locations of reservoirs, canals and artificial flood sources have been identified using Environment Agency and Ordnance Survey data.

4.8.2 The Fluvial Flood Zones, Historical Flood and Defences figure in Appendix B shows the location of the Environment Agency flood storage areas in Leicester City. As stated in section 2.6.22, these include Bushby Brook flood relief basin located at Ordnance Survey National Grid Reference (OSNGR) SK 638 304 and Pulford Drive flood relief basin located at NGR SK 650 304, Knighton Park playing fields located at NGR SK 605 300 and Braunstone Park Lake located at OSNGR SK 558 028. The EA have undertaken broad-scale modelling to assess what the potential risk of breach or catastrophic failure could be on some of these flood storage reservoirs. The broad-scale modelling shows that large areas of the City, following the Braunstone Brook, Wash Brook and Bushby Brook/Saffron Brook watercourse corridors could be at risk of reservoir flooding.

4.8.3 EA broad-scale mapping has been used to assess whether the Level 2 SFRA areas could be at risk from reservoir flooding. It is important to note that the risks are residual and should not be interpreted as an actual risk. Although the consequences failure have been broadly assessed by the EA, the probability of failure has not. For this reason, it should be noted that the maps themselves are not intended to be used for development planning purposes - their primary purpose is for emergency planning.

4.8.4 However it is suggested by the EA that they may be a helpful tool for identifying where assessment of risk from reservoirs needs consideration within a site specific Flood Risk Assessment. Furthermore, it should also be noted that some areas outside of the mapped extents may still be at risk if the manner of reservoir failure differs from that assumed in the mapping. Therefore the mapping should not be the only tool to identify the need for further assessment and that local knowledge and data should also be used.

4.8.5 The Grand Union Canal passes through the study area, orientated north-south. Using British Waterways data, OS mapping and LiDAR data, reaches of the canal that are in close proximity to Level 2 SFRA sites have been assessed to determine the potential risk of breach or overtopping. However, given the close interaction between the River Soar and the canal, flood risk to surrounding areas is dominated by the River Soar.

4.9 Consideration of Climate Change

The impacts of climate change

4.9.1 The impact of climate change on local flood risk is relatively poorly understood. There was consensus amongst climate model projections presented in the IPCC fourth assessment report for northern Europe suggesting that in winter high extremes of precipitation are very likely to increase in magnitude and frequency. These models project drier summers with increased chance of intense precipitation — intense heavy downpours interspersed with longer, relatively dry periods (Solomon et al., 2007).

UKCP09

4.9.2 According to EA guidance for PFRAs, United Kingdom Climate Projections 2009 (UKCP09) provides the most up to date projections of future climate for the UK (http://ukclimateprojections.defra.gov.uk/). In terms of precipitation, the key findings are:

- By the 2080s, under Medium emissions, over most of lowland UK central estimates are for heavy rain days (rainfall greater than 25 mm) to increase by a factor of between 2 and 3.5 in winter, and 1 to 2 in summer.
- By the 2080s, under Medium emissions, across regions in England & Wales the central estimate (50% probability) for winter mean precipitation % change ranges from +14 to +23. Central estimate for summer mean precipitation % change ranges from -18 to -24.

4.9.3 Certain key processes such as localised convective rainfall are not represented within this modelling so there is still considerable uncertainty about rarer extreme rainfall events for the UK. There is greater certainty that heavy rainfall will intensify in winter compared to summer. The proportion of summertime rainfall falling as heavy downpours may increase. However, the impact of these changes on local flood risk is not yet known.

UKCIP02

4.9.4 The PPS25 Practice Guide (section 3.97) notes that pending further work being carried out by Defra and the Environment Agency regarding the impacts of new UK Climate Projections (UKCP09) released in 2009, the UKCIP02 projections are considered adequate. Until the impacts are more certain and guidance is available on the use of the UKCP09 outputs for development and flood risk, the impacts of climate change for the SFRA have been approached in line with PPS25.

4.9.5 PPS25 currently uses the climate projections given in the UK Climate Change Impacts Programme (UKCIP02) and recommends a 20% increase in peak river flow. A 20% increase has therefore been used in river modelling to assess the impacts of climate change. PPS25 also recommends an increase in rainfall intensity of up to 30% to take into account the effects of more intense downpours. Consequently, pluvial modelling has used an increase in intensity of 30% to assess the effects of climate change on flooding from the land.

4.9.6 Available Environment Agency hydraulic modelling outputs that include climate change scenarios have been used to define the increased fluvial flood risk as a result of climate change. Hydraulic modelling (Ordinary Watercourse and pluvial) undertaken as part of this study have included a climate change horizon in line with PPS25.

4.10 Flood Mapping

4.10.1 Flood risk has been mapped in several ways for this study including flood extents, velocity, depth and hazard. A description of each is displayed in Table 4-3 below:

Table 4-3: Description for Type of Flood Risk Mapping

Type of Fluvial Flood Risk Mapping	Description
Flood Extents	Displaying the maximum flood extents for fluvial flooding (including Ordinary Watercourse and Main River modelling) and pluvial flooding.
Velocity	Thematically displaying the flow speeds associated with flooding.
Depth	Thematically displaying the depths associated with flooding.
Hazard	Thematically displaying hazard as a function of depth.

Flood Extent Mapping

4.10.2 Flood extent mapping shows the maximum extent of the flood outline that will occur from each return period.

4.10.3 Extents maps, including the outputs from the EA SFRM2 study are shown in Appendix B and in Section 5. Other mapped outputs were used as part of this study (including the reservoir inundation maps) and are available from the EA. Flood extent maps for the ordinary watercourse modelling have also been produced for Leicester as part of the SWMP.

Flood Depth Mapping

4.10.4 Flood depth mapping shows the depths that occur from each flood event. Surface water flooding was mapped using results from the pluvial modelling for two events – the 1 in 30 year and the 1 in 200 year. For both events, depths were classified into two depth classifications as shown in Table 4-4.

Table 4-4: Depth mapping classification for pluvial mapping

Maximum Depth of Flooding (m)	Classification
>=0.1 - 0.3	Shallow
>0.3	Deep

4.10.1 Flood depth mapping for the ordinary watercourses modelled as part of the Leicester SWMP has also been produced. Mapping for each ordinary watercourse has been produced for five events (1 in 20, 1 in 20 + climate change, 1 in 100, 1 in 100 + climate change and the 1 in 1000 year events) using five classifications of depth as shown in Table 4-5.

Table 4-5: Depth mapping classification for ordinary watercourse mapping

Depth of Flooding (m) Classification	
0 m	< 0.25 m
0.25 m	< 0.50 m
0.50 m	< 0.75 m
0.75 m	< 1.0 m
> 1.0 m	

4.10.2 Flood depth maps are shown in Appendix B.

Velocity Mapping

4.10.3 Velocity mapping displays the varying speeds of the flood waters. The modelling results were thematically mapped in GIS (MapInfo) according to the following maximum velocity classifications as defined in Table 4-6.

Table 4-6: Velocity mapping classification for ordinary watercourse modelling

Maximum Velocity of Flooding (ms^{-1})
0-<0.1
0.1-<0.2
0.2-<0.3
0.3-<0.4
>0.4

4.10.4 Velocity maps for modelled ordinary watercourse have been produced and are presented in the Leicester SWMP.

Hazard Mapping

4.10.5 Flood hazard mapping has been produced for the pluvial modelling and for the ordinary watercourse modelling undertaken as part of the Leicester SWMP. Flood hazard mapping focuses on safety to people and highlights areas that experience flooding that may pose a danger to human life. Hazard mapping can be a useful spatial and emergency planning tool and can assist in identifying whether development is considered 'safe' in the context of PPS25 Annex D the Exception Test.

4.10.6 The pluvial modelling has shown that low lying areas (in particular along the river corridors) in Leicester City could experience a high hazard rating of 'Danger to All'. The flood hazard maps can be used to highlight areas within development sites of medium or high hazard where development should be steered away so as not to increase the population at risk.

4.10.7 The flood hazard maps also highlight areas that would be considered a risk for emergency service infrastructure should a flood occur. High hazard areas can affect the flood response of the emergency services. These areas would also be considered dangerous to people that

needed to escape hazardous flooded areas and therefore development in high hazard zones should be avoided.

4.10.8 Guidance set out by Defra (2005)[13] categorises the flood hazard as a function of depth and velocity as shown in Table 4-7 below.

4.10.9 The flood hazard rating (HR) is calculated as a function of depth, velocity and debris factor based on Defra (2006)[14] using the following equation:

$$Flood\ Hazard\ Rating = ((v + 0.5) \times D) + DF$$

Where:

v = *velocity* (ms^{-1})
D = *depth (m)*
DF = *debris factor (0, 0.5, 1 depending on probability that debris will lead to a hazard)*

4.10.10 A guide to the different groups/vulnerabilities of people that should be considered as falling into each of the danger classifications based on this Hazard Rating[15] is provided in Table 4-8.

Table 4-7: Danger to people relative to different combinations of flood flow Depth and Velocity

Velocity (m/s)	Depth of flooding (m)											
	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00												
0.10												
0.25												
0.50												
1.00												
1.50												
2.00												
2.50												
3.00												
3.50												
4.00												
4.50												
5.00												

Key:
Danger for some
Danger for most
Danger for all

**Taken from Table 13.1 of the Defra/EA FD2320/TR2 report13.*

[13] Defra and Environment Agency. October 2005. '*Framework and Guidance for Assessing and Managing Flood Risk for New Development*', Flood Risk Assessment Guidance for New Development. FD2320 R&D Technical Report 2. Defra London. Table 13.1, Pg. 118.
[14] Defra and Environment Agency. March 2006. *'Flood Risks to People – Methodology'*. Flood Risks to People Phase 2. FD2321 R&D Technical Report 1. Defra London. Table 3.2 Pg. 8.
[15] Environment Agency and HR Wallingford. May 2008. *'Supplementary Note on Flood Hazard Ratings and Thresholds for Development and Planning and Control Purpose'*. Table 2, Pg. 4. http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/FD2321_7400_PR_pdf.sflb.ashx

Table 4-8: Hazard to People as a Function of Velocity and Depth
(Adapted from Table 2 of EA/HR Wallingford 2008 Supplementary Note[15])

HR Threshold (d x (v + 0.5)) + DF) =	Degree of Flood Hazard	Danger Classification
0.75 - 1.25	Moderate	**Danger for Some** (i.e. children, the elderly and the infirm) "Flood zone with deep or fast flowing water"
1.25 - 2.5	Significant	**Danger for Most** people (includes the general public) "Flood zone with deep fast flowing water"
>2.5	Extreme	**Danger for All** (includes emergency services) "Flood zone with deep fast flowing water"

4.10.11 Using the above information, the flood risk within and across Flood Zones at a site can be determined. This allows policies and guidelines to be developed that place less vulnerable development and water compatible land use (for example, playing fields and other green infrastructure) in areas of higher risk, whilst development of higher vulnerability is placed in areas of lower flood risk.

4.10.12 Relevant extracts of hazard mapping are presented for each of the areas assessed as part of this study in Section 5. Full suites of pluvial and ordinary watercourse hazard maps are presented in the Leicester SWMP. Main River hazard mapping for the River Soar and Tributaries can be obtained from the Environment Agency.

5 Level 2 Strategic Flood Risk Assessment

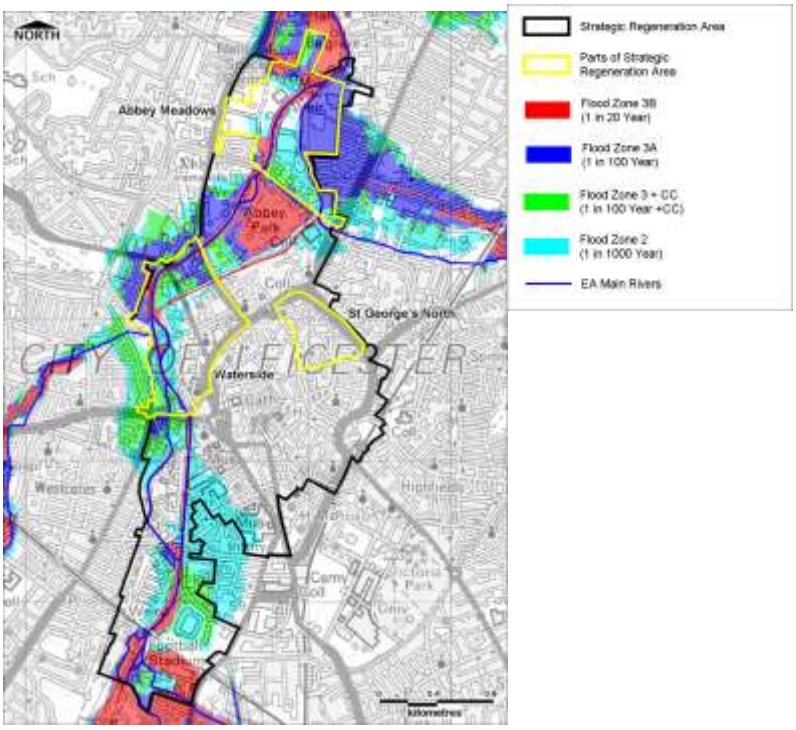
5.1.1 For information regarding potential major development around Leicester please see Appendix D.

5.1 Strategic Regeneration Area

Site Information	
Area Overview	A large regeneration area in the City Centre. The area follows the River Soar/Grand Union Canal corridor and has key transport links into and out of the City.
Existing Use and Topography	As the SRA is situated in along the main River Soar valley, the topography is generally flat. The area is densely populated and heavily urbanised with a mix of land uses from residential and recreational to commercial and industrial.

5.1 Strategic Regeneration Area

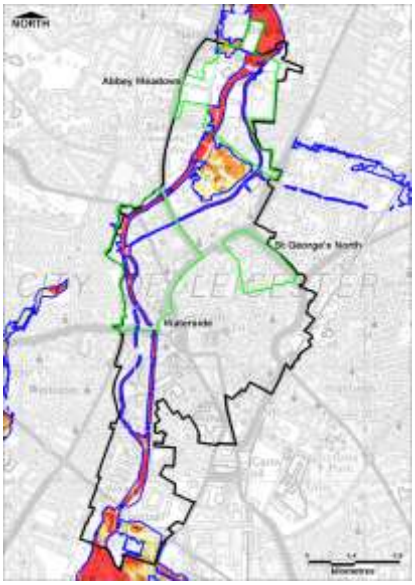
Proposed Use and Vulnerability Classification	The Strategic Regeneration Area will be the focus of major housing development and physical change to provide the impetus for economic, environmental and social investment and provide benefits for existing communities. A mix of uses is proposed for the SRA including: • Leisure uses to broaden the City's offer; • Housing, both to meet a housing need and to provide a City Centre residential population that will stimulate and sustain an even broader range of retail, leisure, education and cultural services; • A science and innovation park to allow the City's Universities to forge links with business; • Future developments associated with De Montfort University campus; • A range of small workspaces, studios and offices to support the small firm economy in manufacturing, creative industries and services; and • Major new office development, to attract Regional and National office occupiers.
Sources of Flood Risk	
Rivers	The River Soar is the main river flowing through the SRA. The main tributaries joining the Soar within the SRA boundaries include the Braunstone Brook, Willow Brook and Saffron Brook. Large areas of the SRA fall within Flood Zones 2, 3a and 3b - a fluvial flood map for the SRA is presented in Appendix B.



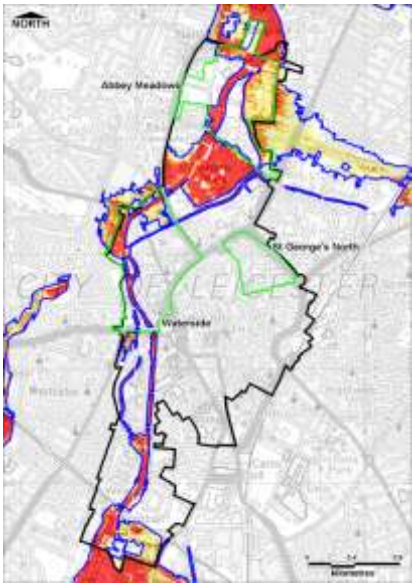
5.1 Strategic Regeneration Area

Flood Hazard mapping has been created from the outputs of Environment Agency detailed modelling using the hazard ratings developed by the Defra R&D (FD2320) project. As can be seen from the maps below, the greatest hazard, and therefore greatest flood risk is to the east of the site, where, during a 1% AEP event including climate change, floodplain depths exceed 1.5m and therefore present a 'danger to all'.

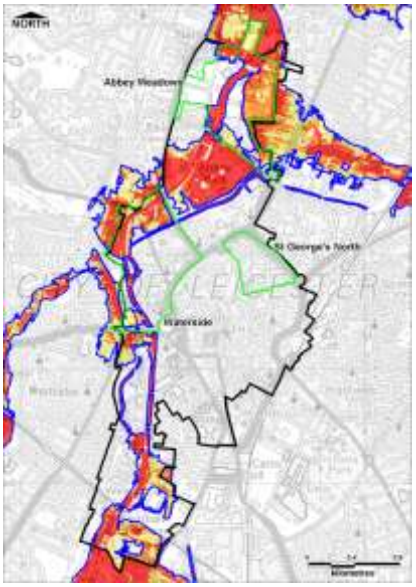
5% AEP
(20 year – FZ3b)



1% AEP
(100 year – FZ3a)



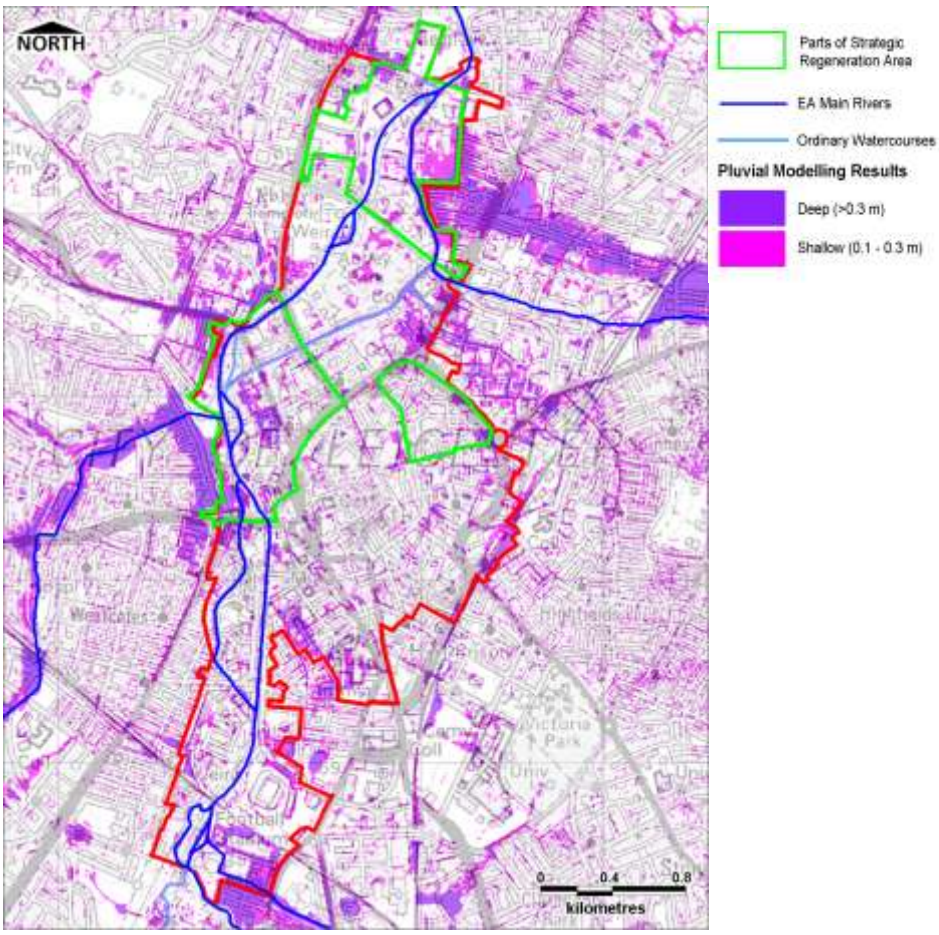
1% + CC AEP
(FZ3a including Climate Change)



Degree of Flood Hazard	Description
Low	**Caution** "Flood zone with shallow flowing water or deep standing water"
Moderate	**Danger for Some** (i.e. children, the elderly and the infirm) "Flood zone with deep or fast flowing water"
Significant	**Danger for Most** people (includes the general public) "Flood zone with deep fast flowing water"
Extreme	**Danger for All** (includes emergency services) "Flood zone with deep fast flowing water"

The flood hazard maps highlight the areas that experience the greatest threat of danger to human life during a flood event. Extremely hazardous areas can restrict the emergency services flood response and the ability of people to escape flooded areas.

5.1 Strategic Regeneration Area

Surface water	Pluvial modelling results indicate that parts of the SRA are at risk of flooding from surface water runoff. The main areas affected include parts of the Waterside area, the eastern extent of Abbey Meadows, parts of the proposed New Business Quarter (railway station in particular) and St. Georges South, areas around the Royal Infirmary and University and the southern extent of the SRA around Aylestone Road and Boundary Road. Access and egress to these areas may therefore be affected during and following heavy and prolonged rainfall events. Environment Agency and LCC Histriocal Flood Maps (HFMs) illustrate that there have been a variety of historical incidents of surface water flooding reported within the SRA (see historical flood map in Appendix B). A pluvial flood map for Leicester, including the SRA, is presented in Appendix B. more information on pluvial flooding can be found in the Leicester SWMP.
	

5.1 Strategic Regeneration Area	
Groundwater	The varying topography across Leicester results in a varied groundwater flood risk across the City centre and the SRA. The hydrogeology assessment (Appendix C) has identified that areas of low-lying ground in the SRA have a higher susceptibility to groundwater flooding. Groundwater flooding incidents are thought to have occurred in Leicester in the past and have affected basements, cellars and other underground facilities. However, according to LCC, it is often unclear as to whether the flooding is caused as a result of high groundwater levels or as a result of nearby drainage and distribution networks (burst water pipes, broken sewers etc.) or other local factors.
Sewers	The majority of Severn Trent sewers within the SRA are separate foul and combined systems. There are also some combined sewers serving the area. The STW DG5 register identifies a number of sewer flooding incidents within and adjacent to the SRA boundary. The recorded incidents were caused by blocked gullies and drains in the local area. The historical sewer flood map for Leicester is presented in Appendix B.
Artificial Sources	The Grand Union Canal flows through the SRA, orientated north to south. The canal is not embanked through the SRA and therefore the residual risk of a breach is considered to be low. There is an arrangement of hydraulic structures on the canal and the river through the SRA. The management of these locks, weirs and sluices during flood events may affect flood levels at the site. There are no reservoirs in the immediate vicinity of the SRA. However, there are several flood storage reservoirs on tributaries of the Soar including Braunstone Brook, Wash Brook and Saffron Brook. A review of the Environment Agency's Online Reservoir Flood Map shows parts of the SRA to be at residual flood risk in the event of a breach in flood storage basins on Braunstone Brooke, Willow Brook and Saffron Brook. .
Flood Defence Infrastructure	
There are a variety of flood defence assets across Leicester City including raised embankments, weirs, flood walls, maintained channels, culverts, flood storage areas, pumping stations and sluices.	
Climate Change	
The Environment Agency's Leicester City SFRM study modelled the effects of climate change on river flooding during the 1% AEP event, assuming a 20% increase in river flows (in line with PPS25). The effect is increased flood depths across the site, though the total flood extent is not significantly increased. Final pluvial model results show that surface water flooding to the area is increased as a result of climate change. Depths and extents are increased and this should be examined in more detail during a site-specific FRA.	

5.1 Strategic Regeneration Area

Residual Flood Risks

Residual flood risks in the SRA are dependent on where specific sites fall within the SRA.

If a site were to be allocated in close proximity to the Grand Union Canal there is a residual risk of flooding from structural failures. There are a number of structures present where the canal and River Soar interact. These sluices and weirs control water levels in the canal. It is important to consider that these structures may present a residual flood risk due to incorrect operation, mechanical failure or poor maintenance.

There are a number of bridge crossings of the River Soar and Grand Union Canal. These crossings may become blocked with debris, particularly during flood flows. These structures therefore present a residual risk of blockage.

A review of the Environment Agency's Online Reservoir Flood Map shows parts of the SRA to be at residual flood risk in the event of a breach in flood storage basins on Braunstone Brook, Willow Brook and Saffron Brook.

Recommendations and Policies

- It is recommended that a consistent suite of flood risk policies is implemented for all developments in the SRA that follow PPS25.
- When producing development proposals and site specific FRAs use all sources of information including the SWMP/PFRA etc.
- Following the application of the sequential and, if necessary, the exception test, if development pressures create a need to develop the areas of the SRA that are at risk of flooding (i.e., Flood Zones 2 and 3, or areas of deep pluvial flooding) – especially those areas that experience high hazard ratings during a 1% AEP event – they should incorporate appropriate mitigation measures and must not increase the risk of flooding to surrounding areas. Careful liaison with the Environment Agency and the LLFA will be necessary during the design and planning process.
- If applicable the Environment Agency's Flood Warning Area should be extended to include those parts of the SRA that fall within Flood Zone 3a and it is essential that any new developments should agree to this prior to development consent.
- Flood volume displaced as a result of development within the Flood Zone 3a plus an allowance for climate change envelope must be compensated for else where within the SRA boundary on a 'level for level' and 'volume for volume' basis.
- Where future development is proposed, sewer networks may need to be upgraded to ensure sufficient capacity is maintained. The effects of climate change may also place further pressure on sewer systems with predictions of milder wetter winters and increased rainfall intensity in summer months. This combination is likely to result in more frequent sewer flooding. Developers should consult with Severn Trent Water to establish what capacity there is and provide evidence as part of their site specific FRA's of any agreements.
- Residual risk from flood risk infrastructure must be considered during evaluation of suitable sites for development allocation – including the risk of reservoir flooding.
- Surface water / pluvial flood risk should also inform the site layout, such that 'highly vulnerable' development is avoided in locations that are shown at the greatest risk of pluvial flooding.

5.1 Strategic Regeneration Area

Recommendations and Policies (cont)

- As the SRA is primarily brownfield, it is unlikely that any development within the area will increase surface water runoff. However, to ensure a sustainable approach to development, SUDS should be implemented to reduce runoff rates and volumes from the developed site, thus reducing the resultant flood risk posed to sites within the SRA itself and adjacent/downstream areas. Incorporating SuDS into green open spaces and other green infrastructure can help to promote multi-use green infrastructure and reduce flood risk.
- A review of BGS data shows that parts of the site (in the vicinity of the National Space Centre) may be suitable for infiltration SUDS, subject to detailed site investigations. There is a historic landfill to the east of the National Space Centre and infiltration SUDS should be avoided in this area to prevent contamination of groundwater.

FRA Guidance

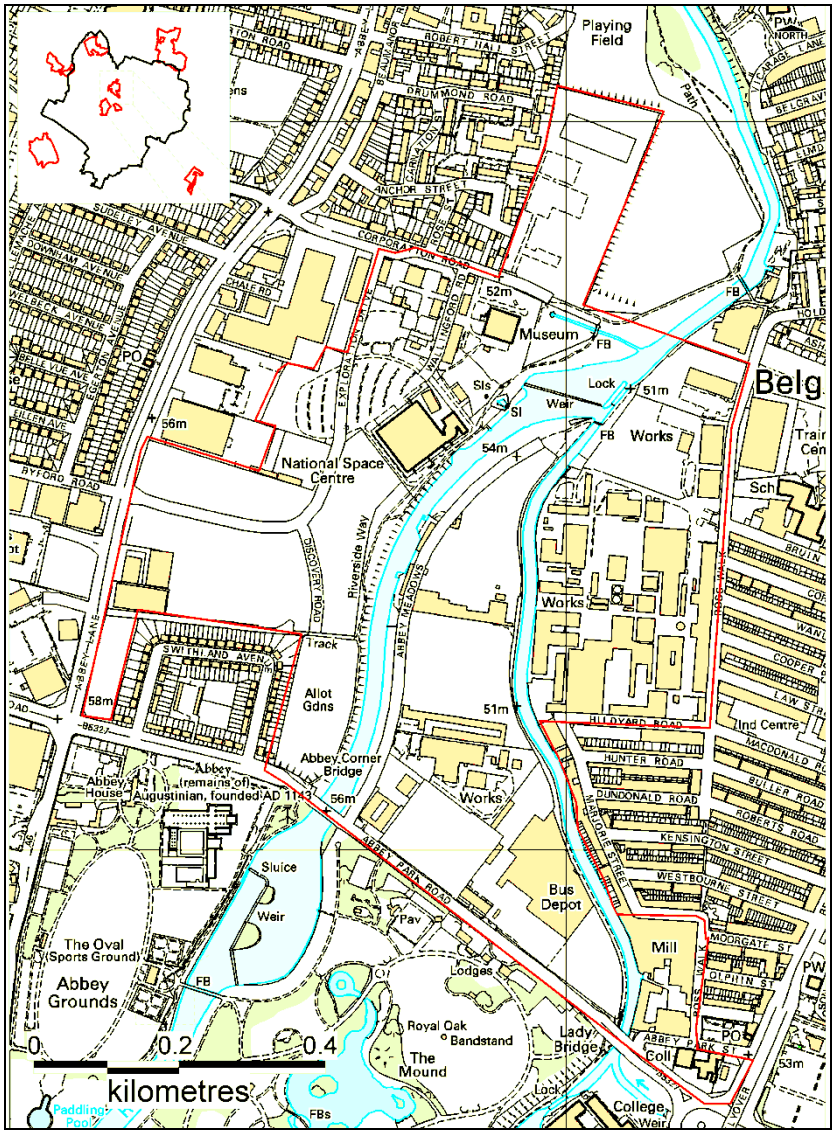
- A site-specific FRA will be required for any development proposed within the SRA that falls wholly or partly within Flood Zones 2 and 3. For sites that do not fall within Flood Zones 2 and 3 (i.e., they are wholly located within Flood Zone 1), an FRA will be required for any development in excess of 1 ha. The FRA will need to consider surface water management.
- To ensure sustainable development, the rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The site specific FRA and drainage strategy should present workable solutions and designs for SuDS on the site. Designs need to be approved by the Leicester SAB.
- Maximum fluvial flood levels for the SRA should be informed by the most up-to-date versions of the Environment Agency's hydraulic models of Braunstone Brook, Saffron Brook, Willow Brook and the River Soar. It is important to note that in some parts of the SRA, the River Soar produces the greatest flood levels, whilst for other parts, Willow Brook, Braunstone Brook and Saffron Brook present the greatest flood levels.
- If, following the sequential and exception tests, development within areas designated as Flood Zone 3 including an allowance for climate change is justifiable:
- Any fluvial flood volume displaced as a result of development must be compensated for on a 'level for level' and 'volume for volume' basis elsewhere within the site boundary, but outside the envelope of Flood Zone 3a including an allowance for climate change. This should be demonstrated using hydraulic modelling.
- Appropriate mitigation and resilience measures should be incorporated both on an individual property-level (such as flood resilient construction) and at a strategic level (such as strategic SUDS or compensatory flood storage).
- A site specific FRA should demonstrate that consideration has been given to the site layout with regards to flood risk from all sources, in line with the recommendations above (sequential approach to site layout).

5.1 Strategic Regeneration Area

FRA Guidance (cont)

- The rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques.
- Appropriate mitigation measures should be incorporated that should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.
- The residual risks identified above (including reservoir flooding) should be adequately investigated and assessed as part of the FRA and mitigation measures implemented accordingly.
- Due to the varying susceptibility of the SRA to groundwater flooding, the risk of groundwater flooding should be quantified by undertaking site-specific investigations. Suitable mitigation measures should be implemented if the investigations show that there is a risk of groundwater flooding, including flood resilient measures and avoiding basements in buildings.

5.2 Core Strategy Policy CS4: SRA - Abbey Meadows



Site Information	
Grid Reference	SK 588 062
River Catchment	River Soar
Site Area	57.5ha

5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

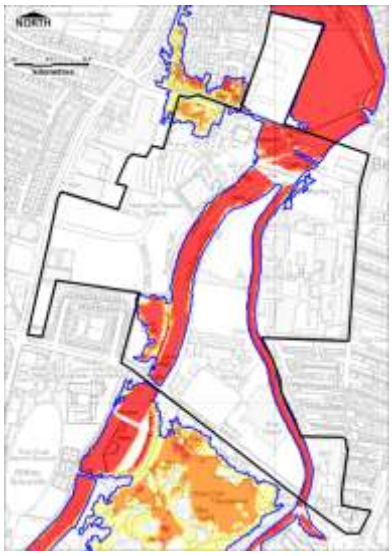
Existing Use and Topography	Abbey Meadows SRA is located in central Leicester close to the existing communities of Belgrave and Stocking Farm. The site is predominantly occupied by commercial properties, and is therefore brownfield. Abbey Lane, Abbey Park Road, Ross Walk and Corporation Road respectively form the western, southern, eastern and northern boundaries of the site. The western and eastern boundaries of the site are predominately formed by existing residential developments. The River Soar and Grand Union Canal flow through the centre of the site in a northerly direction. The site topography slopes generally towards the river from 56.19m in the west and 53.23m AOD in the east to 50.2m AOD at the river.
Proposed Use and Vulnerability Classification	Abbey Meadows falls within the Strategic Regeneration Area of the local authority and is identified in the Core Strategy (Policy CS4) as a key area for delivering economic growth and residential development in the City. It is anticipated that around 2,506 dwellings will be developed in this area (at Wolsley Island, the former BUSM site at Ross Walk and Abbey Meadows West) to accommodate future housing targets. It is understood that work is underway on the construction of around 500 homes on former brownfield land within the Waterfront Abbey Meadows area. In terms of economic development, the Core Strategy indicates that a Science and Innovation Park will be created in the Abbey Meadows area to cater for a research, development and technology based business (Use Class B1b); Innovation Centre Building (Use Class B1a, b and c); Associated Educational Use (D1) and Associated Research Institute (No Use Class). Under PPS25, such residential developments are classed as 'more vulnerable' and the employment uses identified are classed as 'more vulnerable' for the Associated Educational Use (D1) and 'less vulnerable' for the other identified employment uses. These vulnerability classifications are considered appropriate in Flood Zones 1 and 2. For both the residential and the Associated Educational employment use, the Exception Test must be applied for areas falling within Flood Zone 3a.
Sources of Flood Risk	
Rivers	The River Soar and Grand Union Canal flow through the site in a northerly direction. The confluence of Willow Brook with the River Soar is located just beyond the southern site boundary. The Environment Agency's Strategic Flood Risk Mapping (SFRM) study covers the watercourses in the vicinity of the site and has been used to define the risk posed by rivers. **River Soar** In the defended scenario, Flood Zone 3b covers the area in the south of the site currently occupied by allotments and a small area in the north west of the site to the north of the National Space Centre. The entire area to the east of the Grand Union Canal is located within Flood Zone 3a. The majority of the site is located within Flood Zone 2, except for high ground to the west of the River Soar. In some parts of Flood Zone 3a, the maximum modelled flood depths for the 1% AEP event are greater than those from Willow Brook and vice versa.

5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

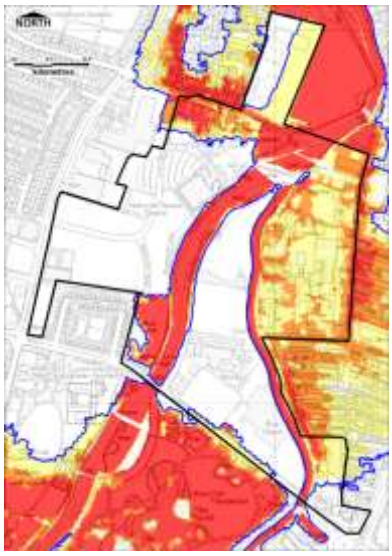
Rivers	At the confluence of the River Soar with the Grand Union Canal in the north of the site, there are hydraulic structures (weirs and locks) that may affect river flood levels at the site. In addition, just upstream of the site there is a sluice and weir arrangement that may affect flood levels passing downstream towards the site. A beam bridge carries Abbey Park Road over the River Soar at the southern boundary. This may also affect flood flows at the site. **Willow Brook** Flood Zone 3b associated with Willow Brook only affects the areas of the site immediately adjacent to the eastern site boundary. The entire site area to the east of the Grand Union Canal is located within Flood Zone 3a. In some parts of flood zone 3a, the maximum modelled flood depths for the 1% AEP event are greater than those from the River Soar and vice versa. The Environment Agency Historical Flood Map indicates that flooding has occurred in the vicinity of the River Soar and Grand Union Canal confluence at the northern boundary of the site. A small area of the site, to the south of the National Space Centre and the west of the River Soar, is located within an Environment Agency Flood Warning Area ('The River Soar at Belgrave' and 'The River Soar at Stocking Farm') and Flood Watch Area ('Upper Soar Catchment').

Flood Hazard mapping has been created from the outputs of Environment Agency detailed modelling using the hazard ratings developed by the Defra R&D (FD2320) project. As can be seen from the maps below, the greatest hazard, and therefore greatest flood risk is to the east of the site, where, during a 1% AEP event including climate change, floodplain depths exceed 1.5m and therefore present a 'danger to all'.

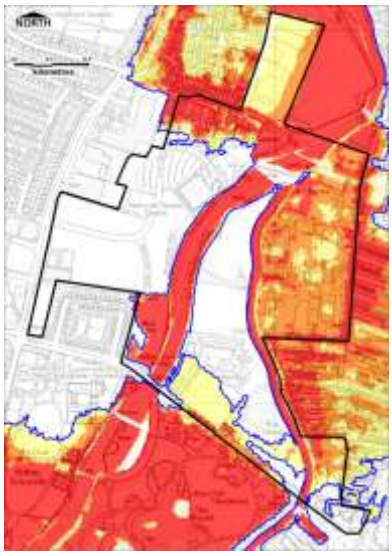
5% AEP
(20 year – FZ3b)



1% AEP
(100 year – FZ3a)



1% + CC AEP
(FZ3a including Climate Change)



5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

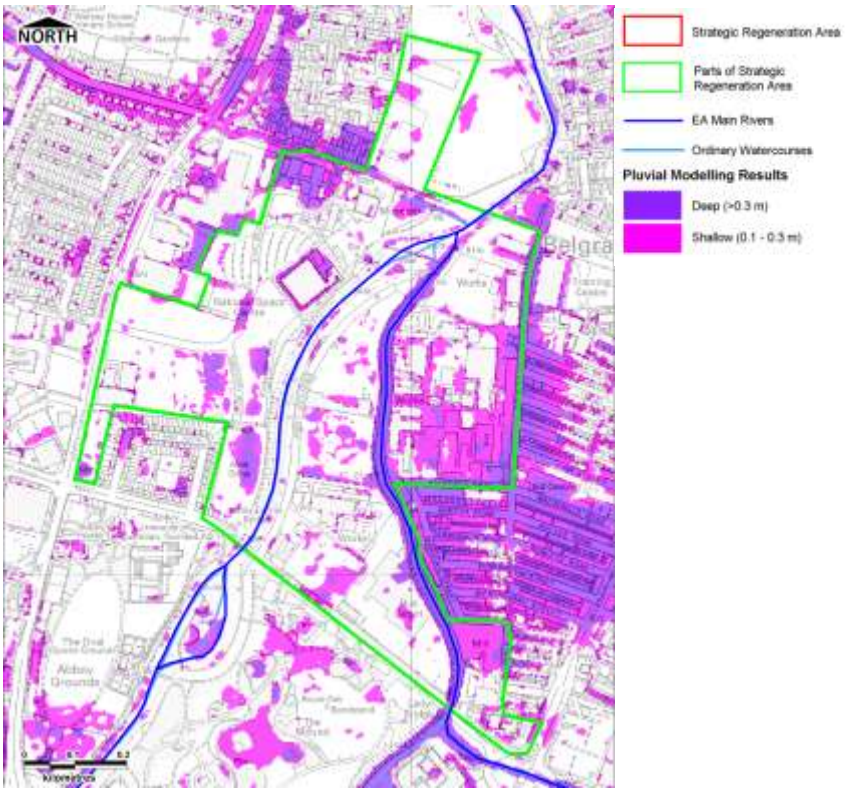
Degree of Flood Hazard	Description
Low	**Caution** "Flood zone with shallow flowing water or deep standing water"
Moderate	**Danger for Some** (i.e. children, the elderly and the infirm) "Flood zone with deep or fast flowing water"
Significant	**Danger for Most** people (includes the general public) "Flood zone with deep fast flowing water"
Extreme	**Danger for All** (includes emergency services) "Flood zone with deep fast flowing water"

The flood hazard maps highlight the areas that experience the greatest threat of danger to human life during a flood event. Extremely hazardous areas can restrict the emergency services flood response and the ability of people to escape flooded areas.

Surface water

The pluvial modelling results indicate that the risk of flooding from surface water runoff is greater in low-lying areas of the site, particularly adjacent to the east bank of the Grand Union Canal and to the north of the National Space Centre.

Environment Agency and LCC Historic Flood Maps illustrate that there have been no historical incidents of surface water flooding reported at the site.



5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

Groundwater	The majority of the site is considered to have a 'very high' susceptibility to groundwater flooding. There are a number of recorded groundwater flooding incidents within the site boundary (in the vicinity of the National Space Centre and at the eastern boundary), as well as in the local area.
Sewers	The site is currently served by separate foul and surface water Severn Trent sewers. The Severn Trent Water DG5 register identifies a number of sewer flooding incidents adjacent to the site boundary. This flooding has been caused by blocked gullies and drains in the local area.
Artificial Sources	The Grand Union Canal flows through the centre of the site, orientated north to south. The canal is not embanked through the site and therefore the residual risk of a breach is considered to be low. There is an arrangement of hydraulic structures at the confluence of the canal and the river towards the north of the site. The management of these locks, weirs and sluices during flood events may affect flood levels at the site. There are no reservoirs in the immediate vicinity of the site. However, there are several flood storage reservoirs on tributaries of the Soar including Braunstone Brook, Wash Brook and Saffron Brook. A review of the Environment Agency's Online Reservoir Flood Map shows parts of the site to be at residual flood risk in the event of a breach in flood storage basins on Willow Brook and Saffron Brook. .

Flood Defence Infrastructure

The NFCDD identifies no raised flood defence infrastructure present at the site. However, there are some raised flood defences located to the immediate north of the site.

Climate Change

The Environment Agency's Leicester City SFRM study modelled the effects of climate change on river flooding during the 1% AEP event, assuming a 20% increase in river flows (in line with PPS25). The effect is increased flood depths across the site, though the total flood extent is not significantly increased.

Final pluvial model results show that surface water flooding to the area is increased as a result of climate change. Depths and extents are increased and this should be examined in more detail during a site-specific FRA.

Residual Flood Risks

As no formal flood defences are present along the watercourses within the site, no defence breach analysis or analysis of defence overtopping is required.

A review of the Environment Agency's Online Reservoir Flood Map shows parts of the site to be at residual flood risk in the event of a breach in flood storage basins on Willow Brook and Saffron Brook. .

The numerous hydraulic structures within and in the vicinity of the site mentioned above present residual flood risks, as they may become blocked or function incorrectly during a flood event.

5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

Recommendations and Policies

- Roll back development from the watercourse to outside Flood Zone 3a to create 'blue corridors' which provide public open space / recreation areas near watercourses and enhance green infrastructure. If this is un-feasible other Green Infrastructure linkages would be required. Development should not encroach within 8m of the watercourses, which is the set byelaw distance for Main Rivers in the Midlands Region Land Drainage Byelaws. This would be beneficial both in terms of flood risk and maintenance access.
- Following the sequential approach, if development pressures create a need to develop the areas of the site that are at risk of flooding (i.e., Flood Zones 2 and 3) – especially the eastern part of the site with high hazard - they should incorporate appropriate mitigation measures which must not increase the risk of flooding to surrounding areas. Careful liaison with the Environment Agency will be necessary during the design and planning process.
- Mixed use (mixed vulnerability) development that follows the principles of the PPS25 sequential approach should be applied within the site. For example, the proposed residential and educational building uses should be situated in Flood Zone 1. The remaining 'less vulnerable' uses should be located within Flood Zone 1 or 2 and only when justifiable, Flood Zone 3. This approach can also be applied within buildings, for example commercial development located at ground floor level and residential development above ground floor level in flood risk areas. However, access and egress must still be made available for the residential uses and where the flood risk on access routes is 'Moderate' or above, 'More or Highly Vulnerable' developments are not likely to be appropriate.
- Flood volume displaced as a result of development within the Flood Zone 3a plus an allowance for climate change envelope must be compensated for else where within the site boundary on a 'level for level' basis.
- The Environment Agency's Flood Warning Area should be extended to include those parts of the site that fall within Flood Zone 3a and it is essential that any new developments should agree to this prior to development consent.
- Surface water / pluvial flood risk should also inform the site layout, such that 'highly vulnerable' development is avoided in locations that are shown at the greatest risk and hazard of pluvial flooding.
- As the area is primarily brownfield, it is unlikely that any development within the area will increase surface water runoff. However, to ensure a sustainable approach to development, SUDS should be implemented to reduce runoff rates and volumes from the developed site, thus reducing the resultant flood risk posed to the site itself and adjacent/downstream areas. Incorporating SuDS into green open spaces and other green infrastructure can help to promote multi-use green infrastructure and reduce flood risk.
- A review of BGS data shows that parts of the site (in the vicinity of the National Space Centre) may be suitable for infiltration SUDS, subject to detailed site investigations. There is a historic landfill to the east of the National Space Centre and infiltration SUDS should be avoided in this area to prevent contamination of groundwater.

Site-Specific FRA Guidance

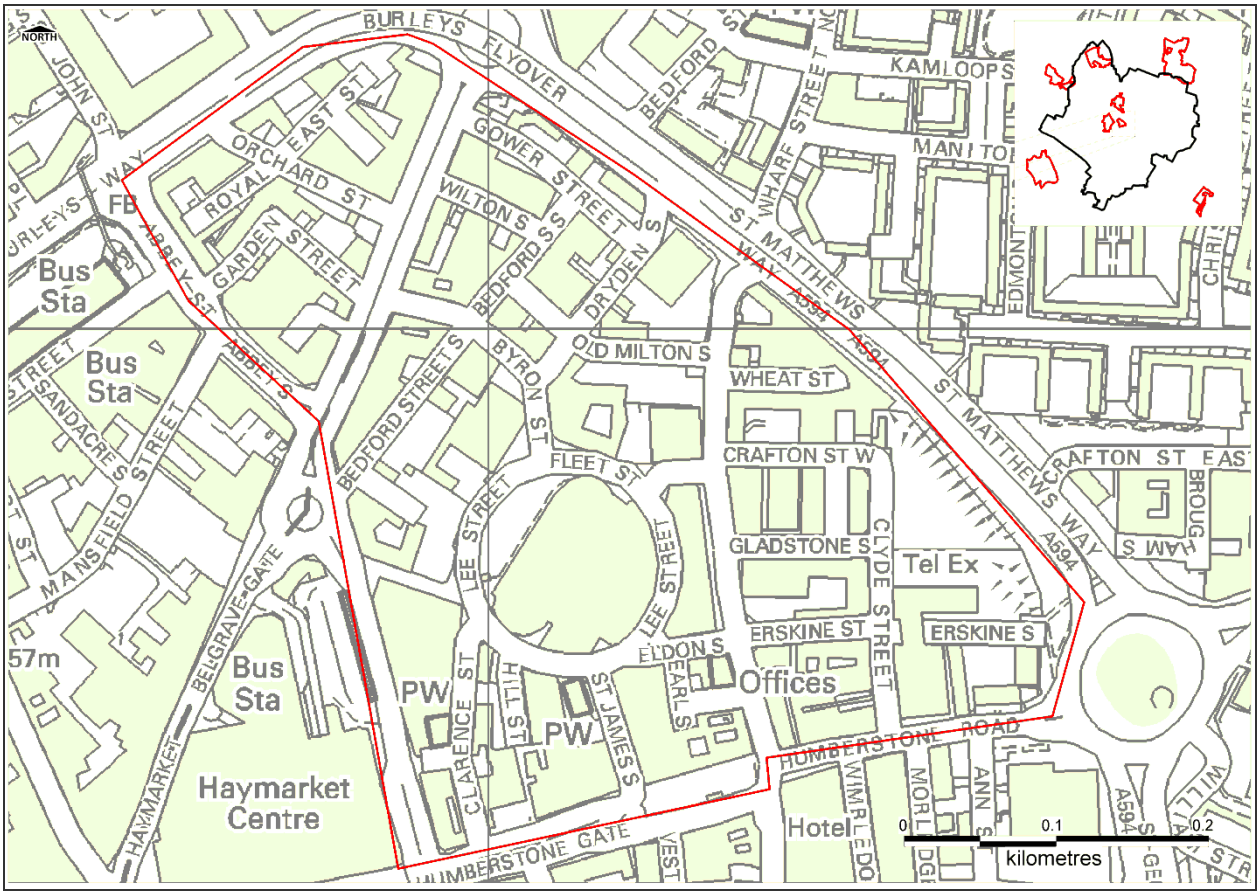
- A site-specific FRA will be required for any development proposed within the SRA that falls wholly or partly within Flood Zones 2 and 3. For sites that do not fall within Flood Zones 2 and 3 (i.e., they are wholly located within Flood Zone 1), an FRA will be required for any development in excess of 1 ha. The FRA will need to consider surface water management and develop a drainage strategy utilising SuDS where feasible.

5.2 Core Strategy Policy CS4: SRA - Abbey Meadows

Site-Specific FRA Guidance

- To ensure sustainable development, the rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The site specific FRA and drainage strategy should present workable solutions and designs for SuDS on the site. Designs need to be approved by the Leicester SAB.
- Maximum fluvial flood levels at the site should be informed by the most up-to-date versions of the Environment Agency's hydraulic models of Willow Brook and the River Soar. It is important to note that in some parts of the site, the River Soar produces the greatest flood levels, whilst for the majority of the remainder of the site Willow Brook presents the greatest flood levels.
- Following the Sequential and Exception Tests, if development within areas designated as Flood Zone 3 including an allowance for climate change is justifiable, appropriate mitigation and resilience measures should be incorporated both on an individual property-level (such as flood resilient construction) and at a strategic level (such as strategic SUDS or compensatory flood storage on a level-for-level basis).
- Floodplain compensation should be on a level for level and volume for volume basis.
- The FRA should demonstrate that consideration has been given to the site layout with regards to flood risk from all sources, in line with the recommendations above (sequential approach to site layout).
- The rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The suitability of infiltration SUDS should be informed by site-specific Ground Investigation (GI).
- The residual risks identified above should be adequately investigated and assessed as part of the FRA and mitigation measures implemented accordingly.
- Due to the susceptibility of groundwater flooding, the risk of groundwater flooding should be quantified by undertaking site-specific investigations. Suitable mitigation measures should be implemented if the investigations show that there is a risk of groundwater flooding, including flood resilient measures and avoiding basements in buildings.
- Appropriate mitigation measures should be incorporated that should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.
- A site-specific FRA should consider provision of site access and egress, taking into account any requirements of the LCC emergency planning department. This is a particularly pertinent issue for the east of the site, which is at risk of flooding from both Willow Brook and the River Soar.

5.3 Core Strategy Policy CS4: SRA - St Georges North

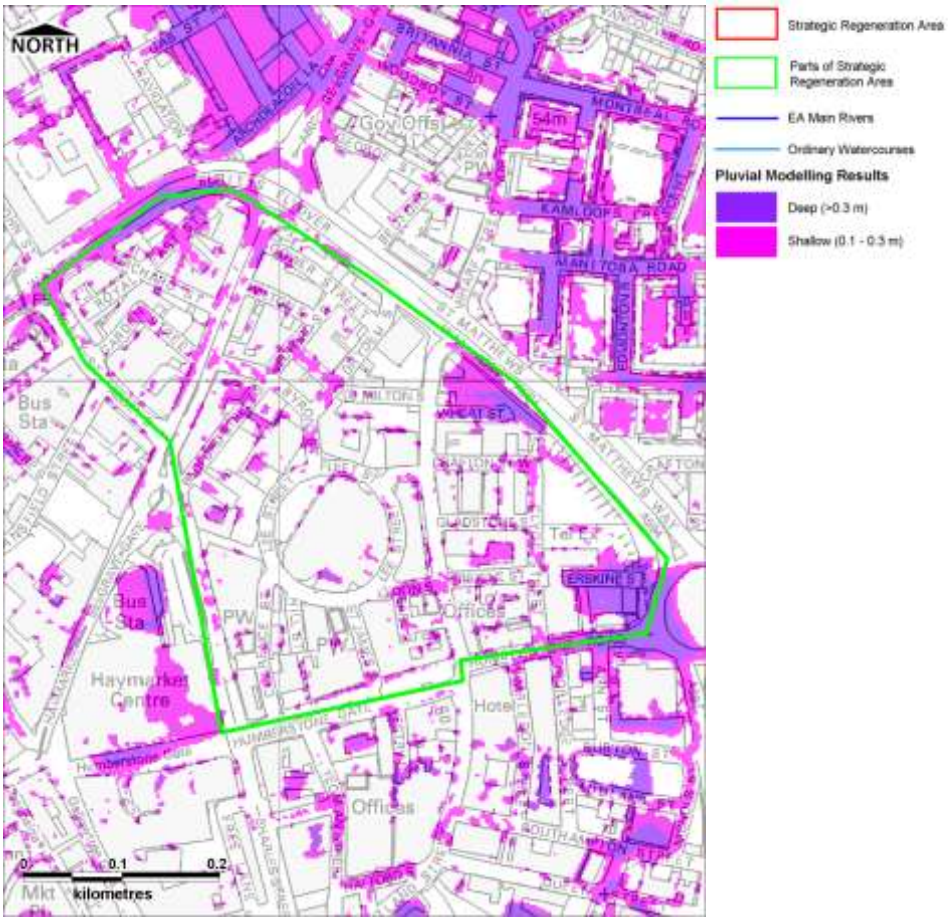


Site Information	
Grid Reference	SK 590 049
River Catchment	River Soar
Site Area	19.1 ha
Existing Use and Topography	St Georges North SRA is located in the central Leicester close to the existing communities of Spinney Hills, Westcotes & Highfield. The site is predominantly occupied by commercial properties, and is therefore considered brownfield. Abbey Street, Humberstone Road, St Matthews Way, and Burleys Way respectively form the western, southern, eastern and northern boundaries of the site. The site topography generally slopes in a north westerly direction from around 59.40m AOD to 53.30m AOD towards the River Soar.

5.3 Core Strategy Policy CS4: SRA - St Georges North

Proposed Use and Vulnerability Classification	St Georges North is located within the Strategic Regeneration Area under Core Strategy Policy CS4. The Leicester Core Strategy (2010) indicates that the St Georges North area has the potential for mixed use regeneration (residential and employment), linking St. Matthew's estate and the City Centre. The Core Strategy states that the area to the north of Humberstone Road provides opportunities for major leisure facilities. Under PPS25, such residential developments are classed as 'more vulnerable' and the leisure and employment uses identified are classed as 'more vulnerable' and 'less vulnerable'. These vulnerability classifications are considered appropriate in Flood Zones 1 and 2. For the residential use and employment / leisure use, the Exception Test must be applied for areas falling within Flood Zone 3a. Should further definition of such employment / leisure development be made available at a later stage, identification of their individual PPS25 vulnerability classifications should be re-visited.
Sources of Flood Risk	
Rivers	The site is located approximately 1 km to the east of the River Soar and approximately 0.6 km south of Willow Brook. The Environment Agency's Strategic Flood Risk Mapping study for these two watercourses indicates that the site is not at risk of flooding from rivers and is wholly located within Flood Zone 1. There are no records that indicate that the St Georges SRA has suffered flooding from rivers historically. It important to note that flooding may have occurred historically, but may have not been recorded. The site is not located within an Environment Agency Flood Warning Area.
Surface water	Pluvial modelling results indicate that the risk of flooding from surface water runoff is greater in low-lying areas of the site, particularly in the north western and south eastern areas where parts of the public highway may experience some shallow and deep ponding of surface water. Environment Agency and LCC flood records illustrate that there have been no historical incidents of surface water flooding have been reported at the site. However, that is not to say that flooding has not occurred in the past.

5.3 Core Strategy Policy CS4: SRA - St Georges North



Groundwater	The entire site is considered to have a 'very high' susceptibility to groundwater flooding. In support of this information, there are a number of records of groundwater flooding across the site.
Sewers	The majority of the site is served by separate Severn Trent Water surface and foul water sewer systems. There are also a small number of combined systems within the site. The Severn Trent DG5 register identifies a number of sewer flooding incidents within the general area where the site is located. Sewer flooding incidents have been caused by blocked gullies and drains in the local area.
Artificial Sources	According to the Environment Agency's website, there are no reservoirs that present a residual risk of flooding to the site. The Grand Union Canal is located to the north of the site. However, there are no raised embankments in the vicinity of the site. Therefore, the risk of canal breach is low.

5.3 Core Strategy Policy CS4: SRA - St Georges North

Flood Defence Infrastructure

The NFCDD identifies no raised flood defence infrastructure present at the site or within the local vicinity.

Climate Change

The Environment Agency's Leicester City SFRM study modelled the effects of climate change on river flooding during the 1% AEP event, assuming a 20% increase in river flows (in line with PPS25). The effect is increased flood depths across the site, though the total flood extent is not significantly increased.

Final pluvial model results show that surface water flooding to the area is increased as a result of climate change. Depths and extents are increased and this should be examined in more detail during a site-specific FRA.

Residual Flood Risks

At present, the residual risk of flooding at the St Georges North SRA is low.

Recommendations and Policies

- Surface water / pluvial flood risk should inform the site layout, such that 'highly vulnerable' development is avoided in locations that are shown to be at the greatest risk of pluvial flooding.
- As the area is primarily brownfield, it is unlikely that any development within the area will increase surface water runoff. However, SuDS should be implemented to reduce surface water runoff from the developed site, and reduce the resultant flood risk posed to adjacent/downstream land uses.
- A review of the BGS data showing underlying ground conditions at the site indicates that it may be possible that infiltration SuDS techniques could be used further at the site depending upon detailed site-specific investigations. If infiltration SUDS are shown to be unsuitable, attenuation SUDS should be used and this should be considered during masterplanning stages, as most attenuation SUDS techniques involve land-take (swales, detention basins etc).
- Early discussions with Severn Trent Water should be undertaken given the potential issues in relation to sewer flooding.
- Suitable surface water runoff rates to be confirmed at the detailed planning stage and during the site specific FRA.

Site-Specific FRA Guidance

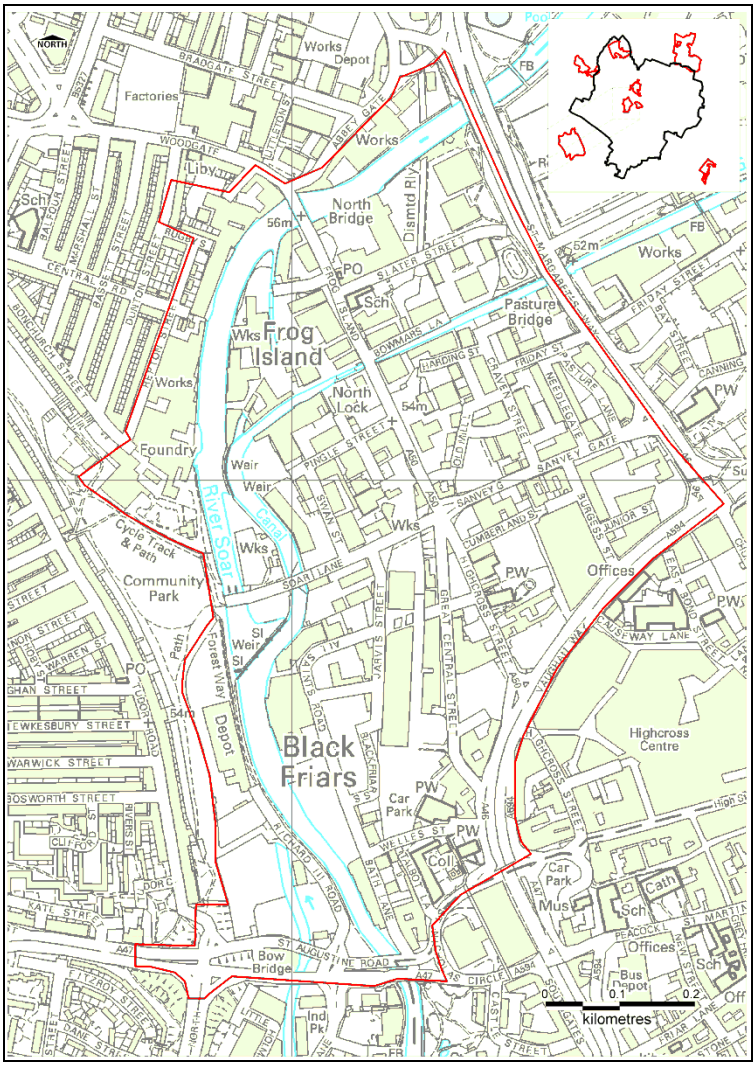
- A site-specific surface water FRA will be required for any development in excess of 1 ha, including those proposed within Flood Zone 1. The FRA will need to consider surface water management.
- To ensure sustainable development, the rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The site specific FRA and drainage strategy should present workable solutions and designs for SuDS on the site. The suitability of infiltration SUDS should be informed by site-specific Ground Investigation (GI). Designs need to be approved by the Leicester SAB.

5.3 Core Strategy Policy CS4: SRA - St Georges North

Site-Specific FRA Guidance (cont)

- Appropriate mitigation measures should be incorporated that should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.
- The FRA should demonstrate that consideration has been given to the site layout with regards to flood risk from all sources, in line with the recommendations above (sequential approach to site layout).
- Due to the susceptibility of groundwater flooding, the risk of groundwater flooding should be quantified by undertaking site-specific investigations. Suitable mitigation measures should be implemented if the investigations show that there is a risk of groundwater flooding, including flood resilient measures and avoiding basements in buildings.
- A site-specific FRA should consider provision of site access and egress, taking into account any requirements of the LCC emergency planning department.
- Appropriate mitigation measures should be incorporated that should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.

5.4 Core Strategy Policy CS4: SRA - Waterside



Site Information	
Grid Reference	SK 581 049
River Catchment	River Soar
Site Area	59.4ha
Existing Use and Topography	The SRA - Waterside area is located in central Leicester close to the existing communities of Westcotes and Stocking Farm. The site is predominantly occupied by commercial properties, and is therefore considered brownfield. Tudor Road, St Augustine Road, Vaughan Way, St Margaret's Way, Abbey Gate and Repton Street form the main boundaries of the site. The site is predominantly surrounded by commercial properties.

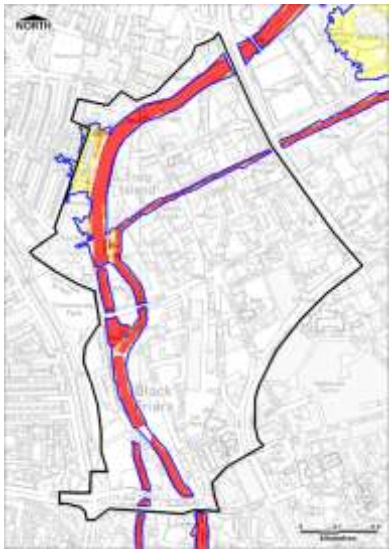
5.4 Core Strategy Policy CS4: SRA - Waterside	
Existing Use and Topography	The River Soar and Grand Union Canal flow through the centre of the site in a northerly direction. The site topography slopes generally towards the river from 63.4m and 57.0m AOD from the east and west respectively to 52.0m AOD in the vicinity of the river.
Proposed Use and Vulnerability Classification	Waterside is located within the local authority Strategic Regeneration Area under Core Strategy Policy CS4. The Leicester Core Strategy (2010) indicates that the Council's aspiration for this area is to develop the Waterside as an attractive, high quality, residential-led, mixed neighbourhood and city leisure attraction, focusing on water, which enhances the riverside, the canal and its ecology, improves connectivity to adjoining areas and reduces the severance effect of the Central Ring Road. Development types proposed within the Waterside area include residential; employment (small scale offices and workspaces and supporting neighbourhood uses), leisure and employment, a new local centre to serve the area on the A50; transport improvements including the potential for a St. Augustine's/Bath Lane link road and bridge; improvements in the provision of public open space and health care facilities. Under PPS25, such residential developments are classed as 'more vulnerable' and the leisure and employment uses identified are classed as 'more vulnerable' and 'less vulnerable'. Any health care facilities would also be classed as 'more vulnerable'. Any transport development would be classified as 'essential infrastructure' and any new open space development would be classified as 'water-compatible development'. These vulnerability classifications are considered appropriate in Flood Zones 1 and 2. For the residential use, employment / leisure use (falling within the 'more vulnerable classification'), transport improvements and for any health care facilities, the Exception Test must be applied for areas falling within Flood Zone 3a. The open space development is appropriate in all flood zones.
Sources of Flood Risk	
Rivers	The River Soar flows through the site in a northerly direction, interacting with the Grand Union Canal via a number of weirs and sluices. The Braunstone Brook confluence with the River Soar is located just downstream of the Soar Lane crossing. Braunstone Brook is culverted from the Fosse Road Recreation Ground, through the Waterside SRA, to it's outfall into the River Soar. The Environment Agency's Strategic Flood Risk Mapping (SFRM) study covers the watercourses in the vicinity of the site and has been used to define the risk posed by rivers below: **River Soar** In the defended scenario, a small area in the north east of the site, to the west of the River Soar, is located within Flood Zone 3b (functional floodplain, 4% AEP). The majority of the area between the River Soar and the Grand Union Canal is located within Flood Zone 3a (1% AEP). The north of the site and west of the site fall within Flood Zone 2 (0.1% AEP).

5.4 Core Strategy Policy CS4: SRA - Waterside

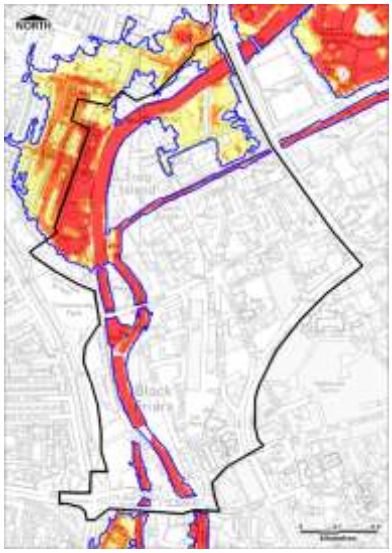
Rivers	**Braunstone Brook** In the defended scenario, the site is not located within Flood Zone 3b (functional floodplain, 4% AEP) associated with Braunstone Brook. The south western corner of the site is located within Flood Zone 2 (0.1% AEP) associated with Braunstone Brook. **Willow Brook** Whilst the confluence of Willow Brook with the River Soar is located approximately 750 m downstream of the Waterside SRA, it is important to note that the Environment Agency's hydraulic modelling shows that, during a 1% AEP flood event, flood water discharging from Willow Brook propagates upstream on the River Soar and the Grand Union Canal, affecting the site. However, the associated flood extents are minor. There are no records that indicate that the Waterside SRA has suffered flooding from rivers historically. It important to note that flooding may have occurred historically, but may have not been recorded. The site is located within an Environment Agency Flood Warning Area (River Soar at Leicester including Westcotes) and 'The River Soar at Stocking Farm') and Flood Watch Area ('Upper Soar Catchment').

Flood Hazard mapping has been created from the outputs of Environment Agency detailed modelling using the hazard ratings developed by the Defra R&D (FD2320) project. As can be seen from the maps below, the greatest hazard, and therefore greatest flood risk is to the west and north of the site, where, during a 1% AEP and a 1% AEP event including climate change, floodplain depths exceed 1.5m and therefore present a 'danger to all'.

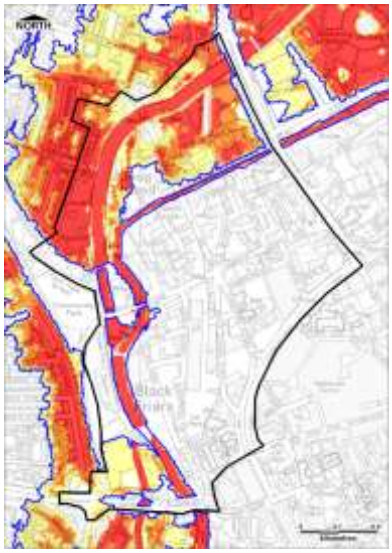
5% AEP
(20 year – FZ3b)



1% AEP
(100 year – FZ3a)



1% + CC AEP
(FZ3a including Climate Change)



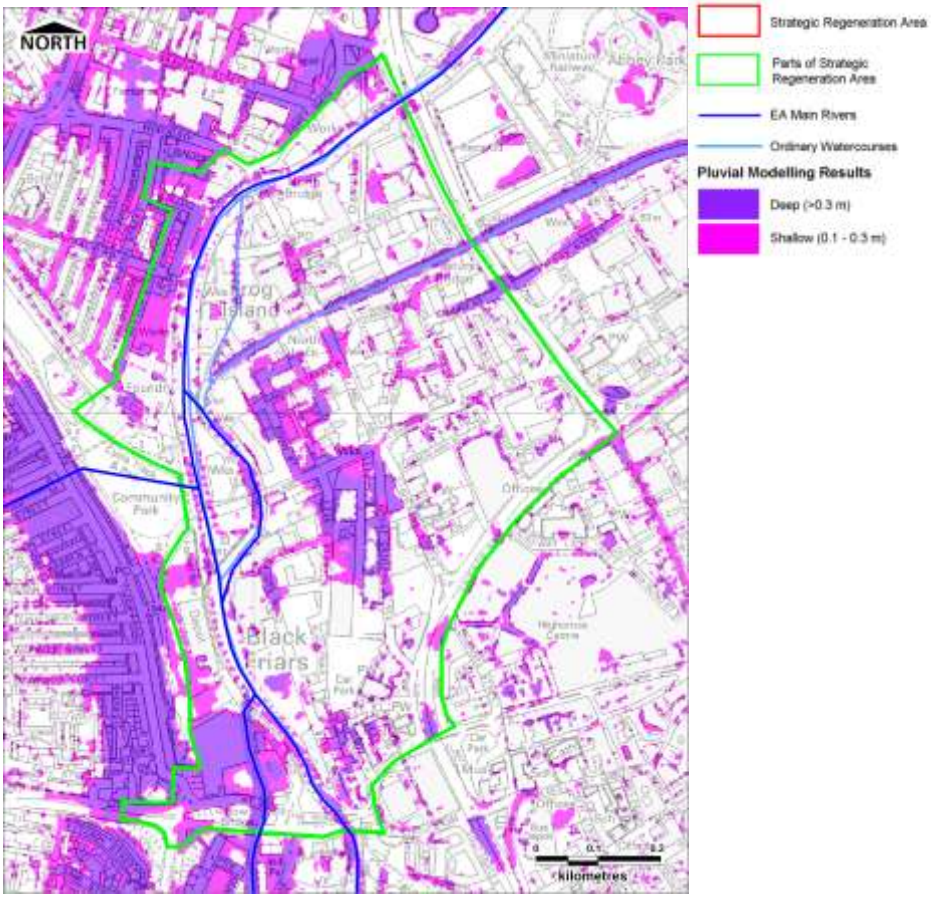
5.4 Core Strategy Policy CS4: SRA - Waterside

Degree of Flood Hazard	Description
Low	**Caution** "Flood zone with shallow flowing water or deep standing water"
Moderate	**Danger for Some** (i.e. children, the elderly and the infirm) "Flood zone with deep or fast flowing water"
Significant	**Danger for Most** people (includes the general public) "Flood zone with deep fast flowing water"
Extreme	**Danger for All** (includes emergency services) "Flood zone with deep fast flowing water"

The flood hazard maps highlight the areas that experience the greatest threat of danger to human life during a flood event. Extremely hazardous areas can restrict the emergency services flood response and the ability of people to escape flooded areas.

Surface water	Pluvial modelling results indicate that the risk of flooding from surface water runoff is greater in low-lying areas of the site, particularly in the western and central areas near to the River Soar. Flooding is generally confined to the public highways, though some properties are also affected. Access and egress may therefore be affected during and following heavy and prolonged rainfall events. Environment Agency and LCC Historical Flood Maps illustrate that there have been no historical incidents of surface water flooding have been reported at the site. However, that is not to say that flooding has not occurred in the past.

5.4 Core Strategy Policy CS4: SRA - Waterside



Groundwater	The majority of the site is considered to have a 'very high' susceptibility to groundwater flooding. Whilst there are no historic groundwater flood events within the site boundary, there are a number of recorded incidents in the local area.
Sewers	The majority of Severn Trent sewers within the site are separate foul and combined systems. There are also some combined sewers serving the area. The STW DG5 register identifies a number of sewer flooding incidents within and adjacent to the site boundary. The recorded incidents were caused by blocked gullies and drains in the local area.
Artificial Sources	The Grand Union Canal flows through the centre of the site in a northerly direction. The canal is not embanked through the site and therefore the risk of a breach is low. Due to the interactions between the canal and the River Soar, the canal propagates floodwaters during significant events, as demonstrated by Environment Agency hydraulic models. A review of the Environment Agency's Reservoir Flood Map shows that the parts of the site to be at residual flood risk in the event of a reservoir breach in Flood Storage Reservoirs – in particular on Braunstone Brook..

5.4 Core Strategy Policy CS4: SRA - Waterside

Flood Defence Infrastructure

The NFCDD identifies no raised flood defence infrastructure present at the site or within the local vicinity.

Climate Change

The Environment Agency's Leicester City SFRM study modelled the effects of climate change during the 1% AEP event, assuming a 20% increase in river flows (in line with PPS25). The effect is an increased flood envelope in the north of the site and flooding in the south of the site in the vicinity of Richard III Road.

Final pluvial model results show that surface water flooding to the area is increased as a result of climate change. Depths and extents are increased and this should be examined in more detail during a site-specific FRA.

Residual Flood Risks

There are no raised flood defences through the site. Therefore, the risk from a breach in flood defences is low.

The Grand Union Canal is not embanked through the site and therefore the residual risk of a canal breach is low. There are a number of structures present where the canal and River Soar interact. These sluices and weirs control water levels in the canal. It is important to consider that these structures may present a residual flood risk due to incorrect operation, mechanical failure or poor maintenance.

There are a number of bridge crossings of the River Soar and Grand Union Canal. These crossings may become blocked with debris, particularly during flood flows. These structures therefore present a residual risk of blockage.

Whilst there are no reservoirs located within or immediately upstream of the site, the Environment Agency's Reservoir Flood Map shows that part of the site is considered to be at residual risk of reservoir breach from flood storage reservoirs on Braunstone Brook.

Recommendations and Policies

- Roll back development from the watercourse to outside Flood Zone 3a to create 'blue corridors' which provide public open space / recreation areas near watercourses and enhance green infrastructure. Development should not encroach within 8m of the watercourses, which is the set byelaw distance for Main Rivers in the Midlands region by the Midlands Region Land Drainage Byelaws.. This would be beneficial both in terms of flood risk and maintenance access.
- If development pressures create a need to develop the areas of the site that are at risk of flooding (i.e., Flood Zones 2 and 3) – especially to the north and west of the site that experience high hazard ratings during a 1% AEP event - they should incorporate appropriate mitigation measures and must not increase the risk of flooding to surrounding areas. Careful liaison with the Environment Agency will be necessary during the design and planning process.

5.4 Core Strategy Policy CS4: SRA - Waterside

Recommendations and Policies (cont)

- Mixed use (mixed vulnerability) development that follows the principles of the PPS25 sequential approach should be applied within the site. For example, the proposed residential uses should be situated in Flood Zone 1. The proposed open space should be located within Flood Zone 3. This approach can also be applied within buildings, for example commercial development located at ground floor level and residential development above ground floor level in flood risk areas. However, access and egress must still be made available for the residential uses and where the flood risk on access routes is 'Moderate' or above, 'More or Highly Vulnerable' developments are not likely to be appropriate.
- Flood volume displaced as a result of development within the Flood Zone 3a plus an allowance for climate change envelope must be compensated for else where within the site boundary on a 'level for level' basis.
- Surface water / pluvial flood risk should also inform the site layout, such that 'highly vulnerable' development is avoided in locations that are shown at the greatest risk of pluvial flooding.
- As the area is primarily brownfield, it is unlikely that any development within the area will increase surface water runoff. However, to ensure sustainability, SUDS should be implemented to reduce runoff rates and volumes from the developed site, thus reducing the resultant flood risk posed to the site itself and adjacent/downstream areas.
- A review of BGS data suggests that infiltration SUDS may be unsuitable for most of the site, though this should be confirmed using site-specific investigations. If infiltration SUDS are shown to be unsuitable, attenuation SUDS should be used and this should be considered during master planning stages, as most attenuation SUDS techniques involve land-take (swales, detention basins etc).
- The Environment Agency's Flood Warning Area should be extended to include those parts of the site that fall within Flood Zone 3a and it is essential that any new developments should agree to this prior to development consent.
- Consideration (at the detailed design/master planning stage) should be given to the potential impact of the proposed highway and bridge improvement works on flood risk.

Site-Specific FRA Guidance

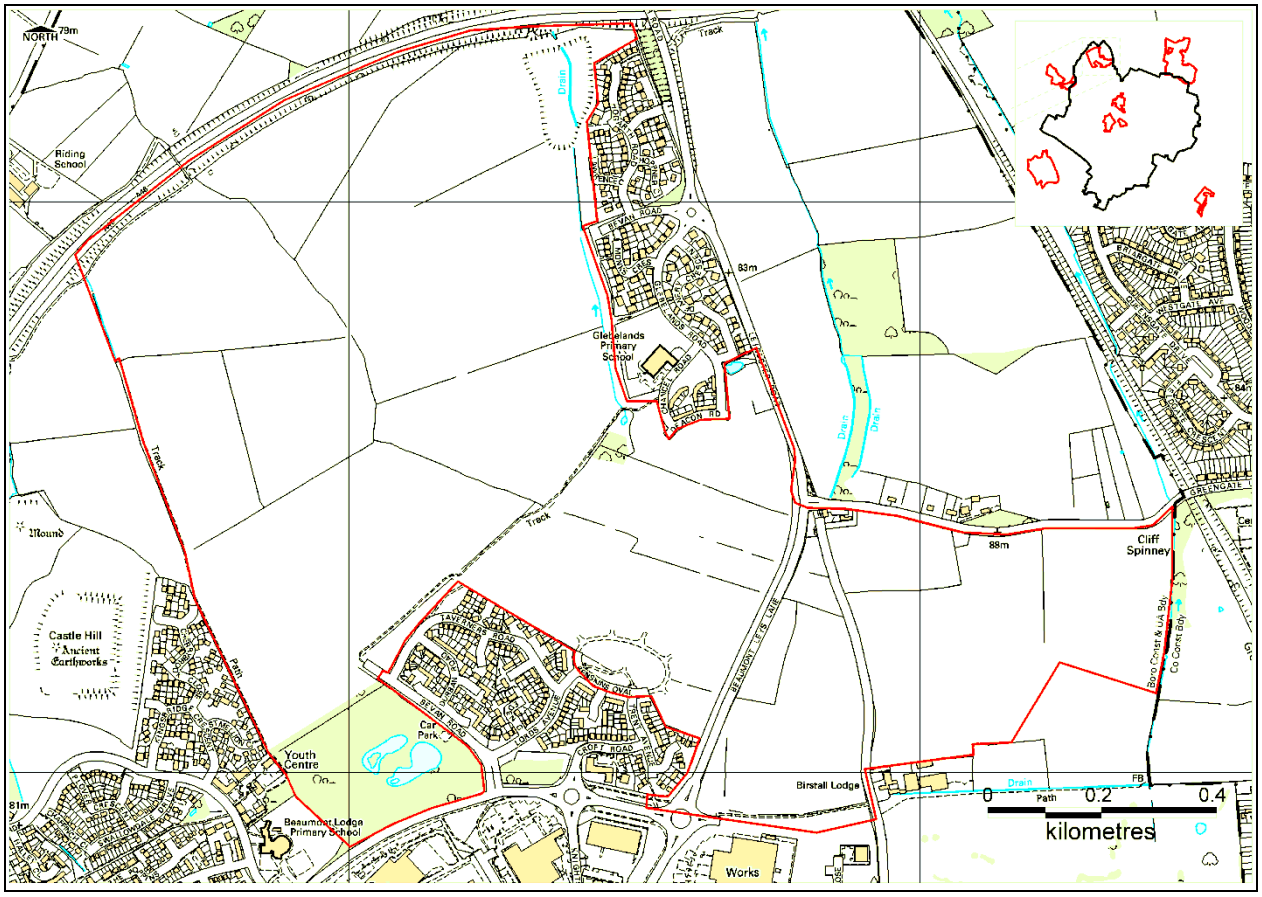
- A site-specific FRA will be required for any development proposed within the SRA that falls wholly or partly within Flood Zones 2 and 3. For sites that do not fall within Flood Zones 2 and 3 (i.e., they are wholly located within Flood Zone 1), an FRA will be required for any development in excess of 1 ha. The FRA will need to consider surface water management.
- Maximum fluvial flood levels at the site should be informed by the most up-to-date versions of the Environment Agency's hydraulic models of Braunstone Brook, the River Soar and Willow Brook. All three models should be used to inform the maximum flood level for any part of the site.
- The FRA should demonstrate that consideration has been given to the site layout with regards to flood risk from all sources, in line with the recommendations above (sequential approach to site layout).

5.4 Core Strategy Policy CS4: SRA - Waterside

Site-Specific FRA Guidance (cont)

- Following the Sequential and Exception Tests, if development within areas designated as Flood Zone 3 including an allowance for climate change is justifiable, appropriate mitigation and resilience measures should be incorporated both on an individual property-level (such as flood resilient construction) and at a strategic level (such as strategic SUDS or compensatory flood storage on a level-for-level basis).
- Any fluvial flood volume displaced as a result of development must be compensated for on a 'level for level' and 'volume for volume' basis elsewhere within the site boundary, but outside the envelope of Flood Zone 3a including an allowance for climate change. This should be demonstrated using hydraulic modelling.
- To ensure sustainable development, the rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The site specific FRA and drainage strategy should present workable solutions and designs for SuDS on the site. The suitability of infiltration SUDS should be informed by site-specific Ground Investigation (GI). Designs need to be approved by the Leicester SAB.
- Appropriate mitigation measures should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.
- The residual risks identified above should be adequately investigated in more detail (including the risks of reservoir flooding) and assessed as part of the FRA and mitigation measures implemented accordingly.
- Due to the susceptibility of groundwater flooding, the risk of groundwater flooding should be quantified by undertaking site-specific investigations. Suitable mitigation measures should be implemented if the investigations show that there is a risk of groundwater flooding, including flood resilient measures and avoiding basements in buildings.

5.5 Core Strategy Policy CS5: Ashton Green

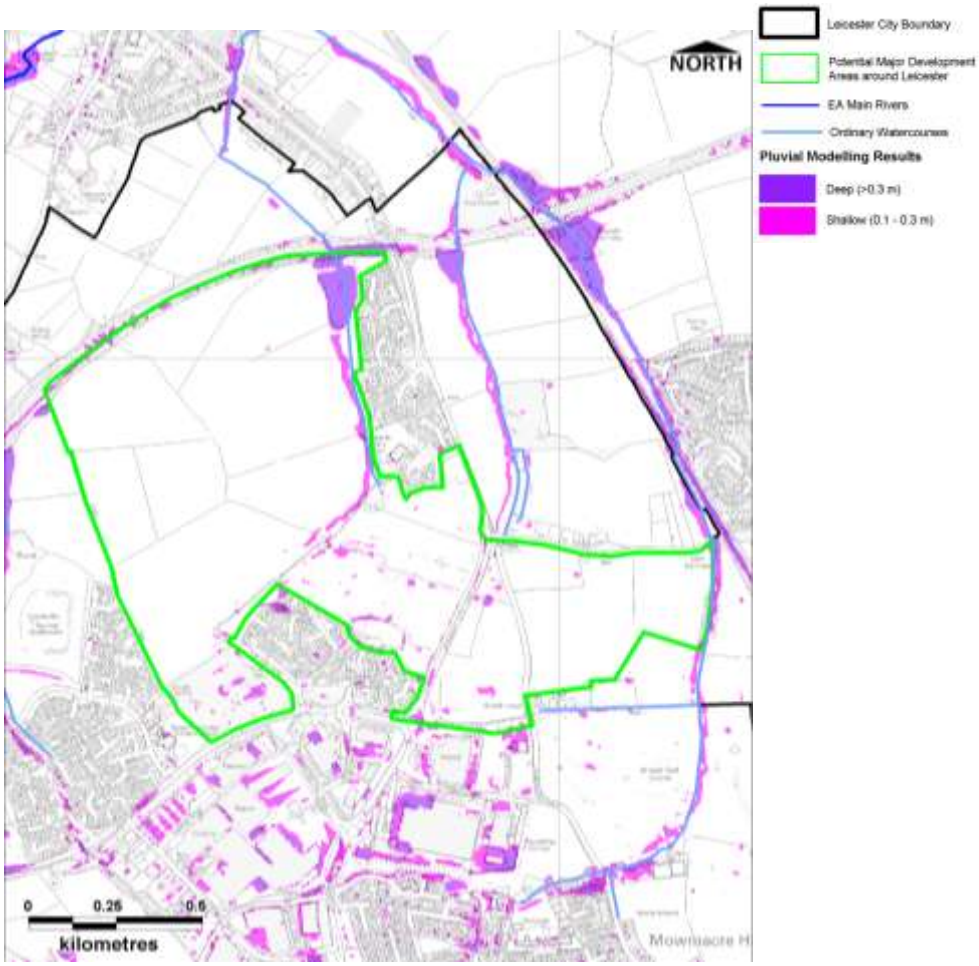


Site Information	
Grid Reference	SK 570 096
Watercourse Catchment	Rothley Brook
Site Area	130ha
Existing Use and Topography	Ashton Green is located on the north western edge of Leicester close to the communities of Birstall and Thurcaston in Charnwood Borough. The site is predominantly occupied by open grassland and agricultural farmland, and is therefore considered to be essentially greenfield. The A46 Bypass forms the north-western and northern boundaries of the site. The western, southern and eastern boundaries of the site are predominately bound by residential developments and agricultural land. The site generally slopes in a north westerly direction from around 90.67m AOD to 71.90m AOD towards Rothley Brook.

5.5 Core Strategy Policy CS5: Ashton Green

Proposed Use and Vulnerability Classification	Ashton Green was granted outline planning permission by LCC on 4th March 2011 and it is identified under policy CS5 of the Core Strategy. The Council envisage that it will be an exemplar of sustainable development, supporting a wide range of sustainable development principles, including reducing carbon impact and climate change (including minimising flood risk). It is anticipated that the site will provide up to 3,500 new dwellings and associated amenities, up to 10 hectares of employment land, schools, open space and other community facilities. The site also continues to be identified within the saved policies of the Leicester Local Plan (2006) as a housing site under policy H01. However, the original allocation was for residential development only on a smaller site, whereas the Core Strategy identifies a larger mixed use development site that can deliver a range of uses over the plan period. Under PPS25 such residential developments and educational facilities are classed as 'more vulnerable', and employment development can be classified as 'more vulnerable' and/or 'less vulnerable'. These vulnerability classifications are considered appropriate in Flood Zones 1 and 2. For residential and educational developments, the Exception Test must be applied for areas falling within Flood Zone 3a. Should further definition of such employment development be made available at a later stage, identification of their individual PPS25 vulnerability classifications should be re-visited.
Sources of Flood Risk	
Rivers	Two small watercourses flowing in a northerly direction have been identified along the western and eastern boundaries of the site. The watercourses are minor tributaries of Rothley Brook and are assumed to provide a drainage mechanism for the existing agricultural land. The watercourses may also present a mechanism for drainage of the adjacent highway. The two minor watercourses could potentially present a flood risk to the site if the channel capacity becomes exceeded resulting in bank overtopping. The Environment Agency's Flood Map does not present Flood Zones associated with the watercourses because the catchment areas are less than 3 km^2. The site is therefore shown to be located within Flood Zone 1. However, the small watercourses may still present a flood risk. Environment Agency and LCC data indicates that no historical incidents of fluvial flooding have been recorded at the site. The site is not located within an Environment Agency Flood Warning or Flood Watch Area.

5.5 Core Strategy Policy CS5: Ashton Green

Surface water	The pluvial modelling results indicate that the risk of flooding from surface water runoff is greater in low-lying areas of the site adjacent to the minor watercourses in the north and east. Environment Agency and LCC Historical Flood Maps illustrate no historical incidents of surface water flooding have been reported at the site. 
Groundwater	The area of the site near to the drain at the eastern boundary has a 'high' and 'very high' susceptibility to groundwater flooding. Since the site is greenfield, any issues with groundwater flooding are unlikely to have been reported.
Sewers	The Severn Trent Water DG5 register identifies that there have been no recorded incidents of sewer flooding within the postcode areas covering the site.
Artificial Sources	There are no canals, reservoirs or other artificial sources that may provide a flood risk in the vicinity of the site.

5.5 Core Strategy Policy CS5: Ashton Green

Flood Defence Infrastructure

The NFCDD identifies no raised flood defence infrastructure present at the site or within the local vicinity.

Climate Change

Final pluvial model results show that surface water flooding to the area is increased as a result of climate change. Depths and extents are increased and this should be examined in more detail during a site-specific FRA.

Residual Flood Risks

At present, the residual risk of flooding at Ashton Green is low. As no flood defences are present along the minor watercourse within the site, no defence breach analysis or analysis of defence overtopping is required.

Recommendations and Policies

- Whilst the watercourses are not Main River, it is recommended that development must not encroach within 8m of the watercourses, which is the set byelaw distance for Main Rivers in the Midlands Region Land Drainage Byelaws. This would be beneficial in terms of flood risk and maintenance access. It is recommended that development be 'rolled back' to a minimum of 20m from the minor watercourses to create 'blue corridors' which provide public open space / recreation areas and increased multi-use green infrastructure near watercourses.
- As the site is currently primarily greenfield, any development within the area will increase surface water runoff unless suitable source control measures are adopted. SUDS must be implemented to manage surface water runoff from the developed site, and as such reduce the resultant flood risk posed to adjacent/downstream land uses. The use of SUDS will assist in creating an exemplar of sustainable development.
- A review of the BGS data showing underlying ground conditions at the site indicates that the site may be unsuitable for infiltration SUDS techniques. Attenuation SUDS are therefore likely to be the most appropriate sustainable method of surface water management. This should be considered during the masterplanning stages, as many attenuation techniques generally involve a greater land take (detention basins, swales, etc).
- Surface water / pluvial flood risk should inform the site layout, such that 'highly vulnerable' development is avoided in locations that are shown to be at the greatest risk of pluvial flooding.

Site-Specific FRA Guidance

- A site-specific surface water FRA will be required for any development in excess of 1 ha, including those proposed within Flood Zone 1. The FRA will need to consider surface water management and develop a drainage strategy utilising SuDS where feasible.
- To ensure sustainable development, the rates and volumes of post-development surface water runoff should be controlled using suitable and adequate SUDS techniques. The site specific FRA and drainage strategy should present workable solutions and designs for SuDS on the site. The suitability of infiltration SUDS should be informed by site-specific Ground Investigation (GI). Designs need to be approved by the Leicester SAB.

5.5 Core Strategy Policy CS5: Ashton Green

- Given the uncertainty of fluvial flood risk on the site, if development pressure creates a need to develop within 20m of watercourses:
    - Detailed hydraulic modelling should be undertaken of the watercourses to determine the extent of Flood Zones 2, 3a and 3b and the potential effects of climate change. Once defined, development should be sequentially allocated, placing land uses of the greatest vulnerability in the areas of lowest flood risk.
    - If development within areas designated as Flood Zone 3 including an allowance for climate change is justifiable in direct relation to flood risk, appropriate mitigation and resilience measures should be incorporated both on an individual property-level (such as flood resilient construction) and at a strategic level (such as strategic SUDS or compensatory flood storage on a level-for-level basis).
- Flood volume displaced as a result of development within Flood Zone 3a plus an allowance for climate change envelope must be compensated for else where within the site boundary on a 'level for level' and 'volume for volume' basis. This must be demonstrated using hydraulic modelling as part of the FRA.
- The FRA should demonstrate that consideration has been given to the site layout with regards to flood risk from all sources, in line with the recommendations above (sequential approach to site layout).
- Due to the susceptibility of groundwater flooding, the risk of groundwater flooding should be quantified by undertaking site-specific investigations. Suitable mitigation measures should be implemented if the investigations show that there is a risk of groundwater flooding, including flood resilient measures and avoiding basements in buildings.
- A site-specific FRA should consider provision of site access and egress, taking into account any requirements of the LCC emergency planning department.
- Appropriate mitigation measures should be incorporated that should not increase the risk of flooding to surrounding areas by obstructing flood flow routes.

6 Site Specific Flood Risk Assessments Guidance

6.1 Overview

6.1.1 In accordance with Paragraph E2 of PPS25: 'Any organisation or person proposing a development must consider whether that development will not add to and should where practicable reduce flood risk. The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use'.

6.1.2 The Level 1 & 2 SFRAs, the SWMP and the EA SFRM2 constitute the best available flood risk information and should be the first port of call for developers when producing site specific FRAs.

6.1.3 Regardless of the presence of the SFRA for Leicester, site-specific Flood Risk Assessments (FRAs) are required for all development in Flood Zone 2 and Flood Zone 3, for CDAs and for sites greater than 1 ha in Flood Zone 1, in accordance with Table D1 of PPS25. These will be reviewed either by the Local Planning Authority or the Environment Agency depending upon the scale and nature of the proposed development (see policies and recommendations in Section 5).

6.2 Level 3 – Detailed / Site-Specific Flood Risk Assessment

6.2.1 Where the quality and/or quantity of information for any of the flood sources affecting a site is insufficient to enable a robust assessment of the flood risks, further investigation will be required. For example it is generally considered inappropriate to base an FRA for a residential care home at risk of flooding from fluvial sources on Flood Zone maps alone. In such cases the results of detailed hydraulic modelling are preferable to ensure details of flooding mechanisms and the onset of flooding is fully understood and that the proposed development incorporates appropriate mitigation measures.

6.2.2 Developers should also identify the residual risk as part of a site specific detailed FRA. Such assessment should be appropriate to the scale and nature of the proposed development and flood risk. Should the potential impact be unacceptable, mitigation should be provided. Hazard mapping, carried out as part of this SFRA and the SWMP should be reviewed and where necessary be expanded on as part of any site-specific FRA. Developers should provide a SuDS proposal upfront (to be agreed with the guidelines and specifications provided by the Leicester SAB) and any large development sites will require a topographical survey.

6.2.3 Data is owned and maintained by a number of different organisations. These include:

- Environment Agency – see section 4.3.2 and section 4.3.3 for further details,
- Leicester City Council – see section 4.3.4 for further details,
- Severn Trent Water – see section 4.3.5 for further details,
- British Waterways – see section 4.3.6 for further details.

6.2.4 At all stages, LCC as the LPA, LLFA and SAB, and where necessary the EA and STW should be consulted to ensure the site-specific FRA provides the necessary information to fulfil the requirements for planning applications.

6.2.5 More detailed recommendations for each of the sites assessed in this SFRA are presented in the site tables in Section 5. Reference should also be made to any applicable Site Allocation DPDs and these will be referenced to each allocated site's individual policy.

6.3 Site Vulnerability and Site Layout

6.3.1 The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas e.g. residential developments should be restricted to areas at low hazard and parking, open space or proposed landscaped areas can be placed on lower ground with a higher probability of flooding.

6.3.2 Flood risk should be considered by developers at the very beginning stages of scheme development. An early consideration for flood risk is crucial to ensure areas of the site at little or no risk of flooding are developed in preference to areas at a higher risk. Flood flow routes through larger sites will follow the sites topography thus incorporating this information into the site plan at an early stage is advised to ensure the best design of the site in flood risk terms.

6.3.3 Structures such as (bus, bike) shelters, park benches and refuse bins (and associated storage areas) located in areas with a high flood risk should be flood resilient and be firmly attached to the ground and should not adversely block flood flown routes.

6.3.4 Reference should be made to the individual site tables presented in Section 5 for an assessment of proposed usage, development types and vulnerability.

6.4 Building Design Recommendations

Finished Floor Levels

6.4.1 Where developing in flood risk areas is unavoidable (following the Sequential and Exception Tests), the most common method of mitigating flood risk to people and property, particularly with 'more vulnerable' (residential) land uses, is to ensure habitable floor levels are raised above the 1% probability (1 in 100 year annual probability) plus climate change flood water level derived for the immediate vicinity within the site (i.e. relative to the extent of a site along a watercourse as flood levels are likely to vary with increasing distance downstream).

6.4.2 To account for sensitivities and uncertainties in predicted flood levels, it is recommended that finished floor levels for developments are set at least 300mm above the 1% probability (1 in 100 year annual probability) plus climate change flood water level. In some cases it may be possible to introduce flood resilient design in lieu of the 300mm freeboard level or to ensure that living spaces are at first floor levels (with garage at ground floor levels for example). However, attention must given to access and egress routes during flood events and the safety of people should not be jeopardised by creating 'marooned' development in times of flooding.

6.4.3 In certain situations (e.g. for proposed extensions to buildings with a lower floor level), it could prove impractical to raise the internal ground floor levels to sufficiently meet the general requirements. In these cases, the Environment Agency should be approached to discuss options for a reduction in the minimum internal ground floor levels provided flood proofing (resilience) measures are implemented up to an agreed level. There are also circumstances where flood proofing (resilience) measures should be considered first.

6.4.4 It is also advised that the adjacent finished external ground levels are also set at a sufficient distance below the recommended internal ground floor levels to mitigate against any localised external flooding.

6.4.5 The use of basement accommodation should be restricted to areas which are not susceptible to groundwater flooding, fluvial or pluvial flooding. Should basement development be required in areas designated by the Environment Agency as susceptible to groundwater flooding, it is advised that more consideration should be given to this source of flooding as part of a site specific FRA following a geological investigation being undertaken.

6.4.6 In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe. Access and egress routes must be at suitable level to be agreed in conjunction with the EA.

6.5 Storm Water Management and Sustainable Drainage Systems (SuDS)

6.5.1 Flood risk management policies require that building developments are 'safe', do not increase flood risk elsewhere and where possible reduce flood risk overall.

6.5.2 PPS25 states that a Level 2 SFRA should identify the need (or not) for an SWMP. An SWMP has been undertaken for LCC and is due for completion in Autumn 2011. This will identify surface water flooding 'hotspots' and provide mitigation options.

6.5.3 In accordance with this SFRA, Annex F of PPS25, Chapter 5 of the PPS25 Practice Guide and Environment Agency guidance, it is strongly recommend that suitable surface water mitigation measures are incorporated into any development plans in order to reduce and manage surface water flood risk to, and posed by the proposed development. This should ideally be achieved by incorporating SuDS.

6.5.4 The key aim of SuDS is to reduce runoff by integrating storm water controls throughout a site in small, discrete units. SuDS should, where possible, mimic the natural drainage process and, in addition to controlling water quantity, should seek to maintain or improve water quality, amenity value and biodiversity. Through effective control of runoff at the source, the need for large flow attenuation and flow control structures should be minimised.

6.5.5 SUDS can be broadly split into three types: Source, Site and Regional control. Source control methods aim to control runoff at or close to the source e.g. green roofs, rainwater harvesting. Site control is the management of runoff from several areas in the local area e.g. routing water to detention basins whilst Regional control involves the management of runoff from a site or a number of sites which typically drains to a balancing pond or wetland. SuDS measures that may be suitable for use in Leicester are presented in Table 6-1 below.

6.5.6 As part of any SuDS scheme, consideration should be given to the long-term maintenance of the SuDS to ensure that it remains functional for the lifetime of the development. New obligations for Lead Local Flood Authorities under the Flood and Water Management Act (2010) mean that LCC will become a SuDS Approving Body (SAB). Therefore all SuDS proposals need to be agreed and approved by LCC prior to being implemented and adopted.

6.5.7 The SuDS National Standards are currently being drafted and will be available for comment in late 2011, due for release in early 2012. When released the National Standards will set out the

requirements for the design, construction and operation of SuDS for residential, commercial and industrial developments and redevelopments.

6.5.8 The National Standards will encourage developers to consider drainage at the earliest stage of planning and take into account local flood risk, planning policies and climate change. It is thought that the National Standards will include principles and hierarchy of where water should end up. As part of LCC's SAB responsibilities Leicester specific guidance on the local standards for SuDS will be developed.As a SAB, LCC will be required to agree and approve SuDS proposals and adopt and maintain the approved SuDS that serve more than one property to the National Standards.

Table 6-1: Summary of SuDS techniques and their suitability to meet the three aims for sustainability

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

Key: ●– highly suitable, ○ - suitable depending on design, × - not suitable

6.6 Green Infrastructure & SuDS

6.6.1 In terms of GI and surface water management, the identification of pluvial flow routes and ponding areas for installation of SUDS are particularly important. SUDS should be incorporated into any new developments and retro-fitted to existing development wherever possible. The advantages of SUDS in GI are summarised in Table 6-2.

Table 6-2: Summary of SUDS and GI (from Ashley et al,, 2011)

Technique	Description	Opportunities for GI
Water butts, drainage layout and property housekeeping	Stormwater management at property level and immediate curtilage.	To direct excess water onto garden areas, store for irrigation and other uses. Can maintain lawns, horticulture and be used for, e.g. indoor plant watering. Increasing proportion of permeable surfaces.
Rainwater harvesting	Direct collection other than the above for toilet flushing or other purposes	May detract from GI if used for purposes other than irrigation
Green roofs	Variety of options, e.g. may promote growth of plants	Roof surface demonstrably green or with vegetation and suitable substrate depth. Water retention on roof may influence other water uses as above
Filter drains	Linear drains / trenches filled with permeable material. Remove pollutants.	Infiltrates runoff but may be an opportunity to plant trees or shrubs on the surface.
Filter strips	Vegetated strips of sloping ground taking runoff away from paved areas and filtering solids.	Usually comprises grassed surfaces and as gently sloping can be considered to be useful GI, although solids capture may result in muddy areas
Swales	Shallow vegetated channels that convey or retain runoff and may infiltrate also filters solids in vegetation	As above and may include shrubs and bushes
Ponds or retention areas	Usually contain standing water but have bankside and marginal vegetation. Remove pollutants by settlement.	A key GI component with attractive marginal and bankside green areas. Aquatic ecology is the most significant.
Wetlands	As ponds, but with shallow standing water and different types of vegetation. Remove pollutants by a range of mechanisms.	Also a key GI component, but wetlands are less common in urban areas due to the land take requirements although recent designs mean these can be used at much smaller size than in the past. When established they are the most rich SUDS for biodiversity.
Detention basins	A combination of the two above, may have presumed but very shallow water as for wetlands, or may be dry until it rains. Usually retains some solids.	Also a key GI component that may be more readily installed than the above in recreational areas or other grassland areas not normally used during rainfall and supporting biodiversity.
Soakaways	Sub-surface structures that store and infiltrate runoff. Remove pollutants.	Useful in GI terms only for maintaining soil moisture, although it may be possible to plant bushes and shrubs on the surface.
Infiltration trenches	As filter drains but wider and allows infiltration through the trench sides	Infiltrates runoff but may be an opportunity to plant trees or shrubs on the surface.
Infiltration basins	As for detention basins but stored runoff can also infiltrate.	A key GI component that may be more readily installed than some of the above, but not in recreational areas or other grassed areas not normally used during rainfall unless the permeability is high.

Table 6-2: Summary of SUDS and GI (from Ashley et al,, 2011)

Technique	Description	Opportunities for GI
Permeable surfaces	As for infiltration systems but with porous paving. Remove pollutants retaining them in upper soil layers.	Some porous paving has openings (concrete lattice) that allow grass to grow creating a green area that is usually visually attractive.
Bio-retention areas (including rain gardens)	Vegetated areas that collect and temporarily store runoff with the express purpose of treating it.	May be amenable to high quality planting. Typically very good at removing solids, nutrients and metals from runoff.
Sand filters	Treatment devices (usually proprietary) for removing pollutants from runoff	Not normally GI as located below ground.
Silt removal devices	As above, although may be in the inlets to ponds and basins	Where located with ponds and basins may be amenable to planting, although frequent de-sludging may damage planting.
Trench-troughs	A combination of infiltration trenches and underdrained conveyance swales used where infiltration capacity is low	Can be valuable means of adding GI into an area where infiltration capacity is low as surfaces are usually grassed.

6.7 SuDS Utilisation within Leicester

6.7.1 All three main types of SuDS (Regional, Site and Source Control) should be utilised in future development in Leicester. It is recommended that LCC continue to work with its strategic partners in the Principal Urban Area to ensure that consistent Regional Scale SuDS incorporated into the proposed major developments surrounding the City. As part of the SWMP, a high level assessment of the potential impact of increased runoff from potential major developments around Leicester was made.

6.7.2 This assessment highlighted that if all potential major development sites were developed with 75% impermeable area with no methods for managing surface water runoff, then peak runoff rates from the sites could increase by over 180%. This could equate to a potential additional 7.5 cumecs in the River Soar at Black Friars during a 1% AEP event. The current estimated 1% AEP peak flow in the River Soar at Black Friars is in the region of 120 cumecs, so this could represent an increase of approximately 6 (see Figure 6-1).

6.7.3 This assessment has highlighted the importance of adopting a consistent overarching policy approach to regional SuDS either at source on each of the potential major development sites, or at strategic areas such as providing flood storage along linear reaches of watercourses. There are significant opportunities to link with Green Infrastructure Strategies in promoting sustainable drainage and storage along river corridors.

6.7.4 Given the greenfield nature of the sites, there are also significant opportunities for some of the potential major development sites to adopt source control and site measures that are consistent with an overarching regional SuDS policy. Furthermore, new or retro-fitted SuDS approaches to the Strategic Regeneration Area should also be encouraged – especially where there are opportunities to incorporate new open spaces and green infrastructure.

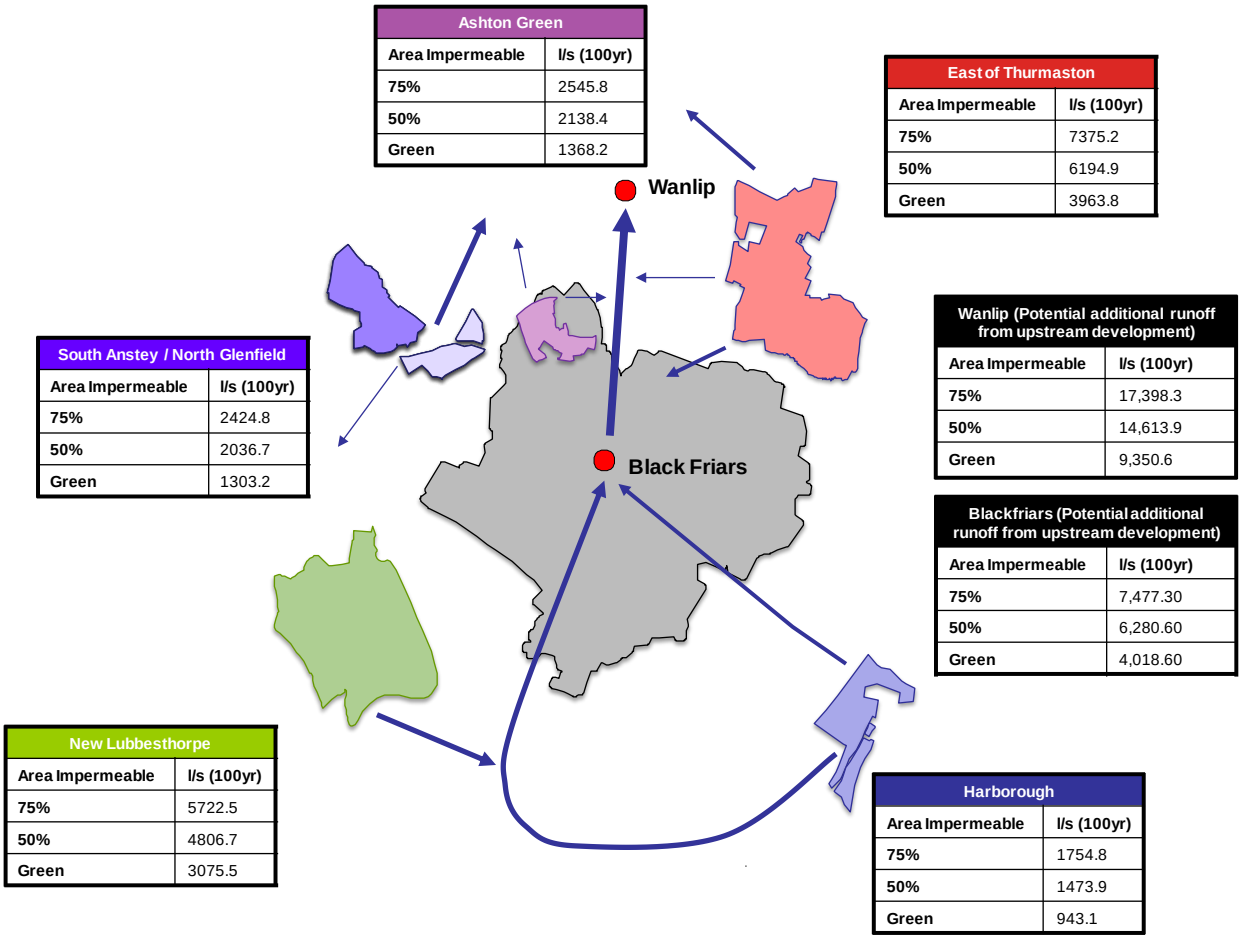


Figure 6-1: Schematic highlighting potential runoff impacts of major development sites around Leicester (not to scale)

6.7.5 Within Leicester City there is the potential for the use of infiltration SuDS to be used across wide areas of the City however due to the underlying nature of the geology these areas are restricted. As shown in Figure 7 in Appendix C areas identified as having 'restricted potential' for infiltration SuDS are probably unsuitable where high infiltration rates are required. However it is possible that low infiltration rate SuDS can be used in conjunction with attenuation SuDS.

6.7.6 In addition to flood and water management, SuDS also provide other benefits including improving the site amenity value, enhancing biodiversity and improving water quality i.e. Green Infrastructure. SuDS are unlikely to be accepted/adopted by LCC unless they provide amenity benefits and linkages with Green Infrastructure. It is recommended that Regional SuDS are incorporated into existing and/or proposed parks and green infrastructure in Leicester where feasible.

6.7.7 It is recommended that where feasible source control techniques are included for all new developments. In addition, opportunities should be sought to implement SuDS into ongoing highway maintenance projects and new highway proposals for example with the use of swales (See Table 6-1). Incorporating SuDS into such projects provides opportunities for off site provision and retrofitting.

6.7.8 More information on SuDS recommendations and solutions for Leicester can be found in the accompanying Hydrogeology Assessment for Leicester in Appendix C.

6.8 SuDS Constraints & Limitations

6.8.1 Whilst it is important to promote SuDS and to adopt a presumption on the use of SuDS for new development and regeneration areas, it is equally important to understand that there are some limitations and constraints to SuDS. SuDS are not always applicable to a site, area or region and many factors can affect the suitability fo SuDS in an area including:

- Ground contamination;
- Ground conditions or infiltration rates;
- Ground use / vulnerability; and
- Capacity of the receiving watercourse.

Ground Contamination

6.8.2 Ground contamination has the potential to contaminate groundwater and/or surface water resources if incorrectly managed. In some cases the nature of the ground contamination may be such that certain types of SuDS (e.g. infiltration techniques) are not appropriate. Ground contamination should be determined by site investigation on a site by site basis and, if necessary, as part of the drainage assessment for site specific FRAs..

Groundwater Use / Vulnerability

6.8.3 Groundwater resources can be vulnerable to contamination from both direct sources (e.g. into groundwater) or indirect sources (e.g. infiltration of discharges onto land). Groundwater vulnerability within the study area has been determined by the Environment Agency, based on a review of aquifer characteristics, local geology and the leaching potential of overlying soils.

6.8.4 The Environment Agency has produced Aquifer Designation maps to identify the potential for underlying geology to support significant volumes of groundwater. The majority of the geology in Leicester is deemed to be Secondary Aquifer B and as such would not restrict SuDS on account of it not containing significant volumes of groundwater. However, Secondary Aquifer B geological strata typically have lower permeability, which may restrict the use of infiltration type SuDS measures.

Groundwater Source Protection Zones

6.8.5 Source Protection Zones (SPZs) are defined to protect areas of groundwater that are used for potable (drinking) supply, including public/private potable supply, (including mineral and bottled water) or for use in the production of commercial food and drinks. Inspection of the available data has identified no part of Leicester City is delimited as a SPZs.

Other Constraints

6.8.6 There are a number of other potential constraints to the use of SuDS that should be investigated as part of a proposed development, these are summarised as follows:

- The depth of the groundwater table;

- Site slopes;
- Surface water run-off quality and quantity;
- Site restrictions;
- Maintenance requirements;
- Economical viability; and
- Ecological considerations.

Planning Considerations for SuDS

6.8.7 The underlying ground conditions of a development site will often determine the type of SuDS approach to be used at development sites as discussed above.

6.8.8 The application of SuDS may require space on development sites to be set-aside. Early consideration of SuDS will assist in determining the space required and identify methods to spread the management of storm water throughout a site using the Management Train principle presented in the SuDS Manual (CIRIA report C697).

6.9 Climate Change

6.9.1 PPS25 and the accompanying Practice Guide include for an increase in the peak rainfall intensity of up to 30%, as well as increase in peak flows in watercourses of up to 20% within 100 years. This will significantly affect smaller urban catchments, leading to rapid runoff into and subsequent increased flows within watercourses, surface water flooding, surcharging of gullies, drains and sewer flooding. The outputs of the Level 2 SFRA will include the increases in flows associated with climate change as suggested by PPS25.

6.9.2 CFMPs have also considered flood risk for the next 50-100 years and have taken into account the flood risk drivers of climate change, urban development and changes in land use. Catchment models and the Modelling and Decision Support Framework (MDSF) software were used in the CFMP to test sensitivity to the flood risk drivers across the catchments in the study area.

6.9.3 Sewer and surface water flooding are likely to become more frequent and widespread under urbanisation and climate change scenarios as the amount of impermeable surfaces and runoff increase, highlighting the importance of SuDS.

6.9.4 The location of future urban developments and flood defences within a catchment can heavily influence flood risk in the area and has the potential to further increase flood risk at areas downstream of such developments. Impacts include the lowering of the SoP offered by flood defences and the carrying capacity of culverts, drains, sewers and watercourse channels. This potentially leads to areas being at risk of flooding that were previously not at risk and highlights the increasing conflicts and pressures that are emerging between climate change scenarios and future development aspirations.

6.9.5 The PPS 1 Climate Change Supplement sets out important objectives in order to tackle climate change, sea level rise and avoid flood risk. The purpose of design policies should be to ensure that developments are sustainable, durable and adaptable to natural hazards such as flooding. Following this guidance, it should be possible to mitigate against increased flood risk through incorporating ‘flood proofing’ measures such as raised finished floor levels into the development design, and/or development of compensatory storage and flood storage basins.

6.9.6 The Adaptation Strategies for Climate Change in the Urban Environment (ASCCUE) project is a study undertaken collaboratively by the University of Manchester, The University of Cardiff, University of Southampton and Oxford Brooks University. The project aimed to further the understanding of the impacts and risks of climate change on towns and cities through three 'exposure units' of human comfort, urban green space and the built environment. One of the aspects examined was surface water runoff during extreme rainfall events. With an increase in development, there comes an increase in the amount of impermeable areas thus leading to increased runoff during storm events. In one of the worst-case modelled scenarios (large urban centre), an increase in rainfall of 56% by 2080, led to an increase in runoff of 82%. This highlights the increasing conflict and pressures that are emerging between climate change scenarios and future development aspirations.

UKCP09

6.9.7 According to EA guidance for PFRAs, United Kingdom Climate Projections 2009 (UKCP09) provides the most up to date projections of future climate for the UK (http://ukclimateprojections.defra.gov.uk/). In terms of precipitation, the key findings are:

- By the 2080s, under Medium emissions, over most of lowland UK central estimates are for heavy rain days (rainfall greater than 25 mm) to increase by a factor of between 2 and 3.5 in winter, and 1 to 2 in summer.
- By the 2080s, under Medium emissions, across regions in England & Wales the central estimate (50% probability) for winter mean precipitation % change ranges from +14 to +23. Central estimate for summer mean precipitation % change ranges from -18 to -24.

6.9.8 Certain key processes such as localised convective rainfall are not represented within this modelling so there is still considerable uncertainty about rarer extreme rainfall events for the UK. There is greater certainty that heavy rainfall will intensify in winter compared to summer. The proportion of summertime rainfall falling as heavy downpours may increase. However, the impact of these changes on local flood risk is not yet known.

7 Meeting the PPS25 Exception Test – Residual Risk Mitigation

7.1 Residual Risks

7.1.1 Residual risks are those that remain with flood mitigation measures in place. For example, proposed development areas that are located behind defences are at residual risk of flooding if those defences fail.

7.2 Flood Resilience and Resistance Measures

> ***'Where there is a low probability of limited shallow depth water entry, but not severe inundation to buildings, the use of flood-resilient construction may be considered.' PPS25***

7.2.1 Within the design of buildings in areas where the probability of flooding is low or in areas where flood risk management measures have been put in place, guidance has been outlined in paragraphs 6.29 to 6.35 of the PPS25 Practice Guide[2] and by the Department of Communities and local Government in 'Improving the Flood Performance of New Buildings'[16].

7.2.2 A number of measures can be used to manage residual risk including:

- Use local topography to guide water away from proposed development and into surface water drainage systems (Section 6.3);
- Flood resilience and resistance measures such as raising floor levels above the flood water inundation level (Section 6.4);
- Use SuDS where possible to reduce runoff rates discharging to local drainage systems (Section 6.5);
- Maintainence of flood risk management/ SuDS features; and
- Flood warning and evacuation plans (Section 7.4).

7.2.3 Flood proofing is a technique by which buildings are designed to withstand the effects of flooding. There are two main categories of flood proofing; dry proofing and wet proofing. Dry proofing methods are designed to keep water out of the building, and wet proofing methods are designed to improve the ability of the property to withstand the effects of flooding once the water has entered the building.

7.2.4 Further guidance is also provided in the CIRIA Research Project 624 'Development and Flood Risk: Guidance for the Construction Industry' (2004). Table 7-1 summarises recommendations made within Table A3.6 of the report for flood proofing measures which can be incorporated within the design of buildings (subject to compliance with Building Regulations).

[16] Communities and Local Government (2007) *'Improving the flood performance of new buildings',* Defra: London.

Table 7-1: Flood Proofing Options

Feature	Considerations To Improve Flood Proofing
External Walls	Careful consideration of materials: use low permeability materials to limit water penetration if dry proofing required. Avoid using timber frame and cavity walls. Consider applying a water resistant coating. Provide fittings for flood boards or other temporary barriers across openings in the walls (dry proofing).
Internal Walls	Avoid use of gypsum plaster and plasterboard; use more flood resistant linings (e.g. hydraulic lime, ceramic tiles). Avoid use of stud partition walls.
Floors	Avoid use of chipboard floors. Use concrete floors with integrated and continuous damp proof membrane and damp proof course. Solid concrete floors are preferable; if a suspended floor is to be used, provide facility for drainage of sub-floor void. Use solid insulation materials.
Fitting, Fixtures and Services	If possible, locate all fittings, fixtures and services above design flood level. Avoid chipboard and MDF. Consider use of removable plastic fittings. Use solid doors treated with waterproof coatings. Avoid using double-glazed window units that may fill with flood water. Use solid wood staircases. Avoid fitted carpets. Locate electrical, gas and telephone equipment and systems above design flood level. Fit anti-flooding devices to drainage systems.

7.3 Emergency Access and Egress

7.3.1 Emergency access and egress is required to enable the evacuation of people from developments and also to provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.

7.3.2 An emergency access and egress route is a route that is 'safe' for use by occupiers without the intervention of the emergency services or others. A route can only be completely 'safe' in flood risk terms if it is dry at all times.

7.3.3 For developments located in areas at flood risk the Environment Agency consider 'safe' access and egress to be in accordance with 'FRA Guidance for new Developments FD2320'[17], where the requirements for safe access and egress from new developments are as follows in order of preference:

- Safe, dry route for people and vehicles;
- Safe, dry route for people;
- If a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people; and

[17] Defra and Environment Agency Flood and Coastal Defence R & D Programme (2005) *Flood Risk Assessment Guidance for New Development',* R&D Technical Report FD2320/TR2, Defra: London.

- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles.

7.3.4 For commercial development ('less vulnerable') it is considered that dry access and egress from the site will be desirable during times of extreme floods. For all new residential development ('more vulnerable'), it is considered that dry access and egress will be essential during times of extreme floods from each residential unit to an area outside of the floodplain. New properties within a 'dry island' of the fluvial floodplain will also require dry access due to the disruption to essential services (gas, water, etc.) that would be experienced during a flood event.

7.3.5 It is necessary to ensure that proposed roads levels are such that emergency access and egress routes are maintained or where possible constructed to a level agreed with the Environment Agency. This can significantly reduce the risk of the proposed development becoming inundated by flooding.

7.3.6 Details of how this will be achieved should be clearly described in site-specific FRAs. This should include:

- A review of any detailed river models (where available);
- A review of flood extents from broadscale modelling; and
- Comparison of flood extents/levels with local ground levels from topographical survey or digital elevation models.

7.3.7 A preliminary assessment undertaken as part of this Level 2 SFRA (for the development areas assessed in more detail) has identified that access and egress is possible. However, the assessment of feasible access and egress routes will require investigation of all potential sources of flooding within the site-specific FRAs for each site.

7.4 Flood Warning and Evacuation Plans

7.4.1 Ensuring people in areas of flood risk are aware of potential flooding is key to ensuring they are prepared, facilitating the protection of property and evacuation where necessary.

7.4.2 The EA operates a flood warning service for many areas at risk of fluvial and tidal flooding. The flood warning stages/codes were updated in November 2010[18]. The service currently consists of three stages:

- **Flood Alert** - flooding is possible and that you need to be prepared;
- **Flood Warning** - flooding is expected and that you should take immediate action. Action should be taken when a flood warning is issued and not wait for a severe flood warning; and
- **Severe Flood Warning** - there is severe flooding and danger to life. These are issued when flooding is posing **significant** risk to life or disruption to communities.

[18] Environment Agency. 2010. Changes to our flood warning service. http://www.environment-agency.gov.uk/homeandleisure/floods/124554.aspx

7.4.3 Each code gives an indication of the expected level of danger. Although some members of the public find Flood Alerts useful, they are predominantly targeted towards professional partners, alerting them to expected flooding of low lying land and roads. Flood Warnings and Severe Flood Warnings are more useful for the public, alerting them to expected property flooding.

7.4.4 All stages of warning are disseminated via Floodline Warnings Direct, which is a free service that provides warnings to registered customers by telephone, mobile, email, SMS text message and fax. Local radio, TV, loudhailers, sirens and Floodline are also used to deliver flood warning messages. The Floodline number is 0845 988 1188, and it is always kept up to date with the EA's latest flooding information.

7.4.5 When developing in flood risk areas is unavoidable, it is recommended that the owners/occupiers sign up to the 'Floodline Warnings Direct' service where the area is designated to receive flood warnings (Environment Agency's website[19]), as a method of mitigating flood risk to people. The flood warning direct service is broadcast in Leicester via BBC Radio Leicester and the Environment Agency's website.

7.4.6 Where a particular site lies within an area not currently eligible to receive flood warnings, it can be registered with the local Environment Agency office as an 'area of interest' in order to receive such warnings. The flood warnings are able to be provided by the service via mobile, telephone, fax or pager.

7.4.7 More detailed information on the likely extent and time scale of these warnings can be obtained by request from the Environment Agency, by their 'Quick-dial' recorded information service, or via their website. The current Environment Agency flood warning area map is provided in Appendix B.

7.4.8 For any proposed commercial or industrial developments within a designated floodplain, or those providing a service to vulnerable groups such as elderly care homes or hospitals, a system for monitoring flood warnings should be developed with designated responsible persons able to monitor and disseminate the warnings. This will provide more time to enable emergency access and egress of staff or residential occupants away from the local area which may become flooded during a flood event (including routes for egress) prior to inundation.

7.4.9 They should also enable sufficient time to implement protection measures for any commercial goods or personal belongings on site through sealing all external doors to prevent flood inflow into such buildings as a precaution.

7.4.10 The exact nature of these emergency plans and procedures should be determined from the results obtained through the detailed FRAs for the individual sites and may be needed in conjunction with other mitigation measures. The need for, and feasibility of flood warning systems for a development should be discussed with the FRA.

7.4.11 Where there are exceptional circumstances in which development is allowed, which is reliant on evacuation, LCC will need to assess whether the proposals are acceptable to their emergency planners and the local emergency services. It is not the remit of the Environment Agency to make recommendations on this matter.

7.4.12 At the site specific FRA stage it is advised that developers contact the Environment Agency and add new development to the current flood warning service where applicable.

[19] http://www.environment-agency.gov.uk

8 Level 2 SFRA Findings

8.1.1 Leicester City is at risk from a variety of sources of flooding and there are significant areas of flood risk within the Leicester City administrative area. The dominant sources include flooding from rivers, the land (surface water) and sewers. Modelling of the watercourses for the Leicester SWMP has identified hotspots of flood risk and CDAs within Leicester City.

8.1.2 A Level 2 SFRA for LCC has been undertaken to assess specific flood risks to the Strategic Regeneration Area (Core Strategy Policy CS4) and other potential major development sites in the Leicester Principal Urban Area:

- Strategic Regeneration Area including:
  - SRA: Abbey Meadows;
  - SRA: Waterside;
  - SRA: St George's North;
- Ashton Green

8.1.3 For each proposed development area, a site assessment form has been completed. The form assesses flood risk to the site from all sources, provides a narrative of proposed uses and vulnerability to flooding and recommends policies and site specific FRA guidance.

8.1.4 Additional potential major development areas in the Leicester Principal Urban Area have also been assessed as a separate document available in Appendix D.

8.1.5 The Strategic Regeneration Area and other potential major development sites around Leicester play an important part in reaching the development aspirations of Leicester and its neighbouring Districts. It is therefore crucial that flood risk is taken into account at an early stage to ensure that any proposed development is sustainable and does not increase flooding elsewhere.

8.1.6 Information has been collected from LCC and key stakeholders including the Environment Agency. From this data, it is clear that the Leicester Principal Urban Area is at risk of flooding from a variety of sources including rivers and watercourses, directly from the land (surface water), from groundwater and from sewers.

8.2 Strategic Regeneration Area

8.2.1 From this assessment, the Abbey Meadows and Waterside parts of the SRA have the most significant flood risks associated with them. Both are subject to flooding from the River Soar and its tributaries which present high hazards to parts of the sites. In addition, both the SRAs are also subject to surface water flooding across areas of each site. The St. Georges North part is less affected by fluvial flooding. However, some of the area is affected by deep surface water ponding. The whole SRA has a high susceptibility to groundwater flooding and, due to its urban nature, has also been subject to sewer flooding in the past.

8.2.2 In accordance with the principals of PPS25, before regeneration activities begin, careful consideration should be given to the layout of the different parts of the SRA, especially with regards to vulnerability of developments and access and egress in times of flooding. Where practicable, efforts should be made to 'make space for water' and follow the green infrastructure

strategy by siting green open spaces and water compatible developments in areas of greatest flood risk.

8.2.3 Any flood risk mitigation measures need to be designed carefully and assessed as part of a site specific FRA to avoid increasing flood risk elsewhere. The SRA should incorporate SUDs (in agreement with the LCC SAB) to sustainably manage surface water runoff and to reduce the potential for increasing surface water flooding to the site or elsewhere (See Section 6.5). Severn Trent Water should also be consulted when designing the surface water management and drainage strategy for each part of the SRA.

8.3 Potential Major Development Sites around Leicester

8.3.1 The potential major development sites in and around Leicester are all large sites situated on green field areas and generally have limited flood risks. Flood risk for most of the sites tends to concentrate along watercourse routes, where the land is generally lower and so surface water ponding can occur in addition to fluvial flooding. It is also along watercourse corridors that susceptibility to groundwater flooding is highest.

8.3.2 It is therefore recommended, in accordance with PPS25, that site layout and development proposals for the potential major development sites around Leicester are steered away from watercourses. Opportunities to incorporate green spaces or blue corridors along watercourses should be encouraged to reduce the risk of flooding to future development within each potential major development site.

8.3.3 It is also important to recognise that much of the potential major development is upstream of Leicester and therefore has the potential to increase flood risk to the City through increased surface water runoff. As part of the SWMP for LCC, broadscale runoff rates have been derived for different development scenarios for each potential development site. This exercise has demonstrated the potential for increased flood risk in Leicester unless a consistent, regional approach is taken to surface water management and SuDS for the Principal Urban Area.

8.3.4 Each of the potential major development sites around Leicester should therefore incorporate SuDS (in agreement with the LCC) to sustainably manage surface water runoff and to reduce the potential for increasing surface water flooding in downstream areas. Where feasible, opportunities to reduce downstream flood risk should also be incorporated. Severn Trent Water should also be consulted when designing the surface water management systems and drainage strategy for each potential major development site to ensure that any future drainage scheme that may be adopted is sustainable.

Appendix A. Data Register

Appendix B. Maps

- Areas Susceptible to Groundwater Flooding
- Draft Pluvial Modelling Results
- Flood Warning Areas
- Fluvial Flood Zones, Historical Flooding and Defences
- Flood Zone 3b (Functional Floodplain)
- Historical Sewer Flooding – Severn Trent DG5 Register

Appendix C. Hydrogeology Assessment

Appendix D. Assessment of flood risks associated with potential major development around Leicester