Derby City Council

Regeneration & Community

Strategic Flood Risk Assessment for the City of Derby: Level 1 Report

Quality Assurance Summary

Issue	Author (name & date issued)	Checked (name & date issued)	Approved (name & date issued)
Draft	[redacted]	[redacted]	
1st amendment	[redacted]dson 29th Jan 2009	[redacted] March 2009	
2nd Amendment	[redacted] February 2010	[redacted] May 2010	
Final Issue	[redacted]dson 1st June 2010	[redacted] July 2010	

All copies of the report are issued a number to represent that the contents have been checked.
This Copy of the level 1 SFRA report is number:…………..

Initials of issuer verifying copy:

Contents List

1. Purpose of the report

This report has been produced in line with the recommendations for the level 1 SFRA outputs contained within the practice guide accompanying PPS25. In this respect the general aims & outputs may be summarised as follows:

- To provide a reference text for Derby City Council showing:
    - Main rivers, watercourses and flood zones 2, 3a & 3b (functional floodplain),
    - Allocated development sites within the flood zones,
- To provide an assessment of the implications of climate change at allocated development sites,
- To provide guidance on site where development may adversely increase the flooding risk to other 3rd party properties,
- To produce textual information describing the areas at risk from other flooding sources including sewers, waterlogging and overland flows,
- Provide information on the existing flood risk management measures, the location of these, the standard of protection and the condition of the assets,
- location of flood management assets including flood protection walls/earthworks, flood relief channels, culverts and flow attenuation & balancing areas,
- To provide guidance on the applicability of Sustainable Urban Drainage techniques,
- To provide guidance and general requirements for the production of site-specific Flood Risk Assessments for development within the City including guidance on the requirements of drainage strategy statements and preliminary design/evaluation studies to be carried out as a part of the planning application process.

1 Limitations of the report

This report is designed to be a general overview of the current flood risks to the City of Derby and is necessarily limited by the accuracy of the information sources used in the report. Some of the limitations are as follows:

- The flood modelling is subject to certain assumptions including:
    - the catchment characteristics,

  - o the levels information along the sides of the watercourse that determine the points at which flooding might occur,
  - o the capacity and condition of the watercourse,
  - o ground levels to assess the movement and spread of floodwater,
  - o The contour maps that have been used to predict the flow of the flood water have been produced from the Lidar digital terrain model (DTM). The raw Lidar data that is obtained from aerial surveys provides a digital surface model (DSM) and includes all the features on the ground at the time of the survey including people, cars, trees, hedges, buildings etc. The data is then manipulated using computer software to remove these features and leave a "bare earth" model that forms the DTM. To accurately predict the direction and depth of overland flood flows, the ground features need to be added back into the model in a controlled way however such a level of work is outside the scope of the level 1 study. The 'bare earth' model nevertheless serves as a general guide to the flow direction and extents of potential flooding subject to the limitations described above.

- The level 1 SFRA does not attempt to model any area in particular detail nor to verify the assumptions used in any of the data sources employed in the report.
- The report is designed to be a 'living document' and should be regularly updated to maintain its usefulness. Most of the information used within the report (produced in 2007/2008) is less than 3 years old. Use of the report in future years should bear in mind the revisions necessary and the validity of data used in the modelling.
- In the absence of a fully detailed hydraulic and overland flow model available for many of the smaller watercourses, the 1% AAP flooding zones have been assessed on the following basis:
    - o flows exceeding the available capacity within a culvert, pipe or channel leading to overtopping of the banks and flows parallel to the watercourse.
    - o Infrastructure failure including the collapse of culverts or sewers where the condition of the infrastructure is of concern. The flooding envelopes have been derived from providing a throttle point at

intervals along a watercourse and then estimating the extents of the overland flows before the water may re-enter the watercourse further downstream.

- Blockages of trash screens in minor watercourses – the estimates for flows are similar to that used for infrastructure failure.

- The flooding risks from sewers are based on assumptions of inflows from the catchment areas and the accuracy of information provided for invert/cover levels, pipe sizes and materials used.
- The area within the study has not suffered a serious flooding event in recent times. The last major flood event from the River Derwent was in the winter of 1965 and was prior to the construction or upgrading of many of the flood defences visible today between Darley Abbey and Borrowash. More recent events upto a 4 or 5% (average annual event probability) severity have been retained within the flood defences or functional floodplain areas. In this respect the models for extreme event flow down the River have not been calibrated against 'real' events. The further away from a known event probability (4% = 1 in 25 year event) that the event is, the greater the effect of the assumptions within the models. This can, of course, mean that the estimates for properties at risk may be an overestimate or underestimate.
- There have been numerous flooding events from the Markeaton brook system including significant inundations of the City centre between Agard Street and River Derwent in the 1930s and a number of smaller, less widespread events since then. Since 1937, when the northern flood relief culvert was completed between Markeaton Park and the River Derwent at Darley Park, the flooding events on the brook system have been limited to a few houses. The behaviour of a possible future flooding event has to be estimated from historical records and the contour plans of the City although the extent of new development over the last 70 years will have certainly changed the flood paths and behaviour of floodwater through the City.
- The SFRA is limited to the area contained within the Derby City boundary.

2 Acknowledgements

Derby City Council is grateful to the following organisations for their assistance in the provision of information used within this report and also with the editing of the report drafts:

Environment Agency (Midlands Office – Nottingham)

Severn Trent Water – Derby Office

Clear Environmental Consultants

Derby City Council – Planning & Development Control

Derby City Council – Highways Design

Derby City Council – Land Drainage & Flood Defence Team

3 Executive Summary

Derby City Council commissioned it's own in-house Land Drainage Team in spring 2007 to prepare a level 1 SFRA to assist the City in meeting the requirements of PPS25 and also one of the requirements of the successful bid for 'growth point' funding for new residential development to meet rising demand within the East Midlands. The brief for the SFRA was discussed and agreed with the Environment Agency and other interested stakeholders within Derby City Council and is designed to follow the guidelines published within PPS25. The area covered by this report includes the full extents of the City boundary and limited further areas towards the A50 to the south and some catchment areas to the north of the City.

The report includes the following information:

- A description and discussion of the flood risks within the City from the major rivers and watercourses (chapter 10 & 11) and includes the extents of flooding zones and protection levels available to parts of the City centre (appendix E) .
- The risks from the River Derwent are discussed in some detail as this is the source of the primary flooding risk to much of the City and adjacent residential areas with around 2200 homes at risk (chapter 10). The flood risk warning measures are also discussed (chapter 17).
- Other watercourses have been modelled and discussed within the report including the Littleover, Markeaton, Chaddesden, Hell and Cuttle brooks – all of which have the potential to inundate significant numbers of properties. The catchments of many of the brooks within Derby include areas earmarked for new residential developments therefore the flooding risk to these areas is a factor in the decisions to be taken when master-planning new development areas.
- Additional risks to the City have been included and discussed including the sewer systems, overland flows and risks from new development areas overloading the existing drainage infrastructure (chapter 12).
- Some notes on the Lower Derwent Flood Risk Management Strategy (chapter 13).
- Advice on site specific flood risk assessments and drainage statements (chapter14) and supporting information for Sustainable Urban Drainage techniques in Derby (chapter 15).

- The limitations of the report are described in chapter 2 and recommendations for further work and study to form the basis of level 2 strategic flood risk assessments.

The outputs from the level 1 study are presented both as a narrative within the report and also as 1:10000 scale plans showing the flooding risks to the City areas in 30km^2 areas on each plan. This will enable the flood areas to be identified on a street by street basis.

It is intended that the document and plans will be revised and updated periodically as the information and flooding risks become more refined and understood however the information is also designed to be viewed using contemporary ArcGIS software that will also include further information on the sizes of watercourses and culverts and also levels information to enable interpretation of the flood zones in more detail.

The report has used a wide range of data and makes reference to other reports kindly supplied by the Environment Agency who work closely with the City Council with regard to the flooding risk from the River Derwent and other watercourses. The EA have audited for this report and the final version here takes into account their comments and amendments and also those from interested parties within Derby City Council.

Finally it is perhaps worth stressing that the report identifies the flooding *risk* to areas of the city based on the available modelling. It should not be interpreted as showing areas that *will* flood. For much of the flooding zones, the extent and depth of flooding is based on the partial or complete failure of existing flood defence infrastructure including flood walls, overflows, screens, culverts and watercourses becoming choked. Significant efforts and funds are continually being expended by the Environment Agency and Derby City Council to both maintain the existing infrastructure to a high degree of performance and also to identify weaknesses and improve matters where practically and economically possible.

Tony Donaldson C.Eng MICE

Land Drainage Team, Derby City Council

March 2010

4 Glossary

Afflux	Increase in upstream water level caused by an obstruction to flow in a watercourse or on a *floodplain*
Annual flood probability, Annual average probability (AAP),	The estimated probability of a flood of given magnitude occurring or being exceeded in a given year. Expressed as a 1 in 100 chance or 1% probability.
Attenuation	To reduce the peak flow and increase the duration of a flooding event.
Balancing Pond	A pond designed to attenuate flows by storing rainwater run-off during a storm event and releasing the water slowly at a controlled rate over an extended period of time. Also known as a 'detention basin'.
Basin	See above. A depression in the ground used to store rainwater run-off. May also be used to infiltrate rainwater into the ground 'infiltration basin'.
Brownfield site	A piece of land or a site that has previously been developed.
Catchment	The area contributing flow or run-off to a particular point on a watercourse system.
Climate Change	Long term variations in the weather patterns and particularly temperature and rainfall thought to be a result of an increase in carbon dioxide emissions from human activity.
Combined sewer	A public sewer used to convey both surface water runoff and foul sewage.
Commuted Sum	A single payment made at the beginning of an agreement to cover maintenance for an agreed period of time.
Culvert	Covered channel or pipe that forms a *watercourse* below ground level.
Cumec	A unit to describe a flow in a sewer or watercourse of one cubic metre per second.
Design criteria	A set of standards agreed by the developer, planners and regulatory bodies that the proposed system should satisfy.
Design event	A historic or notional *flood event* of a given *annual average probability* against which the suitability of a proposed development is assessed and a *mitigation measures*, if any, are designed.
Design flood level	The maximum estimated water level during the *design event*.
Detention basin	A vegetated depression that is normally dry except during severe rainfall events. Used to store rainwater run-off to attenuate flows and may also enable infiltration.
Development	Works resulting in a change of use or character of a piece of land.
Discharge	Rate of flow of water
Field or land drainage	A system of drains to control the *water table* in agricultural land.

Filter drain or filter trench	A linear drain consisting of a trench filled with a permeable material and often with a permeable pipe in the base of the trench. Used to store and infiltrate water into the ground and may also act as a conduit to collect and transfer water through a drainage system.
Filter strip	A vegetated area of gently sloping or flat ground designed to collect water off impermeable areas and convey this to a fillter drain.
Filtration	The act of removing particulates from a fluid by passing it through a filter.
First flush	The initial run-off from a site or catchment following the commencement of a rainfall event. The intial run-off will tend to collect the pollutants on the ground and may be particularly contaminated as a result.
Flap valve	A simple form of non-return valve, employing a hinged flap to prevent reverse flow.
Flood defence	Flood defence infrastructure such as flood walls & embankments, intended to protect an area against flooding to a specified standard of protection.
Flood defence crest level	The level to which the flood defences are constructed (the top of the walls or embankments) expressed as a level to ordnance datum.
Flood event	A flooding incident characterised by its level or *flow hydrograph.*
Flood Zone 1 (<0.1% AAP)	Areas where the probability of flooding from watercourses is through to be less than 0.1% in any given year. This is approximately equivalent to a 1 in 1000 year rainfall event. These areas may still be at risk from flooding from other sources including overland flows, sewers and groundwater.
Flood Zone 2 Flood plain (0.1-1% AAP)	Areas where fluvial flooding should not occur more frequently than a 1 in 100 year (1% AAP)event however they are susceptible to fluvial flooding events between a 1in 100 year (1% AAP) and 1 in 1000 year event (0.1% AAP) if all the defences and mitigation measures are ignored.
Flood Zone 3a Flood plain (>1% AAP)	Areas where water would flood during a 1% or 1 in 100 year storm event if all the defences and mitigation measures are ignored.
Flood Zone 3b Flood plain (>5% AAP)	Areas of the floodplain that are regularly inundated by floodwater (with at least a 5% annual average probability of being flooded). Also called *washlands* or *functional flood plain.* These areas are generally designed to flood regularly and perform an important role in the protection of sensitive locations by storing or providing a flow path for floodwater.
Flood probability	The estimated probability of a flood of given magnitude occurring or being exceeded in any specified time period. See *annual flood probability.*
Flood risk	An expression of the combination of the *flood probability* and the magnitude of the potential consequences of the *flood event*.

Flood risk assessment	A study to assess the risk of a site or area flooding and to assess the impact that a development might have on the prevailing *flood risk.*
Flow control device	A mechanical device to limit the flow or manage the flow either into or out of a *flow balancing* or *attenuation facility*.
Fluvial flooding	Flooding from a river or watercourse
Freeboard	The difference between the *flood defence crest* level and the maximum envisaged *design flood level*.
Functional flood plain (also called Flood Zone 3b)	See *flood zone 3b*
Greenfield runoff rate	The rate of *runoff* of water from a piece of land in an undeveloped or natural state.
Greywater	Greywater is water from domestic uses (other than toilets) and is generally high in detergent and fat contaminants. It is generally not reused due to the cost of adequate filtration.
Groundwater	Water within the ground – often referred to as the water below the *water table*. Groundwater may exist at a number of different levels within the ground depending on the types of material in the ground. The water table often exists approximately parallel to the surface of the ground.
Groundwater flooding	This occurs where the local *water table* rises above the surface of the ground. A common feature of this type is a *springline*.
Hydrograph	A graph showing the variation in water flow in a *watercourse* versus time
Impermeable surface	An artificial (man-made) surface such as a roof, road, car park etc that prevents water passing through it and so generates surface water runoff after rainfall.
Infiltration	The passage of water through the surface layers & into the ground
Infiltration basin	A dry basin designed to promote the *infiltration* of surface water into the ground
Infiltration capacity	A soil characteristic determining the rate at which water may enter the soil.
Infiltration trench	A trench excavated in permeable ground and filled with permeable granular material . Used to promote the infiltration of rainfall runoff into the ground.
Land Drain	Drain used in agriculture to control to level of the local *water table* and reduce the frequency with which the land becomes waterlogged.
Local development documents	Documents and plans that set out the development at spatial strategy for the *Local Planning Authority*
Local Planning Authority	Body with responsibility for planning and controlling development through the planning application system.
Main River	A watercourse designated on a statutory map of watercourses and falling under the control of the Environment Agency & DEFRA.
Material	Matters which need to be taken into account by a planning

consideration	authority when considering an application for planning permission.
Mitigation measure	A generic term used to refer to an aspect of the design of a development that reduces the impact of the development on the local environment and particularly on the flooding risk.
Model agreement	A legal document that sets out the framework for a contract between two parties for the maintenance and operation of a sustainable drainage facility or system.
Ordinary watercourse	A watercourse that falls under the control of the local drainage authority and is neither a private drain nor a main river.
Overland Flow	A situation that arises when the ground becomes saturated and cannot hold any more rainfall. The rainwater then collects on the surface and flows in the direction of the steepest gradient.
Permeable surface & Permeable paving	An area that utilises material that allow water to pass through gaps between the constituent materials into the layers below.
Pluvial flooding	Flooding generated, normally during an intense rainfall event, when runoff flows and accumulates as floodwater without having entered any *watercourse* or *sewer system*. It is a particular problem in dense urban areas although may occur in rural areas. See *overland flows*.
Pond (storage)	A permanently wet feature used to store water in times of heavy rainfall. Frequently a locally important wildlife refuge & amenity
Precautionary principle	The approach to be used in the process of producing a flood risk assessment requiring that a lack of knowledge or certainty regarding the flooding risk or behaviour of a watercourse or drainage system should not be used as a reason for the delay in implementation or avoidance of suitable measures to manage the flood risk.
Rainwater recycling	Used to describe a variety of systems to collect and enable the redistribution or re-use of rainwater falling on roof or pavement areas. These can include water butts and also underground tanks and pumping systems to supplement mains water for certain uses.
Resiliance Measures (to flooding)	Measures taken to improve the ability of a commercial building or domestic dwelling to resist inundation by floodwater or to enable straightforward recovery and re-occupation following a flooding event.
Retention pond	A pond where run-off is detained for a sufficient time to allow settlement of suspended solids and possibly biological treatment of some pollutants.
Riparian	This refers to the ownership of land adjacent to or containing a watercourse. Also the rights and responsibilities of the owners of land are often referred to as *riparian rights/responsibilities.*
River flooding	See *fluvial flooding*.
Runoff	Water flow over the ground surface to the local drainage system. This occurs if the ground is impermeable or saturated or if the

	rainfall is sufficiently intense.
Sequential test	A risk-based approach to flood risk assessment in accordance with Planning Policy Statement no. 25 (PPS25). It uses the principle of defining the types of development that may be considered as suitable for each *flood risk zone*.
Sewerage undertaker	Refers to the organisations responsible for the maintenance of the sewer systems and the appropriate treatment and disposal of both surface water & foul sewage.
Sewer system	The private and public network of piped drainage used to convey rain water and foul sewage from highways and the 'built environment' including houses, shops, car parks, industrial commercial and public buildings. Sometimes the sewer systems carry both surface water runoff and foul sewage in a *combined sewer*.
Soakaway	A subsurface structure into which surface water is conveyed to enable *infiltration* into the ground.
Source control	The control, attenuation and/or treatment of runoff or pollution near to its source or origin.
Standard of protection	Refers to the lowest probability of the event that should not cause flooding at a particular site due to the extent of the mitigation measures in place. Often referred to as '25, 50 or 100 year protection'
Strategic flood risk assessment	A study to examine flood risk issues on a sub-regional scale, typically for a particular river catchment or local authority area.
Sustainable Urban Drainage systems (SUDs)	An approach to the management of rainwater involving particular techniques and control structures to reduce the flood risk impact of new developments on the surrounding areas.
Swale	A shallow linear vegetated depression used to both convey and store runoff particularly from car parks, highways and other paved areas. They may also incorporate infiltration.
Treatment	Improving the quality of water by biological, chemical or physical means.
Water Table	The level of *groundwater* in soil and rock below which the ground is saturated.
Watercourse	Any natural or artificial channel that conveys surface water.
Washland	An area subjected to frequent flooding and used to store, attenuate or convey floodwater.
Wetlands	An area where the natural saturation of the ground or frequent inundation is the determining factor for the particular biodiversity of the area.
Whole-life costing	An approach to the accounting of the cost of a particular flood alleviation scheme or other system that includes all the costs of the construction, operation & maintenance and eventual decommissioning. These costs are usually referenced to a 'present day' cost to enable the comparison between different alternatives.

5 Introduction

5.1 Contexts: Flooding Risk to Properties

5.1.1 Historical

Flooding is a natural phenomenon and cannot be prevented from occurring in absolute terms. Flood defence tends to be a localised solution and in general has served to transmit floodwaters downstream or move a flooding problem elsewhere away from a sensitive location. Ultimately there remains a volume of water that will find its way out of the river channel onto historical floodplains at the first available opportunity.

Development has historically taken place within river valleys and close to rivers as they formed useful communication routes, provided power and water for the industrial uses and also contained prime quality agricultural land. Early developments would have been sited on the nearest piece of raised land close to the river to provide a measure of security against flooding that would occur periodically along the river valley. As developments expanded, particularly through the industrial revolution, the newer housing and industry tended to be located on the lower-lying areas within the floodplain.

The development within the river valley often created restrictions including docks, weirs, training walls, bridges and diversions or braiding of the channel – all of which alters the behaviour of the river and may exacerbate the flooding problems. A second feature of ongoing development and redevelopment is the alterations or neglect of the existing drainage infrastructure including minor watercourses, drainage ditches and culverts/sewers. This, combined with the high density of buildings has created unpredictable flow paths in many cities and towns and ultimately may have increased the flooding depth in many locations.

5.1.2 Societal

Whilst many millions of people live and work within cities and towns that are at some risk of flooding, the communication of this flood risk has historically been poor. The approach to the management of flooding has often been an attempt to distribute sandbags as a last resort to prevent floodwater entering properties. Often too late and with no realistic estimate for the likely depth of floodwater that may occur. This approach has been seen on many occasions to be fundamentally flawed as the time between warning and inundation is generally a matter of a few hours at best. Often no warnings can be given as the behaviour of many small watercourses is poorly understood and the risk and prediction of flooding from sewers is not fully appreciated. A recent case of flooding to properties in Barlby, North Yorkshire (ref. BBC Panorama – “In Deep Water” transcript first broadcast 18th March 2001) highlighted the need to consider the overtopping and failure of existing defences and the plans to cope with such eventualities. There is often a lack of understanding or appreciation of what, in reality, the level of protection means. The results of overtopping, or at worst a breach, of flood defences may result in quite rapid inundation to properties behind the defence as the flows are concentrated in a small location and may rapidly increase in intensity as the flood defences erode under the flow of water.

5.1.3 Engineering

Engineers have grappled with the ideas of prediction of flooding flows and modelling events for nearly two centuries to try and relate rainfall events within a catchment to flooding events within a river system. Some statutory legislation has spurred the development of techniques including the need to predict flows and protect reservoirs from failure under the action of extreme flows (ref. 1930 Reservoir Act). Problems nevertheless still occur as in autumn 2000 with the Aldington Dam in Kent (ref. BBC Panorama – “Underwater Britain” first broadcast 19th November 2000) and most recently, with the Ulley Reservoir in South Yorkshire during the extreme rainfall events of summer 2007. (ref. Pitt Review June 2008)

Following severe flooding in the south-west of England in 1968, the UK Government commissioned the Flood Studies Report to review flood estimation techniques. Published in 1975, the report recommended a statistical analysis approach to the prediction of peak flows and also the development of the ‘unit hydrograph’ to estimate the flows based a ‘design’storm within the characteristics of the particular catchment under consideration. A great deal of work remains to be done in the prediction and estimation of flood risk from all sources as the increase in extreme events is creating particular concerns over the capacity of aging infrastructure including culverts, sewer systems and drainage channels to cater for future events. Flooding risks arise from both a consideration of the capacity of the infrastructure and also over the risk of structural or other failure mechanism creating a barrier to the flow or dispersal of floodwater. Secondary flooding risks arise from the creation of new impermeable areas within the catchments of sewers or watercourses that may create new flooding risks or exacerbate an existing issue.

5.1.4 Governmental

Recent flooding episodes in April 1998, November 2000 and June/July 2007 have refocused attention on the need for a coherent approach to the estimation of flooding risk and also the practical need for there to be a holistic approach to the problems faced. These have included planning guidance issued to Local Planning Authorities (LPAs) to encourage the use of flood risk assessment for new developments. Documents that have been published by DEFRA include “Learning to Live with Rivers” published in 2001 and “Making Space for Water” published in 2005. More recently, the publication of Planning Policy Statement 25 (PPS25): Development and Flood Risk has sought to impose a more rigorous approach to the allocation of development sites away from flood risk areas depending on the anticipated uses of the development and also a requirement for LPAs to consider all sources of flooding within their area as a starting point for the development of flood defence and drainage strategies. Finally, the Pitt Review (final version published June 2008) reported on the flooding incidents that occurred during the summer of 2007 and highlighted a number of lessons to be learned including the need for a greater understanding of the flooding risks to property and the need for a coherent strategy to manage these.

5.2 Background to the Level 1 SFRA for Derby

Derby City Council have been asked to produce a Strategic Flood Risk Assessment (SFRA) following the guidelines within the practice guide companion to PPS25. The Council have split this work into two main parts referred to as level 1 and level 2. The City Council have undertaken the level 1 work using their in-house Land Drainage & Flood Defence team as this enables the broad experience and knowledge from within the team to be used to create this summary document. The boundaries of the study area are outside of the City boundary to reflect known areas of development pressure and extend to:

- Breadsall in the northern part of the area,
- approximately 1km beyond Markeaton Lane in the northwestern part of the area,
- to the A50 in the southern part of the City.

A plan showing the study boundary is included in appendix F.

5.3 Scope and Objectives

The broad aims of the level 1 SFRA are as follows:

- To collate and summarise the available knowledge regarding flooding and flood risk issues within and adjacent to the City boundary.
- to assist the planning processes with a view to land allocation using the 'sequential test' methodology.
- To provide a reference document for a City-wide flood defence and drainage strategy.

The delivery objectives of the level 1 assessment are limited to those stated within the PPS25 companion guide (ref Planning Policy Statement 25: Development & Flood Risk Practice Guide) namely:

- Production of plans showing the planning area, watercourses, main river and flood zones where these can be defined with a high degree of precision.
- Plans showing other areas at risk of flooding from non-fluvial sources including sewers and overland flows.

- Plans showing the areas benefiting from flood defence measures and the standards of protection.
- Details of any flood risk management measures.
- Locations where development may increase the risk of flooding elsewhere.
- Guidance notes on the production of site-specific flood risk assessments and also the applicability of methods for achieving sustainable urban drainage solutions for developments.

5.4 Audit, approval and delivery

The level 1 SFRA is designed to be a ‘living’ document in the sense that it will provide a description of the flood zones within Derby during the summer of 2007. The data will be made available both as a hard copy report and plans and also within the ‘Arcview’ Geographical Information System (GIS) used within the City Council to convey and update information. The data will be made available to outside parties and will be updated and re-issued periodically as a defined revision reference with a particular date of issue. In this way it is hoped that the level 1 SFRA will remain a useful document as the variables effecting changes to the published information also change over time. Examples of this may be an extension to the coverage area or improved flooding risk information or a change to the standard of flood defence in a particular area.

5.5 Planning & Legislative Framework

There are a variety of objectives and targets for Local Authorities to meet with respect to their responsibilities for land drainage and flood defence. In some respects they conflict with the requirements of the ‘sequential test’ as allocations of land for development are made based on a number of criteria.

- Planning Policy Statement 25 (PPS25): Development & Flood Risk (published December 2006)

The following statement is taken from the Communities and Local Government website. “Planning Policy Statement 25 (PPS25) sets out Government policy on development and flood risk. It's aims are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk. Where new development is, exceptionally, necessary in such areas, policy aims to make it safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall. This replaces Planning Policy Guidance Note 25: Development and Flood Risk (PPG25), published July 2001.”

PPS25 has an accompanying practice guide used to guide Local Authorities on the implementation of the policy statement. The practice guide includes information on the production of Regional Flood Risk Assessments (RFA) to cover wide areas including a number of Local Authority areas and drainage systems, Strategic Flood Risk Assessments to cover a single borough or Local Panning Area and also guidance on the production of site specific flood risk assessments (FRA) to be produced on behalf of developers.

The details of the sequential test and exception test are included in the next section of the report with particular reference to Derby.

- Planning Policy Statement 1 (PPS1): Delivering Sustainable Development (published February 2005)

  This statement sets out the framework and issues facing Local Government in producing guidance for development within their area.

  Planning Policy Statement 3 (PPS3): Housing (published November 2006)

  This statement sets out the national planning policy framework for delivery of the Governments housing objectives including guidance on land use, maintaining biodiversity, achieving sustainability and promoting the most efficient and well supported developments in terms of affordability, infrastructure and social cohesion.

- Government Office for the East Midlands - Regional Spatial Strategy for the East Midlands (RSS8)

Policy 36 of the RSS details the requirements of development plans, local development frameworks and the strategies of relevant agencies. It includes the requirements for SFRAs, flooding management schemes, sustainable drainage and development sensitive to the needs of floodplain preservation and management.

- DEFRA High Level Target 5 (HLT5)
  This deals with the returns from Local Planning Authorities on the planning applications where the Environment Agency has commented or provided specific technical advice and the subsequent decisions made by the LPA in granting or refusing planning permission and details of any conditions imposed in light of the EA recommendations.

- Derby City Council – Policy Statement on Flood Defence & Land Drainage
  "Derby City Council will work in partnership with the Environment Agency to reduce flooding through the Planning process and through encouragement of Sustainable Urban Drainage Systems in order to return water to the ground thereby contributing to available ground water and reducing the possible effects of shrinkage of plastic soils.
  Derby City Council will also work with its neighbouring Authorities to secure a sensible long term policy approach with regard to flood mitigation."

- Local Plan Review Jan 2006 (GD3) Flood Protection
  "Except where satisfactory compensatory measures are provided to offset any potential adverse effects of development on the water environment and associated lands, planning permission will not be granted for development which;
  a) lies within undefended areas at risk of flooding
  b) would create or exacerbate flooding elsewhere
  c) results in the loss of natural floodplain
  d) would impede access to a watercourse for maintenance or flood defence purposes

e) does not provide for the adequate management of surface run off using Sustainable Drainage principles, unless it can be demonstrated that their use is inappropriate.

The Council will only permit development within the floodplain, as indicated in the Local Plan Proposals map, if (in the case of sites on or adjacent to Main River):

- It would not increase the risk of flooding to the adjacent area (GD3 3.6);
    - by reducing the capacity of any floodplain,
    - by increasing flows within that floodplain,
    - through the increased discharge of surface water above undeveloped flows,
- The proposed area would not be at risk itself,
- Adequate provision for upkeep and maintenance is provided alongside the river or if (In the case of sites on or adjacent to an Ordinary Watercourse) (GD3 3.5),
- It considers the SUDS options first and demonstrates that this option is neither viable nor suitable,
- Surface Water is disposed of into the watercourse without increasing the undeveloped contribution,
- Proposed discharges meet the full requirements of the Environment Agency.

A full flood risk assessment will be required if in the opinion of the Land Drainage & Flood Defence Team representative for the Local Authority it is considered that there may be an increased risk of flooding as a result of the development or the development itself may be at risk of flooding. Wherever development is permitted the Local Planning Authority may impose conditions or seek agreements to ensure that compensatory measures are provided to alleviate flood risk both on and off site.

The effectiveness of a floodplain should not be impaired by development, its existing occupiers put at risk, or additional discharge from the development exceed the capacity of the watercourse or floodplain downstream.

Where a development proposal is allowed the agreed compensatory element shall be included as part of the Planning application. (GD3)"

No development shall be considered until the authority is satisfied that the above criteria have been met and any existing development, whether vulnerable or not, remains unaffected by any new development proposals.
It is important that any development proposals include an element that will demonstrate that these will both enhance and if possible improve the environment of the specific area proposed for development and that of the surrounding area."

This is the adopted policy of the City Council with regard to the approach of the City Council to the maintenance and management of the land drainage infrastructure and also the service role played by the Land Drainage & Flood Defence team to support the implementation of the policy. It is under review at the present time in the light of revised planning guidance note PPS25."

6 PPS25 – Development & Flood Risk

This section describes the guidance notes within the PPS25: Development & Flood Risk document and associated companion guide PPS25: Development & Flood Risk Practice Guide. The methodology of the 'sequential test' is described along with explanatory notes regarding the flood zones and also the differing vulnerability classification for various types of development.

6.1 Flood Risk Zones (reproduced from table D.1 of PPS25 – March 2010 revision)

Zone 1 Low Probability

Definition
This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

Appropriate uses
All uses of land are appropriate in this zone.

FRA requirements
For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a FRA. This need only be brief unless the factors above or other local considerations require particular attention. See section 13 for minimum requirements.

Policy aims
In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage techniques.

Zone 2 Medium Probability

Definition
This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.

Appropriate uses
The water-compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table D.2 (PPS25) are appropriate in this zone. Subject to the Sequential Test being applied, the highly vulnerable uses in Table D.2 (PPS25) are only appropriate in this zone if the Exception Test (see para. D.9.) (PPS25) is passed.

FRA requirements
All development proposals in this zone should be accompanied by a FRA. See section 13 for minimum requirements.

Policy aims
In this zone, developers and local authorities 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.

Zone 3a High Probability
Definition
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.

Appropriate uses
The water-compatible and less vulnerable uses of land in Table D.2 (PPS25 March 2010 revision) are appropriate in this zone.
The highly vulnerable uses in Table D.2 (PPS25 March 2010 revision) should not be permitted in this zone.
The more vulnerable and essential infrastructure uses in Table D.2 should only be permitted in this zone if the Exception Test (see para. D.9 - PPS25 March 2010 revision) is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.

FRA requirements
All development proposals in this zone should be accompanied by a FRA. See section 13 of the SFRA for minimum requirements.

Policy aims
In this zone, developers and local authorities should seek opportunities to:

i. 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;
ii. relocate existing development to land in zones with a lower probability of flooding; and
iii. create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Zone 3b The Functional Floodplain

Definition
This zone comprises land where water has to flow or be stored in times of flood
Local planning authorities should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But 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, should provide a starting point for consideration and discussions to identify the functional floodplain.

Appropriate uses
Only the water-compatible uses and the essential infrastructure listed in Table D.2 (PPS25 March 2010 revision) that has to be there should be permitted in this zone. It 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.
Essential infrastructure in this zone should pass the Exception Test.

FRA requirements
All development proposals in this zone should be accompanied by a FRA. See section 13 of the SFRA for minimum requirements.

Policy aims
In this zone, developers and local authorities should seek opportunities to:
i. 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
ii. relocate existing development to land with a lower probability of flooding.

6.2 Flood Risk Vulnerability Classification (from table D.2 of PPS25 march 2010 revision)

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. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').
More Vulnerable	Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan**.
Less Vulnerable	• Police, ambulance and fire stations which are ***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 Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, **subject to a specific warning and evacuation plan.**

6.3 The Sequential and Exception tests.

Details and further information is provided on this within Annex D of PPS25. The following paragraphs are reproduced from PPS25 and are intended to provide a simple guide to the principles behind the tests.

6.3.1 Sequential test

i. The aim of the sequential test should be to steer development to areas of lower flood risk. A significant part of this process would be to assess the availability and suitability of sites within areas of lower flood risk. Only where such sites are not available should the latter stages of the sequential test process be considered.

ii. Check the area in which the development is to be located. Is this flood zone 1 (low probability of flooding), zone 2 (medium probability) or zone 3 (high probability). If the development lies well within flood zone 1 then generally no further assessment is necessary at this stage. For 'marginal' zone 1 areas and all development proposed for zones 2 and 3 the proposals should be evaluated in line with points (iii) & (iv) below.

iii. Define the type of development using the 'Flood Risk Vulnerability Classification' within table D.2 of PPS25 Annex D (see previous table).

iv. Using these two pieces of information, consult the 'Flood Risk Vulnerability and Flood Zone Compatibility' matrix within table D.3 of PPS25 Annex D. This details, as a function of both the vulnerability classification and flood zone number, where development 'is appropriate', 'should not be permitted' or where the exception test is required. The table is reproduced here for information only. For further guidance, reference should be made to the PPS25: Development & Flood Risk document and also the PPS25: Development & Flood Risk Practice Guide. Both of these are available at http://www.communities.gov.uk

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Floodplain'	Exception Test required	✔	✗	✗	✗

✔ Development is appropriate
✗ Development should not be permitted

6.4 Exception Test

This is detailed in D9 of Annex D (PPS25). Essentially, the sequential test should be applied rigorously to the type of development proposed to determine whether the exception test should be applied or whether the development should simply not be considered for a particular location. The exception test should not normally be used outside the limits detailed in table D3 of PPS25.

For the test to be 'passed' it should be demonstrated that the development:

- Provides wider benefits to the community that outweigh the flooding risk and,
- The land/site has previously been developed or there is no other land/site available. In this respect it is necessary to consult the local development plan to define the types of development site available for the development in question and then assess each one of these on their merits.
- The site-specific FRA should demonstrate that the development will be safe (not put people in danger from rapid inundation for example), will not increase the flooding risk elsewhere and where possible should reduce the overall risk of flooding. Further information on the requirements for site-specific flood risk assessments is provided later in the report.

7 Data Sources available/used in the production of the level 1 report and notes on suitability and confidence.

7.1 Summary of data collection

Data	**Source of information (or Supplied by)**
Other level 1 assessments to define best practice. Define & understand	Others – availability on internet
Plan showing all rivers, watercourses within or adjacent to the city	DCC Land drainage
Details of each brook course – section by section – start/end/open or culverted/condition Markeaton Bramble Littleover Hell Cuttle Thulston Cotton Lees Chaddesden Boosemoor Dam	DCC Land drainage
Summary of channel long section and cross section data	DCC with EA input for Derwent & Markeaton/Mackworth and others
Flooding Records & maps – all minor incidents – tabulate on a spreadsheet including a location reference (GR). Reference on plans (arcview or acad)	DCC, STW, EA & incident files for each watercourse

Records of all modelling available for the watercourses within and passing through the city boundary. What's been modelled and to what extent and details.	DCC, EA and others
Summary results of all gauging stations in brook courses – only one station I think at St Mary's bridge on the R. Derwent	DCC
Flooding warning schemes – what do we have in the city	DCC data

Stage 2 – Survey and plan data

Data	Who from
Arcview GIS plans showing all the brook courses and levels associated with land in the floodplain. Need to check the format that the planners will use.	DCC
Availability of LIDAR data – reference on a plan	DCC – own records
OS level data from development plans and private sector schemes.	DCC data – planning drawings
Any other levels information – highways design team – footway schemes – reference on a plan showing the highway scheme reference as a source of further detail if/as required.	DCC

Section 3 – Land Use

Data	Who from
Derby City Local Plan	DCC planners
Major (and other significant) developments with planning permission within the catchments and proposed developments.	DCC planners (and district council areas within the catchment areas)

Areas zoned for development	DCC planners (local plan) – also district council plans

7.2 Environment Agency Data

7.2.1 Flood Map Data

****Note that the SFRA plans showing the indicative risk of flooding are not the same plans that have been published by the Environment Agency. Further details of the differences between the plans and the reasoning behind this are included within Appendix D.****

7.2.1.1 Description

Derby City Council receives quarterly updates showing the areas at risk of fluvial flooding from certain watercourses within and around the City. The data is presented as plans showing the areas within flood zones 2 and 3 and also the positions of flood defences and areas of land benefiting from the flood defences. The data is valuable as a guide to the likely extents of areas that may be at risk of flooding from main rivers.

7.2.1.2 Limitations of the data:

- The extents of flood zones assume level information processed from Lidar surveys. Where the areas are gently sloping, any errors in the vertical accuracy of the Lidar may result in the extents of a flooding zone being larger or smaller that it should be.
- The flood zones are based on a ‘worst case’ scenario assuming the absence of any defences. The standard to which an area is defended is not included in the information.
- The information is a ‘snapshot’ based on a particular model run and assuming a particular set of values for the variables in the model.
- The areas for flood zone 3 are perhaps sensitive to small changes in the variables and use significant interpolation from known data as the River Derwent has not flooded through Derby since 1965. This information should therefore be treated with caution and assessed with full and comprehensive knowledge of a site. The information indicates that an area may be at risk of flooding – not that the area *will* flood.

7.2.2 River Derwent at Derby – Final Modelling Report

This report by Black & Veatch on behalf of the Environment Agency was published in September 2006 and is the most contemporary model available for the River Derwent through Derby. The report has considered the previous flooding and high water events on the Derwent and accumulated a significant amount of data including the levels of defences and a consideration of the mechanisms of flooding in parts of the City. In this respect it is probably the most useful source of data for this source of flood risk. Some limitations nevertheless exist as follows:

The last time the River Derwent flooded Derby to a large extent was in 1965 prior to the construction and/or improvement of many of the flood defences in place today. The flood defences have neither been overtopped nor breached since then therefore calibration of the Black & Veatch flooding “with spills” model to simulate the overtopping of existing defences is subject to any assumptions made.

There are areas of the City that are either shown outside of zone 3 when they would almost certainly flood or are shown within flood zone 3 but are at a level where they would be above the likely flood plain. Some areas of the report that perhaps need further investigation include:

- Land to the west of the Derwent between the A38 and Darley Abbey – shown as flooding on the EA Dec 2006 flood maps as zone 2 & 3; not shown as flooding according to the Black & Veatch report.
- Land north of Haslams Lane GR435700, 338453 shown as flood zone 2 on the EA Dec 2006 maps and within 1% spills area on the Black & Veatch mapping.
- Land at Darley Playing Fields – DCC flood zone 3b as exhibited in recent floods (June 2007). Area next to river not shaded on Black & Veatch report .
- City Centre (west side) shown as within flood zone 2 on EA Dec 2006 information yet within 1% annual exceedence zone on Black &Veatch ‘with spills’ model. The flooding mechanism is unclear as the ground levels appear too high for flood flows to be transmitted on west side of River Derwent.

- It is unclear whether Exeter Bridge GR435469, 336413 has been modelled within the Black & Veatch 2006 assessment as a significant obstruction to flows during a 1% AAP event. For a 5% AAP event (June 2007) the bridge had only 300mm freeboard. A 1% AAP event would require an additional 700mm of water to pass through (and over) the bridge. Afflux may be significant.
- The flood cell on the Black &Veatch report appears to cover a part of the city centre including the 'Eagle Centre'. The land is elevated here therefore the graphical representation appears to be incorrect. The extents of the DCC flood zone have been modelled to reflect the contours.
- Parts of Bass' Recreation Ground and Meadow Lane were inundated during the June 2007 event. This flooding was not predicted within the 2006 Black &Veatch 1% AAP 'with spills' model. The extents of the DCC flood zone have been modelled to reflect the contours.
- Pride Park – shown as the limit of FZ3 on the EA Dec 2006 flood zone issue of information. Shown overtopped by flooding cell on the Black &Veatch model (1% AAP 'with spills' event) although the Pride Park development is understood to benefit from defences to a 1% AAP standard. The area has been included within the flood zones however further work is necessary to determine the depth of the flooding and the likelihood of a breach to the existing earthworks defences. The flood defences (within Derby City Council and other 3rd party ownership) are overgrown and inspection is difficult at the present time until the vegetation is removed.
- The 'Litchurch' flood cell has flooding both for a 1% and 0.1% event however the area is split into sections by the elevated roads through Pride Park including the Pride Parkway. For the 0.1% average annual probability event, the south-western part of the area appears to flood only as a result of water passing across the railway near Derby Station.
- The B&V report states a level of uncertainty regarding the flooding of cell DE044R as the friction coefficient for the river has a significant effect on the amount of flooding into this cell. As this cell contains a significant number of residential properties, additional investigation works are required to determine whether a small increase in the height of the flood defences would protect this

area entirely. Also the duration of the flooding event needs to be further investigated to determine the likely volumes and therefore depth in the flood cell.

- The adjacent flood cells DE044R and DE037R have a difference in water level of approx 1500mm for a 1% event (3400mm for a 0.1% event). As the model is 1-dimensional, the gradients and height differences across the flood cells are not available. Further work is necessary to determine the extents of any water flow across Raynesway into the residential areas of Alvaston. At the present time, this area is shown to be within FZ3 however it is possible that the volumes of floodwater in cell DE044R may be sufficiently small that water will not extend to the residential area SE of Raynesway. Additionally, the existing ground levels may be too high to enable water to pass from one flood cell into an adjacent one.

7.2.3 Asset report for defences

- This report by Jacobs Babtie on behalf of the Environment Agency was published in September 2006 and represents a contemporary assessment of the flood defence infrastructure alongside the River Derwent through Derby. The report appears to have been produced using an objective set of criteria and serves as a data source to assess the risk of failure of the defences.
- The report describes and discusses the possible modes of failure as:
    a. slope stability analysis for defences subject to undermining or erosion through animal activity or by river erosion,
    b. condition surveying of the assets by structural inspection including walls, weirs, outfalls, flap valves, bridges and the general condition of the riverbank where this may have an effect on the stability,
    c. seepage potential through, around and under the existing defences by consideration of the ground conditions and material type. In a number of areas this represents a risk to the integrity of the defences and also causes nuisance flooding through seepage into cellars and low-lying land.
- The asset condition survey has also estimated a residual life expectancy for the defence assets within 3 bands: 0-5 yrs, 5-30 yrs and 30+ yrs.

The Black & Veatch 2006 modelling report on the River Derwent also includes a section on the defences alongside the River and this is summarised in appendix E.

7.2.3.1 Notes on defence standards

The standard of flood defence is based on the expectation that a defence will be overtopped or fail during an event of a particular severity. The risk to properties behind the defence is dependent on a number of factors including the following:

- The width of the defence over which water is flowing and the head of water causing flow to take place. This determines the flow rate into the hinterland behind the defence structure.
- The duration of the flooding event – this combined with the flow rate determines the total amount of water to flow over the defence and accumulate behind it.
- The topography of the land behind the defence. If properties are situated within a hollow behind the defence then the depth of water may be sufficient to flood the properties. Also if the flow rate is sufficiently large, the depth of water flowing between properties as it moves across the flood plain may be sufficient to inundate properties.

The standard of protection (see appendix E) has been reproduced from the Black & Veatch report September 2006 based on the current condition and level of the crest of the defence and compared to the likely water levels in the river for particular event return periods. The data does not take into account any increase in the severity or probability of a particular event occurring as a result of climate change. In general, the effects of climate change are generally considered to result in a 20% increase in the flow within a river system for a particular return period storm by the year 2050. For instance using the River Derwent as an example: a 25year storm (with a 4% chance of occurring in any given year) may involve approximately 290cumec based on the 2006 modelling report. The amount of water with the climate change factor added would be 348cumec – equivalent to a ~50year event based on current predictions. In essence this means that the standard of protection offered by a defence will diminish over the next few decades - a ’50 year’ defence standard today might be overtopped by a 25 year event in a few decades time.

The Environment Agency has produced a report on the condition and estimated longevity of the flood defences providing protection to Derby. Three groupings have been used based on the existing condition in 2006 and the expected life of the defences if maintenance ceased. These are 1-5 years, 5-10/15 years and 10-30years. The assessment has defined the life of many of the ‘hard’ defences to 10 years although this lifespan would be enhanced with the continued maintenance regime. The Environment Agency have maintained the majority of the defences along the River Derwent and are expected to continue doing so. Derby City Council maintain defences along the Markeaton Brook and also routinely maintain watercourses throughout Derby.

7.2.4 Report on condition of defences for Pride Park

This report, issued by the Environment Agency in July 2007 describes the condition of the flood defences for the Pride Park development. The defences were not adopted at the time of construction and there is some concern by the EA that they are not to the required 1% protection standard and may not provide the level of protection originally envisaged. The defences are shown as overtopped with consequential flooding to large areas of the Pride Park development during a 1% event. A list of improvement works is described in the report and is currently being considered by Derby City Council.

7.2.5 Hell brook modelling report

This report was produced by JBA on behalf of the Environment Agency in 2006 and provides the most contemporary overall flood model for the brook.

7.2.6 Cuttle Brook modelling report

This report was produced by JBA on behalf of the Environment Agency in 2006 and provides the most contemporary overall flood model for the brook.

7.2.7 STW sewer plans

Derby City Council have traditionally maintained a close working relationship with Severn Trent Water to assist the flow of information between the organisations. This has included regular updates for the foul, combined and surface water sewer infrastructure within the City therefore DCC have comprehensive information available on a GIS system for the positions and sizes of the sewers.

7.2.8 OS tablet maps for Derby

DCC subscribe to the Ordnance Survey mapping service and have tablet OS maps for the whole of the city.

7.2.9 Lidar information

DCC have Lidar information for the City area however this will be interpreted and used for the later stages of the flood risk assessment. The data has been used in the Level 1 report to assist in the delineation of the flood zones from the predicted volumes of floodwater. The Lidar information used is based on an aerial survey. The information used in the SFRA assumes a ‘bare earth’ model – that is without buildings, walls, trees and other vertical features that are ‘filtered out’ during the data processing works. The results from using this information need to be treated with caution as the presence of buildings and other features acts to impede the flow of floodwater and may also increase the depths of flooding and the flooding extents.

7.2.10 Records of known flooding events

There have been a number of minor flooding incidents within the City boundaries in the last 10-15 years and also other incidents for which photographic and anecdotal records exist. These have provided an indication of ‘trouble areas’ that may not be immediately apparent from the EA flood mapping or other modelling. Many of the flooding incidents have involved minor watercourses, sewers, overland flows and general inundation through areas becoming waterlogged or by virtue of being situated in a topographical depression. Flooding events from the River Derwent have been rare and since the 1965 flood have only resulted in relatively minor damage and inconvenience.

7.2.11 Modelling information for small watercourses

Derby City Council have attempted to model the sewer and other inflows to the various minor watercourses including those enmained by the Environment Agency.

This has been done to estimate the potential for flooding from both the surface water sewer system and also from the watercourses. Modelling information obtained from 3rd parties includes the following:

- The River Derwent is a main river and has been the subject of a number of models and studies by the Environment Agency.
- The Markeaton & Mackworth brooks have been modelled in the past by Keeling Chambers on behalf of the City Council as traditionally they have posed a threat to the City as the available capacity of the watercourses and culverts lies between 25-50% of the potential 1% flows.
- Cuttle Brook - (Littleover & Sinfin) modelled by JBA on behalf of the Environment Agency in 2005.
- Hell Brook - (Mickleover & Heatherton) modelled by JBA on behalf of the Environment Agency in 2005.
- Watercourse modelling. Derby City Council have produced model information for a number of watercourse catchments within the City Boundary. The approach taken has been to estimate an impermeable area of $30m^2$ draining to each linear metre of the surface water sewer systems feeding the watercourses. This approach produces an impermeable area of approximately 25-30% of the total area within the urbanised catchments. Where the watercourse drains a predominantly rural area, the approach taken has been to establish the potential run-off from the catchment using the IoH124 methodology and establish an impermeability factor (typically 10-15%) to replicate the overall flows at a particular point. As with any modelling, the outcomes are only as reliable as the input data therefore the resulting flood zone extents are indicative rather than definitive.
- The watercourses modelled by Derby City Council include:
    - Amber Brook (Allestree)
    - Bramble Brook (Mickleover to the City)
    - Chaddesden & Lees Brook system (Oakwood & Chaddesden)
    - Cotton Brook System
    - Dam and Boosemoor Brook systems (Breadsall)
    - Littleover Brook (Littleover to the City)
    - Markeaton Brook (Markeaton Park to the City)

  - Mackworth Brook
  - Thulston Brook
- Where possible, the effect of flow attenuation schemes has been taken into account as contemporary developments around Derby have included, in some cases, balancing ponds and flow control structures.
- The flooding extents for the smaller watercourses will tend to follow the line of the watercourses and have been drawn with this assumption. The flooding extents are only an approximation and therefore should be taken as an indication of the *risk* of flooding occurring rather than an absolute fact. For steeper valley features the flooding risk envelope is narrower than for broader valleys. In each case however the extents of flooding are very dependent on the ground features. These include walls, fences, highway kerblines, dwellings and other buildings and soft landscaping features – hedges, trees & vegetated areas – all of which tend to affect the depth and direction of overland flooding flows.

7.2.12 Anecdotal evidence

Where appropriate, the City Council have spoken to residents who live close to the major watercourses to determine the behaviour of the watercourses during extreme events. This also serves as a 'reality check' to verify some of the assumptions made in the modelled data and outputs. It is also a useful exercise to determine the mechanism through which a property may become inundated.

7.2.13 Development Plan for Derby (2006 adopted document)

The development plan shows the zones adopted for various types of development including public amenity, housing/residential, commerce and industry. Historically, this document has been produced to serve the requirements of the various Planning Policy Guidelines (PPGs) rather than meeting the needs of a sequential test or particular concern for flood risk. Information from the Development Plan has been made available as a part of the general flood risk information within this report.

Particular sites for development within potential flood risk areas are as follows:

- Residential site at Rykneld Road H9, LE2(3) (GR 431338,332736). Risk from watercourses tributaries of Hell Brook, overland flows, sewer flooding & waterlogging.
- Commercial/industrial sites at:
  - Sinfin Moor EP1 (GR 435672,331100 centrally located) – within FZ3 at risk from Cuttle Brook & R Trent. Also waterlogging risk.
  - Alvaston & Celanese sites EP2 (GR 438361,334000 & 439389,333862 & 440000,334114) – within FZ3 at risk from the River Derwent.
  - Pride Park EP3 – within FZ3 partially at risk from the River Derwent.

Design considerations for proposed development sites.

The development sites within the River Derwent corridor are non-residential therefore these 'fit' within the guidelines of PPS25. The effect of climate change however will mean that the risk of inundation to these sites becomes greater in the future. Also the potential loss of floodplain areas may restrict the strategic flood management options in future years. The flood risk assessment for these sites should include details of the surface water management proposals as a gravity discharge to the river will be restricted or unavailable during periods when the river levels are high. In this regard the sites may be inundated as a result of rainfall accumulation rather than as a result of overtopping or failure of the river defences. A secondary factor influencing the development of large tracts of land near the river is the future maintenance and enhancement of flood defences. The developments should be positioned to leave at least an 8m wide margin between the limit of the developed site and the river bank to maintain the legal easement requirements of the Environment Agency.

The development sites within the catchment and flood areas for both the Hell and Cuttle Brooks need careful condiseration:

- The upstream areas of these catchments are intensively developed and the channel of the brook has become restricted through uncontrolled development in the past and also by riparian landowners making a 'land grab' and either covering over the brooks or extending fencelines to enclose the brook wholly within their garden areas. The capacity of the brooks to convey high flows has therefore been compromised and further upstream development may exacerbate existing flooding problems.

- The downstream parts of the catchments (particularly around Sinfin Moor) are shown at risk from widespread inundation during a 1% event. The effect of climate change would be to increase the frequency of flooding to these areas and also the depth and duration of flooding events. Waterlogging or sewer flooding of the areas may also pose a risk as the drainage systems may not perform satisfactorily during periods of high rainfall when the main watercourses are already full.
- The area of Sinfin Moor near the A50 is influence by the water levels in the River Trent to the south of the City Boundary. During high water events on the River Trent water has been observed flowing upstream into the Sinfin Moor area. In this respect, any further development around this area needs to be considered very carefully and the overall strategy for managing flows in the Cuttle Brook system should be a requirement of the development proposals.

7.2.14 Soils information for Derby

This information has been obtained through local knowledge and also from document records and soil classification maps (winter rain acceptance potential - WRAP) produced by HR Wallingford. The assumption on the type of soil is a significant variable when considering the run-off generated from greenfield areas. There are broadly two types of surface soils within the study area. Along the River Derwent corridor, the underlying soils are sands and gravels that are reasonably free-draining although the water table is close to the surface (WRAP classification 1 or 2). Elsewhere, the underlying soils comprise weathered mudstones that generally present as a clayey material with a transition to soft weathered gravel becoming coarser and harder with depth. Generally, the soils are quite ‘heavy’ and tend to become saturated in the winter months (WRAP classification 4). For these clayey soils, the rural runoff calculations, if using the Institute of Hydrology 124 method, should employ a soil index value of 0.45 to provide a realistic estimate of the ‘greenfield’ runoff rate.

The soil characteristics for Derby require a considered approach to the use of Sustainable Urban Drainage as overland flow is a particular problem in the hillier parts of the City. Rainfall tends to accumulate close to the surface in gardens and parkland areas and then flows over the surface often towards other private properties. This subject is discussed further in the section dealing with the requirements of Flood Risk Assessments for new developments.

8 Watercourses

Start - End details UGR references (where known)

Watercourse	Start / Source	Finish / Outfall
River Derwent (within City boundary) A38 to Borrowash	436184 , 339981	440272 , 333834
Amber Brook (Blenheim Dr. to Markeaton Brook)	433663 , 339614	433175 , 338522
Boosemoor Brook (source to confluence with Dam Brook)	438242 , 341357	436603 , 339961
Bramble Brook (Mickleover to Wardwick, City Centre)	432169 , 335456	434988 , 336292
Bramble Brook (Tributary South)	431292 , 335234	432169 , 335456
Bramble Brook (Tributary middle)	431494 , 335592	432216 , 335505
Bramble Brook (Tributary North)	431013 , 335895	432540 , 335872
Bramble Brook (Unnamed tributary)	432149 , 335202	432169 , 335456
Burley Brook (Allestree Park – R. Derwent)	434048 , 341112	435366 , 341069
Chaddesden Brook (upstream of enmainment)	438697 , 337294	437507 , 338760
Chaddesden Brook (unnamed tributary)	437454 , 336945	437984 , 336329
Cuttle Brook (unnamed tributary – Clemsons Park)	432670 , 333822	432856 , 333856
Cuttle Brook (The Hollow to the R. Trent)	433049 , 333748	437729 , 328111
Cuttle Brook (golf course tributary)	435590 , 331514	434693 , 331491
Ferriby/Dam/Folly Brook (Holly Farm to R. Derwent)	439805 , 339802	435802 , 338193
Etches Brook	437119 , 335005	437412 , 334798
Hell Brook (Western Rd. to Twyford Brook)	431368 , 334788	431706 , 329835
Hell Brook (tributary – Lodge Rd. to Bristol Dr.)	430888 , 334556	431314 , 334637
Hell Brook (tributary – Brierfield Way to Hell Brook)	431142 , 333883	431502 , 333721
Hell Brook (tributary – Long Croft to Moorway Lane)	430835 , 333806	432174 , 332322

Holly Brook	432176 , 332320	430838 , 333298
Lees Brook (Locko Rd. to Chaddesden Brook)	440178 , 337373	438697 , 337294
Lees Brook (Locko Park tributary)	441141 , 339118	440178 , 337373
Lees Brook (Spondon tributary)	441041 , 336916	440178 , 337373
Lees Brook (Oakwood tributary)	438766 , 338090	438697 , 337294
Littleover Brook	435146 , 336182	432198 , 334775
Mackworth Brook Tributary	433213 , 337775	432597 , 337058
Markeaton Brook (Upstream of enmainment)[1]	433254 , 338131	432947 , 338879
May Brook	432699 , 332181	432497 , 332919
Nutt Brook	435253 , 337952	435355 , 339067
Party Nook Brook 1	438706 , 333738	437799 , 334168
Party Nook Brook 2	438706 , 333738	437822 , 334045
Thulston Brook	437690 , 331637	439832 , 332011
Thulston Brook (tributary)	437950 , 331435	437800 , 331664
Wood Brook (tributary of Chaddesden brook)	437812 , 338512	438403 , 337209
Unnamed 1 Alfreton Road	435630 , 337528	435615 , 337938
Unnamed 2 Stores Road	435932 , 336627	436218 , 338957
Unnamed 3 Allestree lake outfall	435864 , 340013	435092 , 340458
Unnamed 4 Spondon 1 Oregon Way	439160 , 336451	439448 , 336575
Unnamed 5 Spondon 2 Erewash Boundary	440988 , 334562	441832 , 336210
Unnamed 6 Spondon 3 Spondon Carpets	440494 , 334755	440860 , 336009
Unnamed 7 Spondon 4 Railway & Willow Rd.	440391 , 334815	440288 , 335949
Unnamed 8 Spondon 5 Sewage Works	439529 , 334515	439629 , 334591

[1] This section of Markeaton brook shared centreline boundary with AVBC brook then continues

Unnamed 9 Chaddesden 2 Balfour Beatty	438656 , 334904	438392 , 385568
Unnamed 10 Chaddesden 3 Aldi Culvert	437984 , 336327	437453 , 336945
Unnamed 11 Pride Park 1 EmGas Outfall	437412 , 334300	437118 , 335007
Unnamed 12 Amber Brook Tributary	433835 , 339092	433667 , 339610

List of known watercourses continued from previous page.

Watercourse	Start / Outfall	Finish / Source
Unnamed 13 Broadway upper	434094 , 337762	434061 , 338397
Unnamed 14 Broadway lower	434150 , 337118	434107 , 337768
Unnamed 15 Lavendar Row	4350** , 3384**[2]	434766 , 338549
Unnamed 16 Deepdale Lane	434815 , 330851	433038 , 330938
Unnamed 17 Heatherton	432667 , 332379	432611 , 333756
Unnamed 18 Gorse Close	432671 , 332256	432873 , 333120
Unnamed 19 Mickleover 1 Golf Course	431881 , 333457	432346 , 334216
Unnamed 20 Mickleover 2 Railway side	429978 , 335389	430770 , 336394

[2] references marked with Asterisks ** denote no real knowledge of limits.

Unnamed 21 Radford's Pleasance.	430249 , 334755	430345 , 334783
Unnamed 22 Derwent Avenue	435851 , 339968	435137 , 339897
Unnamed 23 Lees Brook Tributary 1	440180 , 337370	441044 , 336912
Unnamed 24 Lees Brook Tributary 2	440180 , 337370	440671 , 336996
Unnamed 25 Elvaston Castle Lake feed	440671 , 336996	Various feeds
Unnamed 26 - Main drain	434814 , 330851	433040 , 330931
Unnamed 27 Sinfin Moor Lane	434705 , 330839	434400 , 331340
Unnamed 28 Heatherton. to King George V Playing Fields (part new)	432625 , 332715	432552 , 333700
Unnamed 29 Grassmeer Close	432910 , 332688	432914 , 333150
Unnamed 30 Spondon 6 Stoney Gate Road	440392 , 334813	440298 , 335996
Unnamed 31 Kirkstead Close Oakwood	433699 , 337780	438726 , 338196

List of recently enmained Main Rivers

1. Markeaton Brook - from the outfall into the River Derwent at UGR 436056, 335977 to Markeaton lane at UGR 433254, 338132

2. Mackworth Brook - from the confluence with Markeaton Brook at UGR 4332952, 337839 to Markeaton Lane at UGR 433173, 337895

3. Cotton Brook - from the outfall into the River Derwent at UGR 37756, 34871 to the North leg limit at UGR 34578, 34583 and to its South leg limit at UGR 34455, 33962 (Normanton Park)

4. Chaddesden Brook - from the outfall into the River Derwent at UGR 437522, 335722 to UGR 438404, 337206

5. Lees Brook - from its confluence with Chaddesden Brook at 438404, 337206 to UGR 438697, 337294

6. Thulston Brook - from the outfall into the river Derwent at UGR 444246, 331154 to UGR 440405, 331971

7. Cuttle Brook (various legs) - from the outfall into the river Trent at UGR 437732, 328111 to 434844, 332705, plus :- Main Drain at UGR 734816

8. Osmaston Drain at UGR 436369, 331639, Meadow Drain at UGR 434816,

9. 330851, Barrow Drain at UGR 434947,330198.

10. Hell Brook - from the outfall into the River Trent at UGR 432606, 328494 to UGR 431469, 333852 (Bunkers Hill)

9 Flood risks areas of the City of Derby – Derwent Catchment

The following chapter looks at the various potential sources of flooding to the City and provides the flowing brief information:

- An introduction to the watercourse or source of flooding risk
- A list/description of the potential problem areas during a 1% event
- A narrative for the potential behaviour of the catchment during an extreme 1:1000 year (0.1% annual average probability) event.
- An assessment of the effects resulting from failure of the watercourse, sewer or flood defence infrastructure infrastructure.

9.1 River Derwent Corridor

9.1.1 Introduction

The River Derwent is a major watercourse that flows through the centre of the City in a south-easterly direction. The catchment includes the whole of the Derwent Valley, tributary valleys and moorland at the northern end of the catchment. The high rainfall experienced by the upland catchments at the head of the valley has been utilised as a drinking water supply for the East Midland areas in the south of the catchment. To this end, there are 3 reservoirs and associated dams at the head of the catchment. These are the Howden, Derwent and Ladybower reservoirs and together they act as attenuation features for the run-off from the northernmost area of the catchment.
In all, the Derwent catchment totals over 1,200 km^2 in area and is able to produce relatively large amounts of run-off due to the steep catchment and gradient of the rivers within the catchment. Over the course of 50km between the Ladybower reservoir dam and Derby city centre, the River Derwent falls over 125m and is generally kept within a steep-sided valley with few areas of floodplain able to store or attenuate significant volumes of floodwater upstream of Derby.

For these reasons the River Derwent tends to produce high flood flows in proportion to the size of catchment and the river can also rise rapidly. In the recent June 2007 event (approximately a 4-5% AAP event) , the river levels rose from the ‘normal’

700mm (approx 30 cumec) to 2800mm (approx 300cumec) over 30 hours[1]. A 1% event would probably involve flows of 450 cumec and peak in less than 24 hours.

Some recent records of high water events are shown in the following table (reproduced from the Black & Veatch R Derwent modelling report september 2006):

Date	River flows m3/sec	Equivalent AAP event	Time to rise from base flow to peak
Dec 1965	~385	~1.54%	<24 hours (est)
19th June 2007	~300	~4%	30 hours
November 2000	~294	~4%	30 hours
October 1998	~205	~12%	25 hours
29th December 1978	~233	~8%	40 hours
25th Feb 1977	~201	~12%	25 hours
10th Jan 1986	~183	~20%	13 hours
7th Feb 1984	~179	~20%	28 hours
Dec 1991	~174	~20%	10 hours
29th Jan 1995	~174	~20%	25 hours

The most recent serious flooding event in Derby due to the River Derwent was in 1965 during which a large part of the City was flooded particularly around the Chester Green, Mansfield Road and Eastgate areas. Flooding occurred to 2m deep in places and 0.6m flooding depth was widespread. This flooding occurred before the construction of the flood defences that exist today. The standard of protection varies (see appendix E) but is at least to a 25 year event standard.

9.1.2 Flood Risk from overtopping of existing river banks & flood defences

A38 - Darley Abbey

The flood flows from the Derwent are channelled under the A38 road bridge (GR435866 , 339942) and then spread out over the washlands either side of the river. On the left bank the flood defences are intermittent therefore water is able to flow outside the main river channel for approximately 2km bypassing Darley Abbey weir(GR435318 ,338519) and flowing over the sports fields before re-entering the main river channel at Chester Green. The washlands act as a conduit for floodwater and the flooding for events upto a 25year return period is of a nuisance rather than damaging nature generally.

Darley Abbey – Elvaston

The flooding plans from the 'with spills' model (ref – River Derwent at Derby: Final Modelling Report September 2006) Black show the 1% AAP flood plain on the left hand side (north & east side) of the River Derwent:

- Beyond the A61 to the outskirts of Breadsall,
- Including Darley Abbey - the industrial/commercial units and Folly Road,
- Extending to cover the Meteor Centre development,
- Beyond the Croft Road/A61 roundabout the flooded areas extend over Racecourse Park and into the lower lying residential areas next to the park.
- Over the Chequers Road industrial estate.
- Downstream of the City Centre, the flooding areas extend over the Raynesway and Megalaughton Lane industrial areas.

Overall on the left hand side of the river, the flooding extents include all the residential properties within Little Chester, Chester Green and the lower areas of Chaddesden near racecourse park. Approximately 1700 residential properties are at risk from a 1% event. A greater number would be at risk from an extreme event (0.1 to 1% AAP event)

On the right bank there is little risk to property until after the disused railway bridge downstream of the rowing club (GR435140 , 337307). The River includes flood defences on this side of the river although these are shown as overtopped in the 'with spills' model. The flooding extents are as follows:

- Over River Street, Handyside Street, St. Marys Court, Bath Street and Duke Street. The extent of the flooding is shown as Bath Street,
- Downstream of St Marys Bridge including Sowter Road and the areas to the east of Full Street (non residential areas),
- City centre including the Council House, Corn Market, Albert Street, Morledge and the Cockpitt areas including limited areas of Traffic Street and the Eagle Centre (non residential areas),
- Pride Park area (non residential areas),
- Alvaston area between the River Derwent, London Road and Raynesway,
- Areas to the south of the Alvaston Bypass around St John Fisher school between the bypass and Alvaston Street.

Overall on the right hand side of the river, around 500 residential properties are at risk from a 1% event. In addition there are a large number of non-residential properties at risk. A greater number would be at risk from an extreme event (0.1 to 1% AAP event)

9.1.3 Risk from a breach of the defences adjacent to the River

The following table details the width of the high velocity zone for floodwater resulting from a breach of the defences (source Environment Agency, Anglian Region). In essence the risk is directly proportional to the length of the breach and height of the water above the level of the landward side of the defences and diminishes as the distance away from the defences increases. A secondary assumption to be borne in mind is the potential minimum length over which the river defences may breach. For an earth bund defence this is taken to be 50m however for a 'hard' defence such as a sheet piled, masonry or concrete wall the length of breach is assumed to be lower at 20m. Parts of the land adjacent to the River Derwent are protected by a combination of these types of defences.

Breach for Fluvial River (reproduced from EA Anglian Region Guidance Note)

Defence Type	Breach Width (m)	Time to Close (hours)
Earth bank	40	30
Hard defence (wall)	20	18

Width of High Velocity Zone (table reproduced from the SFRA for North Lincolnshire & North East Lincolnshire)

Height of water above landward toe of defence	High Velocity sub zone width (m) for breach widths of:			
	20m	40m	50m	100m
1.0m	20	40	50	100
2.0m	40	80	100	200
3.0m	80	160	200	400
4.0m	120	240	300	600

Particular areas at risk from a breach of the left bank defences are:

- Properties in Darley Abbey,
- Alfreton Road industrial estates,
- Properties off Old Chester Road & City Road,
- Properties in Etruria Gardens,
- Industrial sites – Raynesway & Spondon,

Particular areas at risk from a breach of the right bank defences are:

- Properties in Duke Street & Bath Street,
- Properties between Full Street & the River Derwent,
- Properties close the river defences in Pride Park,
- Industrial/commercial sites off Raynesway,

Generally, the height of the floodwater above the landward toe of the defences is less than 1m for a 1% event therefore the width of the high velocity zone would be less than 40m. One consequence of an increase in the height of a defence to protect property against more severe flooding events is an increase in the width of the high velocity zone behind the defence therefore this approach needs careful consideration including the types, occupants and numbers of properties in the hinterland behind the defence before flood defences are raised.

9.1.4 Extreme Event Scenario

The limitations of the data available to predict flooding events on the River Derwent has been discussed earlier in the SFRA and in particular difficulty in predicting flooding events without a sufficiently extreme baseline event to calibrate the flooding model against. The model predictions for the flows through Derby for the 1:1000 year event (0.1% annual average probability) range from a lower estimate of 600cumec to an upper estimate of 1100cumec. This wide variation reflects the uncertainties regarding the behaviour of the catchment and also the sensitivities of the flow model. The limitations of Flood Zone 2 have been based on the data within the Black & Veatch model report (Sept 2006) – based upon 800cumec flowing through the River Derwent corridor. The predictions of areas at risk during this type of event indicate a wide swathe of land either side of the river and particularly downstream of the City Centre as the river valley widens at this point with fewer natural or manmade barriers to the lateral spread of floodwater.

9.1.5 Secondary Risks from other sources

<u>Sewer flooding</u>

Sewer flooding could be a particular problem during periods of intense rainfall that coincide with a high water event on the River Derwent as the surface water outfalls may be submerged and therefore unable to operate effectively. In this instance the sewers would be likely to flood lower lying areas. A secondary risk is the route offered by sewers for floodwater from the River Derwent if the flap-valves on the outfall headwalls fail to operate properly. There are many areas of Derby at risk from flooding due to this source as the ground levels are below the anticipated level of the floodwater in the river channel.

9.2 Markeaton & Mackworth Brooks Corridor

9.2.1 Introduction

Markeaton Brook is the largest of the watercourses (other than the River Derwent) flowing into the City. The brook rises near to Hulland Ward at 426440,346800 and flows in a generally south-easterly direction towards Derby crossing the City boundary at Markeaton Lane. Mackworth Brook rises near to Windy Arbour at 427040,340510 and flows east towards Derby crossing Markeaton Lane south of the Markeaton Brook. Although the combined flow of 40 cumec during a 1% event is only 10% of that in the River Derwent, the potential for property inundation is significant due to the route of the brook through the City Centre and the restrictions on the capacity of the channel. The two brooks converge near Markeaton Lane on the north-western city boundary and then run in a south easterly direction through Markeaton Park and into the City. The brook is culverted from Ford Street under Jury Street, Bold Lane, The Strand, Victoria Street, Albert Street, Morledge, under the former bus station, the Cockpitt and finally discharging into Mill Fleam. Until the 1850's Markeaton Brook was an open channel through the City centre however the watercourse was culverted by a low-profiled brick arch springing from the channel stonework and latterly by steel Armco sheeting and reinforced concrete. The capacity of the culvert is in the order of 25cumec.
The response time of the 50km^2 catchment is rapid with 50% of the peak flow rate being achieved after around 7 hours and an overall time to reach peak flow at Markeaton Lane of approximately 13 hours.

To counter the frequent and problematic flooding events including one in 1932 resulting in the inundation of much of the City Centre, the Northern Flood Culvert was constructed in 1937 between Markeaton Park and Darley Park to take floodwater away from the centre of Derby and into the River Derwent. The intake works to the culvert were reconstructed in 2005/06 to improve the level of protection to the City. The brook is now considered to be a minor threat to the City assuming the performance of the flood diversion works is maintained however the plans showing the flooding areas have been produced on the basis of the failure/absence of the flood

defences. In general, the watercourse has a capacity of 9-14cumec before overtopping occurs however fly tipping and excessive vegetation growth within the channel reduce this capacity. In this respect there is the potential for catastrophic flooding to occur along the watercourse and within the City as 15-20cumec will flow outside the 'normal' watercourse. Flooding depths may exceed 1000mm in many places.
One potential problem that may exist is the route of the floodwater around the City boundary at Markeaton Lane. Although the flood defence installations are designed to cater for the anticipated 1% flows, the local topography and restrictions in the upstream channels may result in a significant amount of water bypassing the flow diversion works and instead running into Markeaton Park and onwards into the City. To date this has not occurred however the Markeaton & Mackworth catchments are ungauged therefore the flows and return period events are not recorded.

The Markeaton brook is prone to flooding as a result of:

- Insufficient capacity - the brook course is narrow and overgrown in many places. Generally the capacity of the open sections is around 9-14cumec however this is only a third of the required capacity if the flood diversion system at Markeaton Park fails catastrophically.
- Vandalism and fly tipping are prevalent along parts of the open sections of watercourse leading to reduced flow area and blockages.

9.2.2 Potential problem areas for a 1% event:

- Watson Street & Tivoli Gardens (GR 34180, 337178) – the brook course is heavily overgrown and has a capacity of approx 9cumec,
- Areas around Eaton Court, Mundy Street and Leaper Street – the brook has a number of changes in direction and may easily become choked with debris,
- Areas around Bridge Street & St Johns Terrace – the riparian owners have reduced the capacity of the brook course by creating a garden terrace within the banks of the brook. Flooding has occurred here in the past and occurs before the banks are overtopped as the drains back up and flood the properties that sit below the level of the bank crest.

- Between Brook Street & Agard Street – the brook is wide in this area however there are a number of trees alongside the brook therefore the risk of blockage is high. Brook street lies below the bank levels of the Markeaton brook following diversion of the watercourse to a new alignment over 200 years ago. The original course is though to be along Brook street as this road is along the valley floor.
- Areas with and around the perimeter bounded by Ford Street, Stafford Street, Curzon Street, Bold Lane, Jury Street and Willow Row – if the Markeaton Brook Culvert becomes sufficiently restricted by a blockage or collapse then this area may be inundated,
- Areas between Saddlergate/Corn Market and The Strand/Victoria Street/Albert Street/Morledge/Cockpitt – this area is low-lying in comparison to the nearby River Derwent and Markeaton Brook. During a high water event on the River Derwent, the outfall from Markeaton Brook into Mill Fleam becomes submerged and this may lead to backing up and escape of floodwater into the streets via the surface water sewer systems.

In all around 230 residential properties (2006 estimate) are at risk from fluvial flooding due to this source. In addition there are a large number of non-residential properties at risk.

9.2.3 Extreme event scenario:

A 1:1000 year event would create significant problems as there would be flows in the base of the valleys that would not be contained within the brook courses. These may bypass the flood defence installations at Markeaton Park and would flow towards the City. Depending on the degree of attenuation the flows would nevertheless be in excess of the capacity of the brook and culverts so would cause flooding alongside the brook course and through the City. The total combined flows at Markeaton Lane for a 0.1% event are approximately 70cumec.

9.2.4 Failure of infrastructure

The flood defences protecting the City from flooding from the Mackworth and Markeaton brooks comprise the flow diversion weirs adjacent to Markeaton Lane and the Northern flood Culvert. Failure of either of these would probably result in a blockage to the Northern flood Culvert and the combined brook flows passing into Markeaton Park and onwards into the City.

9.3 Amber Brook (Allestree)

9.3.1 Introduction

The Amber brook system drains the Allestree residential area prior to discharging into the Markeaton Brook. The catchment is steep compared to many in Derby and this leads to high flows in many of the culverted and open sections of watercourses. A feature of steep brook courses is a lack of storage along the brook course before water escapes at the lower end. In this regard the brook courses are susceptible to nuisance flooding near the entrances to culverts protected by screens. The drainage system is also susceptible to flooding wherever the gradient of the pipe drainage reduces. This can be seen in the predicted flooding extents at the lower end of the drainage system near to the confluence with Markeaton Brook.

The Amber brook system is prone to flooding as a result of:

- The brook course is narrow in places and has little freeboard,
- There are a number of highway culverts that do not provide sufficient flow capacity.
- The brook course is lined with mature vegetation and this tends to cause screens on the intakes to culverts to block.

9.3.2 Potential problem areas for a 1% event:

The surface water sewers have not been designed to cater for 1% flows so would flood onto areas of highway and 3rd party property. The volumes of floodwater are generally small - in the order of 200m^3 in a few places but generally less than 50m^3. This volume of floodwater should remain within the confines of the highway and re-enter the system via gullies. The steep gradient of the catchment would result in the rapid conveyance of floodwater along the brook courses and through garden areas therefore screens at the entrances to culverts would become choked with debris. In this respect the water would pass along the base of the valleys and low areas and would possibly inundate properties.

9.3.3 Extreme event scenario:

The steep catchment would tend to shed the water quickly and this would inevitably create accumulations of water due to the flow capacity of the valleys being constrained by buildings, fences and other features. The flooding risk would therefore increase for properties lower down the catchment and also those where the valley base reduces in gradient.

9.4 Burley Brook (Allestree Golf Course)

This is a small watercourse draining a part of the country park and some isolated residential areas before flowing across meadows and draining into the River Derwent. It is not considered to pose a significant risk of flooding to properties.

9.5 Bramble Brook

9.5.1 Introduction

Bramble brook is a small watercourse that rises in Mickleover. The head of the catchment has been developed for housing and the surface water sewer system feeds the brook. The brook course falls eastwards towards the A38 where it enters some woodland and the gradient reduces. Accumulations of floodwater occur in this location due to the screens protecting the culverts under the A38 becoming blocked with tree debris. The brook enters a culverted section within the Cheviot Street park (GR 433411, 336190) where there is an overflow weir into a 1200mm dia Severn

Trent Water combined sewer system. During 1% flows it is estimated that approximately 50% of the brook flow at this point (around 1.5-2cumec) overflows into this STW sewer.
From Cheviot Street onwards, Bramble brook flows almost entirely in culverts taking a series of inflows from surface water sewer systems and also a number of combined sewer overflows. The total 1% flow prior to the confluence (GR 434978 ,336282) with the Central Surface Water Sewer is approximately 3cumec. The Bramble brook system appears to operate without flooding along the length of the culverted section however the culverts are approaching 150 years old therefore ongoing repair and maintenance is an important factor in maintaining this capacity. One area of concern is the lack of a clearly defined valley through which floodwater may flow. The course of the Bramble brook has been extensively developed therefore in the event of a failure of the watercourse structure or a severe blockage, the water would tend to spread out and flow between and through buildings along the route of the watercourse. In this regard although the capacity of the brook course through the developed parts of the City appears to beadequate during a 1% AAP event, the *risk* to properties is nevertheless significant due to the nature of the culvert condition & flood path.

The Bramble brook is prone to flooding as a result of:

- The brook course is narrow in places and has little freeboard,
- There are a number of highway culverts that do not provide sufficient flow capacity.
- The brook course is lined with mature vegetation and this tends to cause screens on the intakes to culverts to block.
- Vandalism and fly tipping are prevalent along parts of the open sections of watercourse leading to reduced flow area and blockages on screens and in culverts.

9.5.2 Potential problem areas for a 1% event:

- The areas immediately west of the A38 where the brook runs through woodland (GR432279, 335546). The size and gradient of the brook course results in insufficient capacity and approx 700m3 of floodwater. The flooding is of ‘nuisance’ value rather than threatening property.
- The area within and upstream/downstream of the Kingsway roundabout (A38/A5111 junction GR 432927 , 336131). Approximately 5000m3 is predicted to accumulate based on the 1% flows model. This may inundate a number of commercial & industrial premises. The brook is culverted in this location therefore the flooding event would have to occur via the openings to manholes and gullies. If these flow paths are not available, the brook may back up and flood upstream areas but the higher internal pressures in the culverted pipes may also damage the pipe structures and precipitate flooding. The observed behaviour of the brook course during high-rainfall events is to flood upstream of the A38 due to the culvert screens becoming choked. This almost certainly reduces the expected flow and removes the pressure on the downstream sections of the watercourse.
- The open water course and screen at the intake to the culverted section within the Cheviot Street park (GR433400 , 336197) are particularly prone to fly tipping and this poses a threat to the properties downstream if the brook overflows at this location and finds an alternative path down the valley.
- There are a number of smaller areas of flooding within the sewers feeding the brook system although these are limited to 100-200m3.

9.5.3 Extreme event scenario:

During a 0.1% event the known flooding problems would tend to become worse although the artificial ‘dam’ created by the A38 may attenuate the event and prevent much of the high flows from reaching the City. The majority of the brook course appears to have sufficient capacity to cater for the flows principally due to the ‘self-regulating’ nature of the watercourse and the various attenuation features along the route including wooded areas and culverts.

9.5.4 Blockage assessment

As the brook course is quite narrow and has a number of trash screens on the intakes to the culverted sections, the potential for blockages affecting the performance of the system is high. An extreme event would also be likely to dislodge debris from higher up the banks and add to the overall load conveyed by the brook. Secondly the brook infrastructure is approximately 150 years old and in varying states of disrepair including many sections in need of attention to prevent loss of parts of the brickwork forming the lining and structure of the culvert. The flood risk areas shown on the plans have assumed that the culvert may become totally blocked during an extreme event or suffers a collapse.

9.6 Littleover Brook

9.6.1 Introduction

Littleover brook is a small watercourse that rises in Littleover. The head of the catchment has been developed for housing and the surface water sewer system feeds the brook. The brook effectively commences as an open watercourse immediately west of the Derby Outer Ring Road (A5111) near the Derby City General Hospital (DCGH). This point (GR 433159 , 335151) is where the culverted watercourse & public surface water system draining a part of Littleover is joined by the private system draining the newly refurbished hospital. In all, the two flows total approximately 2cumec. The flows from the DCGH are limited, by the use of on-line storage tanks and orifice plate throttles on the DCGH site, to an agreed rate of 0.825cumec in a 100 year event.

The Littleover brook is prone to flooding as a result of:

- The brook course is narrow and has little freeboard,
- There are a number of highway culverts that do not provide sufficient flow capacity or have statutory services routed through them leading to a reduction in capacity and a tendency to block.
- Increasing development in the upper part of the catchment has increased the rate of run-off beyond the capacity of the brook course and culverted sections.

- The brook course is lined with mature vegetation and this tends to cause screens on the intakes to culverts to block.
- Areas of the brook course have been neglected by riparian owners or crudely culverted leading to a marked reduction in capacity.
- Vandalism and fly tipping are prevalent along parts of the open sections of watercourse leading to reduced flow area and blockages on screens and in culverts.

9.6.2 Potential problem areas for a 1% event:

- The area around the Manor Road Culvert (GR433159, 335151). This culvert predates much of the upstream development and is under-capacity following extensive development of the upstream catchment. Modelling has predicted approximately 500m^3 of flooding here during a 1% event with the potential to flood properties including 15+ homes. Flooding has occurred on a number of occasions here in the past and the brook course reacts very quickly (less than 60 minutes) to the urbanised catchment. To convey the 1% flows, the existing highway culvert has to become surcharged to a depth where flooding would occur at the upstream intake.
- St Cuthberts Road (GR433335, 335184), St Wystans Road (GR433502, 335209), St Albans Road (GR433561, 335182), St Davids Close (GR433631, 335137) – flooding around the highway culverts. Although only St Cuthberts Road is incapable of passing a 1% flow, they are all susceptible to a build-up of debris on the intake screens and also around statutory services that are routed through the culverts. Flooding volumes of 400m^3 are possible leading to inundation of properties.
- The area of open watercourse adjacent to Bramfield Avenue (GR434197, 335103). The watercourse gradient flattens in this area leading to flooding due to a lack of capacity. The problems are exacerbated through debris accumulation on the intake screens to culverted sections. Modelling predicts a flooding volume of approximately 1600m^3 in this location although the water would tend to

accumulate within the vegetated valley and adjacent allotments and the number of properties at risk appears to be small.

- Watercourse between Woods Lane & Boyer Street (GR434565, 335313). Parts of the watercourse have been culverted by riparian owners, leading to a reduction in available capacity. A flooding volume of over $600m^3$ during a 1% event is predicted for this location creating a risk to the ground floor properties flanking the watercourse.
- Lower reaches of the culverted watercourse near to the City centre. During a high water event on the River Derwent, the floodwater may back flow along Mill Fleam (GR435785, 336104) and fill the lower parts of the drainage systems for the Bramble, Markeaton and Littleover brooks. Although the anticipated floodwater levels are below the level of the surface in many cases, if this event coincides with an intense rainfall event over the catchment to the brooks, the reduced discharge capacity due to a surcharged outfall may result in flooding.

9.6.3 Extreme event scenario:

The brook is fed through a network of highway and hardstanding/roof drainage in the upper parts of the catchment therefore the limited capacity of the sewers would prevent some of the potential inflows from reaching the brook course however overland flows would also tend to contribute during a 0.1% AAP event. All the flooding problems that are exhibited during the 1% event would tend to increase in magnitude – volume & depth for the more extreme events. During the extreme event the behaviour of the floodwater may mimic the 'pre-development' behaviour. If the drainage system is surcharged and flooded, then the remaining water will simply flow overland to follow the steepest gradient wherever possible. Overland flows would also tend to be channelled by buildings and kerbed highways and be conveyed along various paths that would not necessarily be predicted from analysis of the landform contours.

9.6.4 Blockage Assessment:

As the brook course is quite narrow and has a number of trash screens on the intakes to the culverted sections, the potential for blockages affecting the performance of the system is high. An extreme event would also be likely to dislodge debris from higher up the banks and add to the overall load conveyed by the brook. Secondly the brook infrastructure is approximately 150 years old and in varying states of disrepair including many sections in need of attention to prevent loss of parts of the brickwork forming the lining and structure of the culvert. The flood risk areas shown on the plans have assumed that the culvert may become totally blocked during an extreme event or suffers a collapse.

9.7 Cotton Brook

9.7.1 Introduction

The Cotton Brook is a watercourse that is almost entirely culverted along the entire length. This situation has arisen as a result of the heavy industrialisation and extensive infrastructure and residential development of this part of Derby. The brook course has two principal tributaries fed by highway sewers at GR434578 , 334581 and GR434456 , 333962. The confluence point is at GR435435 , 334290 at the junction of Pear Tree Road & Dairy House Road. The original courses of a number of tributary watercourses have been lost and it is possible that these will cause problems in the future as the neglected and forgotten culverts begin to fail.

The sewer inflows to the Cotton brook system are a mix of highway and residential drainage and also a significant number of combined sewer overflows. At least nine active overflows are known to discharge effluent from the combined sewers to the sewer via weirs into surface water sewers and then into the watercourse or more directly by a simple weir and cross-connection pipe directly into the culverted watercourse. The Cotton Brook is quite shallow, typically around 2000mm invert depth below the surface so even modest amounts of surcharge may lead to flooding at the surface. Due to the nature of the effluent feeding the sewer, such flooding is of serious concern.

It has also been suggested that the Cotton Brook may overflow into the combined sewer system at certain times as it is frequently at a higher level within the highway than the combined sewer overflows.

The structural units of the watercourse are predominantly brick egg culverts of varying dimensions and conditions however this type of construction is known for its longevity and good performance at dealing with low and high flow volumes.

9.7.2 Potential problem areas for a 1% event:

- Warwick Avenue/Stenson Road junction – approx 500m^3 of flooding.
- Shaftsbury Street South – approx 225m^3 of sewer flooding within the industrial estate.

9.7.3 Extreme event scenario:

During a 0.1%AAP event the flooding is considerably more widespread as a combination of the River Derwent flooding up the brook course and preventing discharge into the River and also due to the flow in the culverts exceeding that available capacity. Potential flooded areas include:

- Warwick Avenue/Stenson Road junction – approx 900m^3 of flooding,
- Shaftsbury Street South – approx 800m^3 of sewer flooding within the industrial estate,
- Lower Dale Road/Normanton Rd/Peartree Rd junction – approx 500m^3 of flooding,
- Lower part of Peartree Rd near the junction with Walbrook Rd – 170m^3 of flooding,
- Along the culverted brook course extending from Holcombe Street to the outfall into the River Derwent,

9.7.4 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the infrastructure is approximately 150 years old and in varying states of disrepair including many sections in need of attention to prevent loss of parts of the brickwork forming the lining and structure of the culvert. The flood risk areas shown on the plans have assumed that the culvert may become totally blocked during an extreme event or suffers a collapse. Cotton Brook presents financial difficulties in producing efficient, effective repairs as the highways over the Brook course are busy with many accesses to businesses and homes. The roads also contain many live services – some of which are routed through the structure of the culvert.

9.8 Thulston Brook

9.8.1 Introduction

Thulston Brook rises near to Shelton Lock (GR437690, 331637) and flows in an easterly direction towards Elvaston. The brook has a shallow gradient falling only 4m over a length of 2500m. A large part of the upper catchment passes through a large balancing lagoon restricted by a 300mm dia throttle pipe reducing the 1% flows from this part of the catchment by around 60% to 0.2cumec. The middle section of the brook forms the southern boundary of the residential area adjacent to Boulton Moor and is fed by both land drains and run-off from the agricultural pastureland and also by the surface water sewer network from the residential estates adjacent to the brook. The lower section of the watercourse at the south eastern fringes of the City has been artificially improved to act as a large volume ditch to cope with high flows and provide on-line storage for stormwater. The ditch has a permanent water level due to the shallow gradient and silt deposition/vegetation in places. The brook assumes a more rural characteristic downstream of the City boundary and follows a meandering course through the River Derwent & Trent floodplains to its eventual discharge into the River Derwent at GR 441316, 331535.

In general the dimensions of the brook course appear to be adequate to convey the anticipated 1% flows at the present time.

Potential flooding risks arise from the following:

- This part of the City is under development pressures for new commercial and residential areas. The gently sloping topography results in generally shallow surface water sewer systems that may become surcharged and flooded during high water events in the brook course.

- The lack of care by some riparian owners along the brook course has resulted in a number of lengths of watercourse where vegetation growth, rear garden encroachment and fly tipping within the brook course may have compromised the capacity of the brook course.
- Thulston Brook has become badly silted over recent years following a lack of maintenance. This has resulted in many of the connections from surface water sewers into the brook becoming partially blocked at the outfall position. This may reduce the performance of the local highway & residential drainage systems.
- Increasing development will alter the catchment characteristics. Unlike many of the urbanised brook courses in Derby that rise and fall quite quickly, anecdotal evidence suggests that the Thulston Brook takes 1 or 2 hours to rise and then tends to maintain a reasonably high flow for a number of hours after the rainfall event has ceased. It is thought that the large areas of arable pasture tend to slow down the flows and flatten the flooding peaks however increasing development may generate much higher flows unless care is taken to encourage and enforce sustainable systems for drainage of new developments.

9.8.2 Potential problem areas for a 1% event:

- Calvin Close and Border Crescent (GR438481, 332007) in Boulton appear to be at risk of surface water sewer flooding during a 1% event. The volumes are small – approximately 200m^3 in total – however low-lying properties may be at risk.
- Crayford Road (GR438472, 332134) - approx 100m3 of flooding, field Lane (GR438633, 332290) - 230m3 of flooding and Falmouth Road (GR439115, 332128) - 50m3 of flooding. Although some properties appear to be at some risk however this volume of flooding may be confined within the highway and garden areas.

9.8.3 Extreme event scenario:

During a 0.1% AAP event, the sewer flooding problems would become more widespread however this is to be expected at the extreme nature of the event far exceeds the design limits of the sewers. The brook course has sufficient capacity however to cater for the anticipated flows and flooding does not appear to occur to properties directly from the brook course.

9.8.4 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the brook course is relatively small and may easily become blocked by debris. A number of the highway culverts are not protected by trash screens - although the dimensions of the culverts is reasonable. The floor of the valley is quite broad therefore the out-of-bank flows should spread out to a shallow flow path leading to a widely flooded area however the depth may be less than 250mm.

9.9 Chaddesden, Wood & Lees Brooks

The Chaddesden and Lees brooks system is one of the largest in Derby in terms of overall flow volumes, brook dimensions and catchment areas. Wood brook and Lees brook confluence at GR 438406,337209 immediately south of Lees Brook Community College and the combined watercourse is known as Chaddesden brook.

9.9.1 Wood Brook

This brook is fed by a network of surface water sewers in the residential area of Oakwood and Chaddesden. In the last three decades, the catchment characteristics have changed from sloping pasture and arable land to intensively developed housing estates and associated infrastructure. The drainage infrastructure uses some large pipe sizes to convey the flows quickly towards the culverted and open watercourses. The catchment falls from approximately 120m AOD to 55m AOD at the confluence with Lees Brook, with an average slope of 1 in 40 however the gradient is considerably steeper than this in places.

In parts of the catchment there are culverted watercourses and open watercourses routed alongside each other perhaps resulting from piecemeal development of the area and an increase in the rate of run-off. This would have necessitated the need for either widening existing watercourses or using statutory powers to construct new sewers. The latter approach seems to have been utilised extensively.

Potential flooding risks arise from the following:

- Sheet run-off and overland flows. The catchment has been extensively developed and essentially comprises dwellings, hardstanding areas, lawned gardens and grassed public amenity areas. All these surfaces generate appreciable rates of run-off and this, combined with the sloping topography, generates large surface flows. Sheet run-off is a known problem in parts of Oakwood and this problem is likely to become greater in the future as gardens become more developed, amenity areas and lawns become compacted, drives are widened and infill development removes scrub areas or encroaches on ‘green’ areas. It is conceivable that most of this upper catchment area is at risk during a 1% event if the ground is already saturated.
- Old watercourses. Prior to the development of the residential neighbourhoods this area was used for arable farming and grazing. The land had a network of ditches and land drains and these were often deliberately removed or otherwise lost during the redevelopment. Experience within Derby City Council is that water within the relicts of these drainage systems tends to flow along historical flow paths despite the drains having been cut-off or removed.
- Sewer flooding. The steep catchment enables water to flow quickly through the sewer network however this effectively shortens the time of concentration and potentially creates flooding problems in a few places where flow exceeds the available surcharged capacity.
- Watercourse flooding. In general, the culverted sections of watercourse have adequate capacity, however, the risk of flooding remains for the open sections if intakes are choked or poor maintenance, interference and neglect by riparian owners reduces capacity.

9.9.1.1 Potential problem areas for a 1% event:

- Springwood Drive (GR438663, 338992) – risk of sewer flooding,
- Saundersfoot Way, Springwood Drive, Tredegar Close (GR438888, 338867) – risk of sewer flooding,
- Area between Convent (GR 439070, 338668) and Kirkstead Close (GR438784 , 338042) risk of flooding along route of former watercourses & overland flows,
- Morley Road (GR 438755, 337580) – low point on highway therefore risk from flooding at Highway culvert and also from highway drainage.

9.9.1.2 Extreme event scenario:

During a 0.1% event, the flooding problems would invariably get worse with significant sewer flooding and overland flows throughout the catchment. The brook courses would probably flood to a greater extent, however, the increased volume of water would possibly accumulate elsewhere before reaching the main watercourse.

9.9.1.3 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the brook course is relatively small and may easily become blocked by debris. Out-of-bank flows would be likely to follow the line of steepest flow through the catchment and this is frequently different to the course of the watercourse. In this respect the flooding may affect properties at some distance from the watercourse.

9.9.2 Lees Brook

Lees brook rises in Locko Park on the north side of Derby at GR441141, 339118. The catchment is predominantly arable land, pasture, parkland and some wooded areas. There are some areas of buildings, hardstanding and residential areas notably the northern part of Spondon that feeds one of the tributary brooks. Lees brook meets the Wood brook near to Lees Brook Community College at GR438697, 337294. The soils within the rural catchment are generally derived from weathered mudstones and

therefore tend to shed water quite quickly. The soils index value used for the Institute of Hydrology 124 rural run-off estimation is 0.45. This, combined with the general slope of the ground leads to a short time of concentration. For the flow modelling in this case, a time of entry of 60 minutes has been chosen to attempt to simulate saturated ground and a heavy rainstorm. The watercourses will generally flow at approximately 1m/sec unless choked with debris and undergrowth.
The upper catchment including various land drains and tributary streams contributes approximately 6-7cumec, during a 1% AAP event, to the overall flow in the brook at GR438697, 337294. The brook lies within a deep trapezoidal channel at this point that appears to be the result of both erosion and also due the land either side being built up. A further 5-7cumec enters at this point from the urbanised catchment of Wood brook at Lees Brook Community College.

The Lees Brook has the potential to flood and almost certainly has out-of-bank flows every few of years. These are likely to be contained close to the brook course however as the brook flows within a well-defined valley with capacity to contain the likely flood flows. It is possible that flooding will occur to the minor roads that cross the route of the culvert.

9.9.3 Combined Chaddesden (and Lees) Brook

The combined brook commences at the confluence of Wood Brook and Lees Brook at the southern boundary of Lees Brook Community College. The brook is a trapezoidal earth channel approximately 2-3m deep and 10-15m wide at the top of the banks. It is heavily vegetated and overgrown in parts. It is estimated that the combined brook course conveys approximately 11cumec during a 1% event and a further 4-5 cumec enters at (GR438405, 337206) from an urbanised catchment of a tributary watercourse. The brook has a rectangular channel section formed from precast concrete segments for approximately 200m downstream before reverting to a trapezoidal, vegetated channel through Chaddesden Park. From this point onwards there are other limited inflows to the brook system from rural & urban drainage sources contributing approximately 2cumec. The brook enters a culverted section

(4m*2m concrete box) at (GR438062 , 336389) and re-emerges immediately south of Nottingham road in a deep earth channel adjacent to Meadow Lane. The brook enters a culvert again at (GR437775, 336131) and finally re-emerges at (GR437510, 335770) as a left bank tributary into the River Derwent.

Potential flooding risks arise from the following:

- Watercourse flooding. In general, the culverted sections of watercourse have adequate capacity however the risk of flooding remains for the open sections if intakes are choked or poor maintenance, interference and neglect by riparian owners reduces capacity.
- The open sections of the watercourses have variable bank levels and freeboard offering different factors of safety against flooding.
- Flooding via piped sewers. During a 1% event it is possible that the brook course water levels will be higher than some adjacent highway and property levels therefore some potential for 'backflow' exists and this may cause nuisance flooding in places.
- Overtopping of the banks of the watercourse. The open sections of the watercourses have variable bank levels and freeboard offering different factors of safety against flooding.
- Breach of defences. In places the flooding protection is afforded by either shallow earth bunds or concrete/masonry walls. If these failed during a high-water event, some inundation of neighbouring low-lying properties is likely.
- Flooding from the River Derwent. During an extreme event on the River Derwent it is possible that water may back-flow along the culverted watercourse and overtop into low-lying areas near the brook and the river.

9.9.3.1 Potential problem areas for a 1% event:

- Properties adjacent to the brook course between Lees Brook Community College and Maine Drive (GR 438376 , 336979) north of Chaddesden Park.
- Low-lying areas within Chaddesden Park.

- Properties between the junction of Autumn Grove/Meadow Lane (GR 437,878 , 336204) and the A52 dual carriageway including Ashworth Avenue & John Berrysford Close.
- Overall around 80 residential properties are at risk of flooding.

9.9.3.2 Extreme event scenario:

During a 0.1% event, the flooding problems would invariably get worse with significant sewer flooding and overland flows throughout the catchment. The brook courses would probably flood to a greater extent and the depth of flooding to properties may increase by a few hundred millimetres. The extents of flooding would probably not increase greatly as the valley sides are reasonably steeply sloping. Overall, around 40 additional properties may be at risk. This report does not contain an estimate of the overland flow risk in the Chaddesden and Oakwood areas however a failure on the brook courses or sewers that are routed approximately parallel with the contours may create overland flows that would not necessarily follow the line of the brook courses. In this respect there may be significant overland flows that could inundate properties some distance away from the sewer or brook course that has failed.

9.9.3.3 Blockage Assessment:

The potential for blockages affecting the performance of the system is moderate as the cross-sectional area of the watercourse is larger that many in Derby. Typically, the area available for flow exceeds 15m^2 therefore smaller debris may become washed down the brook course rather than catch on the sides and become held up. Out-of-bank flows would be likely to follow the line of steepest flow through the catchment and this tends to follow the line of the brook in its lower reaches. The amount of flow is considerable however therefore a large number of properties may be inundated as a result of a partial or total blockage of the brook. A secondary concern is the capacity of the brook to function adequately when the outfall is submerged by high water levels in the River Derwent.

9.10 Dam & Boosemoor Brook System

9.10.1 Introduction

This brook system lies immediately to the north of the City Boundary and enters the River Derwent near to Darley Abbey. Although presently ouside the Derby City Council boundary, the area may be the subject of expansion from increased residential development in the future and has therefore been briefly considered within the SFRA.

9.10.1.1 Dam Brook

The Dam brook drains a predominantly rural/agricultural catchment area of approximately 300ha. The brook rises near to Holly Farm at (GR439805, 339802) and flows westwards towards Breadsall. The brook course has been extensively altered through the village including sections of highway and private culvert, numerous small bridges to serve private driveways and artificial channel profiles. Once through the village, the brook is routed along ditch channels along field boundaries (again it appears that the course of the brook has been altered in the past – perhaps to feed mills or water meadows) to the confluence with the Boosemoor brook at GR436603 , 339961. The course of the brook falls approximately 60m over a distance of 3.5km from its source to the confluence with the Boosemoor brook.

9.10.1.2 Boosemoor Brook

The Boosemoor brook rises near to Breadsall Priory at GR438242, 341357 and flows generally SSW towards Breadsall via generally natural channels. The brook enters the village near Frog Hall at GR437093, 340144 and at this point the gradient becomes flatter and the channel becomes more artificial with some small bridges and a highway culvert at GR436963, 339987. The brook flows westwards away from Breadsall along managed ditch channels to the confluence with the Dam Brook. The brook falls 85m from its source to the confluence over a distance of 2.5km.

The combined brook is known as the Dam brook and flows towards the junction of the A38 & A61. The brook flows generally southwards adjacent to the eastern edge of the A61 before crossing underneath the road and entering the 5% AAP floodplain of the River Derwent. The brook crosses under the railway and flows south along the western boundary of the Alfreton Road Industrial Estate before crossing under Haslams Lane at GR435757, 338424. During the recent November 2000 and June 2007 events on the River Derwent, both approximately 4% AAP events, the Dam brook and adjacent flood embankment have formed the eastern boundary of the flood plain. The brook discharges into the River Derwent near Folly Road in Darley Abbey at GR435802, 338193.

9.10.2 Estimate of Flows

Using the IoH 124 methodology, the Dam brook catchment has the potential to generate approximately 3.5cumec for a 1%AAP event upstream of the village of Breadsall. The brook course has been approximately modelled using WinDes software using an impermeability factor to produce a similar rate of flow. The roughness characteristics and approximate dimensions of the brook courses have been chosen in an attempt to replicate the general state of the brook course and the likely behaviour during an extreme event.
Using a similar approach, the Boosemoor brook may generate a flow of approximately 3cumec upstream of Breadsall. The flows will tend to attenuate along the length of the brook once it enters the flood plain of the River Derwent west of the A61 although here the brook course ceases to be a flooding risk in comparison to the main river.

Potential flooding risks arise from the following:

- The open sections of the watercourses have variable bank levels and freeboard offering different factors of safety against flooding.
- Flooding via piped sewers. During a 1% event it is likely that the brook course water levels will be higher than some adjacent highway and property levels therefore some potential for ‘backflow’ exists and this may cause nuisance flooding in places.

- Overtopping of the banks of the watercourse. The open sections of the watercourses have variable bank levels and freeboard offering different factors of safety against flooding.

9.10.3 Potential problem areas for a 1% event:

- The property and highway adjacent to GR438642, 339713 as the culvert may block and lead to localised flooding.
- Properties adjacent to the Dam brook course downstream of the highway culvert on Brookside Road at GR437394, 339583,
- Properties in the village below the 56m contour level that forms the upper boundary of the potential flooding areas. It is conceivable that the brook will overspill onto Brookside Road and spread out through the village in a westerly direction.
- Overall around 60 residential dwellings may be at risk.

9.10.4 Extreme event scenario:

The brook course flooding issues are approximately the same although the magnitude of flooding increases and the depth to which properties are inundated will also increase. It is possible that the flooding will not affect any more properties than for a 1% event as the village has appreciable gradients and would tend to confine the floodwater.

9.10.5 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the brook course is relatively small and may easily become blocked by debris. Out-of-bank flows would be likely to follow the line of steepest flow through the catchment and this may be different to the course of the watercourse in the sections where the brooks have been diverted to suit various purposes over the years. In this respect the flooding may affect properties at some distance from the watercourse.

10 Flooding Risks to the City of Derby - Trent Catchment

10.1 Hell Brook

10.1.1 Introduction

Hell brook rises in the southern part of Mickleover (GR431368, 334788) with the upper part of the catchment comprising residential areas. The brook is fed by a surface water sewer network. The catchment slopes to the southeast and is urbanised comprising numerous sewer systems and balancing areas draining into an open watercourse with residential developments on one or both sides.

The lower part of the brook system, downstream of Heatherton (GR432183, 332319), has a much lower gradient across the Stenson Fields area and it is in this area that flooding occurs both from waterlogging of the ground and also from the brook overtopping.

To reduce the risk of flooding of the brook system, many of the newer housing developments have been designed with surface water systems draining via balancing areas to reduce the inflows into Hell Brook. Future housing developments within and adjacent to Heatherton & Stenson Fields (some with outline planning permission already granted) would need to be carefully designed to avoid areas that are within flood zone 2 or 3 and also incorporate sustainable drainage to reduce the flooding risk to other downstream areas.

The Hell brook system has been modelled on behalf of the Environment Agency by JBA Consulting (ref. Hell Brook Flood Risk Mapping Final Report 2006). This report is available from the Environment Agency and has been used as the basis for the flood zones shown on the SFRA plans. Additional modelling has been carried out by Derby City Council to examine the sewer networks feeding the brook and estimate the inflows, capacity and flooding potential within the residential areas as the sewers become overwhelmed during an extreme event. Highway and residential/commercial estate drainage tends to be designed to convey flows for a 20% AAP event as a ‘worst case’ therefore some localised flooding is to be expected during a 1% AAP event.

The purpose of the modelling is to identify vulnerable areas in order to assess the infrastructure provision for new developments. Prediction of the flow regime in the upper reaches of the catchment is difficult as the sewers and small watercourses are incapable of passing the anticipated 1% flows. These would instead move through the catchment as overland flows leading to many small areas of water accumulation and flooding. The theoretical flows at each of the main channel nodes are unlikely to occur simply due to the limitations of the conveyance capacity.

The flooding risks arising from Hell Brook have been known for some time and the catchment contains a number of on-line and off-line storage basins in order to reduce the peak flows in the brook course. In general these appear to function adequately however the issue of flooding from these storage areas exists, particularly considering the general lack of maintenance and general neglect they tend to experience. Many newer developments in the lower parts of the catchment include stormwater attenuation tanks and balancing areas including the Heatherton developments between Rykneld Road and Moorway lane.

Potential flooding risks arise from the following:

- Sheet run-off and overland flows. The catchment has been extensively developed and essentially comprises dwellings, hardstanding areas, lawned gardens and grassed public amenity areas. All these surfaces generate run-off therefore this fact combined with the sloping topography of the upper part of the catchment has the capacity to generate large surface flows. Sheet run-off is a known problem in parts of newer residential areas with generally smaller gardens and permeable areas as a proportion of the total area. This problem is likely to become greater in the future as gardens become more developed, amenity areas and lawns become compacted, drives are widened and infill development removes scrub areas or encroaches on ‘green’ areas. It is conceivable that most of this upper catchment area is at risk during a 1% event if the ground is already saturated.

- Old watercourses. Prior to the development of the residential areas the land was used for arable farming and grazing. The land had a network of ditches and land drains and these were often deliberately removed or otherwise lost during the redevelopment. Experience within Derby City Council is that water within the relicts of these drainage systems tends to flow along historical flow paths despite the drains having been cut-off or removed.

- Sewer flooding. The steep catchment enables water to flow quickly through the sewer network, however, this effectively shortens the time of concentration and potentially creates flooding problems in a few places where flow exceeds the available surcharged capacity.

- Watercourse flooding. In general, the culverted sections of watercourse have adequate capacity, however, the risk of flooding remains for the open sections if intake screens become choked by debris or vegetation or poor maintenance, interference and neglect by some riparian owners reduces capacity.

- Waterlogging of the lower parts of the catchment may be a problem in the future if an extreme rainfall event falls on already saturated ground. This may also generate slow-moving overland flows as described earlier.

10.1.2 Potential problem areas for a 1% event:

- Areas around the balancing area at Bradwell Close (GR431443, 334379). The brook is throttled at this point to create a balancing area in the valley. The sewers feeding this may surcharge and flood during extreme rainfall events. The discharge is restricted by a 450mm (approx) diameter orifice plate over the upstream end of a 525mm dia pipe underneath the artificial dam structure at the southern end of the area. The capacity of the balancing area is approximately 5000m3 before overtopping would occur on the weir overflow at the southern end.
- The balancing area adjacent to the junction of Brierfield Way & Kipling Drive (GR431150, 333868). Modelling of the sewer inflows and available capacity indicates that approximately 2000m3 of water may accumulate in this area during a 1% event. It is unclear at the present time whether the balancing area may cater for this amount of storage. If not, some spillage onto surrounding areas is possible .

- Castleshaw Drive (GR431439, 333013) – the sewers feeding the balancing area may surcharge during extreme events leading to some flooding of highways and possible flooding of private property.
- Pastures Hill (GR 431890, 333415) – there is a large trash screen in this location to protect the highway culvert. The trash screen accumulates significant amounts of debris necessitating regular cleaning. The residential areas to the southwest of the brook course are at risk of flooding from overtopping of the banks in this location.
- Junction of Rykneld Road & Hollybrook Way (GR431517, 332926) – some flooding possible if debris accumulates in the brook channels and also due to small diameter sewers being unable to convey rainwater to the brook course quickly enough.
- North of Moorway Lane / West of Brookdale Drive (GR432130, 332325) – area shown prone to flooding. DCC Flood Zone 3.
- Areas SE of Moorway Lane around Pastures Hill Farm (GR432452, 332087) – Flood Zone 3. Extensive flooding during a 1% event (and probably for less extreme events) including properties around Havenwood Grove (GR433012, 332,184). This whole area is noted as a floodplain for the Hell Brook and is known to flood regularly.
- Overall around 50-100 dwellings may be at risk.

10.1.3 Extreme event scenario:

During a 0.1% event the brook flows would increase by around 20% and flooding volumes in many locations may increase by upto 60%. Particular risk areas (apart from the surface water sewers that are at a general risk flooding during this type of event) include the following:

- Flooding on Wade Drive (GR431342, 334703).
- Areas around the balancing area at Brierfield Way (GR431443 , 334379). As the water level within the balancing area rises it is possible that the sewers around this area may flood.

- Area immediately north of the A38 at GR431477, 334252. The balancing area adjacent to the junction of Brierfield Way & Kipling Drive (GR431150, 333868). Modelling of the sewer inflows and available capacity indicates that approximately 5000m3 of water may accumulate in this area during a 0.1% event. It is likely that the surrounding areas will flood as the balancing area is unable to store this water.
- Balancing area adjacent to Foxbrook Close (GR432269, 333488) – 1200m^3 of water accumulation – some overspill likely.
- Castleshaw Drive (GR431439, 333013) – the sewers feeding the balancing area may surcharge during extreme events leading to some flooding of highways and possible flooding of private property.
- Pastures Hill (GR431890, 333415) – it is likely that there will be a significant accumulation of water at the upstream end of the highway culvert following a blockage of the trash screen. The residential areas to the southwest of the brook course are at risk of flooding.
- Junction of Rykneld Road & Hollybrook Way (GR431517, 332926) – some flooding possible if debris accumulates in the brook channels and also due to small diameter sewers being unable to convey rainwater to the brook course quickly enough. 2000m^3 expected during a 0.1% event.
- North of Moorway Lane / West of Brookdale Drive (GR432130, 332325) – area shown prone to flooding. Flood Zone 3.
- Areas SE of Moorway Lane around Pastures Hill Farm (GR432452, 332087) – Flood Zone 3. Extensive flooding including parts of Dalesgate Close/ Havenwood Grove /Boylestone Drive residential area.

10.1.4 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the brook course is relatively small and lined with trees over much of the length of the watercourse. In this respect it may easily become blocked by debris and is recognised as a particular problem at the present time particularly at Pastures Hill Road. Out-of-bank flows would be likely to follow the line of steepest flow through the catchment and this may be different to the course of the watercourse in the sections where the brooks have been diverted to suit various purposes over the years. In this respect the flooding may affect properties at some distance from the watercourse.

10.2 Cuttle Brook

10.2.1 Introduction

Cuttle brook rises in the Pastures Hill/Littleover area (GR432670, 333822) with the upper part of the catchment comprising residential areas. The brook is fed by a surface water sewer network from Hillsway (GR432719, 334229), Carlisle Avenue (GR432737, 333664), The Hollow (GR433004 , 334124) and associated small side streets. Cuttle Brook as a culverted watercourse commences at the junction of Carlisle Avenue & The Hollow. The brook becomes an open watercourse after it crosses under Brooklands Drive (GR433332, 333709).

Cuttle brook is characterised by an urbanised catchment comprising numerous sewer systems draining into an open watercourse with residential developments on one or both sides.

The lower part of the brook system, downstream of Sunnydale Park (GR433880, 333345), has a lower gradient that flattens further once the course of the brook reaches Sinfin Moor (GR435542, 332122). The lower reaches of the brook through the commercial & industrial areas to the southeast of the Derby-Burton railway have been subject to many alterations and various culverting approaches over the years. Unlike the Hell Brook catchment, the residential areas are older and do not include stormwater balancing or attenuation facilities. Instead, they convey water through a network of surface water sewers directly to the brook course.

The Cuttle brook system has been modelled on behalf of the Environment Agency by JBA consulting (ref the report). This report is available from the Environment Agency and has been used as the basis for the flood zones shown on the SFRA plans. Additional modelling has been carried out by Derby City Council to examine the sewer networks feeding the brook and estimate the inflows, capacity and flooding potential within the residential areas as the sewers become overwhelmed during an extreme event. Highway and residential/commercial estate drainage tends to be designed to convey flows for a 20% AAP event as a ‘worst case’ therefore some flooding is to be expected during a 1% AAP event. The purpose of the modelling is to identify vulnerable areas in order to assess the infrastructure provision for new developments. Prediction of the flow regime in the upper reaches of the catchment is difficult as the sewers and small watercourses are incapable of passing the anticipated 1% flows. These would instead move through the catchment as overland flows leading to many small areas of water accumulation and flooding. The theoretical flows at each of the main channel nodes may not occur due to the limitations of the conveyance capacity.

The flooding risks arising from Cuttle Brook have been known for some time following occasional flooding events and feedback information from local people living adjacent to the brook course. Derby City Council are aware of the shortcomings in knowledge of the brook routes particularly around the areas of Stenson Road (GR434051, 333001), Caxton Street, Sinfin Lane & Wilmore Road (GR435114, 332491) – in all these areas there are conflicting records over the exact routes of the culverted brook course following a number of bifurcations and diversions over the years. These will be investigated over the next few years to better establish the routes and capacities available.

Potential flooding risks arise from the following:

- Sheet run-off and overland flows. The north-western part of the catchment has been extensively developed and essentially comprises dwellings, hardstanding areas, lawned gardens and grassed public amenity areas. All these surfaces generate appreciable rates of run-off therefore this fact combined with the sloping topography of the upper part of the catchment has the capacity to generate large surface flows. Sheet run-off is a known problem in parts of newer residential areas in Derby with generally smaller gardens and permeable areas as a proportion of the total area. This problem may become greater in the future as gardens become more developed, amenity areas and lawns become compacted, drives are widened and infill development removes scrub areas or encroaches on 'green' areas. It is conceivable that parts of the upper catchment area is at risk during a 1% event if the ground is already saturated.

- Old watercourses. Prior to the development of the residential areas the land was used for arable farming and grazing. The land had a network of ditches and land drains and these were often deliberately removed or otherwise lost during the redevelopment. Experience within Derby City Council is that water within the relicts of these drainage systems tends to flow along historical flow paths despite the drains having been cut-off or removed.

- Sewer flooding. The steep catchment enables water to flow quickly through the sewer network however this effectively shortens the time of concentration and potentially creates flooding problems in a few places where flow exceeds the available surcharged capacity. In the flatter parts of the catchment the flexibility of the sewer system is reduced, compared to steeper catchments and drainage routes, as the available surcharging is limited before the sewers begin to flood. In the lower-lying parts of the catchment, the sewers close to the routes of the open and culverted watercourse may back-up and flood due to higher water levels in the nearby brook.

- Watercourse flooding. In general, the culverted sections of watercourse have adequate capacity however the risk of flooding remains for the open sections if intake screens become choked by debris or vegetation or poor maintenance, interference and neglect by riparian owners reduces capacity.

- Waterlogging of the lower parts of the catchment may be a problem in the future if an extreme rainfall event falls on already saturated ground. This may also generate slow-moving overland flows as described earlier.

10.2.2 Potential problem areas for a 1% event:

- Sewer flooding around The Hollow and Carlisle Avenue.
- Flooding from the watercourse immediately downstream of Brooklands Drive. This could also affect properties in Taverners Crescent and Willson Avenue as the

culvert has been narrowed as a result of some riparian owners extending their gardens and steepening the banks of the brook course.

- Rosamunds Ride area (GR433875, 333594) – the brook course capacity is considerably less than the anticipated flows here therefore surcharging occurs regularly as the brook course backs up from Sunnydale Park.
- Sunnydale Park – there is an existing flow balancing area and throttle pipe installed by Severn Trent Water. This balancing pond has been studied as a part of the Environment Agency model and overall the storage area will accommodate approximately 20,000m3 of water equivalent to a 1 in 5 year event for the catchement. For more severe events, the balancing area will flood – probably into nearby properties and will adversely affect upstream and downstream areas. It is interesting to note that the possible inflow (see earlier note regarding the limitations of the catchment to convey the flows) during a 1 in 100 year storm is over 6cumec and the available brook capacity upstream of the balancing area is considerably less than this. In this respect, flooding to properties that are served by the sewer networks or that are adjacent to the brook course upstream of Sunnydale Park is possible.
- Sewer flooding within the residential areas off Wellesley Avenue (GR433989, 333121) as the sewers are of small diameter and the topography is quite flat.
- Flooding along Wellesley Avenue following the failure or exceedance of the capacity at the Sunnydale Park balancing area.
- Flooding around the junction of Wellesley Avenue & Stenson Road. Over fifteen residential properties are shown to be at risk from the brook flooding during a 1% AAP event. This area is also known to be susceptible to nuisance flooding from short-duration intense storms as the highway drainage tends to pool within the junction. The brook course is believed to have a much greater capacity than the sewer and culvert records indicate following works by Severn Trent Water to increase the capacity through provision of a relief culvert. There is a recommendation to further investigate this area to better establish the true flooding risk.
- Keldon Avenue & Stenson Avenue (GR434288, 332887) – at risk of flooding if the screen on the culvert entrance at Keldon Avenue becomes blocked.

- Sinfin Lane, Thackery Street, Wilmore Road and the Rolls Royce site (GR435160, 332519). The culverted brook course appears to have insufficient capacity for a 1% AAP event and significant flooding of low-lying areas is possible. Modelling of the potential inflows has also highlighted an under-capacity issue with the culverted watercourse system draining the Victory Road developments (GR435489, 332711) through the Rolls Royce site into the culverted Cuttle brook.
- Sinfin Moor – much of this area lies within Flood Zone 3 and acts as a storage area for floodwater from the River Trent to the south as well as for the Cuttle brook. In this regard it is a particularly high risk area.
- It is quite possible that overland flows will move through the whole of the catchment becoming deeper in the lower reaches as the water slows down and accumulates. The estimated flows that would be generated by the catchment are far in excess of the flows that may be accommodated by the sewers or watercourses therefore overland flows may result either from runoff being unable to enter the drainage systems or from the drainage systems overflowing and the resultant floodwater moving downhill following the path of least resistance. This is often the steepest gradient however roads and other urban features may also direct the floodwater along unexpected paths.
- Overall, around 200+ residential properties may be at risk of direct flooding from the brook course and a further 300+ properties at risk from surface water sewers flooding.

10.2.3 Extreme event scenario:

The flows in the brook course system may increase by upto 50% during a 0.1% event compared to the 1% event. The flooding volumes also increase significantly with 100% increases in the volume of floodwater accumulating in places. Flooding zones may become significantly wider in the lower, flatter parts of the catchment. It is quite possible that overland flows will move through the whole of the catchment becoming deeper in the lower reaches as the water slows down and accumulates.

10.2.4 Blockage Assessment:

The potential for blockages affecting the performance of the system is high as the brook course is relatively small and lined with trees over much of the length of the watercourse. Also the watercourse is difficult to access in many places and this is likely to exacerbate the problems due to the time taken to access and clear blockages. Out-of-bank flows would be likely to follow the line of steepest flow through the catchment and this may be different to the course of the watercourse in the sections where the brooks have been diverted to suit various purposes over the years. In this respect the flooding may affect properties at some distance from the watercourse.

11 Other Flood risks to the City

11.1 Flood risk - Overland flows

Where the ground becomes saturated or the water is unable to soak-away or be directed to a local drainage or where flooding of a watercourse or sewer occurs, the rainfall/water will tend to flow across the surface in the direction of the steepest gradient. This will continue until the water reaches a local low point, enters a drain or floods a property.

Vulnerable areas include those at the lower parts of a slope or housing estate or where an urban area borders agricultural land, golf course or parkland that slopes towards the urban area. Another common cause of overland flows is on developments where the original hedge lines and network of minor watercourses has been removed to suit a new layout. In periods of prolonged or heavy rainfall, the accumulated water may flow on the surface along the lines of old watercourses. It is difficult to pinpoint problem areas other than by the record of incidents that have been reported.

Areas at risk of this type of event include:

- Allestree,
- Oakwood & Chaddesden,
- parts of Littleover, Hillcross and Sunny Hill,
- Upper Hell Brook & Cuttle Brook

11.2 Flood risks – Sewers

There are areas within Derby that may be at risk of flooding from sewers. Generally, the sewers were designed to cater for storm return periods between 5 and 30 years therefore they can be expected to exhibit flooding during a 1:100 year event. Where this occurs the consequences will be runoff unable to enter the sewer system and also water flooding out of the sewer system at various points, driven by the hydraulic head in the sewer above the flooding point. In both cases water would either accumulate near to the flooding point if the ground is flat or depressed or would flow overland along the line of the steepest gradient. This would be a particular problem during periods of intense rainfall that coincide with a high water event on the River Derwent and other watercourses as the surface water outfalls may be submerged and therefore unable to operate effectively. In this instance the sewers would be likely to flood lower lying areas. A secondary risk is the route offered by sewers for floodwater from the major watercourses if the flap-valves on the outfall headwalls fail to operate properly. There are many areas of Derby at risk from flooding due to this source as the ground levels are below the anticipated level of the floodwater in the watercourse channel.

If the capacity of the sewers is unable to cater for the rainfall intensity, the result will be flooding from sewer usually via the manhole covers and road gullies. This type of flooding tends to coincide with summer thunderstorms and is generally very localised and typically of a short duration usually remaining within highway boundaries. Areas at risk from this type of event are often at the base or lower parts of a hill where the gradient of the sewer eases. Properties that have a ground floor level lower than the level of the adjacent road may be at risk from this type of event. An added complication in Derby is the widespread network of combined sewers where the rainwater and foul sewage share the same pipe. These were built many years ago prior to the requirements to provide separate foul and surface water systems coming into force. There are numerous overflows from this type of sewer within the City to divert the excess flows into either an adjacent watercourse or into a newer surface water sewer that may be nearby.

11.3 Flood risk – waterlogging

In this instance, the accumulated water is unable to flow away from a property either because the property is in a dip or because there is a physical barrier preventing rainfall from flowing away or infiltrating into the ground. Alternatively a ‘spring line’ may form either in the wetter seasons or following a prolonged spell of rainfall. In either event the water may accumulate in hollows until it reaches a level where it may enter a drain or overspill the edge of the hollow and flow away.

Within Derby the problems do not appear to be widespread based upon the very limited number of enquiries received by the Land Drainage Team. This may be because topography is steeply sloping and the underlying ground is, with the exclusion of the Derwent floodplain, weathered Mercian Mudstones. This material does not promote the flow of water through the strata and is not regarded as a significant aquifer.

This scenario may occur anywhere the ground dips locally or where a development has removed the previous drainage system or severed the route of piped land drains or ditch courses. Other locations are in areas of reclaimed marsh or flat moorland areas including Heatherton, Stenson Fields and Sinfin & Boulton moors.

11.4 Flood risk – development

As with many cities within the East Midlands, Derby is undergoing a period of expansion from infill of sites, redevelopment of brownfield land and also new development within 'greenfield' areas (ref. Derby Local Plan: 2006 revision). The latter type of development is perhaps the one that tends to exacerbate the flooding risk unless very carefully planned and controlled. Flooding risk tends to increase as a result of the following:

- Increases in the impermeable areas feeding the sewers or networks of watercourses. Many of the sewers within the City are utilised to their full capacity during extreme events. Increasing the inflows to the sewers from an increase in the impermeable areas feeding the sewers could create problems as the sewers may flood areas not currently at risk. Fringe developments on the outskirts of the City centre comprising large retail, commercial and/or office developments have the potential to generate large flows from roof and car parking areas. Examples of this are the developments near to Victory Road south of the City centre. The developments discharge into the surface water sewer system that ultimately discharges into a culverted watercourse tributary of the Cuttle brook. The culverted watercourse appears to be susceptible to flooding through the Rolls Royce site off Wilmore Road.
- Removal of existing ditches and drainage to facilitate new development. In a number of parts of the City, the development of greenfield areas has resulted in

the removal of the network of land drains and field ditches or diversions and severing of the network. This tends to create problems as the existing networks act as storage/attenuation facilities and also convey water from other areas. Problems have occurred in Oakwood and Spondon recently where residents have alerted Derby City Council to flooding problems. These appear to have resulted from old watercourses being severed or filled in & built over.

- Removal of flooding zones. Where development occurs within a potential flooding zone or washland area, the drainage regime will change and the floodwater will either inundate the new development or alternatively move elsewhere to create a new washland area or exacerbate an existing problem.

12 Lower Derwent Flood Risk Management Strategy

Ref: Lower Derwent Flood Risk Management Public Consultation Document

The River Derwent through Derby is currently the subject of a detailed study and proposals by the Environment Agency (Midlands region) as the potential flooding problems through Derby exhibited by the contemporary modelling works are severe. The EA have estimated that upto 5,000 properties may be at risk and the consequent economic risk to Derby from a major flood closing the City centre for a few days is unacceptable.

The River Derwent is a particular problem to Derby as the valley upstream of the City is quite steep with little capacity to store or attenuate floodwater. In this regard the options for defending Derby are rather limited. A secondary limitation to the options available arises from the economic costs of the various options. The Environment Agency has considered various options including the following:

(i) Improve the existing defences by reconstruction/adding height/adding new defences – in general this approach has been discounted for the following reasons:

- The defences would need to be much higher than they are now – upto 2m higher than the existing banks or defences.
- The higher water levels through Derby would increase the flooding risk to both upstream and downstream properties.
- The higher flood defences would be visually intrusive and would also create engineering difficulties for the bridges that cross the River. The link between the City & the River would also be lost or diminished due to the size of the defences.

(ii) Increase the amount of storage upstream of Derby to remove the flood peak. This approach would have a limited effect however the volume of floodwater is too great to be entirely stored and extensive flooding would nevertheless occur. Additionally, the storage area would sterilise a large amount of land and would create other flooding problems upstream of the storage area.

(iii) Build a bypass channel or culvert around Derby to divert floodwater away from the City centre. This option has been discounted on the basis of cost and engineering difficulties at the present time.

(iv) Improve the capacity of the River Derwent to pass the required flows through the City. This option, known as the 'blue corridor' involves the realignment of defences to create a wider path for the River Derwent to flow along. This has the benefit of requiring lower height defences set further back from the River. At the present time (May 2010) the Environment Agency are preparing this option as a detailed planning application with a schedule for the work from 2012 onwards.

13 Guidance for developers in site-specific flood Risk Assessments

The requirements for site-specific flood risk assessments to accompany planning applications are as follows:

- consideration of flooding risk *from* the development including:
    - an assessment of the existing drainage system on the site and the pre-development discharge rate,
    - calculated discharge rates from the development and the available capacity within the receiving watercourse or sewer,
    - flood paths over the development and the flows off-site towards 3rd party property based on failure of the on-site drainage system. It is a requirement of Derby City Council that 100 year (plus climate change allowance) rainfall volumes and flows are retained on the site and must not flow onto other 3rd party land.
    - overland flows arising on the development and the routes towards 3rd party property for more extreme events than a 1 in 100 year event,

- consideration of the flooding risk *to* the development including the risk from:
    - watercourses and main rivers and the pathway to & through the site. An assessment of the level of protection against the site flooding is required,
    - sewers – surface water & combined,
    - highway and 3rd party run-off,
    - failure of the on-site drainage system leading to ponding on the site,
    - overland flows,
    - assessment of the emergency access routes to & from the site in the event of a flooding incident.

- In addition to the above requirements the City Council recommends that a drainage statement is produced detailing:
    - existing foul/combined and surface water drainage systems serving the site,

- estimate of the rate of discharge from the existing or previous site with supporting calculations, plans & reasoning,
- preliminary results from on-site testing and desk studies to determine the ground conditions, previous uses of the site and the suitability for Sustainable Urban Drainage (SUDs) techniques to be used on the site,
- sketch designs describing the proposed surface water drainage solution for the site with supporting calculations,
- the maintenance and management of the drainage system where it is to remain in private ownership.

14 Application of SUDs techniques within Derby

As described earlier in the report, the City Council aims to minimise the flows into the sewers and watercourses within the City to reduce or control the risk of flooding as far as possible. In this regard the application of management techniques to reduce the discharge of surface water from development sites to 'greenfield' rates is vital to achieve the policy objective of reducing flood risk. In essence the SUDs approach is to try to mimic the pre-development behaviour of the site, limiting the discharge of surface water and enabling the infiltration of water into the ground.

The ground conditions in the undeveloped parts of Derby are typically organic soils with a clayey subsoil overlying gravely clays trending to weathered mudstones at depth. Overall, the ground conditions do not appear at first sight to be suitable for infiltration however a consideration of the behaviour of the natural environment demonstrates that the rainwater is attenuated within the soil matrix and then may infiltrate into the weathered mudstones albeit at a slow rate. Typically, much of the City has soils with a 'winter rain acceptance potential' (WRAP) class of 4. This essential means that Greenfield run-off rates are quite high as the soils are easily saturated and once in this state, the ground behaves as if it is impermeable.

In parts of the City near to the main watercourses, the ground conditions comprise sands and gravels as river terrace deposits and also areas of silt and clay. The former ground conditions should be suitable for infiltration methods although an appreciation of the ground water level is required when assessing the suitability of a particular design. Areas of silts and clays would typically pose difficulties for infiltration methods however they may still be applicable with increased storage.

The hierarchy of approaches should ideally be as follows:

- the use of local water recycling initiatives including rainwater collection in water butts or underground tanks & re-use as water for the garden or in the latter case to supplement the treated water used for toilet flushing,
- storage & infiltration on site using swales, detention & infiltration basins and washland areas,
- storage & infiltration on site using soakaways,

- storage & infiltration on site with an overflow to other drainage systems outside the site limiting the discharge to greenfield rates,
- storage on site with a controlled discharge to other drainage systems outside the site.

The following situations may preclude the use of infiltration methods:

- Where ground conditions are essentially impermeable leading to excessive or impractical storage requirements,
- High ground water levels,
- proximity of other structures & foundations renders the use of infiltration systems inappropriate,
- where contamination within the ground may be mobilised and spread by the direct infiltration of water into the ground.

Derby City council has recently produced a SUDs guidance document and this will be available to developers in 2010. DEFRA are currently working on a set of design standards for sustainable drainage systems in order that drainage designs may be subjected to a formal scrutiny process prior to being adopted. The details of this process are being reviewed and are expected to be published in 2010.

15 Conclusions/Recommendations

Derby City Council has demonstrated foresight in maintaining a Land Drainage team within the Authority to monitor, model and maintain many of the brook courses within the City. The general flooding risks to Derby have been known for some time and measures have been taken to reduce these where possible and where funding allocations have permitted. The purpose of this report has been to objectively quantify the risks in order to form the basis for a wide-ranging flood defence and drainage management strategy. The scope of the report and the study area has been quite broad therefore the conclusions are also general and describe the risks to properties rather than specifically recommending a course of action.

The principal conclusions from this report are as follows:

15.1 Risks from the River Derwent

Derby city centre and the corridor of development for upto 1km either side of the river are at risk of flooding during a 2%AAP event and probably for events with a higher probability of occurrence. In particular, the left bank of the river appears to be vulnerable upstream of the City centre with over 1000 dwellings at risk of rapid inundation upto 2m deep. The residential areas of Alvaston and Allenton are also at risk from both overtopping and failure of the flood defences. Again, inundation is likely to be rapid especially if a breach occurs in the right bank defences.

The City centre has a reasonable level of defences (estimated by the Environment Agency as 1% standard or 1:100 year protection between the Silk Mill and 5-Arches bridge) on the right bank of the river however if blockages occur against Exeter, St Mary's and Derby Rail Junction bridges (5-Arches bridge) this may create much higher upstream water levels that may cause overtopping of defences.

On the left bank the level of protection is much lower with protection levels as low as 4% or 1:25 year protection estimated between Little Chester footbridge and Longbridge Weir. Risk also exists within the City centre as a result of water backing-up and flooding through drainage conduits with direct connections to the River

Derwent. Parts of the City are lower than the anticipated flood levels in the River therefore some flooding via drainage pipes and gullies may occur. A further risk exists from the minor watercourses draining into the culverts through the City centre. In the event of high water levels, the culverts may not have enough capacity to convey the anticipated flows from the minor watercourses and this may lead to flooding of areas remote from the River.

15.2 Risks from other watercourses

15.2.1 Markeaton & Mackworth Brooks

The overflows at Markeaton Park into the Northern Flood Culvert should provide a high level of flood defence from these watercourses following improvement works in 2005/2006. The standard of flood protection is nevertheless dependent on the regular maintenance of the assets including the de-silting of stilling ponds, structural inspections of culverts/spillways/intakes/outfalls and the regular clearing of debris from screens and out of the watercourse channels.

15.2.2 Amber Brook

A minor watercourse with some risks of flooding to properties although quite localised. Flood risk dependent on the amount of maintenance.

15.2.3 Burley Brook

A minor watercourse draining Allestree Golf Course. There are some flooding risks associated with the brook, but only to landscape areas.

15.2.4 Bramble Brook

Flooding risks to the City assuming the failure of infrastructure however the capacity to carry the estimated flows appears to be adequate. Significant maintenance required to keep the current level of protection. Further investigation of the A38 culverts required to assess the role in attenuating the flows.

15.2.5 Littleover brook

Significant known flood risk to properties as the watercourse and culvert capacities are considerably less than required. Very short time of concentration therefore warnings of flooding are not practical. Improvements are required to reduce the risks.

15.2.6 Cotton Brook

Generally adequate although the failure of infrastructure would cause widespread flooding. Combined sewer overflows form a large part of the inflows to the culverted watercourse. Further investigation required to determine the effects of a surcharged outfall into the River Derwent on the performance of the culvert.

15.2.7 Thulston Brook

This watercourse has a mixture of rural and urban catchments. The performance is influenced by the degree of maintenance of the lowest reaches of the watercourse as there is a permanent water level near to the eastern boundary of the study area due to heavy silting/vegetation. The brook requires a programme of restoration including de-silting and vegetation/debris clearance. Generally the capacity of the watercourse appears to be adequate although development pressures may increase the inflows to the brook course over the next few years. This part of Derby is quite low lying with very shallow gradients on the sewers and watercourses therefore flooding may be extensive where it occurs.

15.2.8 Chaddesden, Wood & Lees Brooks

A significant urbanised catchment in the lower reaches of these watercourses with a large rural catchment upstream. The catchment is quite steep and the clayey soils produce rapid rates of run-off once the upper parts of the soils become saturated. The brook systems have been extensively culverted through the residential areas of Oakwood and Chaddesden and, in general, the capacity of the open and culverted network seems to be adequate. There remains a significant flood risk to properties near to the brook if the brooks or culverts become blocked by debris or if the infrastructure fails in some way. The inundation of properties may be rapid as the lower reaches of the brook are estimated to convey approximately 17cumec during a 1% AAP event.

15.2.9 Dam & Boosemoor Brooks

A significant risk to Breadsall village with little prospect of mitigation other than through civil engineering works to improve the capacity of watercourses and culverts. Although a left bank tributary to the River Derwent, the risk to areas other than Breadsall is low.

15.2.10 Hell Brook

This is an important watercourse as it drains a large part of the western side of the City area. The brook has a number of flood risk areas around it at the present time although these are generally limited to discrete groups of dwellings. Areas of concern include Brierfield Way and also areas to the south of Moorway Lane/Bakeacre Lane as the flooding in this area is predicted to be widespread. Improvements required toreduce the flooding risks.

15.2.11 Cuttle Brook

The brook course has been extensively modified and drains a large part of the south-western part of the City. It discharges into the River Trent and is understood to be susceptible to flooding from the River Trent flowing up this tributary watercourse. There are large numbers of residential properties at risk from this watercourse in various locations along the route and also areas at risk of sewer flooding due to surcharged outfalls into the Cuttle brook and a general lack of capacity. The brook course appears to have been neglected both from a lack of enforcement of riparian responsibilities and also from a lack of general maintenance to promote efficient conveyance of flows. Further study and a significant planned maintenance programme would be required to manage the flood risks.

16 Flood Risk Management and Warning Systems

The usefulness of flood risk warning systems for many of the watercourses within Derby is questionable as the 'time of concentration' – the time lag between the commencement of a major rainfall event and the commencement of flooding from a watercourse- is in the order of two or 3 hours. In this respect the provision of a warning is likely to be too late to be of practical use to residents or businesses within the potential flooding zones. The larger watercourses may be treated differently however as the time of concentration is much longer therefore warnings to prepare for the possibility or probability of flooding may be useful.

The Environment Agency Operate a flood warning system for the River Derwent throughout the length of the River. The warnings are given out as news bulletins on local radio and television and also as an automated message that is sent to telephone numbers that have registered to be contacted in this way. The warning systems are based upon the recognised approach of issuing messages as follows:

Flood Watch – this suggests that flooding of low-lying areas and roads is expected and persons living in flood zone 3 should be prepared to take action.

Flood Warning – flooding of vulnerable homes & businesses is expected in the next few hours. People receiving this warning should take appropriate measures to safeguard their possessions and erect any local flood defences they have.

Severe Flood Warning – severe and widespread flooding within the flood zones is expected in the next few hours. People should prepare for flooding and make sure they either move to higher ground or to another place of safety.

All Clear – this is a message give out following any of the three warnings above to inform people within the vulnerable areas that the immediate flooding risk has passed.

For Derby, the return periods that are likely to generate the particular flood warning communications based on the current defence standards within the City are as follows:

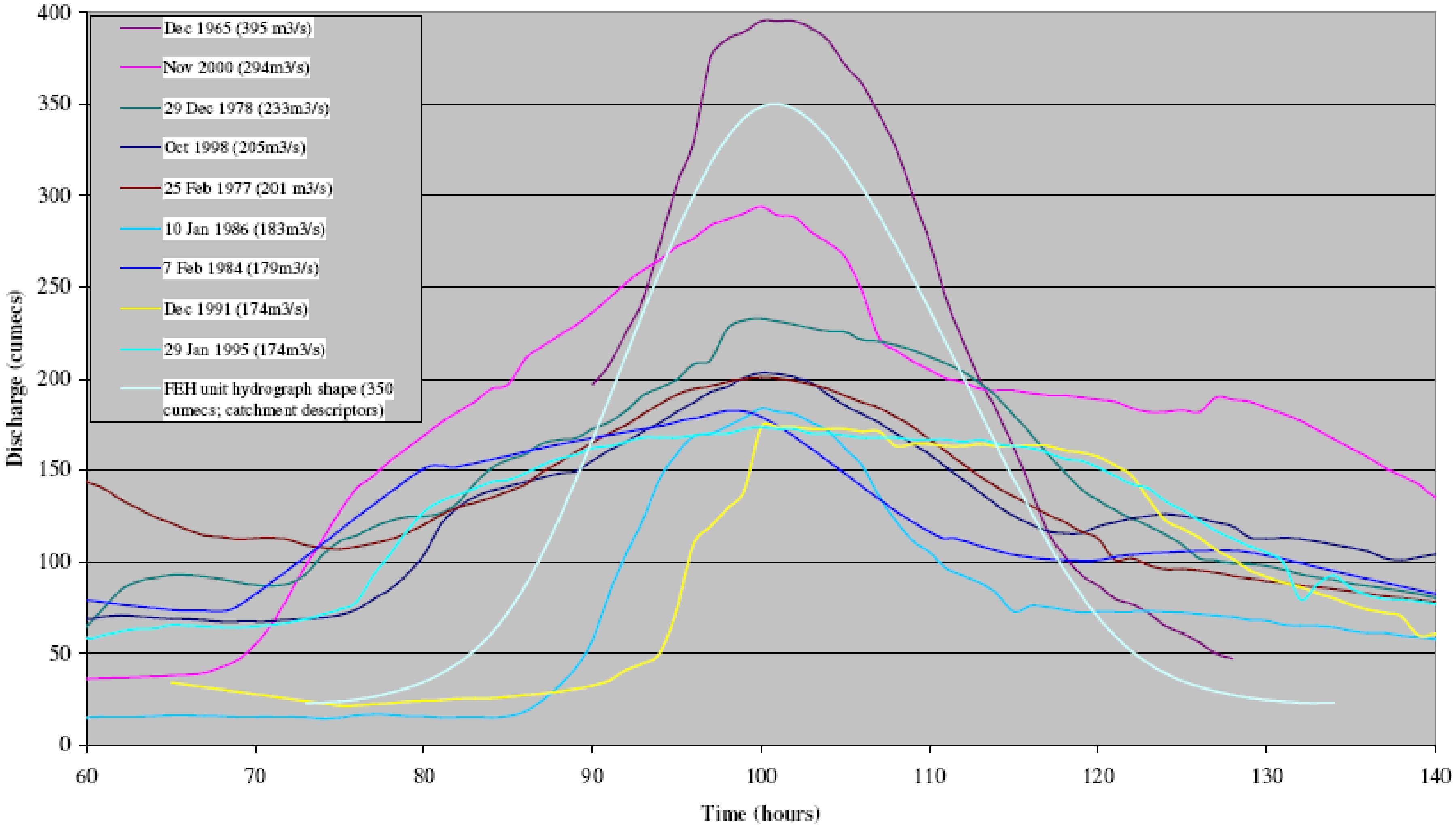
Flood Watch – a 1 in 10 year (10% average annual probability) event.

Flood Warning – a 1 in 25 year (4% average annual probability) event.

Severe Flood Warning – a 1 in 50 year (2% average annual probability) event.

The Derwent Valley has a relatively steep gradient and overall, a small time of concentration in comparison to many other river catchments therefore the time interval between the river flowing normally to reaching severe flood level is of increased importance in the response arrangements required to protect persons & property in the event of a likely flood event. The following diagram shows the hydrographs for the River Derwent (reference Black & Veatch: River Derwent in Derby Final Modelling Report September 2006).

This shows the response time for the hydrograph based on the catchment descriptors is around 15 hours from a low base flow of 50cumec to a severe flood of 350-400cumec. A 1 in 100 year (plus climate change) flood flow rate through the City is estimated to be 540cumec. The time taken for the river to rise from the flood watch status approx 200cumec to severe flood status is only approximately 8 hours therefore the predictions for Derby need to be based both on the actual flow rate at any given point and also the rate of increase in flow at the various gauging stations within the catchment. The Environment Agency and Meteorological Office are working to improve the prediction arrangements in order to estimate the likely flows resulting from the accumulation of rainfall within the catchment coupled with the degree of saturation of the soils and extent of vegetation. This approach has been advocated in the Pitt Report (published June 2008) and would provide a longer lead-in time and enable a measured, comprehensive response from the appropriate Emergency Planning teams.


Dec 1965 (395 m3/s)
Nov 2000 (294m3/s)
29 Dec 1978 (233m3/s)
Oct 1998 (205m3/s)
25 Feb 1977 (201 m3/s)
10 Jan 1986 (183m3/s)
7 Feb 1984 (179m3/s)
Dec 1991 (174m3/s)
29 Jan 1995 (174m3/s)
FEH unit hydrograph shape (350 cumecs; catchment descriptors)
Discharge (cumecs)
Time (hours)
0
50
100
150
200
250
300
350
400
60
70
80
90
100
110
120
130
140

17 Recommendations for further work and investigation – level 2 FRA.

It is anticipated that further stages of work into the flood risk to Derby will be undertaken however it is envisaged that this will focus on particular areas or catchments rather than the City as a whole. The catchments within the City are reasonably discrete and development plans tend to fit within separate brook catchments. The recommendations may be split into five areas:

17.1 Further survey work:

- The brook courses require further investigation and topographical surveys – it is expected that this work will be done to serve either level 2 SFRA work or alternatively the Surface Water Management Plan.

17.2 Further study and investigation:

- There are areas of Derby where the drainage system is not fully understood – pipe sizes, overflows and arrangements of intakes and outfalls. These include the following:
    - Cuttle brook – Flow capacity of the watercourse at throttle points and balancing/attenuation capacity available.
    - Cuttle Brook - Stenson Road to Thackery Street.
    - Hell Brook – capacity of the brook course at various throttle points including the balancing areas along Brierfield Drive and also adjacent to Pastures Hill.
    - Cotton brook – flow capacity and direction of the combined sewers overflows into or out of the Cotton brook system. The structural adequacy of the existing brick culverts has also been questioned recently therefore the full implications of a structural failure and collapse need to be investigated. A model is required to assess the overland flows resulting from this scenario at various locations along the culverted brook course.
    - Oakwood – the sloping topography of the Oakwood residential neighbourhoods has given rise to overland flows during extended periods of wet weather in the past. The consequences of failure of the culverted and open

watercourses and also the sewer system are not fully understood. An overland flow model may be useful in this area.

  - Chaddesden Brook – lower part downstream of Nottingham Road. The watercourse appears to have ample capacity in this location however the risk and consequences of blockage by debris or vegetation needs to be understood as the overland flows may inundate a large number of residential properties.

- condition surveys of the Land Drainage assets within the City are being processed at the present time and also being retendered at the time of writing (early 2009). The work to update the condition surveys is planned for 2009/10.

17.3 Further modelling:

- Flooding flows from all sources including the failure of sewers, overland flows and watercourses. Certain areas of Derby require further analysis including Chellaston, Sunny Hill, Chaddesden & Oakwood, City Centre areas including the Markeaton Brook corridor & between Osmaston Road & the River Derwent.
- Flooding for a variety of return periods where an existing risk has been highlighted,
- The flow into and out of particular flood cells needs to be understood to define the precise mechanism and route for flooding. It is presently unclear how water spreads and moves within the flooding areas alongside the River Derwent and through other flood risk areas,
- The depth and velocity of flooding within the flood zones should be estimated to assess the hazard and damage potential.
- Breach and overtopping analyses for the existing flood defences and further survey work to establish the crest levels and condition of the defences.

17.4 Production of draft guidelines:

- A plan and schedule of vulnerable assets (communication, power distribution, traffic control, materials storage etc) needs to be prepared to assess the risk to these,
- The location of proposed emergency shelters needs to be checked for access and location outside flood zones,

- A plan of action to identify those at risk and provide guidance on flood protection,
- Guidance for Derby City Council planning authority on the sites for new infrastructure, residential & commercial developments,

17.5 Provision of a 'scope of works':

- Description of the options available and/or measures to be taken to reduce flood risk assist in particular areas. As reduction of risk in one area may increase it elsewhere, the drainage models need to be flexible enough to consider such 'what if' scenarios,
- Production of tools to assist with the cost/benefit analysis for flood defence or mitigation schemes,

18 Appendices

18.1 Appendix A: References

Publishing Authority	**Title**	**Date published**
Communities & Local Government	PPS 25 – Development & Flood Risk	March 2010 (amended version)
Communities & Local Government	Planning Policy Statement 25: Development & Flood Risk Practice Guide	December 2009 (amended) version)
DEFRA	Making Space for Water	March 2005
Institution of Civil Engineers	Learning to Live with Rivers	2001
Environment Agency	River Derwent at Derby Final Modelling Report	2006
Environment Agency	Cuttle Brook Flood Risk Mapping Final report	May 2006
Environment Agency	Hell Brook Flood Risk Mapping Final report	May 2006
Environment Agency	River Derwent Strategy Scoping Report	2007
Environment Agency	Report on Flood Defence Assets (Excel Spreadsheet)	2007
Environment Agency	Report on Flood Defences at Pride Park	Issued to Derby City Council Aug 2007
BBC Panorama	“Underwater Britain”	Broadcast 19th November 2000
Derby City Council	Derby Local Plan: 2006 revision	2006
BBC Panorama	“In Deep Water”	Broadcast 18th March 2001
Communities & Local	Pitt Review – Learning	June 2008

Government	Lessons from the 2007 Floods	

18.2 Appendix B: Modelling and Survey Information

The following information is held within Derby City Council and is available for inspection or reference as required:

Watercourse	**Survey**	**Flow Model**	**GIS information**
Markeaton & Mackworth brook	Yes – levels and cross sections. As built surveys for the flood defence weirs.	Yes (produced by Keeling Chambers 2003). Calculations&models for flood defences at Markeaton Park.	part
Amber brook	no	Windes model	Part
Bramble brook	yes	Windes model	part
Littleover brook	yes	Windes model	Part
Cotton brook	CCTV survey	Windes model	Part
Thulston brook	yes	Windes model	Part
Chaddesden & Lees	yes	Windes model	Part
Dam & Boosemoor	yes	Windes model	Part
Hell	yes	Windes model & EA ISIS model	Part
Cuttle	yes	Windes model & EA ISIS model	Part

18.3 Appendix C: Local contact Details for Adjacent Authorities.

Authority	**Contact Name & Details**
Amber Valley Borough Council PO Box 19 Town Hall, Market Place Ripley DE5 3QX	[redacted] [redacted]
Erewash Borough Council Merlin House Merlin Way Ilkeston DE7 4RA	[redacted] [redacted]
South Derbyshire District Council Civic Offices Civic Way Swadlincote DE11 0AH	[redacted] [redacted]
Derbyshire County Council Highway Maintenance County Offices Matlock DE4 3AG	South East Area Maintenance Manager [redacted]
Highways Agency Area 7 Amscott. The Willows Ransom Wood Business Park	[redacted]

Southwell Rd. Mansfield NG21 0HJ	[redacted]
Environment Agency Trentside Offices Scarrington Road West Bridgford Nottingham NG2 5FA	[redacted] on [redacted] [redacted]
Severn Trent Water Ltd. Asset Adoptions Great Central Road Mansfield NG18 2RJ	[redacted] k [redacted]

18.4 Appendix D: Flood risk maps for the city areas

The following categories have been used for the flooding risk areas:
DCC flood zone 2: the extreme event flood risk envelope with an annual average risk of occurance of between 0.1 % & 1%. The flooding outline represents a "low probability but severe consequence" event and is based upon projected data from the available modelling. Derby has not experienced any events within living memory of this severity therefore the modelling data does not have good quality observed data to calibrate the model from. In this respect the data should be used with a cautionary approach.
DCC flood zone 3a: high risk of flooding with an annual risk of flooding greater than 1%. As with DCC flooding category 2, Derby has not experienced a severe event of comparable magnitude within recent times, the last severe event being a 1.5% probability event in 1965 before many of the flood defences were constructed therefore the detailed flooding mechanisms have been approximated rather than based on observation.
DCC flood zone 3b: very high risk of flooding with an annual risk of flooding greater than 5%. These areas are often referred to as "functional flood plain" or "washland areas" as they tend to be inundated on a regular basis.

Notes on constructing the Derby City Council flood zone areas:
1. Within the river Derwent model area, the flood zones were drawn to suit the levels identified in the Black & Veatch River Derwent Modelling Report (sept 2006 issue) by following the appropriate contour (from the Lidar survey data). The flood zones do not take account of defences that exist.
2. Elsewhere within Derby, the flooding flow paths were drawn by making the broad assumption that overland flows from the brook courses would follow the approximate line of the brook course and would be between 50 & 100mm deep. No formal overland flow modelling has been performed at this stage therefore the zones are designed to provide an indication of flood risk along a watercourse rather than an absolute definition of the likely flood plain. Further detailed work on all the open and culverted brook courses is therefore required to "firm up" the flooding zones however this is outside the scope of the level 1 SFRA. A secondary concern within the level 1 SFRA has been to estimate the potential effect of a blockage or infrastructure failure in the smaller watercourses where a culvert collapse or accumulation of debris against a trash screen would tend to create a severe problem.

The DCC flood zone areas differ from the flooding risk zones published by the Environment Agency for the reasons stated below. .

Area	Location / Coordinate	Difference	Reason for the difference
Breadsall	Dam Brook between 437717, 339597 and 436501, 340036	DCC flood zone 3a shown. No EA FZ3 shown (FZ2 is shown)	Flooding risk from the Brooks through Breadsall. Zones based on the hydraulic model & contours. There is no overland flow model at present therefore

			an estimate has been used. The overland flows are likely to be in the order of 25-50mm deep however these may pool locally into a greater depth through gardens and properties where features (walls, fences, buildings etc) prevent overland flows from following the steepest route and cause an accumulation of water.
Darley Abbey	River Derwent right bank 435486, 338899	FZ3a on EA maps but not on DCC maps	Ground levels are above 0.5% average annual probability flooding level (49.7m) at Node DE061
Meteor Centre	River Derwent left bank 435888, 338563	FZ3a on DCC maps but not on EA maps	This area is separated from the River by the railway – possibly at *risk* of flooding – water may be transmitted throught culverts or sewers under the railway.
Chaddesden (Race Course Park)	River Derwent left bank 436352, 337708 to 436749, 336623	FZ3a is more extensive on DCC maps	Based on the depth of flooding in the LB3 (with spills) flood cell from the B&V River Derwent report (2006) and the existing contours supplied by the EA. There is some uncertainty here as the flood cell is large and would take several hours to fill to the level as proposed. The flooding route would appear to be via the Eastgate area of the City therefore future development here may inhibit the flow of water and reduce the volume within the flooding cell. Further work is required to understand the full nature of the flooding risk however this is outside the scope of the level 1 SFRA.
Pride Park	River Derwent right	FZ3a on EA maps	Ground levels are too high

(southern part)	bank 437424, 335007	but not on DCC SFRA plans	to flood based on the water levels at the nearest nodes on the River Derwent and the contour levels from the EA lidar data.
Alvaston	River Derwent right bank 437641, 334498 to 437847, 334,082	FZ3a on EA maps but not on DCC SFRA plans	Ground levels are above the water level of the 'with spills' model for the flood levels in the Alvaston DE044R flood cell. The nature of flooding here is important – a breach of the R Derwent defences rather than overtopping (assumed in the model) would conceivably cause more widespread and deeper flooding however the defences appear to be robust, include a tarmacadam footpath on the upper part are are considered to be at negligible risk of breaching.
Wyvern area – former landfill site	River Derwent left bank 437838, 335425	FZ3a on EA maps but not on DCC SFRA plans	The landfill site levels have, according to the site developer, been raised to lift the site out of FZ3a.
Areas around Celanese and Severn Trent Works	River Derwent left bank	FZ3a areas are more extensive on EA maps than DCC maps.	The areas shown on the DCC SFRA maps are based on the flooding water levels at various river nodes being lower than the existing ground levels shown on the lidar survey information.
Southern part of A5111 Raynesway	River Derwent right bank 438589, 333575	FZ3a on EA maps – not on DCC SFRA maps.	Levels of the road and adjacent houses is higher than the FZ3 levels from the R Derwent Model when extrapolated between flood cells.

Alvaston	The flooding route to access the residential area east of the A5111 and south of the Alvaston Bypass is unclear. The flooding model levels for the flood cells and river nodes indicates that the levels of the floodwater may be too low to cross the highways and that this area may be isolated from any flood risk. The area has nevertheless been shown within FZ2 & FZ3 until such time as the flood flow paths (or lack of) can be properly verified.		
Alvaston	River Derwent right bank 438911, 333664	FZ3a on EA maps – not on DCC SFRA maps.	Levels of the road and adjacent houses is higher than the FZ3 levels from the R Derwent Model when extrapolated between flood cells.
Alvaston	R Derwent right bank 439212, 333158	FZ3a on EA maps is more extensive than on the DCC SFRA maps.	Levels of the road and adjacent houses is higher than the FZ3 levels from the R Derwent Model when extrapolated between flood cells.
Chaddesden	Chaddesden Brook right bank. Locko Road 440158, 337387 to A52 (Brian Clough Way) 437642, 335951	EA & DCC maps differ.	EA flooding zones are offset from the brook course. The EA do not have modelling evidence to reinforce the flooding zones therefore the DCC flood category 3a is based upon a simple catchment model to estimate the flows in the brook course and channel capacity. The flooding zones have been produced based upon the lidar topographical information.
Allestree	Amber Brook 433666, 339606 to 433269, 338561	No EA maps for this brook course	This brook has been modelled by DCC but is not shown on the Environment Agency flood risk maps.
Markeaton Brook	From the western City boundary 432937, 337891 to Ford Street 434765, 336564	The DCC Flood category 3a areas are more extensive than the areas shown on the EA maps.	The DCC areas are based on the potential flood flows arising for a failure of the flood defence infrastructure at Markeaton park and the likely available flow paths for the floodwater. As these are through an urban area, the precise nature of the overland flow routing is

			unclear at the present time.
Bramble brook	Upstream areas from west of the A38 (432145 335432) to the trash screen at Cheviot Street playing field (433411, 336192)	Flooding category 3a on DCC maps but not on EA maps	The Environment Agency may not have data for this area. The DCC mapping is based on a hydraulic model for the brook course and also on the observed behaviour of the brook during heavy rainfall events. The flooding risk area immediately west of the A38 Kingsway Island has not been observed flooding and this is thought to be because the culverts under the A38 are choked with debris. This impedes the modelled flows passing to the downstream areas.
Bramble brook	Areas downstream of Uttoxeter Old Road (434035, 336135) to the confluence with the Central Surface Water Sewer at the junction of Wardwick and Curzon Street	The flood risk areas differ. The EA flooding areas are more extensive and cover the area between Great Northern Road and the former line of the railway.	The DCC maps assume that floodwater would not flow towards the north of Great Northern Road as the ground here appears to be higher that the flooding node point from the brook. This needs to be verified with a surface flow model – scheduled for 2010 as a part of the Bramble Brook flood risk reduction study.
Littleover Brook		Shown on DCC maps but not on EA maps.	This brook is not included within the EA flood maps. The DCC flood zones are based upon an estimate of the brook flows and the possible flow paths based on the flooding from various points along the brook course.
Hell Brook	Mickleover (431245, 334640) to A50 (431777, 330382)	DCC flood zones are more extensive than those shown on the EA maps.	The DCC study has considered the tributary watercourses and also the risk from the failure of surface water balancing areas and infrastructure based on the DCC hydraulic

			model. The DCC SFRA maps have included an area of FZ3b – functional flood plain on the area around Hall Pastures Farm (432401, 332100) as this has been indicated by the Hell Brook modelling study produced on behalf of the EA.
Cuttle Brook	Clemsons Park 432679, 333829 to Sinfin Moor/A50 (437460, 329544)	DCC flood zones are more extensive than those shown on the EA maps.	The DCC study has considered the tributary watercourses and also the risk from the failure of surface water balancing areas and infrastructure based on the DCC hydraulic model. The DCC SFRA maps have included an area of FZ3b – functional flood plain on Sinfin Moor as this has been indicated by the Cuttle Brook modelling study produced on behalf of the EA.
Thulston Brook	Shelton (437692, 331635) to Snelsmoor Lane (439849, 332007)	Not on EA maps	The DCC flood zones are based on a limited hydraulic model.
Cotton Brook	Normanton & Peartree areas	Not on EA maps.	Cotton Brook is a culverted watercourse with a number of combined sewer overflows. There is a risk of flooding both as a result of the capacity being exceeded and also from the failure of the infrastructure.

Table 2 – differences in Flood Zone 2 maps when compared to the Environment Agency plans. The EA model for the River Derwent makes reference to the difficulty of predicting the flows for a 1 in 1000 year event as there is a lack of data available to validate the model. This reservation also applies to the 0.1% flows for all the brook courses covered within the level 1 SFRA. The problem relates to the

extrapolation of the existing available data and being able to assess the effect of changing the variables in the model used to produce the estimate of flows.

Area	**Location / Coordinate**	**Difference**	**Reason for the difference**
Breadsall	Dam Brook between 437717, 339597 and 436501, 340036	DCC flood zone 2 is more extensive than EA maps	Flooding risk from the Brooks through Breadsall. Zones based on the estimated flows and contours. There is no overland flow model at present therefore a reasonable estimation has been used.
Darley Abbey	River Derwent right bank 435486, 338899	FZ2 on EA maps but not on DCC maps.	Ground levels are above 0.1% AAP flooding level (50.4m) at Node DE061
Chaddesden (Race Course Park)	River Derwent left bank 436352, 337708 to 436749, 336623	FZ2 is more extensive on DCC maps	Based on the depth of flooding in the LB3 (with spills) flood cell from the B&V River Derwent report (2006) and the existing contours supplied by the EA.
City centre	River Derwent right bank.	FZ2 more extensive on DCC maps than EA maps	DCC flooding areas are based on the estimated water levels at the DE051u & DE050u nodes upstream of the Exeter Bridge and Longbridge Weir respectively and the existing ground levels in the city centre.
Castleward Area	River Derwent right bank.	FZ2 more extensive on DCC maps than EA maps	DCC flooding areas are based on the estimated water levels at the DE049u node upstream of the Derby (Five Arches) rail bridge and the existing ground levels in the Castleward area.
Osmaston Rd	Russell Street area (436245, 334219)	FZ2 on EA maps but not on DCC maps	The ground levels are above the water levels in the adjacent flood cell.
Chaddesden	Chaddesden Brook right bank. Locko Road 440158, 337387 to A52	EA & DCC maps differ.	EA flooding zones are offset from the brook course. The behaviour of the flooding during extreme

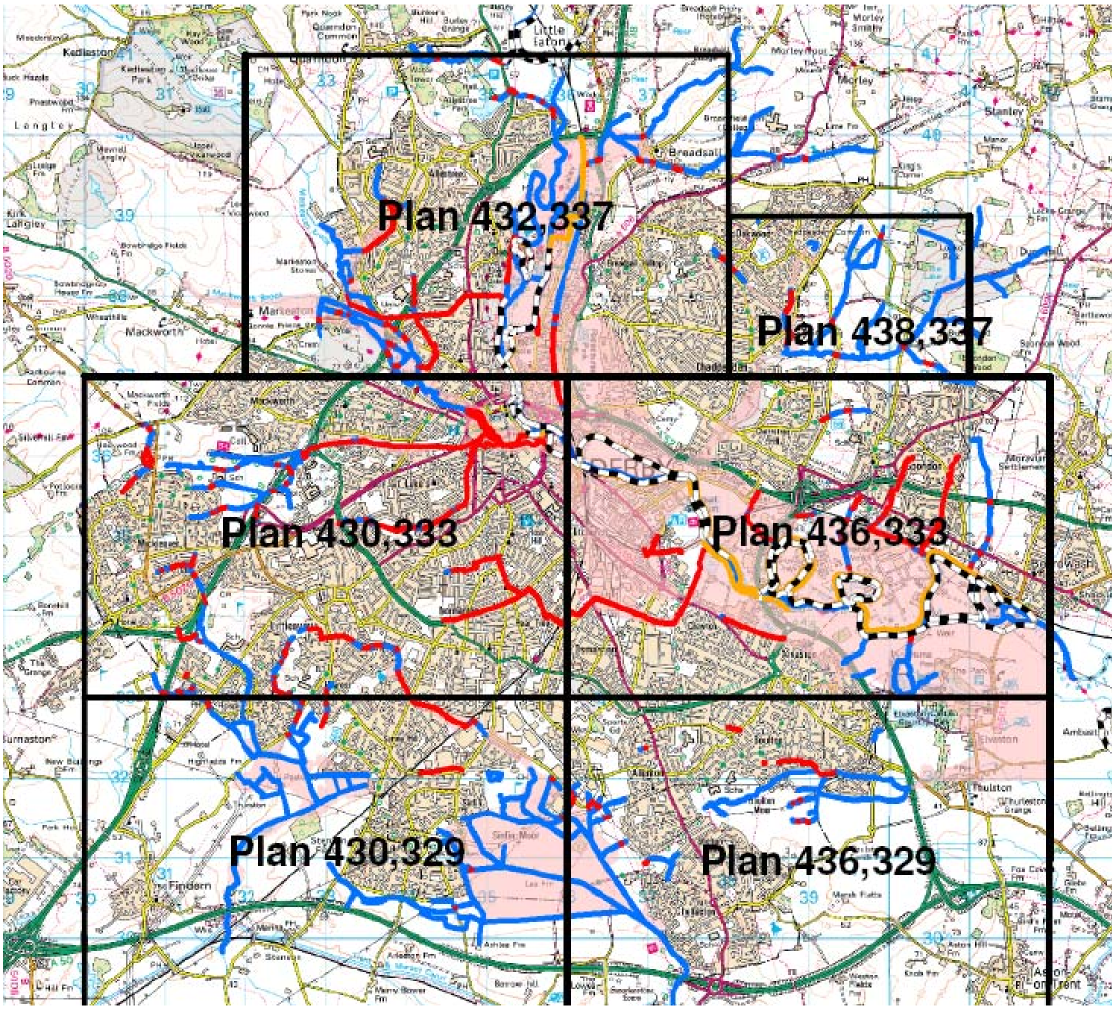
	(Brian Clough Way) 437642, 335951		events within the Oakwood area and within sewers and tributary watercourses is not fully understood. The extents of the DCC flooding zones are based upon the likelihood that the capacity of the watercourses will be exceeded and the overland flows are assumed to follow the route of the watercourse however this is uncertain pending further studies.
Allestree	Amber Brook 433666, 339606 to 433269, 338561	No EA maps for this brook course	This brook has been modelled by DCC but is not shown on the Environment Agency flood risk maps.
Markeaton Brook	From the western City boundary 432937, 337891 to Ford Street 434765, 336564	The DCC Flood Zone 2 areas are more extensive than the areas shown on the EA maps.	The DCC areas are based on the potential flood flows arising for a failure of the flood defence infrastructure at Markeaton park and the likely available flow paths for the floodwater.
Bramble brook	Upstream areas from west of the A38 (432145 335432) to the trash screen at Cheviot Street playing field (433411, 336192)	FZ2 on DCC maps but not on EA maps.	The Environment Agency may not have data for this area. The DCC mapping is based on a hydraulic model for the brook course and also on the observed behaviour of the brook during heavy rainfall events. The flooding risk area immediately west of the A38 Kingsway Island has not been observed flooding and this is thought to be because the culverts under the A38 are choked with debris and this prevents the modelled flows passing to the downstream areas.
Bramble brook	Areas downstream of Uttoxeter Old Road (434035, 336135) to the confluence with the	The flood risk areas differ. The EA flooding areas are more extensive and	The DCC maps assume that floodwater would not flow towards the north of Great Northern Road as the ground here is higher.

	Central Surface Water Sewer at the junction of Wardwick and Curzon Street	cover the area between Great Northern Road and the former line of the railway.	
Littleover Brook		Shown on DCC maps but not on EA maps.	This brook is not included within the EA flood maps. The DCC flood zones are based upon an estimate of the brook flows and the possible flow paths based on the flooding from various points along the brook course.
Hell Brook	Mickleover (431245, 334640) to A50 (431777, 330382)	DCC flood zones are slightly more extensive than those shown on the EA maps.	The DCC study has considered the tributary watercourses and also the risk from the failure of surface water balancing areas and infrastructure based on the DCC hydraulic model.
Cuttle Brook	Clemsons Park 432679, 333829 to Sinfin Moor/A50 (437460, 329544)	DCC flood zones are more extensive than those shown on the EA maps.	The DCC study has considered the tributary watercourses and also the risk from the failure of surface water balancing areas and infrastructure based on the DCC hydraulic model.
Thulston Brook	Shelton (437692, 331635) to Snelsmoor Lane (439849, 332007)	Not on EA maps	The DCC flood zones are based on a limited hydraulic model.

The 1:10000 scale flood risk maps are labelled with a 6-figure grid reference of the point near the lower left hand corner of the drawing. The drawing number is the same as the grid square reference. For instance if the OS grid coordinates are 430000, 329000 the drawing is referenced as 430329.

Note, that the plans should not be used at a more detailed or larger scale than 1:10000 due to limitations in the accuracy and precision of the underlying data.

The grid squares covered on the drawings are as follows:


Plan 432,337
Plan 438,337
Plan 430,333
Plan 436,333
Plan 430,329
Plan 436,329

18.5 Appendix E: River Derwent Flood defences and standards of protection (source Black & Veatch River Derwent final modelling report September 2006).

Left bank Defences	**Standard of protection (years) based on 2006 reference date – no allowance for climate change has been made.**
Nooneys Pond – GR 436167, 339971 to GR 436160, 339029 Earthbund defences/railway embankment	100
Chester park – GR 436160, 339029 to GR 435874,339074 Earthbund alongside Folly Brook	25
Chester park – GR 435874,339074 to GR 435755,338427Earthbund alongside Folly Brook north of Haslams Lane	100
Darley Mill - – GR 435379, 338699 to GR 435562,338507 – earthbund to the NE of the area	100
Darley Mill: Folly Road & Haslams Lane - GR 435562,338507 to GR 435397, 338,552 – earthbunds protecting properties along the road (constructed following 1965 floods)	50
Darley Mill: alongside Derwent GR435387, 338692 to GR435344, 338553 – masonry/concrete walls	75
Chester park – GR 435772, 338398 to GR 435713, 338206 Earthbund alongside Folly Brook south of Haslams Lane next to rugby pitches	50
Chester park – GR 435713, 338206 to GR 435312,337556 Earthbund along east side of Darley Playing Fields between rugby club & tennis courts	25
Chester park – GR 435312,337556 to GR	100

435229,337208. Derwent House & City Road – masonry & concrete walls & earth embankment alongside Parkers Piece field.	
Etruria Gardens - GR 435229,337208 to GR 435328,337028 – concrete wall.	100
South of Etruria Gardens to St Mary's Bridge – masonry & concrete walls	25
St Mary's Bridge to Exeter Bridge – GR 435328,337028 to GR 435481, 336433 masonry walls, bridge abutments & earthbunds	25
Exeter Bridge to Longbridge weir GR 435481, 336433 to GR 435662, 336377 - earth bund & masonry wall	25
Longbridge Weir to Meadow Lane GR 435662, 336377 to GR 435920, 336289 – masonry wall	75
Meadow Lane to Derby Junction (5-arches) rail bridge GR 435920, 336289 to GR 436134, 335950 – few defences present- masonry wall forming river bank.	25
South of Derby Junction – earthwalls	100 (generally)
Right bank Defences	**Standard of protection (years) based on 2006 reference date – no allowance for climate change has been made.**
Little Chester Footbridge to St Mary's Bridge GR 435208, 337159 to GR 435359, 336781– earthbund and masonry walls (recently strengthened in 2007)	50-75
St Mary's Bridge to Exeter Bridge GR 435359, 336781 to GR 435448, 336404 – earthbund, hard landscaping & low masonry wall/riverside walkway	25
Exeter Bridge to Bass' Recreation Ground GR 435448,	100

336404 to GR 435774, 336331– masonry/concrete walls	
Bass' Recreation Ground to Derby Junction (5-arches bridge) GR 435774, 336331 to GR 436149, 335899 - earthworks & general elevation of land & roadways	100
Derby Junction (5-arches bridge) to Sports Centre (David Lloyd) – GR 436149, 335899 to GR 436411, 335,795 earthbund/masonry revetment	25
Sports Centre to Wilmorton Rail Bridge GR 436411, 335,795 to GR437686, 334987- earthbund	75-100
Wilmorton Rail Bridge to Raynesway GR437686, 334987 to GR 438395, 334258 - earthbund	100
Raynesway downstream – earthbund	25-50