Bassetlaw District Council

Strategic Flood Risk Assessment

VOLUME THREE TECHNICAL SUMMARY

January 2010

FINAL REPORT

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CONTRACT

This report describes work commissioned by Bassetlaw District Council by order number 901008. Bassetlaw District Council's representative for the contract was Richard Schofield. Karen Shuttleworth, Francesca Hurt, Matthew Hemsworth, Richard Roebuck and Georgina Niciecki of JBA Consulting carried out the work.

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PURPOSE

This document has been prepared solely as a Strategic Flood Risk Assessment Report for Bassetlaw District Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by Bassetlaw District Council for the purposes for which it was originally commissioned and prepared.

ACKNOWLEDGMENTS

JBA would like to thank all those at Bassetlaw District Council, the Environment Agency, the Idle & Ryton IDB and British Waterways who provided information and data to support this project. Their assistance is gratefully acknowledged.

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EXECUTIVE SUMMARY

This report is a Strategic Flood Risk Assessment (SFRA) for Bassetlaw District Council. It is a Level 2 SFRA that incorporates the requirements of a scoping study SFRA (Level 1) and increased scope SFRA (Level 2). This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 *Development and Flood Risk* (PPS25).

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

A thorough review of existing information and the construction of new hydraulic models has identified the level of flood risk in the Bassetlaw area from fluvial (river flooding) and other sources.

In accordance with current guidance, the flood scenarios considered in the SFRA are typically the 1 in 20, 1 in 100 and 1 in 1000 year annual chance flood events, which may also be expressed as 5%, 1% and 0.1% Annual Exceedance Probability (AEP) flood events.

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

This report is Volume 3 of the SFRA Technical Summary.

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ABBREVIATIONS

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

GLOSSARY

Annual Exceedance Probability	e.g. 1% AEP	Refer to 'probability'.
Brownfield		Brownfield (sites or land) is a term in common usage that may be defined as 'development sites or land that has previously been developed'. Prior to PPS25, the term 'Brownfield' was used in Governmental Guidance and Statements, but in PPS25 has been replaced with 'Previously-developed land'. See 'Greenfield'.
Catchment Flood Management Plan	CFMP	A strategic planning tool through which the Environment Agency will seek to work with other key decision-makers within a river catchment to identify and agree policies for sustainable flood risk management.
Compensatory Storage		A floodplain (flood storage) area introduced to compensate for the loss of storage as a result of filling for development purposes.
Core Strategy	CS	This is the strategic vision of an area and is a central pillar of the Local Development Framework, comprising: A Vision, Strategic Objectives, a spatial land use strategy, core policies and a monitoring and implementation framework. The Core Strategy is a Development Plan Document which will determine overall patterns of future development, identifying broad locations where future growth will take place. All other Development Plan Documents should be in broad conformity with the Core Strategy Document The Core Strategy is a mandatory document, and a timetable for production is set out within the Local Development Scheme.
Defended Area		An area offered a degree of protection against flooding through the presence of a flood defence structure.
Development Plan Documents	DPDs	These documents have Development Plan Status and consequently form part of the statutory development plan for the area. A DPD will be subject to an independent examination. Typical documents that will have DPD status include the Core Strategy, Site-specific Allocations of Land, Proposals Map, and Area Actions Plans (where needed).
Exception Test		An integral part of the risk-based approach at the core of PPS25, the Exception Test is designed to allow for those exceptional circumstances when, for wider sustainability reasons, development not entirely compatible with the level of flood risk may be permitted. For the Exception Test to be passed, all three of its components must be fulfilled.
Flood Estimation Handbook	FEH	Provides current methodologies for estimation of flood flows for the UK.
Flood Hazard		A classification system developed by DEFRA/Environment Agency that gives an assessment of the hazard posed by a flood event at a given location. It is defined using the maximum modelled flood depth, velocity and a factor to allow

		for debris.
Floodplain		Any area of land over which water flows or is stored during a flood event or would flow but for the presence of defences.
Flood Risk Assessment	FRA	A detailed site-based investigation that is undertaken by the developer at planning application stage.
Flood Risk Management		The introduction of mitigation measures (or options) to reduce the risk posed to property and life as a result of flooding. It is not just the application of physical flood defence measures.
Flood Risk Vulnerability Classification		Refer to Section **Error! Reference source not found.**.
Flood Zone 1	FZ1	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
Flood Zone 2	FZ2	This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1%-0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year.
Flood Zone 3a	FZ3a	This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Flood Zone 3b	FZ3b	This zone comprises land where water has to flow or be stored in times of flood. This is land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood.
Fluvial Flooding		Flooding caused by the overtopping of river or stream banks.
Formal Defence		A flood defence asset that is maintained by the Environment Agency.
Freeboard		A ‘safety margin’ to account for residual uncertainties in water level prediction and/or structural performance, expressed in mm.
Functional Floodplain		An area of land where water has to flow or be stored in times of (fluvial) flooding.
Greenfield		Greenfield (sites or land) is a term in common usage that may be defined as ‘development sites or land that has not previously been developed’. Prior to PPS25 the term ‘Greenfield’ was used in Governmental Guidance and Statements, but in PPS25 has been replaced with ‘Undeveloped land’ See ‘Brownfield’.
Informal Defence		A structure that provides a flood defence function, however is not owned nor maintained by the Environment Agency.
Internal Drainage Board	IDB	An Internal Drainage Board is a statutory body that provides storm water management by operating and maintaining an artificial surface water drainage system.

ISIS		1-Dimensional hydraulic modelling software used to demonstrate flow within river channels
JFLOW		Proprietary 2-Dimensional hydraulic modelling software package developed by JBA, which demonstrates overland flow in floodplains
Local Development Framework	LDF	The Local Development Framework is made up of a series of documents that together will form part of the Development Plan. Broadly, Local Development Framework documents fall into two categories: - Development Plan Documents - Supplementary Planning Documents.
Local Development Scheme	LDS	A Local Development Scheme is a public statement of the Council programme for the preparation of Local Development Documents which will form the Local Development Framework.
Local Planning Authority	LPA	Local authority with responsibility for determining whether proposed developments are approved or otherwise.
Main River		A watercourse designated as such by DEFRA that is regulated and maintained by the Environment Agency using their permissive powers.
Measure		A deliverable solution that will assist in the effective management (reduction) of risk to property and life as a result of flooding, e.g. flood storage, raised defence, effective development control and preparedness, and flood warning.
Mitigation		The management (reduction) of flood risk.
Option		Refer to 'measure'.
PAG2		Project Appraisal Guidance (PAG) 2 (Strategic Planning) outlines the DEFRA requirements against which the Environment Agency must demonstrate that they are managing flood risk in a strategic (catchment wide) manner.
Probability	e.g. 1%	A measure of the chance that an event will occur. The probability of an event is typically defined as the relative frequency of occurrence of that event, out of all possible events. Probability can be expressed as a fraction, percentage or a decimal. For example, the probability of obtaining a six with the shake of a fair die is 1/6, 16% or 0.166. Probability is often expressed with reference to a time period, for example, annual exceedance probability. For example, a 1% AEP event is an event with a 1% chance of occurring or being exceeded in any one year.
Proposals Map		This is an Ordnance Survey based map that spatially illustrates policies and proposals within LDDs. The Proposals Map will show planning policy designations and land allocations identified within DPDs, statutory land use and landscape designations and other land and area based designations. It will form part of the statutory

		development plan.
Residual Risk		The risk that inherently remains after implementation of a flood mitigation measure (option).
Return Period	e.g. 1 in 100-Year	The expected (mean) time (usually in years) between the exceedance of a particular extreme threshold. Return period is traditionally used to express the frequency of occurrence of an event, although it is often misunderstood as being a probability of occurrence.
Risk		The threat to property and life as a result of flooding, expressed as a function of probability (that an event will occur) and consequence (as a result of the event occurring).
Sequential Flood Risk Test	SFRT	The assessment and 'categorisation' of flood risk on a catchment-wide basis in accordance with PPS25.
Site Specific Allocations Development Plan Document		A mandatory document, the Allocations Development Plan Document is a high priority item for preparation, details of which are provided in the Local Development Scheme. Prepared in conformity with the Core Strategy, once approved, the Allocations Document will identify sites for development as part of the delivery of the overall planning strategy for the area.
Standard of Protection	SoP	The return period to which properties are protected against flooding
Strategic Flood Risk Assessment	SFRA	The assessment of flood risk on a catchment-wide basis for proposed development in a District
Strategic Flood Risk Management	SFRM	Considers the management of flood risk on a catchment-wide basis, the primary objective being to ensure that the recommended flood risk management 'measures' are sustainable and cost effective
Supplementary Planning Documents	SPD	Supplementary Planning Documents, or SPD, support DPDs in that they may cover a range of issues, both thematic and site specific. Examples of SPDs may be design guidance or development briefs. SPDs may expand policy or provide further detail to policies in a DPD. They will not be subject to independent examination.
Sustainable Drainage Systems	SuDS	Current 'best practice' for new development that seeks to minimise the impact upon the localised drainage regime, e.g. through the use of pervious areas within a development to reduce the quantity of runoff from the development.
TUFLOW		2-Dimensional hydraulic modelling software package with links to ISIS, which demonstrates overland flow in floodplains
Uncertainty		A reflection of the (lack of) accuracy or confidence that is considered attributable to a predicted water level or (modelled) flood extent.
Washlands		Areas which are not susceptible to flooding in a 20 year flood event and hence not classified as Flood Zone 3b, but are considered of vital importance as floodplains and should therefore be treated as functional floodplain

Windfall Sites	Sites that become available for development unexpectedly and are not included in a planning authority's development plan as allocated land.

1 INTRODUCTION

1.1 Background

In September 2008 JBA Consulting was commissioned by Bassetlaw District Council (BDC), to undertake a Strategic Flood Risk Assessment for Bassetlaw District, which includes the towns of Worksop and Retford and smaller villages.

This SFRA has been prepared in accordance with current best practice, Planning Policy Statement 25 *Development and Flood Risk* (PPS25)[1]. The SFRA is in four volumes and this report is volume 3 Technical Summary. The study area is shown in Figure 1-1.

Figure 1-1: Study Area

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2 EXISTING FLOOD RISK DATA

2.1 Data Collection

The table below lists the data that was made available/obtained for the Bassetlaw SFRA. This data comprises known or perceived flood risk issues within the district, development pressures and constraints and current policy governing development within flood risk affected areas. The majority of this data has been recorded and included in the GIS data layers used to undertake the assessment.

Table 2-1: Data availability for use in the Bassetlaw SFRA

Data Type	Use within SFRA
OS 10k Basemap	Flood Risk Mapping
Flood Zone Map	Initial Flood Zone delineation
Main river map	Flood Risk Mapping
National Flood and Coastal Defence Database (NFCDD) data	Demonstrate defended and undefended areas
LiDAR Digital Elevation Model	Flood Risk Mapping
NEXTMap Digital Elevation Model	Flood Risk Mapping, where LiDAR coverage insufficient
River Ryton hydraulic model	Flood Risk Mapping
River Idle hydraulic model	Flood Risk Mapping
Tidal Trent hydraulic model	Flood Risk Mapping
Catchment Flood Management Plan	Background information
Internal Drainage Board maps	Background information, flood risk
British Waterways Maps	Background information, flood risk
BDC Engineers maps and reports	Background information, flood risk

2.2 Existing Flood Risk Studies

2.2.1 River Idle Flood Risk Mapping Study (March 2005)

This study was carried out by JBA Consulting for the Environment Agency. It is the only comprehensive modelling exercise on the River Idle post completion of several phases of flood alleviation works from the 1970's onwards. The River Idle model commences at the confluence with the Rivers Maun and Poulter, south of Retford, and ends at the outfall with the River Trent at West Stockwith pumping station.

Information is available in this study for a range of return periods, producing defended flood outlines up to the 1 in 200 year flood event. Information was not available for a 100 year climate change scenario or 1000 year scenario.

Flood alleviation on the River Idle consists of a number of designated washland areas, previous regrading of the River Idle channel and construction of flood embankments. As part of the River Idle Study a breach analysis was carried out using JFLOW software to establish the impact upon the villages of Misson and Mattersey.

2.2.2 Tidal Trent Strategy (July 2005)

This study was undertaken by Black & Veatch Consulting Ltd for the Environment Agency. It builds upon existing flooding information available for the tidal stretch of the River Trent from Cromwell Lock to Trent Falls. The study establishes the extent of the 1 in 100 year floodplain of the River Trent and the condition and standard of flood defences. The report identifies the area likely to be at risk of flooding if the defences failed, however this has been produced using 1-dimensional software and is therefore only a broadscale indication.

This study does not, unfortunately, contain any climate change flood maps or associated flood levels.

2.2.3 Retford Beck

The Environment Agency has recently completed a Preliminary Strategic Review (PSR) of the Retford Beck, which investigated flood alleviation options. It is possible that the findings of the PSR will be taken forward by the Environment Agency's National Capital Programme Management Service (NCPMS) as part of a Feasibility Study looking at the environmental, economic and social impacts of a flood alleviation scheme.

2.2.4 River Ryton Flood Risk Mapping Study (March 2008)

This study was undertaken by JBA Consulting for the Environment Agency. It provides flood mapping for a range of return periods, including climate change outlines, for the River Ryton from Worksop Road in Lindrick to the confluence with the River Idle near Bawtry. The River Ryton study also includes modelling of Oldcotes Dyke.

The River Ryton study established that flooding to Worksop Town Centre begins at about a 1 in 50 year flood event and that there are only limited sections of formal flood defences along the River Ryton immediately upstream of its confluence with the River Idle.

2.3 Flood Defence Data

An extract from the Environment Agency's National Flood and Coastal Defence Database (NFCDD) has been supplied and provides information about existing defences in the area, as well as categorising them by type and providing information on who owns and maintains them. The NFCDD information did not include details of the current condition of the defences.

The type of flood defences and the levels of protection offered vary. In addition to the defences listed, other features exist, both natural and man made which have the potential to contain or divert flood flows and hence provide an informal defence function.

Flood defences along the River Idle and River Ryton are made up of both formal (i.e. maintained) and informal (i.e. not maintained). The River Trent defences in Bassetlaw are maintained by the Environment Agency.

Table 2-2: NFCDD Flood Defence Information for Rivers Ryton and Idle

River Ryton – Formal Defences maintained by the Environment Agency

Grid Reference	Description
SK 65786 92073	Flood Bank (Idle confluence)
SK 58538 79101	Flood Wall
SK 65730 92140	Flood Bank (Idle confluence)

SK 58543 79088	Flood Wall (Ryton Street)
SK 58522 79077	Flood Wall (Ryton Road)
SK 58324 79076	Flood Wall (Central Avenue)
SK 58644 79137	Flood Wall (Watson Road)
SK 58290 79087	Ramp
SK 58363 79081	Flood Wall (Central Avenue)
SK 58580 79130	Flood Wall (Watson Road)
SK 58349 79083	Flood Wall (Cricket Club)

River Ryton – Informal Defences not maintained by the Environment Agency

Grid Reference	Description
SK 55135 81324	Railway viaduct (Shireoaks)
SK 59593 78980	High Hoe Road bridge (Bracebridge)
SK 59020 79030	Priorswell Road bridge
SK 58595 79133	Road bridge wall (Watson Road)
SK 57354 79421	A57 Road Bridge
SK 55534 80621	Spring Lane Bridge (Shireoaks)
SK 56003 79657	Steetley Lane Railway Bridge
SK 55301 80894	Thorpe Lane Bridge (Shireoaks)

River Idle – Formal Defences maintained by the Environment Agency

Grid Reference	Description
SK 71750 95660	Flood Bank
SK 68654 93571	Flood Bank
SK 67350 94830	Flood Bank (Northwith Hill)
SK 65386 92747	Flood Bank (Newington to Bawtry)
SK 78990 94708	Flood Wall and Sluice
SK 78953 94760	Flood Gate (West Stockwith)
SK 78676 94985	Flood Bank (Upstream of West Stockwith pumping station)
SK 76499 96128	Flood Bank (Upstream of Haxey Bridge)
SK 73631 96617	Flood Bank
SK 70556 79629	Flood wall along Hollows street (Ordsall)
SK 70946 77982	Flood Bank (Eaton)
SK 66422 93520	Flood Bank
SK 65840 92600	Flood Bank (Bawtry)
SK 78760 94970	Flood Wall and Sluice (West Stockwith)
SK 78730 94930	Flood Bank (West Stockwith)
SK 78699 95029	Flood Bank (Upstream of West Stockwith pumping station)
SK 77463 95509	Flood Bank (Downstream from Haxey Gate road bridge)
SK 76498 96234	Flood Bank (Haxey Gate Inn)

SK 78976 94738	Flood Wall and Sluice
SK 78967 94764	Flood Wall
SK7896194726	Flood Wall (West Stockwith)
SK7895094810	Flood Bank (West Stockwith)
SK7872294988	Flood Wall (West Stockwith)
SK7870694966	Sluice Gate (West Stockwith)
SK7893094789	Flood Wall (West Stockwith)
SK7870095010	Flood Wall (West Stockwith pumping station)
SK7781095232	Flood Bank
SK7868794988	Flood Wall (West Stockwith pumping station)
SK6985090070	Flood Bank (Downstream of Wiseton pumping station)
SK7091289234	Flood Bank (Upstream of Wiseton pumping station)
SK7110389350	Flood Bank (Upstream of Wiseton pumping station)
SK7138085680	Flood Bank
SK6580092080	Flood Bank (Upstream of River Ryton confluence)
SK6733393615	Flood Bank
SK6642093510	Flood Bank
SK6538892716	Flood Bank
SK6560992628	Flood Bank
SK6898089516	Flood Bank (Mattersey)
SK7041089480	Flood Bank (Abbey farm, Mattersey)
SK6899189533	Flood Bank (Mattersey)
SK7778595221	Flood Bank
SK7749495358	Flood Bank (Downstream of Haxey Gate Road Bridge)
SK7649496273	Flood Bank (Haxey Gate Inn)
SK7652596193	Flood Bank (Upstream of Haxey Gate Road Bridge)
SK7164296033	Flood Bank
SK7164096030	Flood Bank
SK6906594397	Flood Bank
SK6716293940	Flood Bank (Newington)
SK7037084320	Flood Wall
SK7082076340	Flood Bank (Gamston)
SK7897194769	Flood Bank (West Stockwith)
SK7201096573	Flood Bank
SK7057380242	Flood Bank (between railway crossings)
SK7419596635	Flood Bank
SK7168495668	Flood Bank
SK6741593649	Flood Bank (Newington)
SK6906494650	Flood Bank (Misson)
SK5947684510	Flood Wall (Jerusalem farm to Greenway)
SK5964884585	Flood Wall (Opposite Sewage pumping station)

River Idle – Informal Defences not maintained by the Environment Agency

Grid Reference	Description
SK7749495455	Railway Bridge
SK7654396203	Haxey Gate Road Bridge
SK7038281309	Bridgegate Road Bridge
SK7096178002	Eaton Road Bridge
SK6558092670	Mattersey Road Bridge
SK7749195496	Misteron Soss Railway Bridge
SK7031080660	Albert Road Bridge
SK6896589523	Mattersey Road Bridge - Left Abutment
SK7654096185	Haxey Gate Road Bridge
SK7028580669	Masonry Wall (Albert road)
SK7029180657	Albert Road Bridge
SK7054280364	Masonry Wall (South Retford)
SK7049881430	Amcott Road Bridge
SK7055479611	Ordsall Road Bridge
SK7083876342	Gamston Road Bridge

NFCDD data also includes defences alongside the River Trent within Bassetlaw. The NFCDD data includes defences along the full length of the River Trent within Bassetlaw and the extent of these defences is shown in Figure 2-1.

Figure 2-1: NFCDD EA maintained defences on the River Trent within Bassetlaw

Areas Benefiting from Defences (ABDs) are defined as those areas which benefit from formal flood defences in the event of flooding from rivers with a 1 in 100 year chance in any given year. Villages alongside the River Trent benefit from the protection of defences.

The River Trent CFMP outlines future policy for flood defences within the Bassetlaw district. This is detailed volume 1.

2.4 Hydraulic Modelling

A summary of hydraulic models used and what they have been used for is shown below:

2.4.1 River Idle Flood Risk Mapping Study (March 2005)

This study was carried out by JBA for the Environment Agency and has been used within the SFRA. The 25 year outlines generated from this river model have been used as functional floodplain for the purposes of the SFRA. The 100 year defended outline has been used within the District and further 1 dimensional modelling undertaken to generate the 100 year with climate change defended outline and the 1000 year defended outline. The model was also used as the starting point for the 2d TUFLOW modelling conducted as part of this SFRA, which produced more accurate 1 in 100 year flood outlines and 1 in 100 year flood outlines with climate change within Retford.

As part of the River Idle Study a breach analysis was carried out using JFLOW software to establish the impact upon the villages of Misson and Mattersey and this information is included in the report.

2.4.2 Tidal Trent Strategy (July 2005)

This study was undertaken by Black & Veatch Consulting Ltd for the Environment Agency. The Trent river model was used as the starting point for the 2 dimensional JFLOW modelling conducted as part of this SFRA, which produced indicative flood outlines during overtopping and breach of the Trent defences.

2.4.3 River Ryton Flood Risk Mapping Study (March 2008)

This study was undertaken by Jeremy Benn Associates Ltd for the Environment Agency and has been used within the SFRA. The 20 year outlines generated from this river model have been used as functional floodplain for the purposes of the SFRA. The 100 year, 100 year plus climate change and 1000 year defended outlines have been used across the district. The model was used as the starting point for the 2d TUFLOW modelling conducted as part of this SFRA, which produced more accurate 1 in 100 year flood outlines and 1 in 100 year flood outlines with climate change within Worksop.

2.5 Topographical Data

The essential dataset required for flood modelling and mapping is a ground model or Digital Elevation Model (DEM). The main source of DEM data for Bassetlaw is LiDAR (Light Detection and Ranging) data, however there were locations adjacent to the Trent where this was not available and therefore NEXTMap was also used in these locations, as shown in Table 2-3.

Table 2-3: DEM Availability

Data type	Owner	Resolution	Filtering	Coverage of Bassetlaw
NEXTMap SAR	JBA	5m	Filtered	100%
LiDAR	Environment Agency	2m	Filtered and unfiltered	60%

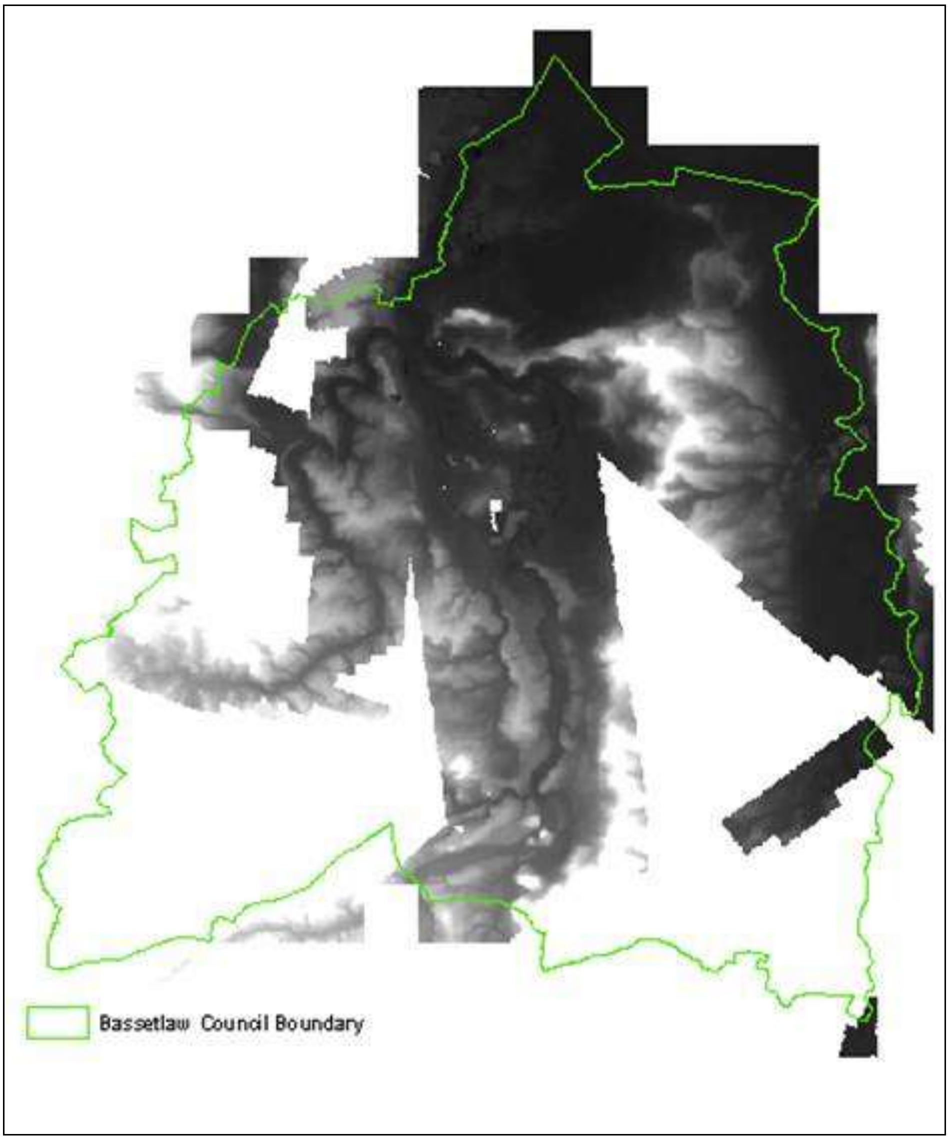
LiDAR data is used in preference to the NEXTMap data as it has a higher vertical accuracy. Both LiDAR and NEXTMap are more accurate on flat ground the degree of accuracy decreases substantially for vegetated and built areas. Inaccuracies are reduced by a process of filtering.

Filtered LiDAR data was provided by the Environment Agency and trimmed to remove land outside the Bassetlaw boundary that was not required for this study.

The null values (holes in the LiDAR or areas of no data) were filled using data interpolation. The LiDAR survey records the top of bridges and embankments. In some areas, it was necessary to "puncture" lower levels through high ground, where there was known to be a possible flow route underneath. The introduction of flow routes through higher ground was based on site visits and consultation with the EA and BDC.

The current coverage of LiDAR data in Bassetlaw is shown in Figure 2-2. The LiDAR is shown in grey, with the lower land being a darker shade of grey and the higher land being a lighter shade.

Figure 2-2: LiDAR Digital Elevation Model - Coverage for Bassetlaw

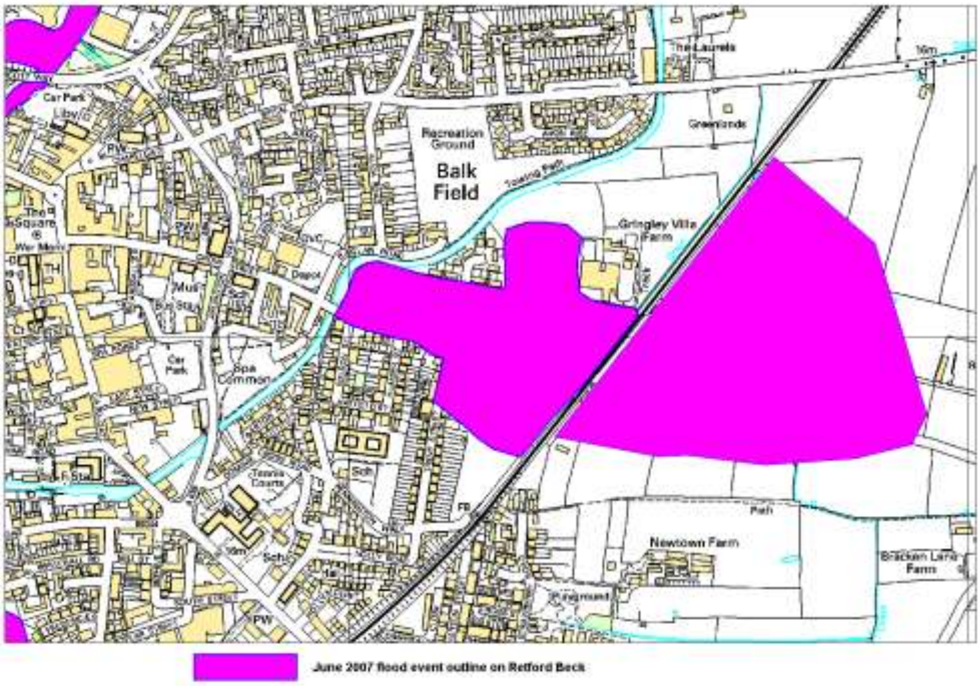


2.6 History of Flooding

Recorded historical flood events in Bassetlaw from rivers are spread throughout the majority of the year, although there is a significant number that have occurred during the months of July to September. Severe floods have affected parts of Bassetlaw in 1922, 1932, 1958, 1964 and 2007; however, information on these events is sparse except for the recent June 2007 event.

The River Ryton flooded in June 2007, overwhelming the existing flood alleviation measures and damaging 273 properties in Worksop, of which 130 properties were residential, while the River Idle broke its banks in a few locations within Retford and Ordsall. Flooding of Retford Beck also impacted upon a number of properties.

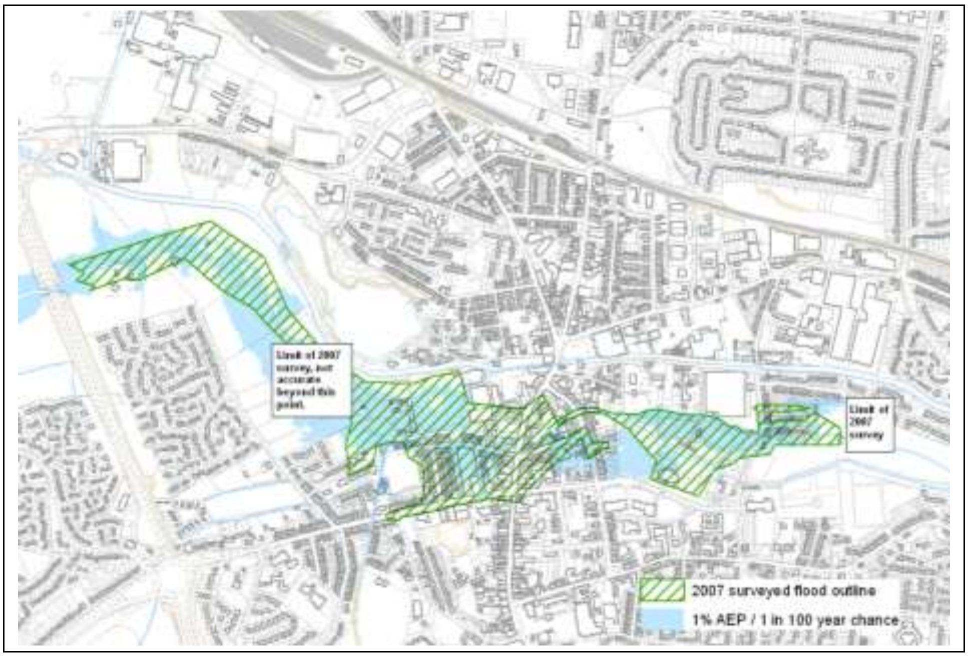
Figure 2-3: Retford Beck June 2007 Flood Outline



There are many uncertainties in the estimated flow of the 2007 flood event and therefore pinpointing a return period on the flood is difficult. Estimates in other reports have varied from a 1 in 150 year annual chance flood to somewhere between a 1 in 100 to a 1 in 300 year annual chance flood.

BDC Engineers and the EA provided surveyed flood outlines of the 2007 flood. These were compared with the modelled flood outlines. An example is shown in Figure 2-4 and the full drawings for Worksop and Retford are included in Volume 4.

Figure 2-4: Worksop surveyed and modelled flood outlines



BDC Engineers and the Rivers Idle & Ryton IDB also provided information on flooding issues relating to smaller drains and from sewers and these are annotated on the maps contained within the SFRA.

The surveyed flood outlines were used to corroborate or highlight inconsistencies in the modelled outlines, which would be expected to remain either entirely inside or entirely outside the surveyed flood outlines. Where inconsistencies were found checks were carried out on the accuracy of the survey and modelling and adjustments made where necessary.

Severn Trent Water (STW) provided a register of recorded flooding from sewers within Bassetlaw and this has been used to prepare the All Sources Flood Risk maps. The STW register is a live document, updated should further flood incidents be recorded, and was correct at December 2008.

2.7 Limitations of Background Information

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

The Environment Agency's Flood Zone maps are based on generalised river modelling only and are limited by way of not including all minor watercourse floodplains or the effects of any defences. The Flood Zone maps are produced from a national mapping project and provide flood zone mapping from the points where river catchments reach an area of $3km^2$. Therefore, for any site (including those below 1ha) adjacent to an unmapped watercourse, a site-specific FRA will be required to establish the true floodplain extent and flood risk to the development site.

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

Limitations of the existing river modelling studies used in the report should be acknowledged due to the nature of flood risk mapping, estimation of catchments and hydrology. Watercourse surveys, changes since the studies, new developments, additional structures and constraints, seasonal variations in the roughness of watercourse channels due to growth of vegetation and maintenance of the channel will all have an effect on the flood risk. The outlines for the River Ryton and Idle have been taken directly from existing river model studies. With the exception of the Retford Beck, where a new river model was built specifically for this SFRA, existing river modelling studies formed the starting point for all 2d modelling carried out as part of the level 2 assessment of flood risk

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

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3 LEVEL 2 ASSESSMENT OF FLOOD RISK

3.1 Introduction

The purpose of the modelling of breaches and overtopping is to show the likely degree of flood hazard (in terms of flood depths, velocity and Flood Hazard Rating) within the Flood Zone areas and for planning purposes to derive a delineation of residual risk that can be used by BDC and developers.

For the Bassetlaw SFRA, JBA has carried out detailed hydraulic modelling to identify the residual risk using existing and new ISIS models, and new 2d TUFLOW 2d models.

An appraisal of the effect of any failure of flood defences, whether formal defences maintained by the EA or informal defences, in order to establish areas of residual risk, rapid inundation and low-lying areas. Within Worksop and Retford, new maps have been produced based on 2d modelling carried out for this SFRA. New maps have also been produced to create breach outlines for the River Trent based on 2d JFLOW modelling carried out for this SFRA and the potential impact of the River Trent CFMP on the District has also been considered. For other areas within Bassetlaw, existing breach mapping has been utilised where available, including the River Idle from the River Idle Study.

3.2 Flood outlines for Retford Beck

Background

Retford Beck is located to the East of Retford and has a catchment area of approximately 6km^2. The upstream area of the catchment is dominated by arable agriculture, whilst the downstream area of the catchment is heavily urbanised.

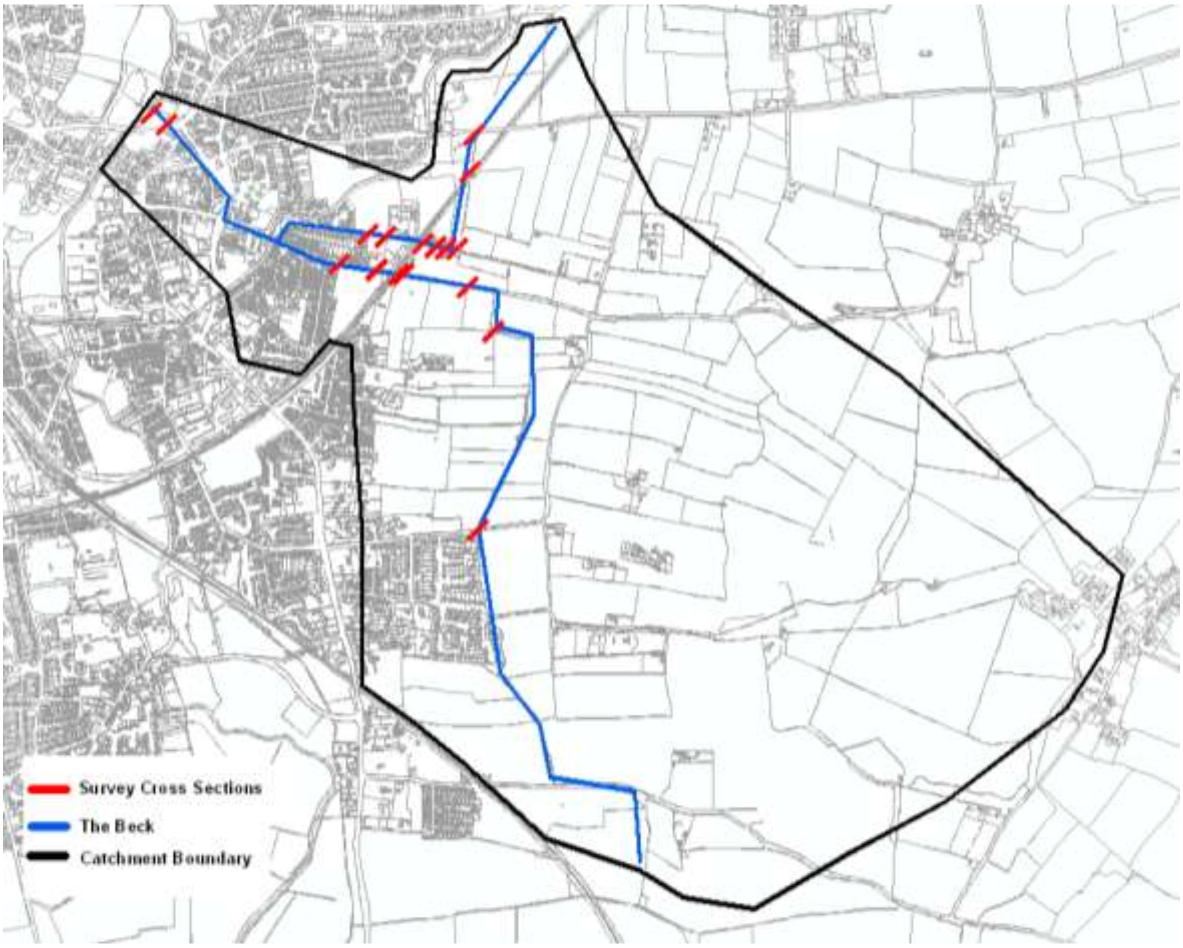
The beck consists of two arms, one to the north and one to the south, both arms are fed by several land drains.

The catchment area to the east of the railway has historically being noted as marshland despite the construction of several drainage ditches.

To the west of the railway the beck is heavily culverted. Culverts are long and the water course is confined in most instances. The culvert beneath Trent Street is known to be under sized and has resulted in the Environment Agency pumping water over land to bypass the constriction. Flows are also restricted to passing through two culverted sections passing beneath the railway embankment, this restriction retains flows on the eastern side of the railway.

The beck meets with the River Idle at 470526, 381524. The catchment boundary and Retford Beck can be seen on Figure 3-1.

Figure 3-1: Retford Beck catchment and cross section locations



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Data collection

(i) Survey

A topographical survey of Retford Beck was commissioned for hydraulic modelling purposes. The survey included cross sections of the watercourse and all major structures, including culverts and bridges. The survey cross sections can be seen in Figure 3-1.

(ii) LiDAR

Floodplain topographic information covering the Retford Beck catchment was obtained from the Environment Agency in the form of a number of ASCII files of LiDAR ('Light Detection and Ranging') data.

Hydrology

Due to the small size of the Retford Beck catchment and the difficulty in finding a donor catchment (a similar catchment elsewhere with quality data available) the use of the Flood Estimation Handbook (FEH) was not possible. The IH124 (Flood estimation for small catchments) method was used. This method is suitable for estimating peak flows of catchments <25km^2.

Modelling approach

A 1D river model was first constructed in ISIS. This provided the data required for a 2D model, which simulates the overland route of any flood water overtopping the watercourse banks. JBA's 2D flood routing software JFLOW was used to model the effects of flooding from the Retford Beck.

(i) Manning's Roughness Value

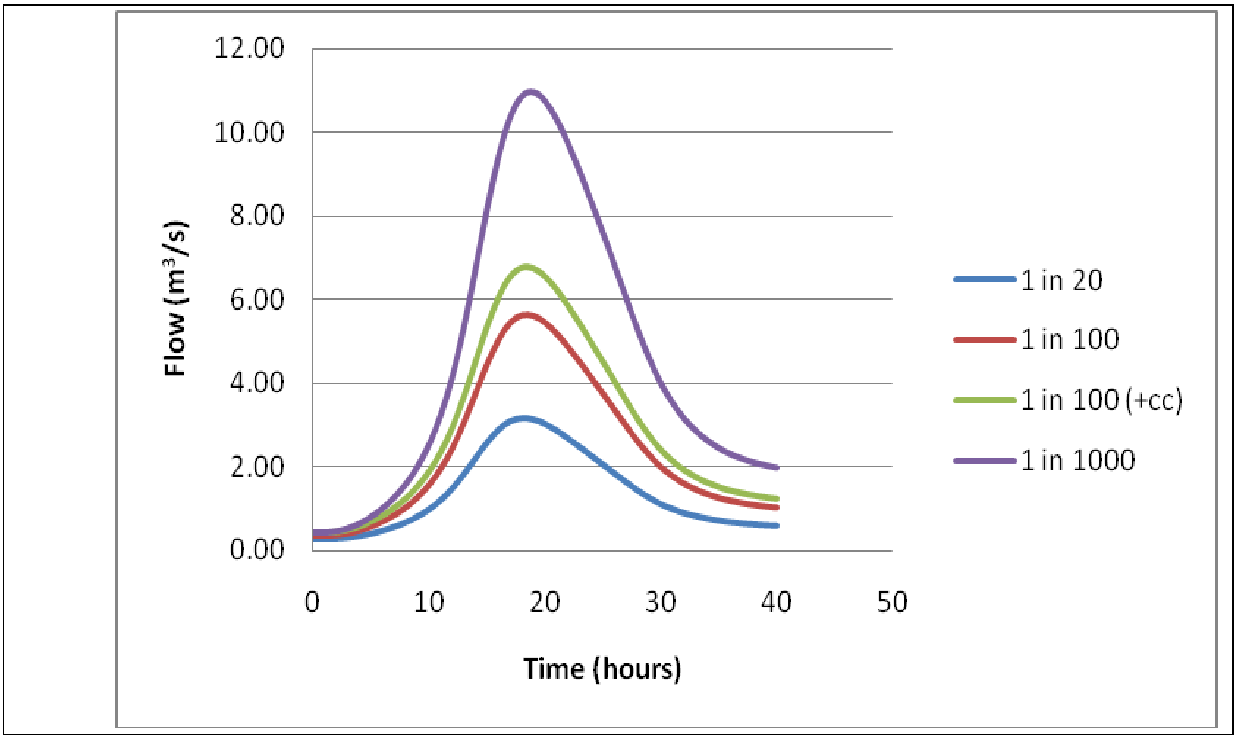
The Environment Agency specification for flood mapping suggests that flood levels should be predicted using a model representing the typical condition. The manning's roughness value used for Retford Beck was 0.06 which represents a vegetated channel and flood plain.

(ii) 1D modelling

A 1D model was built to model flows in the Retford Beck, using the topographical survey data and the catchment flows calculated using the IH124 method. Two inflow points were used; one for Retford Beck and one for a small drain which feeds into Retford Beck. The model uses the 1D ISIS modelling software and covers the extent of Retford Beck.

The model was run for 20 year, 100 year, 100 year with climate change and 1000 year annual chance flows. It was found that the culvert beneath Trent Street on the southern arm of the beck was too small to convey peak flows in all the flood events modelled. Flood water backed up in the channel and spilled out of bank. A theoretical spillway into a reservoir unit was added to the ISIS model to allow for any flows not able to pass through the culvert. A flow hydrograph over this spill unit was extracted for each return period. This is representative of out of bank flood flow. The flow hydrographs can be seen in Figure 3-2.

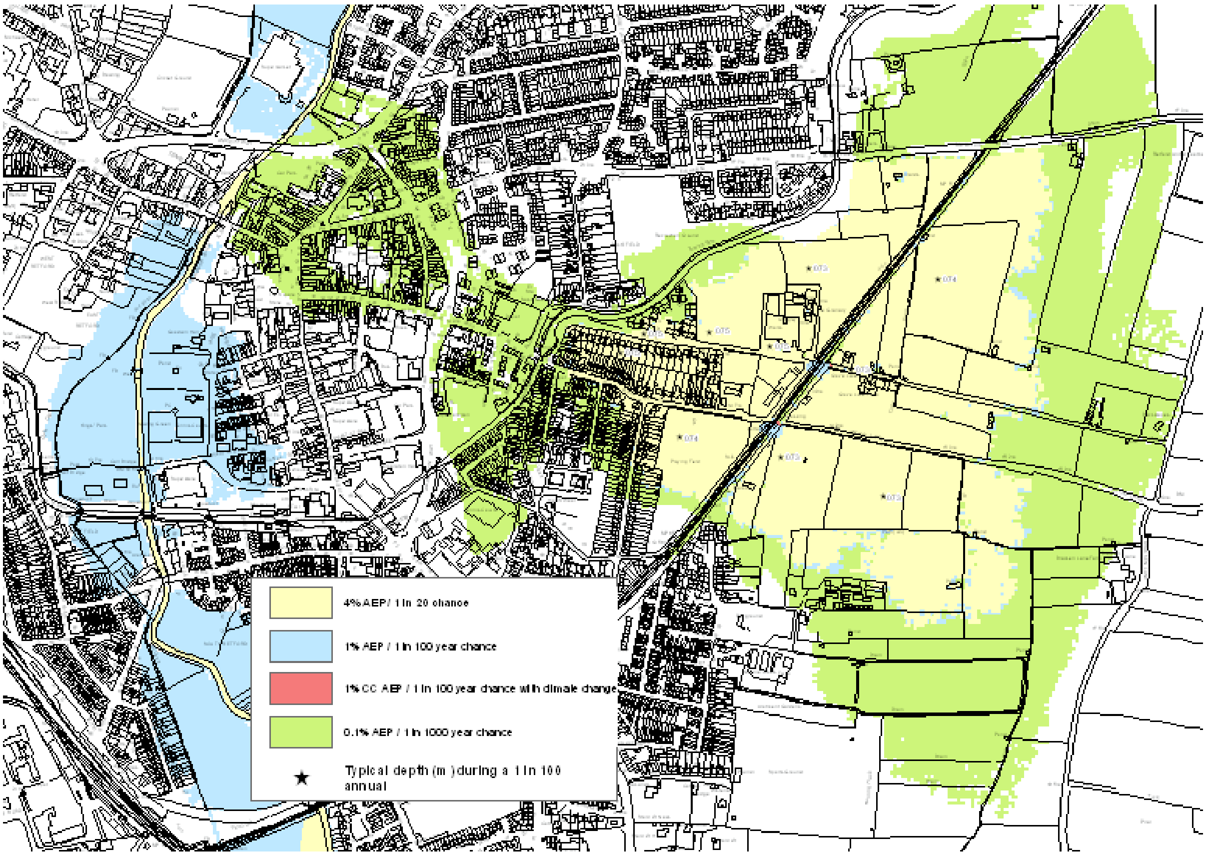
Figure 3-2: Retford Beck Flow Hydrographs



(iii) 2D modelling - JFLOW

In order to determine the true nature of flooding in the Retford Beck catchment 2D JFLOW flood routing software was used to model the 20 year, 100 year, 100 year with climate change and 1000 year annual chance floods. Flow hydrographs extracted from the ISIS model reservoir spill were put into JFLOW, giving the indicative flood outlines below. The extent of flooding is shown to be similar in a 1 in 20 year and a 1 in 100 year annual chance flood, however the depth of flooding would be greater in a 100 year flood (Figure 3-3).

Figure 3-3: Retford Beck JFLOW model results



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Flood Dynamic Maps

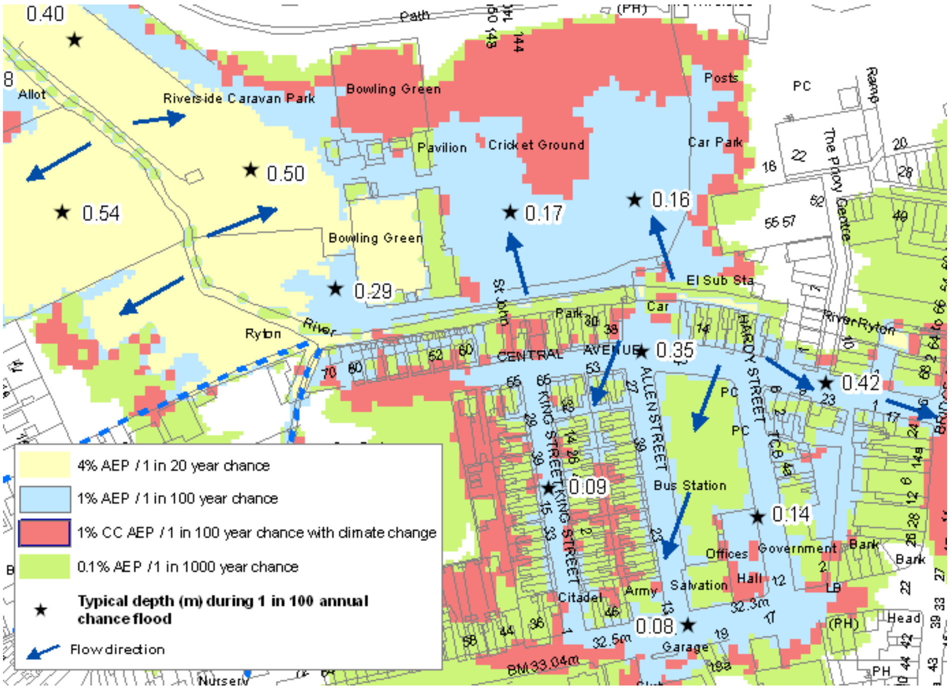
Flood Dynamic Plans have been produced identifying extent, depth and sequence of flooding for various scenarios at the key planning benchmarks (1 in 20, 1 in 100, 1 in 100 plus climate change and 1 in 1000). This detailed appraisal has been limited to Worksop and Retford where there is likely to be the greatest development pressure. These draw upon existing flooding information and will be developed iteratively based upon continued feedback from target users.

Physical features have been appraised, either natural or man made, which may convey or divert flood flow to other areas not considered to be directly at risk from the cause or origin of the flooding. This includes consideration of the ability of the Chesterfield Canal to convey flood flows and the potential impact of this on sites alongside the Canal though Worksop. TUFLOW 2d modelling was utilised in order to fulfil this task and the findings informed preparation of the Flood Dynamic Plans.

Reference to historic incidences of flooding is included and the circumstances that gave rise to them. Information has been sought from BDC Drainage Department, the Environment Agency, British Waterways and the Rivers Idle & Ryton Internal Drainage Board.

An example is shown in Figure 3-4 and the full Flood Dynamic Maps for Worksop and Retford can be found in Volume 4.

Figure 3-4: Worksop Flood Dynamic Map Extract



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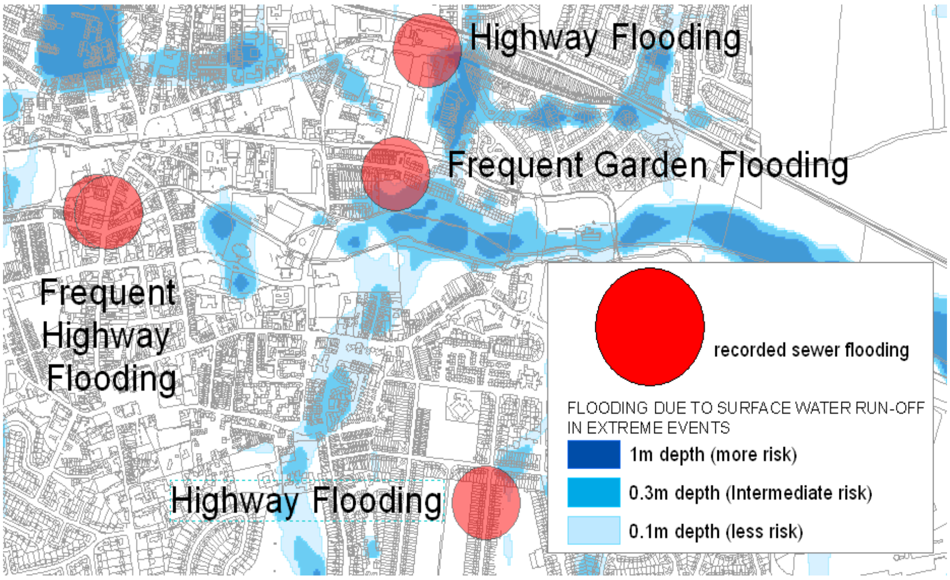
All Sources Flood Risk Maps

In addition to fluvial flood risk from the Rivers, other sources of flooding including the Chesterfield Canal, groundwater, overland flow and surface water drainage also need to be considered when planning future development. Consideration of these sources of flooding is not included in Flood Zone allocation. Local drainage issues have the potential to cause substantial damage and distress. When considering development proposals, known drainage and surface water problems need to be taken into account.

Sewer flooding records were made available for use in this SFRA. The All Sources Flood Risk Maps in volume 4 show the areas which have historically suffered sewer flooding problems. This highlights the need for further investigation only and is not intended to preclude development. It is possible that works may have been carried out to resolve sewer flooding issues. These maps also show areas which could be susceptible to flooding from surface water run-off during extreme rainfall events, when sewerage (drains, culverts etc) are likely to be overwhelmed and the ground is likely to be saturated, resulting in rainfall flowing overland and collecting in any low lying areas. The surface run-off flooding shown on the All Sources Flood Risk Maps is a broad scale representation of the possible effects of a 1 in 200 year extreme rainfall event. Again, this information is intended to highlight the need for further investigation only and not rule out development. It is possible that, in some places, the sewers might be capable of storing a large proportion of the rainfall.

An example of an All Sources – Sewer and Surface Water Run-off Flood map is shown in Figure 3-5. These have been produced for Worksop, Retford and villages within Bassetlaw where flooding problems are known to exist or where development has been considered in previous Planning Documents.

Figure 3-5: Worksop Sewer and Surface Water Flood Map Extract



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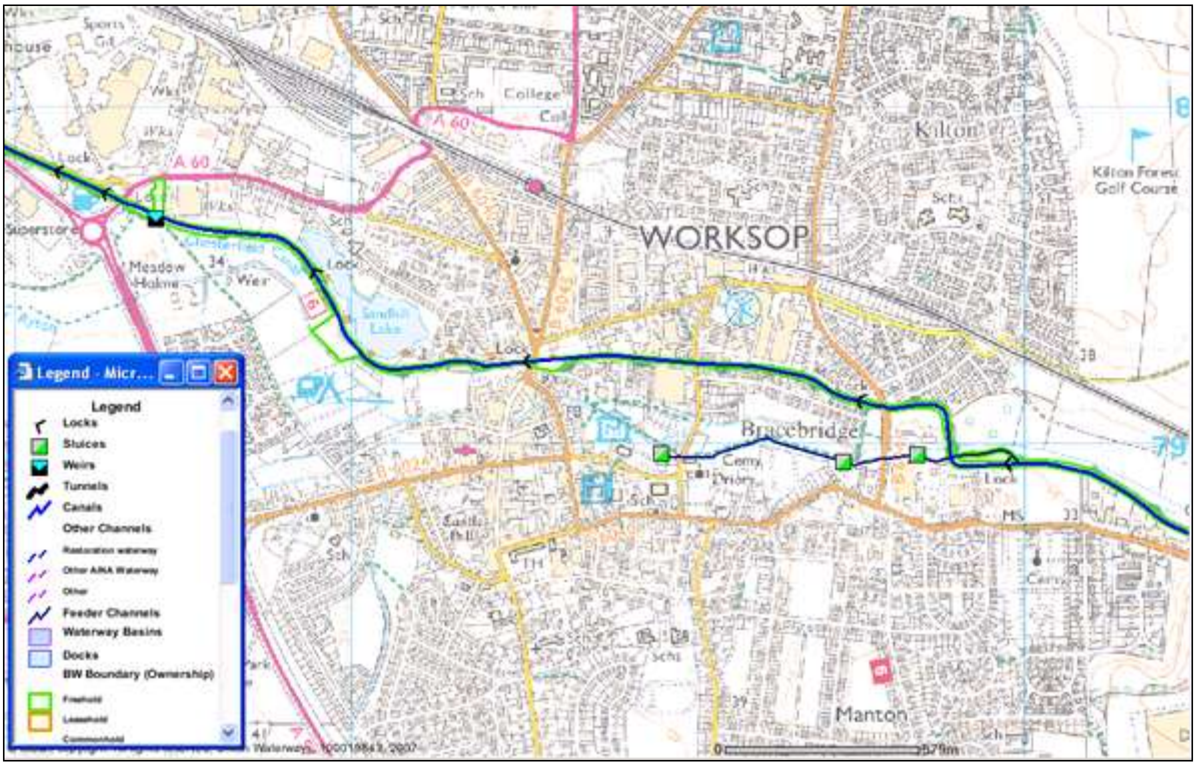
Potential flooding from the Chesterfield Canal has been considered in the SFRA. British Waterways were consulted and reported no problems due to breaches or leakage from the canal. Figure 3-6 shows the assets in Worksop managed by British Waterways. The operation of the sluices is annotated on the Flood Dynamic Maps. The river modelling takes into account interaction between rivers and the canal.

Figure 3-6: Assets in Worksop managed by British Waterways



Although the canal is maintained, the residual risk of flooding from the canal exists where it is elevated above adjacent land. Typical breach scenarios have therefore been simulated using JFLOW 2d modelling software at two notional locations where the canal is elevated.

Standard of Protection Maps

An appraisal has been included of the standard of protection provided by existing flood risk management infrastructure, together with an appraisal of any features, either natural or man made, which may act either as a barrier to flood flow or serve to reduce flood risk. NFCDD data has been consulted to determine the location of formal defences maintained by the EA. Informal defences are also shown on the maps. The standard of protection offered by the defences is discussed based on the results of hydraulic modelling. The annotated maps can be found in volume 4.

Simulation of Canal Breaches using JFLOW

2D JFLOW v7.0 modelling software was used to simulate two canal breaches. This requires the input of a Digital Elevation Model (DEM) and a flow hydrograph.

Breach Locations and Dimensions

Possible canal breaches have been considered in Retford and Worksop. The assumed locations are at notional points where the Chesterfield Canal is higher than the surrounding ground level. In both cases the Canal is approximately 0.5m above the surrounding ground level. The assumed breach width for both Retford and Worksop is 40m.

The volume of water that could potentially leave the canal if there was a 0.5m deep breach was calculated as the area between the lock gates upstream and downstream of the breach location multiplied by a depth of 0.5m. Table 3-1 shows the area and volume of the canal sections, for the breach scenarios considered in Retford and Worksop.

Table 3-1: Canal Section Dimensions

	Area (m^2)	Volume (m^3/s)
Retford	7569	3784.5
Worksop	9409	4704.5

Flow hydrographs

A spreadsheet was created which simulates a breach in the canal embankment and generates a hydrograph representing the flow through the breach over time. The spreadsheet is based on the standard weir equation and volume of water in the canal section at the start of the breach. The standard weir equation is:

$Q = c\ w\ h^{1.5}$

Where: Q = flow rate (m^3/s)

c = weir coefficient (dimensionless)

w = weir width (m)

h = head (height of water above weir crest) (m)

The canal is modelled as a reservoir of known volume, where the volume at the start of the simulated breach is given by the plan area of the canal multiplied by depth of water above the breach crest. For any given situation the weir coefficient and width of breach are constant. For both the Retford and Worksop breaches the weir coefficient is 1.6 and width of breach is 40m. Only the head of water (height of water above breach crest) changes with time. For each timestep the spreadsheet calculates the volume of water discharged from the canal via the breach using the standard weir equation. The volume of water that has flowed out of the canal is then subtracted from the previous volume and the new head calculated. This process repeats until all of the available water has flowed out of the canal section. At each timestep, the results are recorded as flow rate versus time, plotting the results gives a hydrograph of the simulated breach event.

To distribute the flow across the 40m breach the total hydrograph was divided into two hydrographs each representing 20m of the breach width. These two hydrographs were used as the inflows points for the JFLOW v7.0 simulation. The maximum flow over the 40m breach is 22.6m^3/s for both the Retford and Worksop breaches. The total hydrograph for the 40m breach and the divided hydrographs used for the inflow points for Retford and Worksop are shown in Figures 3-7 and 3-8 respectively.

Figure 3-7: Retford Flow Hydrographs

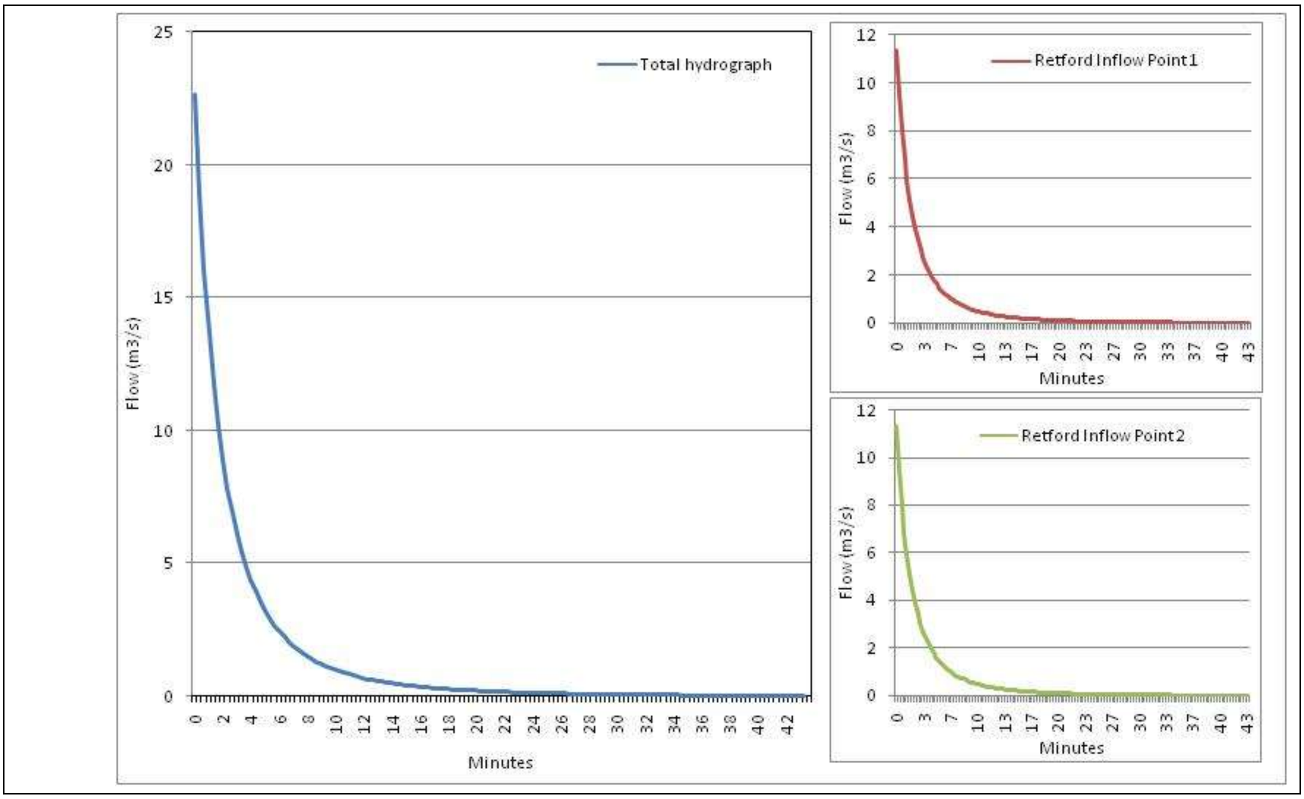
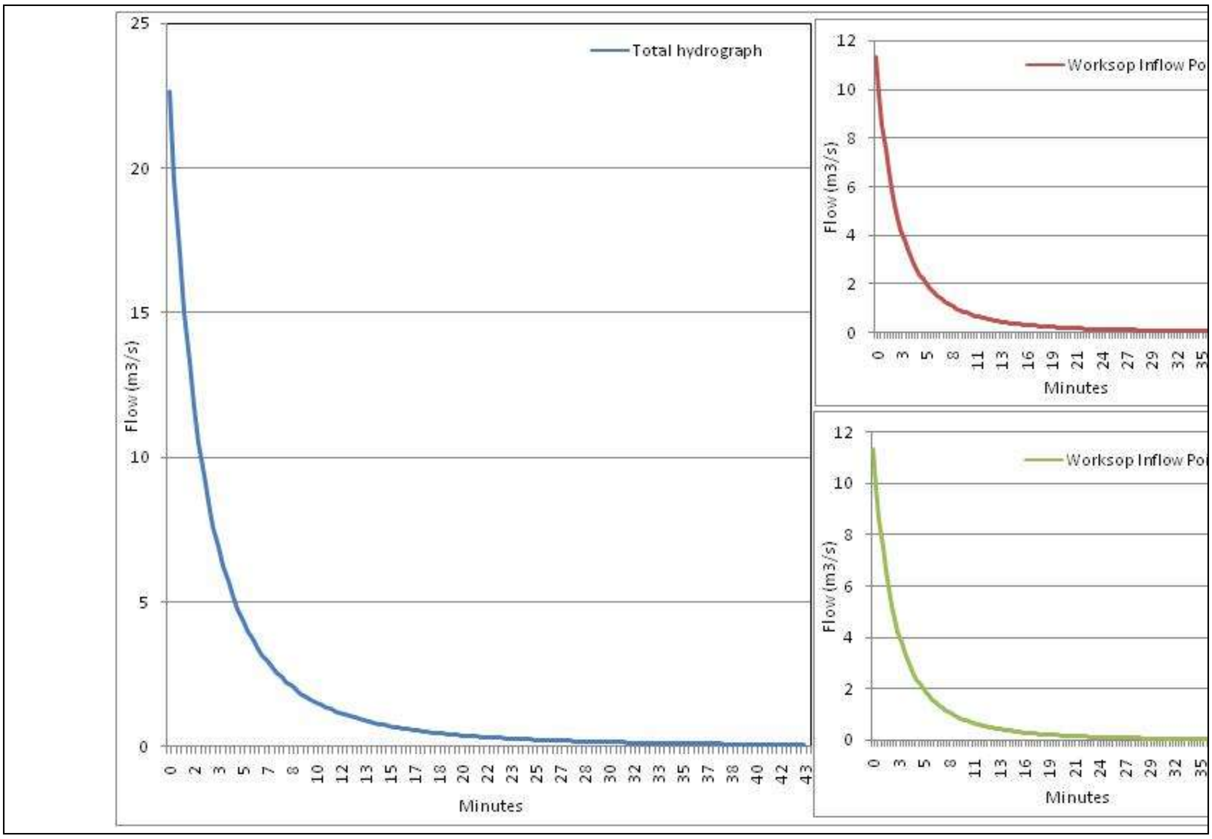


Figure 3-8 Worksop Flow Hydrographs



DEM

Filtered LiDAR data provided by the Environment Agency was trimmed to remove land away from the breach area that was not required for this study.

The null values within the trimmed LiDAR section were removed. Where appropriate, bridge elevations were replaced with an average elevation of the adjacent land for all areas where in reality water would flow under the bridges.

JFLOW Model Setup

Inflow Points

The two model inflow locations for both Retford and Worksop are shown in the Table 3-2.

Table 3-2: NGRs for Inflow Points

	National Grid Reference	
	Inflow Point 1	**Inflow Point 2**
Retford	470304, 380737	470349, 380737
Worksop	459164, 379219	459197, 379217

Parameters

The cell size was set at 6m and flow was not allowed into null values.

Canal Breach Simulation Results

The JFLOW results show the area estimated to flood and the depth of the water should the canal breach at the locations specified. The results from the JFLOW simulations for Retford and Worksop can be seen in Figures 3.9 and 3-10 respectively. These figures show the area that would flood and the depth of flood waters should the canal bank breach at the specified locations (Table 3-2).

A breach could occur at any location where the canal is higher than the surrounding land; these results should be taken as examples of the flood risk if breaches should occur.

Figure 3-9: Retford Canal Breach Indicative Outline

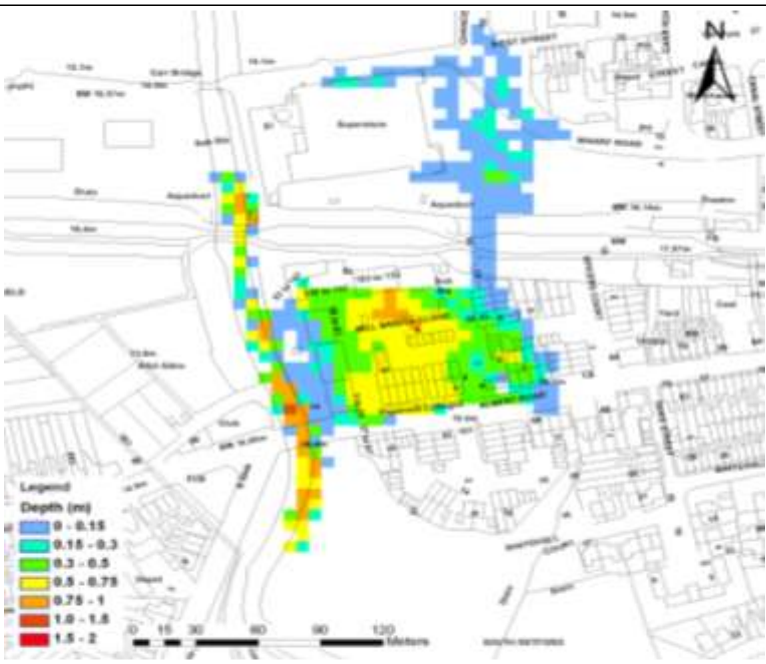


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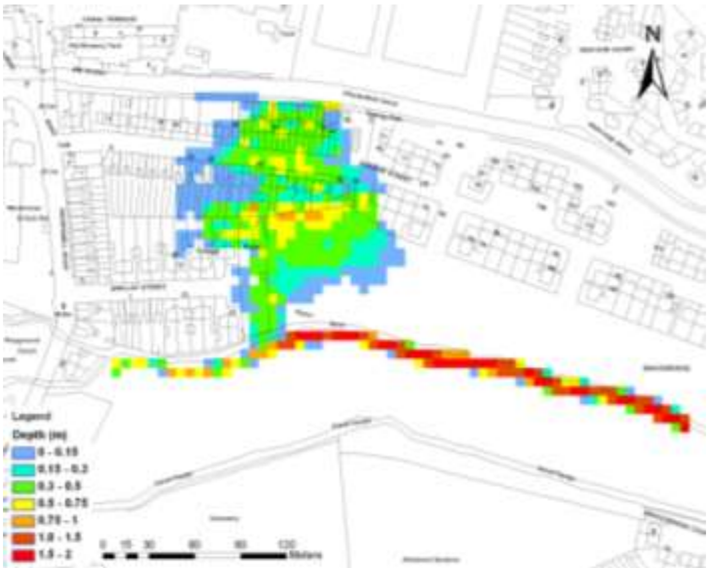
Figure 3-10: Worksop Canal Breach Indicative Outline



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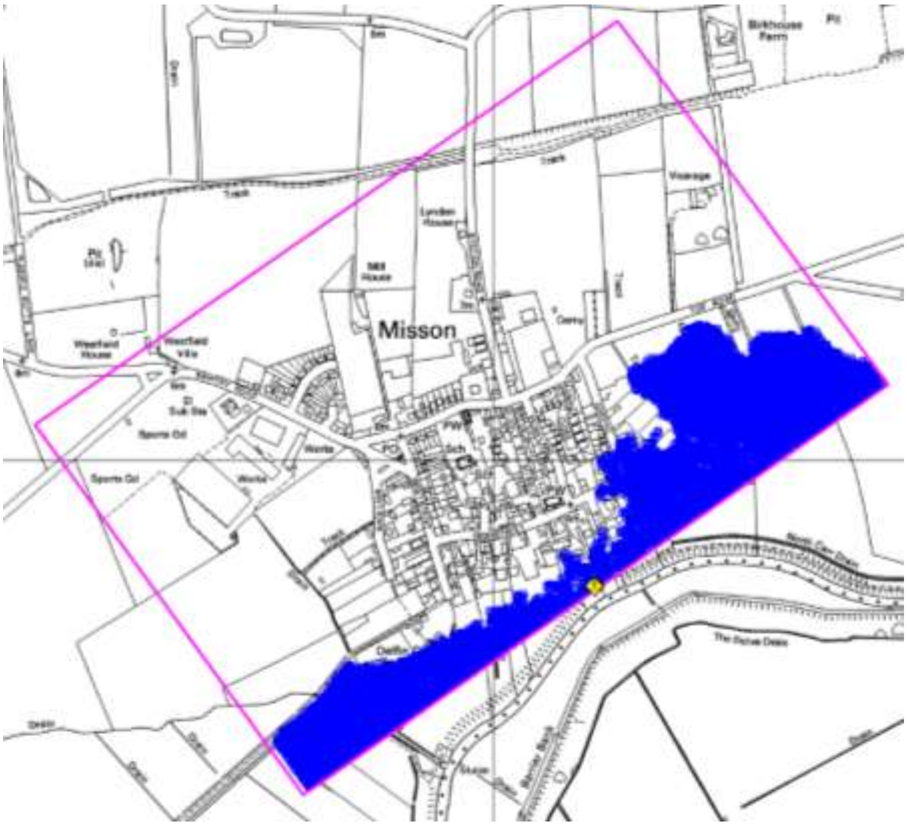
Misson and Mattersey Defence Breaching

Misson

A breach was modelled in the small earth embankment situated on the left bank of the watercourse to the south of the village of Misson, close to River Lane. Model results indicate that if a breach were to occur in this embankment during a 1% AEP flood event along the watercourse, flood water would inundate River Lane from the south and Gibdyke from the south-east, causing a flood risk to a number of properties in the south-east of the village. Flood water is also shown to move along the floodplain in a downstream direction, inundating open land to the east of the village.

Figure 3-11: Flood defence breach at Misson



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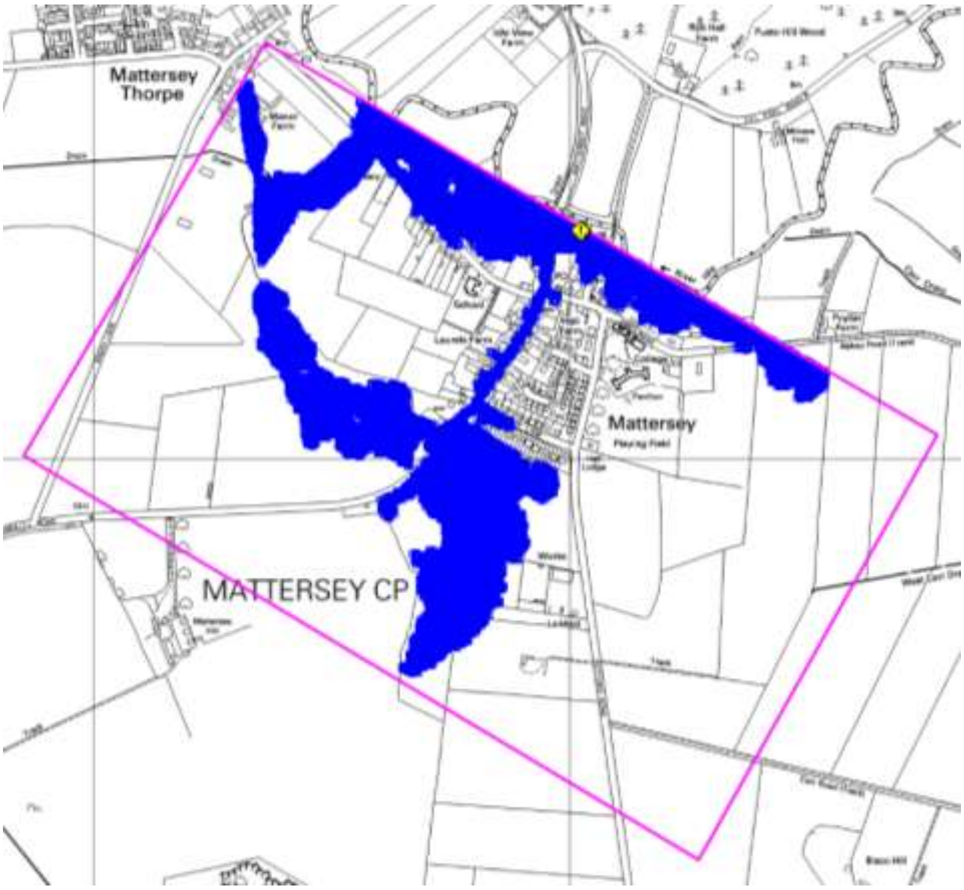
Mattersey

A breach was modelled in the left bank earth flood embankment between Mattersey Road Bridge and the footbridge upstream of the road bridge. Model results indicate that a significant number of properties, which stand adjacent to the watercourse to Abbey Road and Thorpe Road, would be at risk of flooding if a flood defence breach were to occur during a 1% annual probability flood event. The volume of flood water passing through the breach is shown to be significant for floodwater to flow southwards from the watercourse along Ranskill Road, causing a flood risk to a number of properties along the road, before ponding over a large area of open land to the south of the village. Flood water is also shown to inundate the western end of Job Lane causing a flood risk to a number of properties along the lane.

Figure 3-12: Flood defence breach at Mattersey



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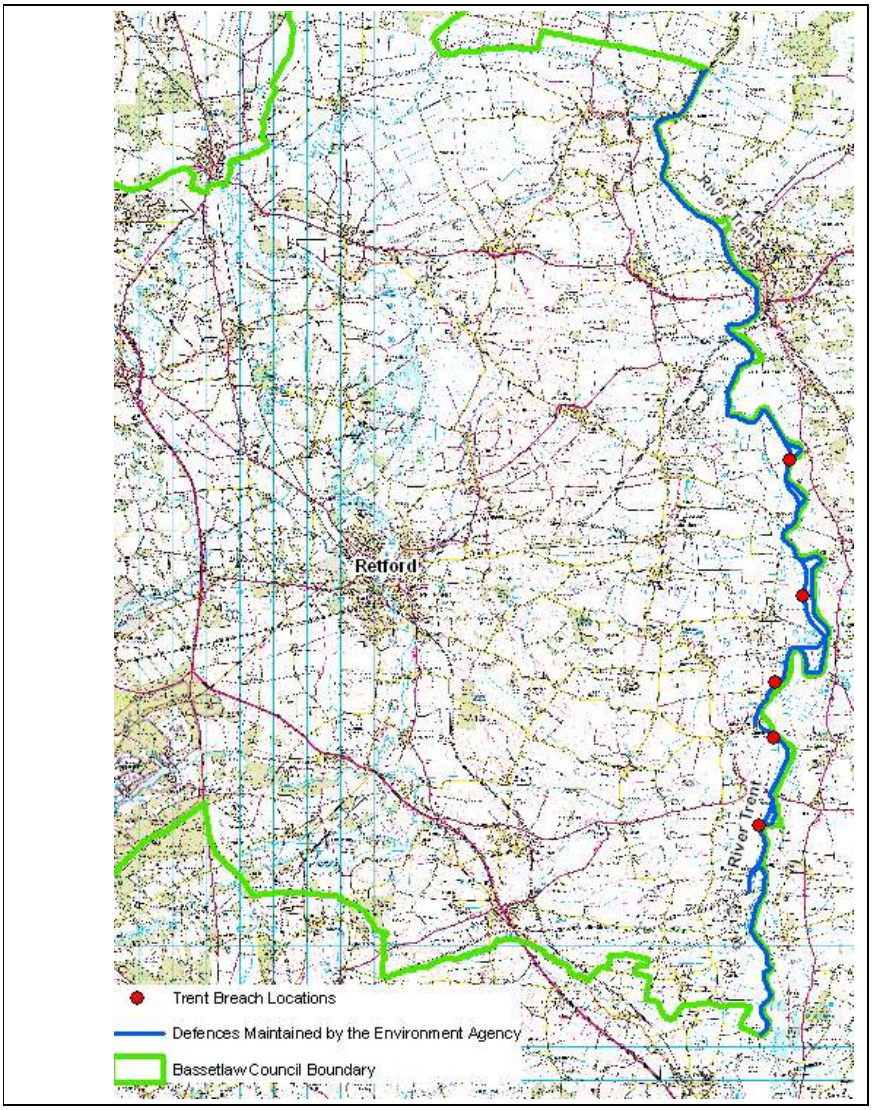
Simulation of River Trent Defence Breaches using JFLOW

2D JFLOW v7.0 modelling software was used to simulate five breaches of the River Trent defences in Bassetlaw. This required the input of a Digital Elevation Model (DEM) and several flow hydrographs.

Breach Locations and dimensions

Breach locations were taken from the 1D River Trent ISIS model supplied by the Environment Agency and these are shown in Figure 3-13. Each breach was 100m in width.

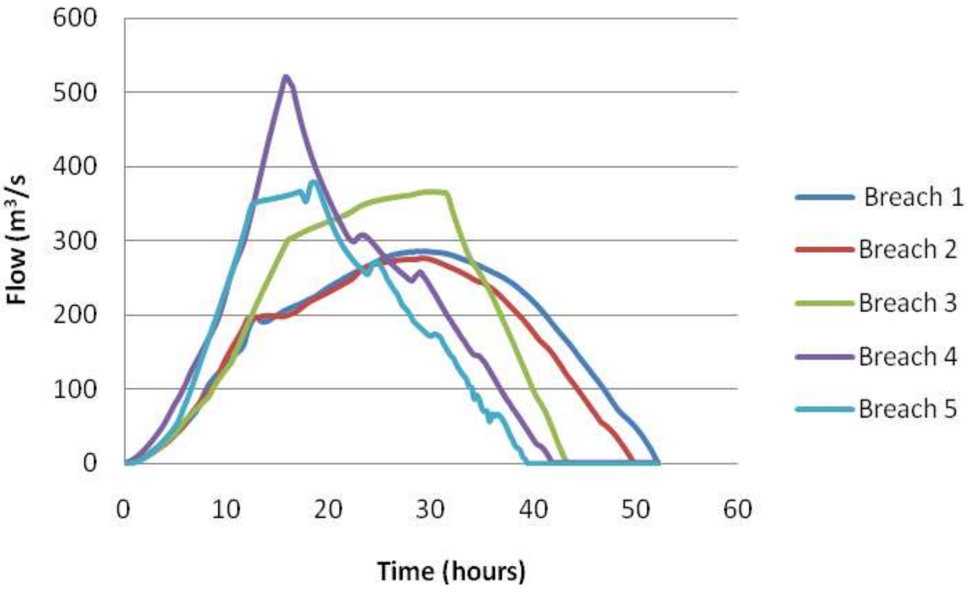
Figure 3-13: River Trent Breach Locations



Flow hydrographs

The 1D River Trent ISIS model supplied by the Environment Agency was run for a 100 year fluvial and 2 year tidal flood scenario. Flow hydrographs were extracted from spills at each breach point and these were put into the 2D JFLOW model (Figure 3-14).

Figure 3-14: River Trent Breach Flow Hydrographs



DEM

Filtered NEXTMap data was trimmed to remove land away from the breach area that was not required for this study. The null values within the trimmed area were removed.

JFLOW Model Setup

Inflow Points

Inflow points for each breach location are shown in the Table 3-3.

Table 3-3: NGRs for Inflow Points

	National Grid Reference
	Inflow Point
Breach 1	481492, 373539
Breach 2	481914, 376177
Breach 3	481974, 377835
Breach 4	482785, 380377
Breach 5	482383, 384426

Parameters

The cell size was set at 6m and flow was not allowed into null values.

River Trent Defence Breach Results

The JFLOW results show the area that would flood and the depth of the water should the River Trent defences breach at the locations specified. The results from the JFLOW simulations for the River Trent can be seen in volume 4..

2d TUFLOW Modelling

To model depth of flooding and flood hazard from the River Idle through Retford and the River Ryton through Worksop, the existing 1D ISIS models of the two rivers were linked with 2D TUFLOW models. TUFLOW demonstrates the likely flow direction, flood depth and flood velocity of floodwaters that have left the river channel and entered into the floodplain. 1D models are computationally very efficient. However, they suffer from a number of drawbacks when applied to floodplain flows. A coupled 1D-2D model combines with the one-dimensional open channel flow model and uses the DEM (ground model) of a flood plain to simulate more accurately the flow in the floodplain and the interaction with other features such as embankments and drains.

Four scenarios were simulated for both the River Idle and River Ryton: 1% AEP flood with defences; 1% AEP plus 20% increase for climate change flood with defences; 1% AEP flood with breaches through defences; 1% AEP plus 20% increase for climate change flood with breaches through defences. Each simulation produced results for water depth, water level and flood hazard.

The TUFLOW 2D domain used LiDAR for ground level data. In places the LiDAR ground levels had to be amended to better represent lakes, flow paths under bridges, and areas where the filtering of vegetation led to inaccurate ground levels. Defence heights and ground levels behind defences were also amended where they could not be picked up accurately by the LiDAR.

The ground roughness values (Manning's N) that were applied in the modelling process were: 0.04 (grassland), 0.025 (road/street network and lakes) and 0.1 (buildings). The buildings were represented as areas of high roughness to represent the permeability of buildings.

<u>Breach Locations</u>

Table 3-4 shows the defence levels and ground levels at each breach location.

Table 3-4: Details of Breach Locations

River	Breach Location	Average Defence Crest Level (m)	Average Ground Level (m)
Idle	Bus Depot, Amcott Way	16 (from LiDAR)	13.5
Idle	Memorial Square	14.7	13.5 (from LiDAR)
Idle	Albert Road Mill	16 (from LiDAR)	14
Ryton	Central Avenue Gardens	33	32 (from LiDAR)
Ryton	U/s Confluence with The Canch	33	32 (from LiDAR)

Following discussions with the Environment Agency three breach locations were identified in Retford along the River Idle, and two were identified in Worksop along the River Ryton. The breach invert levels were determined by interrogating the LiDAR data at the toe of the defence structure.

TUFLOW software does not allow for 'dam failure'[1] to be modelled. Therefore, to assess the breaching of flood defences, it was assumed that the defences breached were 50m wide. Environment Agency guidelines state that hard flood defences will have a breach width of 20m and that soft flood defences will have a breach width of 50m. However, as the NFCDD defence data was either nonexistent or incomplete at the defence locations a conservative approach was taken and breach widths of 50m used for all breaches.

Flood Hazard Mapping

With the aim of allowing application of the Sequential Test, the flood depth and velocity data derived from the flood defence breach and overtopping modelling is used to produce a map of flood hazard. It was agreed with the Environment Agency that flood hazard was to be mapped according to the methodology given in the DEFRA report FD2320[2]. This methodology was clarified and affirmed in the Supplementary Note published in May 2008[3].

The flood hazard rating was developed to make it easier to define the level of risk to people from flooding in order to help plan responses. The formula below provides a means to calculate the flood hazard rating for every grid cell in the Digital Terrain Model. The Hazard Rating is based on flood depth, velocity and a value to allow for likely debris during flood. The flood hazard rating is calculated using the equation:

$$\text{Hazard Rating} = d \times (v + 0.5) + DF$$

d is depth (m)

v is velocity (m/s)

DF is the debris factor with a value of 0.5 or 1.

The velocity component of the flood hazard rating includes an adjustment factor of 0.5. The DEFRA Flood Risks to People research project identified that an adjustment factor of 0.5 was required in order to reflect the wide variation in velocity in the degree of associated hazard[4].

Where maximum flood depth at any grid cell is less than or equal to 0.25m, a DF of 0.5 is applied and where the maximum flood depth is greater than 0.25m, a DF of 1 is applied. This method of applying debris factors is discussed in the Supplementary Note on mapping flood hazard and is considered most appropriate for urban areas. Table 3-55 depicts a matrix of flood hazard ratings, based on the maximum modelled flood depth, velocity and debris factor.

[1] Planning Policy Statement 25: Development and Flood Risk – December 2006

[2] DEFRA/Environment Agency. 2005. Flood Risk Assessment Guidance for New Development. R&D Technical Report FD2320/TR2.
http://sciencesearch.defra.gov.uk/Document.aspx?Document=FD2320_3364_TRP.pdf

[3] DEFRA/Environment Agency. 2008. Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose.
http://sciencesearch.defra.gov.uk/Document.aspx?Document=FD2320_7399_PR.pdf

[4] DEFRA/Environment Agency. 2006. The Flood Risks to People Methodology. R&D Technical Report FD2321/TR1. http://sciencesearch.defra.gov.uk/Document.aspx?Document=FD2321_3436_TRP.pdf

[1] Dam Failure = when a wall of water many metres high burst through a structure.

Table 3-5: Flood Hazard Rating Matrix

Velocity	DF = 0.5			DF = 1					
v (m/s)	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00
0	0.55	0.60	0.63	1.15	1.20	1.25	1.30	1.40	1.50
0.1	0.56	0.62	0.65	1.18	1.24	1.30	1.36	1.48	1.60
0.3	0.58	0.65	0.69	1.24	1.32	1.40	1.48	1.64	1.80
0.5	0.60	0.70	0.75	1.30	1.40	1.50	1.60	1.80	2.00
1	0.65	0.80	0.88	1.45	1.60	1.75	1.90	2.20	2.50
1.5	0.70	0.90	1.00	1.60	1.80	2.00	2.20	2.60	3.00
2	0.75	1.00	1.13	1.75	2.00	2.25	2.50	3.00	3.50
2.5	0.80	1.10	1.25	1.90	2.20	2.50	2.80	3.40	4.00
3	0.85	1.20	1.38	2.05	2.40	2.75	3.10	3.80	4.50
3.5	0.90	1.30	1.50	2.20	2.60	3.00	3.40	4.20	5.00
4	0.95	1.40	1.63	2.35	2.80	3.25	3.70	4.60	5.50
4.5	1.00	1.50	1.75	2.50	3.00	3.50	4.00	5.00	6.00
5	1.10	1.60	1.88	2.65	3.20	3.75	4.30	5.40	6.50

Once a Flood Hazard Rating has been calculated, it is categorised, as shown in Table 3-6. Maps of the flood hazard for each breach and overtopping simulations modelled are shown in Section 10.

Table 3-6: Flood **Hazard Rating Classification**

Flood Hazard Rating	Colour Code	Classification
Less than 0.75		Very Low Hazard – Caution
0.75 to 1.25		Danger For Some – Includes children, the elderly and the infirm
1.25 to 2.0		Danger For Most – Includes the general public
More than 2.0		Danger For All – Includes the emergency services

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4 SUMMARY OF FLOOD RISK IN BASSETLAW

A thorough review of existing information and new more detailed flood modelling work has identified the level of flood risk in the Bassetlaw District. This is summarised below:

Table 4-1: Summary of Flood Risk within Bassetlaw

Source of Flooding	Potential			Comments
	High	Med	Low	
Fluvial Flooding (Rivers)	X			Fluvial flood risk is high within Bassetlaw. The urban areas of Retford and Worksop have minimal flood defence protection and fluvial channels have a limited capacity. The majority of flooding affects open ground, although in more extreme flood events, existing buildings are affected.
Pluvial Flooding (Drainage)		X		It is expected that during moderate rainfall events the drainage system capacity is likely to be exceeded in some areas and further development in these areas will exacerbate this problem
Surface Water Run-off		X		The overall risk to the district remains moderate due to the topography. Sturton Le Steeple and Beckingham and other villages located on heavy clay soils are more likely to be prone to surface run-off problems
Groundwater			X	The risk of groundwater flooding is low. The risk is greater in areas adjacent to watercourses and localised areas close to abandoned mines where groundwater pumping has ceased. This is not thought to be a problem at present but future rebound should be monitored at proposed development sites.