NOTTINGHAMSHIRE PRELIMINARY FLOOD RISK ASSESSMENT

Preliminary Assessment Report and Identification of Flood Risk Areas

July 2023

Nottinghamshire County Council

Acknowledgments

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Executive Summary

As Lead Local Flood Authority (LLFA), Nottinghamshire County Council (NCC) has a statutory duty to prepare, publish and review a Preliminary Flood Risk Assessment (PFRA). The PFRA is a high-level screening exercise to identify areas where flood risk is significant (known as Flood Risk Areas). The PFRA requires the preparation and publication of a Preliminary Assessment Report (PAR) on past and future flooding, including consideration of the consequences of that flooding and the identification of Flood Risk Areas. The PFRA covers the risk of flooding from local sources, namely Ordinary Watercourses, surface water and groundwater. It does not consider directly flooding from Main Rivers, such as the River Trent. This report is a review and update of the existing PFRA for Nottinghamshire, it includes the contents of the Preliminary Assessment Report and also addresses whether there are any areas where the flood risk is significant in accordance with the nationally defined thresholds.

Using historic flood data and Environment Agency surface water flood mapping to predict possible future flooding, the PFRA assesses the significant harmful consequences of past flood events and discusses the potential consequences of flooding in vulnerable areas of Nottinghamshire.

A Flood Risk Area is a location where flooding is deemed significant. In Flood Risk Areas the Regulations require LLFAs to prepare Flood Risk and Flood Hazard Mapping and complete a Flood Risk Management Plan. The threshold for significance used to determine Flood Risk Areas for this assignment being that 30,000 people could be affected by local flooding at a particular location. No areas of Nottinghamshire were found to cross this threshold. However, the PFRA has identified clusters of areas where possible harmful consequences to people, property, critical services, Environmental Sites and Cultural Heritage could occur.

The flooding in June 2007, July 2013 and the winter of 2019/2020 clearly highlighted how vulnerable our communities are to localised flooding. In addition to the PFRA, NCC have produced a Local Flood Risk Management Strategy for the County under the Flood and Water Management Act (2010). The findings of the PFRA will be used to inform the Local Flood Risk Management Strategy to consider how NCC as the LLFA will prioritise those areas at greatest risk of flooding across the County.

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Abbreviations and definitions

AEP	Annual Exceedance Probability
AMP	Asset Management Plan
AStSWF	Areas Susceptible to Surface Water Flooding
BC	Borough Council
CFMP	Catchment Flood Management Plan
Cllr	Councillor
COMAH	Control of Major Accident Hazard
CONFIRM™	Highways Asset Management System used by Nottinghamshire County Council
DC	District Council
DG5	Register kept by Water Company
EA	Environment Agency
FCERM	Flood and Coastal Erosion Risk Management
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FMfSW	Flood Map for Surface Water
GIS	Geographical Information System
IDB	Internal Drainage Board
HAMS	Highways Asset Management System
LLFA	Lead Local Flood Authority
LLPG	Local Land and Property Gazetteer
LRF	Local Resilience Forum
LSG	Local Street Gazetteer
OS	Ordnance Survey
NCC	Nottinghamshire County Council
NFM	Natural Flood Management
RMA	Risk Management Authority
PAR	Preliminary Assessment Report
PFRA	Preliminary Flood Risk Assessment
PFR	Property Flood Resilience
SFRA	Strategic Flood Risk Assessment
SUDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
UK	United Kingdom
USRN	Unique Street Reference Number
WaSC	Water and Sewerage Company

1. Introduction

1.1 Scope of report

Nottinghamshire County Council as a Lead Local Flood Authority (LLFA) has responsibilities, duties and powers to help manage flood risk from localised sources. The Flood Risk Regulations (2009) require LLFA's to complete a Preliminary Assessment Report (PAR) on past and future flood risk from local sources of flooding. The Regulations also require the LLFA to identify, in its opinion, significant Flood Risk Areas. These two actions make up the Preliminary Flood Risk assessment (PFRA) which Nottinghamshire County Council as LLFA for the County must review every six years. This report is the PFRA review for 2023.

A Preliminary Assessment Report is a report that identifies past floods, and the possible harmful consequences of future floods. The report is based on the following:

- relevant information which is in the possession of the person preparing the report.
- relevant information which is in the possession of the Environment Agency.
- relevant information which is in the possession of an authority.
- relevant information which is available to the public.

Flood Risk is defined as the combination of the probability of flooding occurring (which is often expressed as a return period or Annual Exceedance Probability), and the potential consequences should flooding occur (for example on people, homes, business, critical infrastructure, critical services and the environment (including sites of cultural heritage).

This PFRA covers the risk of flooding from local sources, namely:

- Surface runoff - meaning water on the surface that has not yet entered a watercourse, drainage system or public sewer.
- Groundwater - meaning water below the ground that is in direct contact with the ground or subsoil.
- Ordinary watercourses – includes lakes, ponds and other areas of water that flow into an Ordinary Watercourse. Ordinary Watercourses are those that are not defined as Main River by the Water Resources Act (1991) and shown on the Environment Agency's Main River map.

The PFRA considers past flooding and past flood events which have caused significant harmful consequences. It also considers where future flooding may occur across the County and the consequences this might have for people, properties, the environment and cultural heritage. To comply with Regulations, the PFRA considers whether the flood risk in any part of Nottinghamshire is considered significant in a national context and so would be classed as a Flood Risk Area. Where a Flood Risk Area is identified there are requirements under the Flood Risk Regulations (2009) for LLFAs to prepare Flood Risk and Hazard Mapping and a Flood Risk Management Plan. The threshold for significance that determines the locations of Flood Risk Areas, one of the indicators to define the threshold being that 30,000 people could be affected by local flooding (note that this does not include flooding from Main River).

The PFRA does not consider flooding directly from Main Rivers, such as the River Trent, large raised reservoirs, burst water mains or from any part of a sewerage system. However, it does consider where there may be interactions between other sources of flooding. Under the Flood Risk Regulations (2009), the Environment Agency are obliged to consider flooding from Main

Rivers, the Sea and Reservoirs. They have exercised an exception clause and will not be producing a PFRA. This means that they will prepare Flood Risk and Hazard Mapping and undertake Flood Risk Management Plans for the respective flood sources for the entire area under their responsibility.

1.2 Aims and objectives

The objectives of the PFRA are:

- Bring together information on past flooding and its consequences to understand where it has had significant harmful consequences.
- Bring together information on flooding that may happen in the future to understand where it may have possible harmful consequences.
- Work with the Risk Management Authorities (RMAs) across the County and our neighbouring LLFAs to better understand the distribution of local flood risk across the County.
- Use the information as evidence to decide if there should be any Flood Risk Areas in Nottinghamshire that meet the national thresholds.
- Develop the PFRA in such a way that there is a clear link with the Local Flood Risk Management Strategy.

The first stage of the PFRA is to prepare the Preliminary Assessment Report which describes a broadscale and strategic assessment of flood risk across the County. This is to inform the identification of significant Flood Risk Areas.

The Nottinghamshire PFRA does not attempt to assess flood risk in detail at all locations across the County. It is the first step in a process of assessing flood risk and bringing together data and understanding from across the County to inform our work as a Lead Local Flood Authority. Figure 1 shows how we intend the PFRA to fit into the framework of strategies and plans, each with increasing level of detail and supported by both partnership working and local democracy through the role of Elected Members and by working with our local communities.

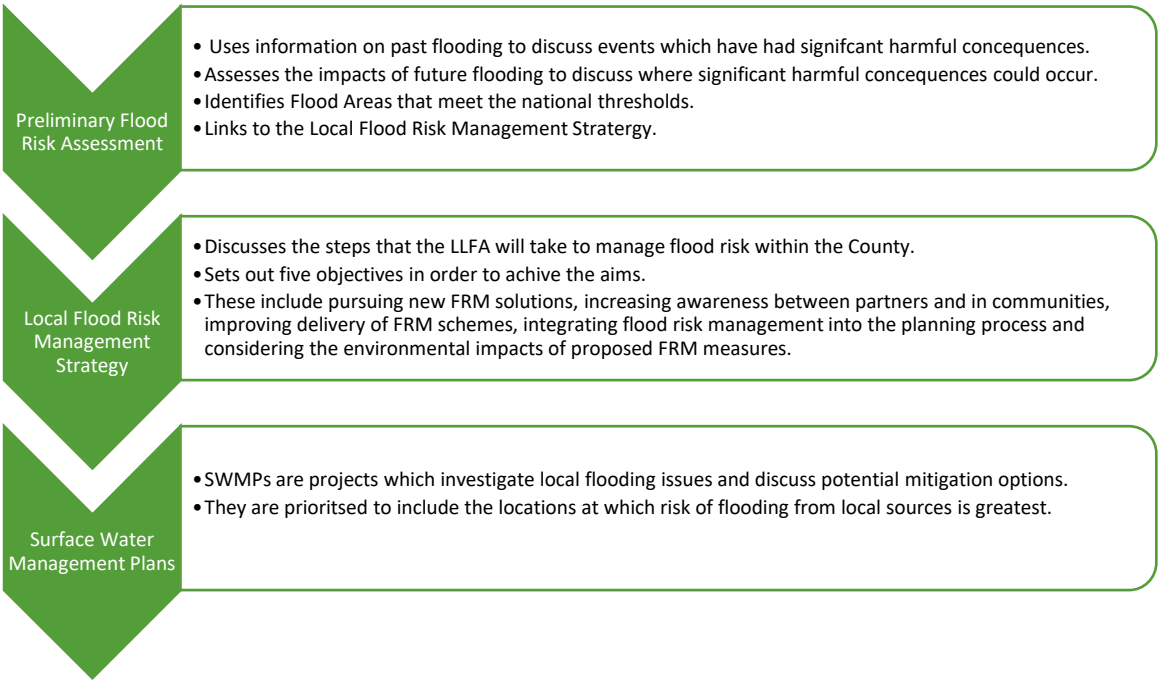

Figure 1. Strategic flood risk management studies in Nottinghamshire

1.3 The Local Flood Risk Management Strategy

The PFRA does not set out to discuss how NCC will manage flood risk, but instead assess flood risk within the County. The PFRA is linked to the Local Flood Risk Management Strategy (2021) which sets out the objectives and measures that the LLFA will take to manage flood risk for all areas of the County. The Strategy discusses five objectives that the LLFA will pursue to reduce and manage flood risk. These include pursuing new FRM solutions, increasing awareness between partners and in communities, improving delivery of FRM schemes, integrating flood risk management into the planning process and considering the environmental impacts of proposed FRM measures.

The Local Flood Risk Management Strategy acknowledges that hard engineered options to flooding are only one example from a toolbox of actions that the LLFA can choose from. There are a wide range of options to help manage flood risk and these will be delivered by working across service areas within the County Council and wider organisations, including the seven District and Borough Councils, Internal Drainage Boards (IDBs), the Environment Agency and Water and Sewage Companies.

Softer engineered options such as Natural Flood Management (NFM) measures are now used as part of catchment based holistic strategies to manage flood risk. Other non-structural options, including spatial planning, emergency planning, and measures such as the Community Flood Signage Scheme which empowers and supports communities to become more resilient to flooding are also used. These will remain key components within our future management of flood risk.

Surface Water Management Plans are used to deliver the strategy in critical locations where flood risk is high and/or the sources of flooding are complicated and further investigation is justified. In these locations the LLFA will undertake detailed options appraisal within a partnership, collaborating with other relevant RMAs to prepare realistic and achievable Action Plans. It is noted that in many places such detailed work is not likely to be justified or necessary, for example where the flood risk is relatively low and partners can identify quick wins, such as supporting applications for Property Flood Resilience (PFR) grants or changing the camber of

a local road to divert water into a field instead of nearby houses. Even where flood risk is higher, such solutions may be more appropriate and particularly so where the mechanisms of flooding are very complicated, and it is likely that a capital scheme would quickly become economically unviable.

1.4 Introduction to Nottinghamshire

Nottinghamshire is a County in the East Midlands, which covers an area of around 2,087km^2 (Figure 2). The County has a population of 828,200 (Nottinghamshire County Council, 2022). In Nottinghamshire, some services for local communities are shared between the County and District/ Borough Councils, and in some instances Parish or Town Councils. The Boroughs in Nottinghamshire are Broxtowe, Gedling and Rushcliffe. The Districts are Ashfield, Bassetlaw, Mansfield and Newark and Sherwood. The City of Nottingham is a unitary Council created in 1998, which nestles within the wider area of Nottinghamshire.

As a County Council, the local communities are represented by 66 Elected Members (Councillors). There are separate lead Elected Member who represent Nottinghamshire County Council and Nottingham City Council at the Regional Flood and Coastal Committee. The Cabinet Member for Transport and Environment oversees flooding issues on the Council Cabinet.

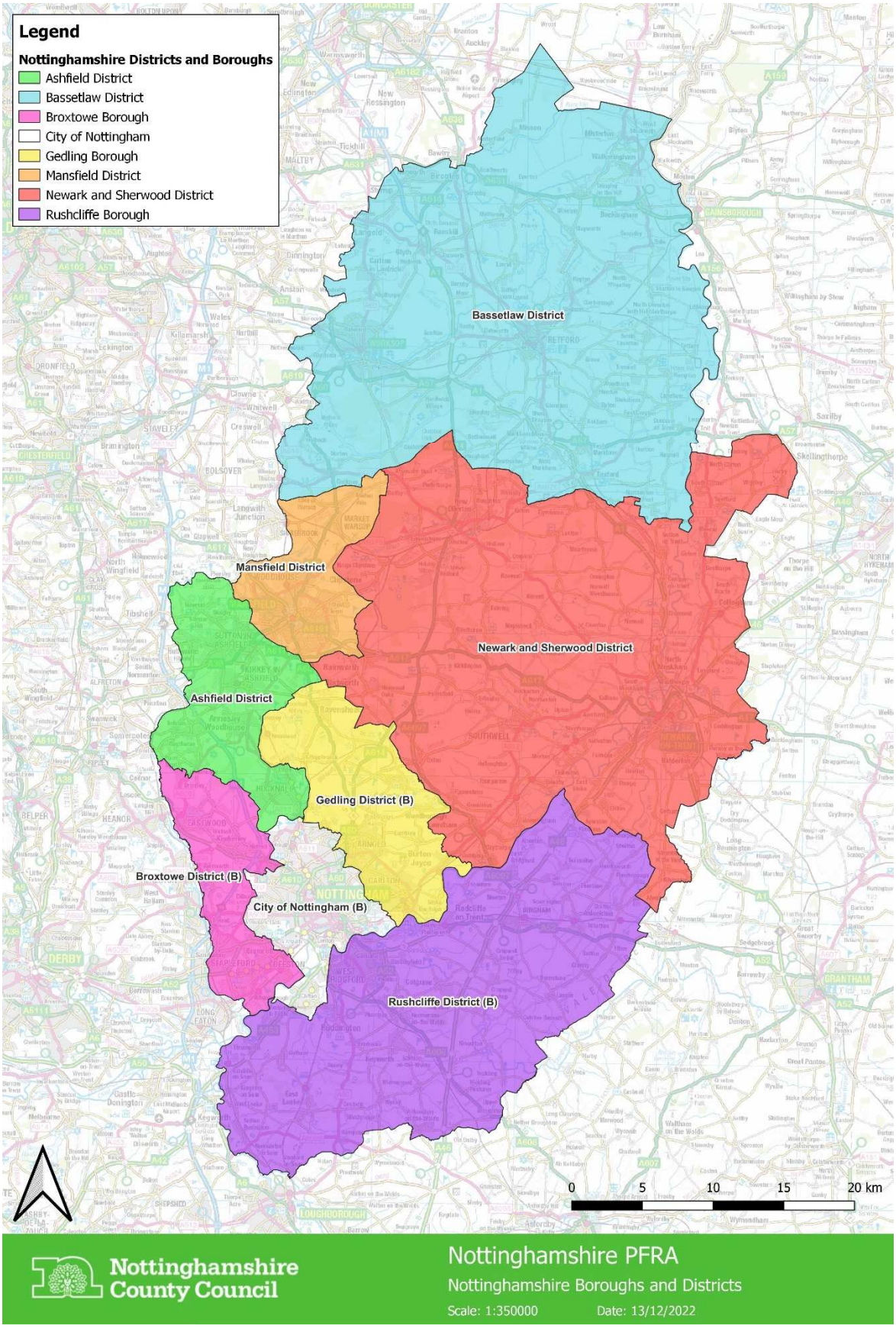

Figure 2. Nottinghamshire Districts and Boroughs.

The County is largely drained by the River Trent and its tributaries which flows northwards into the Humber Estuary, although a small part of the County to the north east drains into the River Witham and over towards the East Coast. The floodplain of the River Trent is relatively flat and flooding has caused major damage and disruption in the past, such as in 1947 and 2000. The flooding of June 2007 highlighted the vulnerability of Nottinghamshire to more local sources of flooding, such as surface water and the sewer and highway drainage networks becoming overwhelmed and affected by backing up from Main Rivers and Ordinary Watercourses.

More recent flood events have highlighted the vulnerability of property to surface water flooding. For example, intense rainfall events across Nottinghamshire in 2013 and in Worksop in 2022, have caused flooding due to surface water drainage systems becoming overwhelmed. Other urban areas in Nottinghamshire are also likely to be vulnerable to surface water flooding, due to the high coverage of impermeable surfaces, hilly landscape and nature of urban watercourses, which in some cases have been culverted over time as urban centres have expanded.

Flooding in rural areas can be influenced by upstream land management promoting rapid runoff during storm events and the limited capacity of many of the smaller watercourses, highways drainage and sewer network (where one exists). In areas of special drainage needs, Internal Drainage Boards (IDBs) manage the drainage characteristics of the area. Such areas often rely on pumped drainage and flood waters can pond and take longer to drain.

The pattern of flooding is further complicated by the underlying geology. Nottinghamshire lies within a broad belt of sedimentary rocks, which dip gently eastwards from the Pennine axis of Derbyshire towards Lincolnshire and the North Sea basin. There are coal measures to the west, which has influenced the distribution of past mining activity. In places the solid geology is overlain by drift geology of former glacial and river deposits, such as Marshall gravels, many sites of which have been excavated over time including Attenborough Lakes. In areas underlain by clays and less permeable drift geology, there is likely to be a faster response to rainfall due to lower ground infiltration rates.

The condition and location of drainage assets also has an important local influence on flooding. Some of the localised flooding incidents reported to us and our partners are related to blockage, failure or misconnection of the local drainage network, including culverted watercourses, surface water sewers and highway gullies. As the LLFA, NCC investigate such issues and have systems in place to store historical drainage designs and map the locations of highway drainage networks.

2. Lead Local Flood Authority responsibilities

2.1 Introduction

2.1.1 The Nottinghamshire Plan

Flood risk management takes a holistic approach and crosses a range of functions in local government, including Highways, Spatial Planning, Emergency Planning, Sustainability and Climate Change. We cannot manage flooding on our own, since rainfall and runoff do not respect administrative, political or organisational boundaries. Our Nottinghamshire Plan 2021-2031 recognises that working in partnership with people, organisations and businesses will contribute towards a shared vision for Nottinghamshire. One of the ambitions is improving health and wellbeing in all our communities, whilst another is to grow our economy and improve living standards. Reducing flood risk in Nottinghamshire is imperative if these ambitions are to be realised for residents and businesses. Furthermore, another ambition is to reduce the County's impact on the environment. Through the implementation of NFM features and Sustainable Urban Drainage Systems (SUDS) within the county, wider environmental benefits are being achieved.

2.1.2 Flood Risk Regulations (2009) and the PFRA

Following the flooding of summer 2007, the government commissioned an independent review chaired by Sir Michael Pitt (The Pitt Review). The final report, published in June 2008, highlighted the gaps with respect to responsibility for local sources of flooding.

The following legislation has brought forward recommendations from the Pitt Review, notably:

- The Flood Risk Regulations (November 2009)
- The Flood and Water Management Act (April 2010)

The Flood Risk Regulations (2009) transposed EU Directive 2007/60/EC into UK law and so require the LLFA to prepare and publish a Preliminary Flood Risk Assessment (PFRA). The PFRA is a high-level screening exercise to identify areas where flood risk is significant (known as Flood Risk Areas). The PFRA requires the preparation and publication of the Preliminary Assessment Report (PAR) on past and future flooding. The PFRA must include consideration of the consequences of that flooding and the review and identification of Flood Risk Areas. The development of the PFRA is also linked to the preparation of the Local Flood Risk Management Strategy required under the Flood and Water Management Act (2010).

2.1.3 Flood and Water Management Act (2010)

The Flood and Water Management (2010) sets out responsibilities of Risk Management Authorities and initiated the creation of LLFA's.

The implementation of the Act is a complicated task, since many of the functions carried out by local government sit across two tiers (and in some instances three tiers, including town and parish councils). The following are areas where there is involvement of more than one level of local government:

- Spatial Planning, with Highways Development Controls, Minerals and Waste Planning and County Council Development Control sitting at County level, but the majority of planning functions with respect to policy planning and development control sitting within District and Borough Councils.

- Emergency planning, response and recovery being shared across first and second tiers as appropriate, with the main driver being the Civil Contingencies Act (2004).
- Drainage, with the Highways Drainage function sitting at County level and land drainage responsibilities under the Land Drainage Act (1991) sitting with the LLFA and Internal Drainage Boards.

There are two types of rivers identified within the Act, Main Rivers and Ordinary Watercourses. Main Rivers are larger rivers whilst Ordinary Watercourses are smaller watercourses such as ditches, drains and dykes. Table 1 summarises the responsibilities that different organisations across Nottinghamshire have under the Flood and Water Management Act (2010).

Table 1. Roles and responsibilities under the Flood and Water Management Act.

Risk Management Authority	Strategic Level	Operational Level
Environment Agency	Strategic overview for all sources of flooding, National Strategy Reporting and general supervision	Main rivers Sea Reservoirs
Lead Local Flood Authority (County Council)	Input to the National strategy Produce PFRA Produce Local Flood Risk Management Strategy	Surface Water Ordinary Watercourses Groundwater
Four District and three Borough Councils Internal Drainage Boards	Input to the National and Local Strategies Emergency Planning	Ordinary watercourses Potential delegation for other local sources

2.2 Governance and Partnership

2.2.1 Risk Management Authorities in Nottinghamshire

Table 2 shows the organisations in Nottinghamshire that are now Risk Management Authorities. As an LLFA, Nottinghamshire County Council is also classed as an RMA.

Table 2. Risk Management Authorities (RMAs) in Nottinghamshire.

District or Borough Councils	Internal Drainage Boards	Water Companies	Other
• Ashfield District • Bassetlaw District • Broxtowe Borough • Gedling Borough • Mansfield District • Newark and Sherwood District • Rushcliffe Borough	• Trent Valley IDB • Isle of Axholme and North Nottinghamshire IDB • Doncaster East IDB • Upper Witham IDB	• Anglian Water (note drainage function is only in part of Newark and Sherwood District) • Severn Trent Water	• Environment Agency • VIA East Midlands Ltd

2.2.2 Neighbouring LLFAs

Catchments within Nottinghamshire can cross into neighbouring LLFA administrative boundaries. Our shared integrated urban drainage issues with Nottingham City Council, which is also a unitary authority and Lead Local Flood Authority is an example of this. In addition, Nottinghamshire has catchment boundaries shared with Derbyshire (County), Rotherham (Unitary), Doncaster (Unitary), North Lincolnshire (Unitary), Lincolnshire (County) and Leicestershire (County).

It is important to work across County borders, not only to reduce the likelihood and consequences of flooding to our local communities, but also to develop new ideas which are emerging within the flood risk industry. Nottinghamshire County Council work in particularly close partnership with neighbouring RMA's through the East Midlands Local Resilience Forum and the Strategic Flood Risk Management Board.

2.2.3 Nottinghamshire and Nottingham Strategic Flood Risk Management Board

The Strategic Flood Risk Management Board has been set up with Nottingham City Council, with the focus of the Board being to manage and reduce existing flood risk and provide strategic advice and direction, alongside guidance on resources and the prioritisation of activities. The Board operates at a Strategic level, with membership including Members from the County Council and City Council who sit as RFCC chair, Senior Officers from NCC, Nottingham City Council, IDBs, Severn Trent Water Ltd and the Environment Agency.

2.2.4 Communication with partners and the public

Nottinghamshire County Council work closely with partners and the public to maximise the outputs of its flood risk management activities. Communication is a critical component of this as NCC aim to work closely with partners and communities to manage flood risk together. NCC as the LLFA are experienced in working closely with RMA's and local community groups, such as Parish Councils and Flood Action Groups to act as appropriate to reduce flood risk.

To develop our communication strategy, NCC deliver interactive education sessions to schools, colleges and universities. The sessions develop the pupils understanding of flood risk and highlight the many ways in which it is manged. Interactive tools such as the Augmented Reality Sandbox and SUDS Model are used to solidify theory and pass on knowledge in an interactive way.

Image: Nottinghamshire County Council's SUDS Model.

Image: Augmented Reality Sandbox being demonstrated at Bilborough College.

3. Methodology

This PFRA brings together information on past and future flooding in Nottinghamshire. It contains all the information required for the Preliminary Assessment Report and addresses whether there are any areas where the flood risk is nationally significant. As such it satisfies the two stages of the PFRA requirements as described in the Flood Risk Regulations (2009). For the purposes of this report, the threshold for nationally significant flood risk areas has been set at 200 persons or 20 non-residential properties or 1 critical service per km grid square where flooding would occur to a depth of 300mm during a 1 in 100 year return period flood.

3.1 Past Flooding in Nottinghamshire

For the purposes of assessing past flooding, recorded flooding data obtained from the 2011 PFRA review forms the basis of the data set. This data set was initially collected from multiple sources including District and Borough Councils, Parish and Town Councils, Water Companies, VIA East Midlands and Elected Members. Appendix A1 summarises the data that was readily available for the 2011 PFRA. Data requests were sent to partner organisations at the end of November 2010. A large number and variety of organisations were approached and not all had or held data that could be made readily available. In 2011, It was considered that the appropriate information had been collated for the purpose of the PFRA and any further data would only add to the detail rather than affect the decisions that are taken. The River Witham and River Trent Catchment Flood Management Plans (CFMPs) were reviewed for information on local sources of flooding and potential interactions between systems and background information was used to supplement the PFRA as suitable.

Using nationally available information, the Environment Agency's Historic Flood Map was reviewed. The map shows that extensive areas of Nottinghamshire have been affected by flooding in the past, although this appears to be largely in relation to Main River flooding and there were limited attribute information associated with the data. The British Hydrological Society Chronology of British Hydrological Events was also used. The PFRA hence relies on local data, which is of better resolution and more suitable for local flood risk management purposes, rather than national data.

Since the 2011 PFRA was published, the historic flooding data set has been developed with flooding records added to it as they occurred by NCC as the LLFA. The data set contains records of internal and highway flooding.

For the purpose of reporting past floods, a flood is deemed significant if it:

1) caused internal flooding to five or more residential properties, or
2) flooded two or more business premises, or
3) flooded one or more items of critical infrastructure, or
4) caused a transport link to be totally impassable for a significant period.

The historic flood records were filtered to enable a more detailed analysis of internal flooding compared to flooding which did not affect property but highways only. Some records were found to have resolutions which were set at street or settlement level. These records were split into individual properties affected to increase the resolution to single property scale. The resulting data was reviewed by the NCC FRM team in September 2022 to assess its accuracy based on expert knowledge of the flood affected area. A cut off was applied on the 1st of September 2022

with regards to past flooding data used to inform the PFRA. GIS mapping software was then used to assess the number of years in which a flood was recorded between 1998 and 2022. The number of flood records per km^2 grids was also assessed to visualise the distribution of recorded flood occurrences across Nottinghamshire.

3.2 Future Flood Risk in Nottinghamshire

To assess future flood risk to property, the EA Surface Water Flood Depth data for 1 in 100 year events was used (Environment Agency, 2022). Flood depths < 30cm were removed from the data as it was deemed that internal property flooding would occur at flood depths > 30cm. The resulting Surface Water Flood Depth layer was used to extract buildings which were identified to be at risk using the OS Buildings layer. Buildings which were intersected by or wholly contained within the Surface Water Flood layer were extracted. The EA National Receptor Database was then applied to determine the property type of at-risk buildings such as residential, commercial or critical service. Property type was split into three categories: Residential, Commercial or Critical Infrastructure. Nottinghamshire was split into a grid squares of 1km^2 and points (at risk properties) per grid square were counted using GIS tools to spatially assess and display the data. To calculate the number of people at risk within a grid square, the number of residential properties at risk within the grid square was multiplied by the national average household occupancy of 2.4 (ONS, 2022). Appendix A2 shows the datasets that exist that can give us information on where flooding might happen in the future.

The thresholds used to determine potential harmful consequences are the same as the national analysis and are reflected in the symbology of the map outputs:

- Number of people at risk ≥ 200
- Number of Critical Services at Risk ≥ 1
- Number of Non-Residential Properties at Risk ≥ 20

To assess flood consequences to cultural heritage and environmental sites, the following datasets have been used:

- Properties, including residential, businesses and critical services – Environment Agency National Receptor Database/ Local Land and Property Gazetteer (LLPG) – a detailed property count based on the footprint of buildings has been undertaken.
- Cultural heritage and environmental sites and agricultural land – National Receptor Dataset provided by the Environment Agency. Listed Buildings based on a detailed property count. SHINE data. Historic Village Cores. Parks and Gardens. Battlefields. Scheduled Monuments.

Note that our analysis has been largely based on 1km grid squares and hence where this follows the County border. Please refer to the appropriate County or Unitary PFRAs for information on the Locally Agreed Surface Water Information for these areas.

A comparison of historic flooding records and future flood predictions was then undertaken. This analysis allowed for an assessment of any areas which had previously been flooded but had not been identified during the future flood risk analysis. Therefore, a more accurate picture of potential flood risk for Nottinghamshire is obtained.

3.3 Data quality

The PFRA has been informed by a wealth of information from organisations across the County. It is important that for any flood risk management study NCC has addressed the underlying assumptions, resolution and limitations that lie behind the data.

The 2011 PFRA developed two systems to manage data quality:

- A data register which scored data quality based on the method presented in the Multi-Coloured Manual and reproduced in the Defra SWMP Guidance.
- In relation to past flooding events NCC carried out a "condensing" exercise where information has been brought together so that we could consider the consequences of past flood events across the County. The data came from a range of different sources, with some data being specific at property level, but much of it at street or settlement level. A resolution field was developed so that data is not taken out of context in the future (for example settlement data taken to mean the point location itself that actually flooded or multiple sources of point data representing the same flood event being taken to mean multiple incidences of flooding to the settlement).

Following on from this, a robust method of data keeping was established and continues to be used to record incidences of flooding. The data collected has been examined and verified by NCC members of staff who have expertise in flood risk in the areas associated to the data.

3.4 Data Limitations

3.4.1 Past Flood Data

Prior to the Pitt Review (2008), there was uncertainty regarding responsibility for collecting data on local sources of flooding. Many of the flooding records are descriptive, incomplete, or not geographically referenced, and recording of the consequences is not clear. Therefore, incidences of flooding before this date may not have been recorded. However, it must be noted that a significant amount of data related to the 2007 summer floods exists within this data set. As previously mentioned, NCC now record flood data in a robust manner, following a set methodology and have responsibility to upload the data to Resilience Direct for other members of the Local Resilience Forum to view.

Information on the actual extent of past flooding and flow conveyance routes is available in some instances through the post flood investigative reports that have been undertaken primarily for Bassetlaw District Council, Newark and Sherwood District Council and Newark Area Internal Drainage Board. This information has already been considered where it exists through such detailed studies which in turn have made locally detailed recommendations for flood risk management actions and/or may have informed locally detailed flood modelling and mapping. Information from these studies has informed the collated flood history shown on Maps A-C.

Interactions between different sources of local flooding and between local sources and Main River sources are common and it is often difficult to determine exactly what source is responsible for any impact. Very little information is available on the probability of past flooding pre 2011 and estimating this can be problematic. This is because many incidents of flooding from local sources are the result of very heavy and localised rainfall, which is not always recorded up in the rain gauge network.

The pattern of past flooding that we have shown in the PFRA is intrinsically linked to availability of records of past flooding and record keeping amongst the different organisations. There has been a lack of record keeping from local sources of flooding pre 2011, except perhaps largely in the case of Ordinary Watercourses by our District and Borough Councils and Internal Drainage Boards. The detail and quantity of information available is linked to both the frequency of flooding, resources available to record collect, store and maintain information and the systems that have been historically used to store information. Much information is available as

"personal working knowledge". The past flooding data gives NCC as the LLFA important and useful information which is highlighted in Table 3.

Table 3. Information on past flooding.

Past flooding information	Comment
Where flooding has happened	Usually at a property level resolution but not always the exact location, especially as we go back further through the historical record.
When flooding happened	In most cases the exact date is recorded. Information on the duration of flooding is not well recorded. Information on the probability of flooding is rarer, although many with working experience will be able to provide an estimate of flooding frequency.
Why flooding has happened	The sources of flooding are sometimes noted but water often comes from multiple sources and assumptions about where the water has come from might have been made.
How flooding happened	Information on the mechanisms of flooding may be provided e.g. related to culverts or bridges. Information might also be available on work that has been undertaken since to alleviate flooding. In some cases flooding may have been due to a rare occurrence of circumstances and is unlikely to happen again.
What happened	Information on flood consequences is often missing or incomplete but where it is available is extremely useful as an actual observation of the impacts that flooding has had.

3.4.2 Future Flood Risk Estimation

Information on future flooding is largely based on predictive flood modelling techniques and whilst the hydraulic theory that sits behind these models has been the subject of much research over time, including that observed from physical models, a model is only ever a simplification of reality. The quality of the output from the model will only ever be as good as the quality of the data that goes into a model and the assumptions and decisions that have been made about the modelling. However, for strategic purposes models are the best way of estimating how flood risk might change in the future as a consequence of the effects of climate change.

The EA Surface Water Maps do not fully represent flooding which occurs from ordinary watercourses. Whilst in some instances, the ordinary watercourse is shown within the surface water flood map, in some instances buildings which are at risk during a 1 in 100 year event are not captured within the results.

Using a threshold of flood depth greater than 30cm could misrepresent flooding for some areas. For example, in some locations in Nottinghamshire, properties are set lower than the highway surface level. In this instance, using a threshold to indicate internal flooding of a depth greater than 30cm could mean those properties are not represented fully in the PFRA.

3.4.3 Data licensing, restrictions and security

Following the initial data collection in 2011, the collected data was used as a platform to develop a long-term data management approach. This covered the collection, storage and maintenance of flood related data and information within the County Council to support two way sharing of data and information with partners, both within and external to the County Council itself. To protect data from unauthorised use, change, copying or loss and cover Intellectual Property Rights, the vast majority of data that is used to inform flood risk management is shared under license agreements. Accordingly license agreements have been established as appropriate. In some instances, such agreements may limit the use of the information provided for the PFRA for further use.

The Data Protection Act 2018 is the UK's implementation of the General Data Protection Regulation (GDPR). The data collected and stored has been done so in line with this law. Much of the information on flooding is sensitive, particularly where this related to information on individual properties that have been affected for reasons of property blight. Predictive mapping for future flood events is reliant on the underlying assumptions and level of detail that any flood modelling study will necessarily take. Hence it is common to describe flooding locations by street or community and show flood mapping at a scale at which individual properties cannot be identified, especially where this is being used in a strategic context, such as to inform the PFRA.

4 Past flood risk

The number of years in which flooding has been recorded in a specific area between 1998 and 2022 is shown in Maps A and B, with both internal and highway flooding shown in Map A and records where internal flooding only is recorded shown in Map B. Results in Map A show that Worksop, Retford, Mansfield and Burton Joyce all have 11 or more years where flooding to either highway or property has been recorded. To examine the data further, Map B has been produced to show the number of years where internal flooding has been recorded in a property, and so removes the highway flooding data. Within this map, internal flooding has been recorded in six individual years within Worksop, Lowdham and Burton Joyce with five flood years recorded within Mansfield. Other notable areas highlighted in Map B include Retford, Newark on Trent, Balderton, Arnold, Bingham, Holme Pierrepoint, West Bridgford, and Gotham all of which have recorded flooding within 4 individual years.

Although these maps give an indication of previous flood risk, they do not assess the number of properties flooded during historic flood events. Map C has been created to assess the number of properties recorded as suffering internal flooding between 1998 and 2022. This map shows particularly high concentrations of recorded internal flooding within Worksop, Retford, Sutton on Trent, Lowdham, Gunthorpe and Arnold. Other notable areas with a high number of internal flood records per km^2 include Hucknall and Southwell which have both suffered major flood events historically.

Image: Business flooded in Sutton on Trent in 2018.

The Trent floodplain traces a line from northeast Nottingham to Newark and then north into North Lincolnshire. The data in Maps A, B and C shows a correlation between the Trent floodplain and historic flood records, which is expected due to the flood risk from fluvial events. This highlights the difficulties in separating out data from different sources of flooding especially during large fluvial flood events, such as 2000 and 2007, when there are complex interactions with local sources of flooding.

It must be acknowledged that the historic flooding maps have been created based on the availability of information, and so limitations to them exist as some floods will not have been

recorded or some property flooding may have not been captured. Additionally, as record keeping accuracy has improved since the first PFRA created in 2011, a skew in the data may exist as improvements in recording accuracy during more recent events means that a greater number of flood affected properties are correctly captured.

Figure 3 summarises the number of settlements that are known to have experienced internal flooding over different flood years. The figure demonstrates that the data is skewed in relation to the availability of information. A greater amount of information is available in recent years, due to increased accuracy and resolution in data capture since the creation of the first PFRA in 2011. This is demonstrated as the flood records for the year 2000 show that 25 settlements were recorded to have experienced internal flooding. The 2000 floods were a historic significant flood event, with Nottinghamshire suffering widespread and devastating flooding. However, Figure 3 shows that since 2011 when a new data collection system was introduced, the number of settlements experiencing internal flooding exceeded that recorded in the year 2000 in four years between 2011 and 2022. This may be due to the improved accuracy of data collection since 2011. A summary of past flooding recorded in Nottinghamshire is shown in Appendix A1.

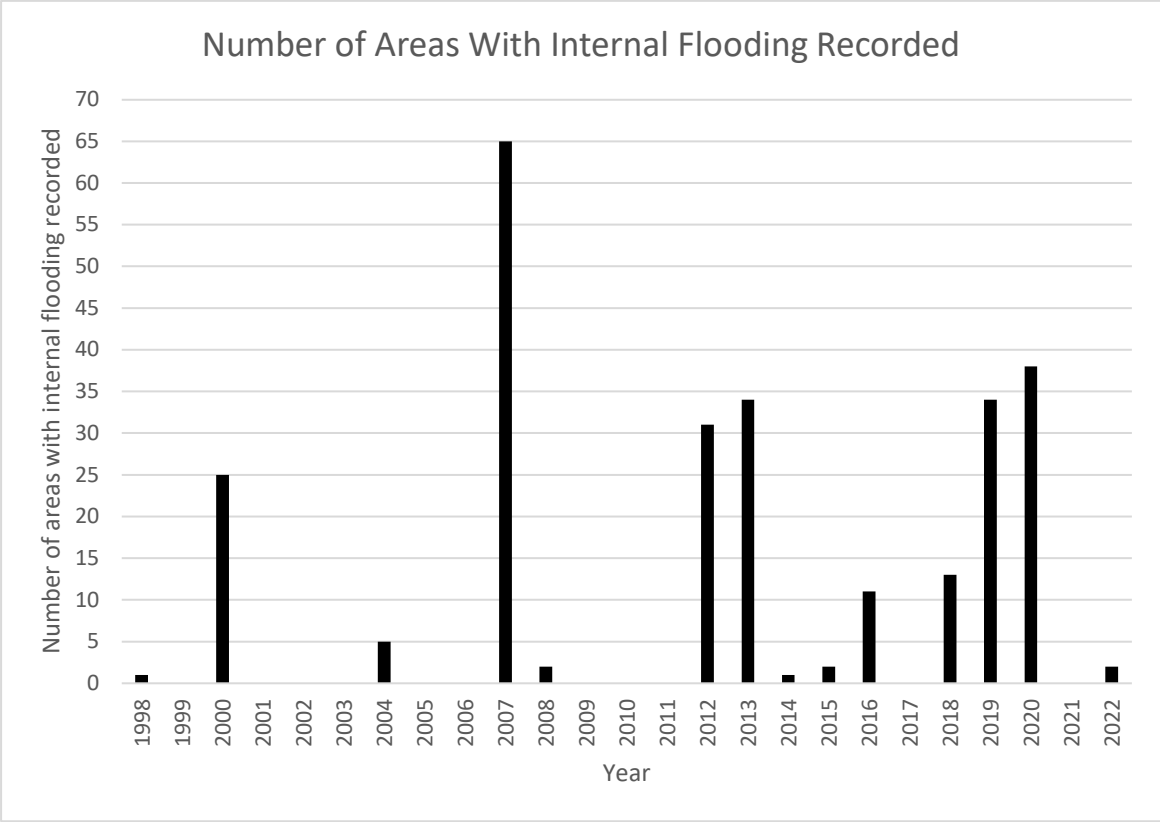

Figure 3. Graph showing influence of data availability on records of past flooding.

Whilst a substantial quantity of information has been collated for the purpose of preparing the PFRA this PAR only describes information that is considered to be relevant. It was not felt necessary or appropriate to reproduce the full details of past flooding information across the County for the purpose of the PFRA. It is our intention that all the information collected for the PFRA will feed forward and be used in the Local Flood Risk Management Strategy and will inform the other work NCC will undertake given our powers and duties as a LLFA as appropriate.

4.1 Surface water and Ordinary Watercourses

The District, Borough and IDB role in relation to land drainage and Ordinary Watercourses has in many cases encouraged relatively detailed records to be kept of flooding from local sources. Existing data shows that events which had the biggest impact on receptors occurred in June/ July 2007, July 2013 and Winter 2019/20.

Recorded flooding incidents originating from Ordinary Watercourses in the County have usually been caused by two types of rainfall event. The first being intense rainfall events, typically occurring in summer, leading to surface water runoff exceeding the capacity of local drainage, Ordinary Watercourses and associated structures such as culverts. This was evident in 2013 when high intensity rainfall fell within Nottinghamshire causing flooding to areas including Hucknall, Southwell, Calverton and Lowdham. More detail on these events can be found within the resultant Section 19 reports published by NCC online.

The second rainfall event type being longer duration storms, typically in winter, during which rainfall falls on already saturated ground causing overland flow generation. This was found to be a cause of flooding in Winter 2019/20 in areas such as Worksop, Retford and Lowdham. Again, more information can be found within the published Section 19 reports for these events.

Surface water flood events are usually caused by high intensity rainfall events falling onto an urban area during which the drainage systems become overwhelmed. During the 2013 event, this was found to be a source of flooding for some properties, but some interaction with ordinary watercourses was also observed. A more relevant example of such flooding is the Worksop 2022 flood event. During this event high intensity rainfall falling onto the urbanised catchment overwhelmed drainage systems and flooded over 100 properties. Investigation into this flood event found little interaction with watercourses with pluvial flooding being the main cause of flooding.

The River Witham CFMP (2008) reports that around 26% of flood records in the catchment are from surface water or sewers. It identifies the following surface water flooding mechanisms: surface water runoff and backing up of drainage systems, blockage of surface water drainage network or ditches during high rainfall and high rainfall or local groundwater levels causing ponding in low lying areas. It identifies parts of the Upper Witham catchment in Nottinghamshire as being at low risk of surface water flooding.

The River Trent CFMP (2010) reports that around 20% of flood records in the catchment are from surface water flooding. The CFMP notes that surface water flooding can be caused by rainfall runoff, insufficient drainage capacity in steeper upland areas, older urban areas with large impermeable areas and farming practises. It also recognises the potential for flooding when surface water is prevented from out falling into watercourses when there are high water levels. It recognises this as a problem downstream of Nottingham, where surface water needs to outfall through embankments into the River Trent. It also recognises that flooding from blocked culverts and screens is an issue in the CFMP area.

Summer 2007

The estimated number of properties flooded per District in summer 2007 is shown in Figure 4. The flooding affected residential properties, businesses, schools and local infrastructure including roads, electricity substations and sewage works. Access into many of the villages in Nottinghamshire was affected as roads were flooded and a police helicopter was used at North Leverton. A number of schools were severely damaged and there were a number of power failures.

The impact on the people of Nottinghamshire and local communities was immense and the flooding has been described as “the most significant natural disaster the Newark and Sherwood

District area has experienced since 1947" (Newark and Sherwood District Council, 2009). Beyond the immediate damage to properties, there have been harder to quantify consequences for human health, including trauma, worry and anxiety and economic impact to businesses both within and beyond flooded areas. It has been suggested that the rainfall for May, June and July had 0.6 – 0.5% AEP (175/200 year return period).

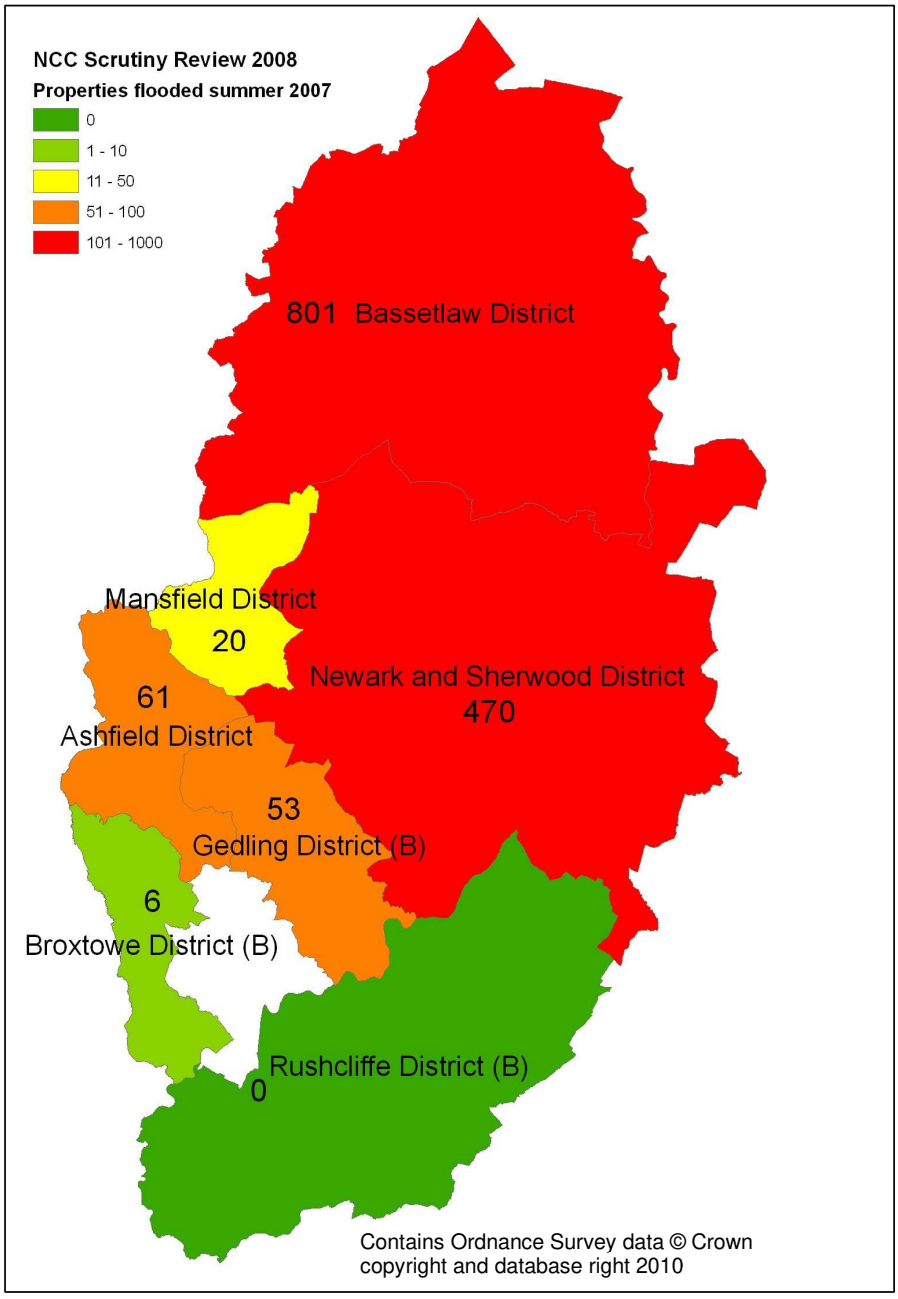

Figure 4. Properties flooded in summer 2007 by District/ Borough

It is interesting to observe the effect of flood history on the perception of the risk of flooding from surface water and local watercourses. The flooding of June 2007 did not cause any major flooding to the south of the County and yet it is known that flooding had a major impact in settlements to the south of the County in the early 1980"s. Had this PFRA been undertaken

then, it is likely that more detailed information on this flooding would have been readily available and this would show a different pattern of flooding. This perhaps highlights the difficulties in relying solely on past flooding information to inform the understanding of flood risk across the County.

July 2013

In July 2013, Hucknall, Southwell, Calverton, Lowdham, Eastwood and Thurgarton suffered flooding due to a high magnitude, low frequency flood event caused by high intensity rainfall as a result of a convective storm system over Nottinghamshire (Suri and Page, 2014). Rainfall readings from the Nottingham Trent University Casella tipping bucket rain gauge (located within the Brackenhurst campus on the outskirts of Southwell), recorded 107.6mm in 75 minutes. The intensity was such that 102.8mm of this fell within an hour. Due to the intensity of rainfall, affected settlements suffered significant damage with a large number of internal flood incidents recorded. In 2013, 1595 incidents of internal flooding were recorded within the database, many of these attributed to the July flood event.

Flood sources were combined, with urban drainage overwhelmed and large quantities of runoff originating from the catchments causing flooding as drainage systems could not cope. Due to the intensity of the rainfall, lag times were predicted to be short with little time for flood resilience to be realised before flooding impacts occurred. This flood event highlights the risk of short duration, high intensity rainfall in Nottinghamshire especially in catchments where clay soils and steep topography exacerbate runoff generation.

Image: Southwell flood July 2013.

Winter 2019/20

Over the 2019/20 winter period, Section 19 reports were published following internal flooding in Bingham, Cropwell Butler, East Markham, Egmanton, Gotham, Jacksdale, Lowdham, Radcliffe on Trent, Retford, Shireoaks, Sutton Bonington, Tollerton, Trowell, Woodborough and Worksop. During this period, a wet winter caused saturated ground which was then combined with heavy rainfall resulting in excessive amounts of runoff. This is attributed to the cause of flooding in many of the related Section 19 reports. Some areas, such as Retford, experienced internal flooding on two separate occasions during this winter.

Image: Worksop flood November 2019.

4.2 Groundwater

The historical data has little instance of groundwater flooding in Nottinghamshire, although this is likely to be due in part to groundwater flooding being disguised amongst other sources of flooding, including from Main Rivers, where it is likely to rise up through the gravels of the River Trent floodplain. The allocation of a source of flooding in our historical records has in many cases been based on assumptions and it is not clear whether the source has been correctly identified. It is understood that there are high groundwater levels in parts of the County, including Ashfield and groundwater flooding has been reported at Bleasby, Staythorpe and Egmanton in Newark and Sherwood. Groundwater and watercourse issues have also been identified at Hucknall where it is understood that PFR has been put on properties.

The Environment Agency PFRA Guidance identifies that groundwater rebound is an issue in Nottingham. The Draft Nottingham Surface Water Management Plan identifies that there are several spring fed watercourses in the City and that former tanning, bleaching, brewing, chemical, mining and lace-making industries made extensive use of groundwater held within the underlying sandstone. There is some evidence that ground water levels are recovering as extraction has stopped or is declining and the City Council has received reports of flooded basements and cellars that have historically been dry.

Groundwater flooding is not recognised in the River Trent CFMP as a significant problem across the entire CFMP area, apart from some local areas. The River Trent CFMP recognises flooding through alluvial gravels and sands "does occur within the main Trent valley where aggregate extraction is undertaken, causing occasional flooding in unexpected areas, but more generally just resulting in areas which routinely tend to become more waterlogged when river levels are high". The flood records for the River Witham CFMP only identify one groundwater flooding incident, which is not in Nottinghamshire.

Based on the evidence collected we consider that in future there will be a need to pay closer attention to the collection of data on groundwater and groundwater flooding.

4.3 Canals

The industrial legacy of Nottinghamshire means that there is a network of navigable or previously navigable waterways in the County that are largely now used for recreation purposes. Flooding from canals can be caused by overtopping from excess water entering the canal or breach of canal embankments. Waterways include the Erewash, Nottingham, Beeston, Grantham, Chesterfield and Nottingham Canals. The majority of these are managed and maintained by the Canal and Rivers Trust.

The Nottingham Canal is a Local Nature Reserve and is generally managed by Broxtowe Borough Council and advice from the Nottinghamshire Wildlife Trust.

4.4 Sewer flooding

The drainage network across the County is complex with assets explained in Table 4.

Table 4. Sewer asset types in Nottinghamshire.

Network	Ownership/ responsibility*	Comment
Private sewers draining properties and hardstanding	Landowner	
Highway gulley network designed to drain roads	Highways authority (County Council or Highways Agency)	In some cases this also drains contributing areas.
Sustainable Drainage Systems (SUDS)	Landowner/ management company/ local authority	
Surface water sewers that drain properties and roads	Water company where adopted, local authority, landowner, other	In some instances these may be considered to be culverted watercourses.
Foul sewers that take away waste water from properties	Water company where adopted	These have combined sewer overflows to watercourses to relieve pressure during storm events.
Combined surface water and foul sewers	Water company where adopted	Some other sewers are likely to act as defacto combined sewers due to misconnections.

The Flood Risk Regulations (2009) and the Flood and Water Management Act (2010) consider flooding from sewers where this is caused by "an increase in the volume of water (including snow and other precipitation) entering or otherwise affecting the system" and not failure e.g. pumping stations or blockage.

The water companies use the DG5 Register to prioritise spending on schemes to alleviate sewer flooding, which are taken forward into Business Planning (known as Price Reviews) and the Asset Management Plan (AMP) period 5 years cycles of investment (currently in AMP7 2020-2025). The water company maintain the DG5 Register as a live document. The DG5 Register is part of a larger register of all incidents, including those that are likely to occur less frequently and all those reported to them (including where the source of flooding may not be sewer related). It is important to note that the DG5 is a record of flooding that has happened and not properties at risk of sewer flooding. It is also not a record of all past flood incidents related to sewer flooding reported to the water company because properties are removed if a flood alleviation scheme has been completed.

There is limited information that is readily and consistently available on the capacity of the sewer network across the County. The causes of flooding in Nottinghamshire are inter-related and in many cases sewer flooding will only be part of the picture. Such flooding may be caused by high water levels in receiving watercourses preventing water outfalling from the network and/ or excess surface water flowing overland entering the sewer network and causing it to surcharge. Ownership issues compound this and there are instances where the drainage network has been identified as problematic, but ownership cannot be easily ascertained.

4.5 Significant harmful consequences

The Flood Risk Regulations (2009) require us to identify if there has been flooding from local sources in Nottinghamshire that has had significant harmful consequences to human health, economic activity or the environment (including cultural heritage) and might have significant harmful consequences if they were to occur again.

Previously within the 2011 PFRA and the 2017 Nottinghamshire PFRA review, events which had significant harmful consequences were defined as those which had significant consequences of the scale that had registered on a national scale. However, as Nottinghamshire has previously suffered from localised intense rainfall events which did not register at a national scale, it was considered that his definition was no longer reflective of significant harmful consequences.

For the purposes of the Nottinghamshire PFRA 2023, an event occurring after 2011 with significant harmful consequences is defined as being an event during which a major incident was declared. Flood events during which a Major incident was declared are shown in Table 5.

A major incident is defined thus:

An event or situation, with a range of serious consequences, which requires special arrangements to be implemented by one or more emergency responder agencies.

Notes:

a) 'Emergency responder agencies' describes all Category 1 and 2 responders as defined in the Civil Contingencies Act (2004) and associated guidance.

b) A major incident is beyond the scope of business-as-usual operations, and is likely to involve serious harm, damage, disruption or risk to human life or welfare, essential services, the environment or national security.
c) A major incident may involve a single-agency response, although it is more likely to require a multi-agency response, which may be in the form of multi-agency support to a lead responder.
d) The severity of consequences associated with a major incident are likely to constrain or complicate the ability of responders to resource and manage the incident, although a major incident is unlikely to affect all responders equally.
e) The decision to declare a major incident will always be a judgement made in a specific local and operational context, and there are no precise and universal thresholds or triggers. Where LRFs and responders have explored these criteria in the local context and ahead of time, decision makers will be better informed and more confident in making that judgement.

Table 5. Summary of past flooding with significant harmful consequences in Nottinghamshire.

Date	Location	Major incident declared?	Comments
July 2013	Eastwood, Hucknall, Lowdham, Southwell, Thurgarton	Yes	High intensity summer rainfall event with localised impacts caused by surface water and ordinary watercourse flooding.
November 2019	Bingham, Egmanton, Lowdham, Gotham, Jacksdale, Rhodesia, Retford, Shireoaks, Tollerton, Worksop	Yes	Prolonged winter rainfall event with increased runoff due to saturated ground.
February 2020	Bingham, Cotgrave, East Markham, Lowdham, Gotham, Radcliffe on Trent, Sutton Bonnington, Tollerton, Trowell, Woodborough	Yes	Prolonged winter rainfall event with increased runoff due to saturated ground.

5 Future flood risk

5.1 Introduction

Future flood risk has been predicted within the PFRA using GIS methods and modelling data developed by the Environment Agency. Data from previous flood records has also been used within the assessment. It is predicted that the severity and frequency of flooding will increase as a consequence of climate change. Intense rainfall events are expected to be experienced more frequently during the Summer and prolonged heavier rainfall events during the Winter. Accordingly, there is a need to estimate possible impacts of flooding in the future so that NCC can develop strategies and deliver projects to mitigate flood risk for vulnerable communities. The information derived from this assessment will also help NCC to take a proactive approach to how it manages flood risk.

5.2 Surface water and Ordinary Watercourses

The Surface Water Flood Risk Mapping Information has been analysed to assess the consequences of surface water flooding on receptors (human health, economic activity, environment and cultural heritage). A number of maps have been produced that show the distribution of flood consequences across the County, based on the Locally Agreed Surface Water Information.

Key messages that these maps show:

- Map E: **Number of people at risk from flooding**. People that could be affected are distributed across the County and concentrated in the urban centres of Worksop, Retford, Mansfield, Newark-on-Trent, Collingham, Sutton-in-Ashfield, Hucknall, Arnold, Carlton, Netherfield, Beeston, Stapleford and West Bridgford. The map highlights that many villages in rural areas are vulnerable to flooding.
- Map F: **The number of properties at risk of flooding**. This map shows the total number of properties at risk of flooding (residential and non-residential). It therefore does not split residential and commercial properties. Areas of Worksop, Mansfield, Sutton in Ashfield, Arnold, Calverton, Carlton, Netherfield, Stapleford and Beeston are found to have high concentrations of properties at risk.
- Map G: **The number of residential properties at risk from flooding**. Concentrations of residential properties at risk reflect findings in Map F. This map displays residential properties at risk and so gives additional detail to Map F.
- Map H: **The number of commercial properties at risk from flooding**. This map displays commercial properties at risk and so gives additional detail to Map F. Notable areas with higher concentration of Commercial properties at risk include Worksop, Mansfield, Sutton on Trent, Newark on Trent, Arnold and Calverton. The consequences of flooding to business in rural areas could have more wide-ranging consequences than in the larger urban areas, where for example alternative shops, pubs and doctors' surgeries are some distance away.
- Map I: **The number of critical services at risk from flooding**. The number of critical services at risk is particularly dense around Sturton le Steeple, Worksop, Mansfield, Sutton on Trent, Arnold, Carlton, West Bridgford and Keyworth. Where there are such high concentrations, the consequences of surface water flooding are likely to be particularly severe and disruptive to that locality.

- Map J: **Comparison of historic internal floods and properties at risk of flooding**. This map overlays the number of properties at risk of future flooding over the number of properties historically flooded. Therefore, grid squares which are blue are areas which have been previously flooded but have not been identified as at risk from future flooding. As the future flood risk predictions only take into consideration flooding from local sources, it is reasonable that areas along the Trent Corridor, which is a Main River, have not been identified as at risk as part of this study even though they have experienced historic flooding. However, some areas around Worksop, Whatton, Tollerton, Costock, Cotgrave and Gotham have previously experienced flooding although they do not have a significant predicted future flood risk. For this reason, historic data should be combined with predicted data in these areas to build a more accurate picture of flood risk.
- Map K: **Environmental sites that could be affected by** flooding are distributed across the County. It should be borne in mind that flooding can have both a positive or negative effect on the condition of conservation sites and that some habitats, such as wetlands might benefit from frequent flooding.
- Map L: **Cultural heritage sites that could be affected by flooding** are distributed across the County, with a particular concentration around Mansfield and Southwell.

5.3 Groundwater

The geology across the County varies and areas with more porous/permeable geology, notably sandstone and limestone, have more potential to store groundwater. In such areas fluctuating groundwater levels are more likely to give rise to ephemeral spring fed watercourses. In other areas underlain by less porous clay, the geology has less potential to store water. This is complicated by overlying drift geology, related to deposits from the last ice age and by the River Trent and tributaries as they have meandered over the floodplain over time, eroding and depositing material and through periodic flooding. Water travels easily though river gravels and groundwater levels are often closer to the surface in river valleys. Flooding on the floodplain of larger river systems is often related to groundwater before water flows overland after the river overtops its banks.

Future flooding from groundwater is indicated by the National Areas Susceptible to Groundwater Flooding data, which is shown on Map M. The map shows the risk of groundwater emergence as a percentage for each 1km square. Particular susceptibility is related to the floodplain of the River Trent as it passes through Nottingham, north eastwards to Newark-on-Trent and then north towards the Humber Estuary. Areas around Carlton-in Lindrick, Rhodesia, Market Warsop, Hucknall, Gotham and Bunny also show a higher susceptibility. However, it should be noted that this does not consider all the forms of groundwater flooding to which the County is vulnerable and in particular groundwater rebound following cessation of industrial extraction.

This map is not intended to be used to identify actual areas where groundwater might flow or pond and it is not sensible to attempt to analyse this data for the number of properties at risk, as not all the properties in each 1km square will be susceptible and there is no probability information attached to this data.

The Environment Agency guidance suggests that “unless an area identified as “susceptible to groundwater flooding" is also identified as “at risk from surface water flooding", it is unlikely that this location would actually experience groundwater flooding to any appreciable depth, and therefore it is also unlikely that the consequences of such flooding would be significant.” We

recognise that there are potentially several mechanisms that may cause groundwater flooding in the County, largely related to flooding through alluvial gravels, particularly on the floodplain of the River Trent, the underlying geology and groundwater rebound following cessation of industrial extraction. NCC will assess the local flood risk from groundwater flooding in more detail as appropriate as part of our Local Flood Risk Management Strategy.

5.4 Canals

Bassetlaw District Council have modelled the effect of a breaches in the Chesterfield Canal in Worksop and Retford in their Strategic Flood Risk Assessment. The SFRA notes that 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". The results therefore do not provide a complete picture of areas that could be affected by a breach in the Chesterfield Canal across the District and the volume of water is related to the capacity of the canal in those locations. In addition, such flooding can be considered to a residual risk, rather than overtopping of the canal network, which may be related to inflows from watercourses during flood conditions. Therefore, although the information is of value we have not used it as part of our PFRA review.

5.5 Sewer flooding

No predictive information is available on future flood risk from sewer flooding at this time. Information regarding potential flooding is assessed by Severn Trent Water Ltd.

5.6 Climate change

5.6.1 UKCP18 predictions for the East Midlands

Climate projections using UKCP18 data provided by the Met Office is available for the East Midlands for the years 2050 and 2080. Table 7 shows the median projections under a RCP 4.5 and RCP 6.0 emissions scenario. Further detail including the range of results produced by UKCP18 is available on the Met Office website.

Table 6. UKCP18 RCP 4.5 and 6.0 projections for the East Midlands.

	RCP 4.5		RCP 6.0	
	2050s	2080s	2050s	2080s
Summer mean precipitation change (%)	-14	-23	-13	-27
Winter mean precipitation change (%)	+7	+12	+6	+14
Mean temperature summer (˚C)	+1.9	+3.2	+1.8	+3.7
Mean temperature winter (˚C)	+1.4	+2	+2.4	+4

The data suggests that winter rainfall is likely to increase, which may increase the likelihood of prolonged winter rainfall and resultant flooding events. Although summer mean precipitation is predicted to be lower in the future, higher temperatures in summer may trigger more convective

thunderstorms, which are more likely to cause flooding from surface water and on smaller watercourses. Furthermore, higher summer temperatures could result in the crusting of clay soils which has been a contributing factor to summer floods in some Nottinghamshire catchments.

5.6.2 Corporate Environment Policy Statement and Corporate Environment Strategy

Nottinghamshire County Council approved its Corporate Environment Policy Statement and Corporate Environment Strategy in March 2020. These documents set out the Council's commitment to protecting and enhancing the environment. The Council declared a climate emergency in May 2021, furthering the commitment to delivering on these actions to tackle climate change and ensure Nottinghamshire has a greener future. The environment is also a key theme within The Nottinghamshire Plan.

5.6.3 Implications for Flood Risk

Climate changes can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability. Wetter winters and more prolonged rainfall falling on saturated soils may increase river flooding. Intense rainfall causes more surface runoff, increasing localised flooding and erosion. In turn, this may increase pressure on drains, sewers and water quality.

NCC have committed to the use of sustainable FRM methods which can help to mitigate against the impacts of climate change. Promoting sustainable development and SUDS, which considers the impacts of future climate change, helps us adapt and manage the risk of floods in the future. Combining engineered FRM measures with NFM measures ensures that a more sustainable approach is taken and wider benefits beyond flood risk reduction are realised.

5.7 Planning Policy and Future Flood Risk

It is possible that long term developments might affect the occurrence and significance of flooding. However current planning policy aims to prevent new development from increasing flood risk.

In England, Planning Policy Statement 25 (PPS25) focuses on positive planning at all levels to deliver appropriate sustainable development. The aim of the policies for managing flood risk through the planning system is to avoid inappropriate development in flood risk areas. The key message of PPS25 is to avoid such inappropriate development and to locate away from flood risk whenever possible. The approach it adopts to do this is to assess risk so it can be avoided and managed.

PPS25 requires that LPA's prepare Strategic Flood Risk Assessments to an appropriate level of detail to allow the Sequential Test to be applied in the site allocation process. This is an essential part of the pre-production/evidence gathering stage of the plan preparation process. This process ensures that future flood risk is taken into account when assessing the viability of future development.

Adherence to Government policy ensures that new development does not increase local flood risk. However, in exceptional circumstances the Local Planning Authority may accept that flood risk can be increased contrary to Government policy, usually because of the wider benefits of a new or proposed major development. Any exceptions would not be expected to increase risk to levels which are "significant" (in terms of the Government's criteria).

6 Identification of Flood Risk Areas

6.1 National assessment

Using the assessment method that has been applied, no areas in Nottinghamshire were identified as meeting the national thresholds to be classed as a Flood Risk Area. We have used the evidence in this report to review the indicative Flood Risk Areas, in terms of whether there should be Flood Risk Area(s) in Nottinghamshire.

The national thresholds for significance are:

- 30,000 people.
- 150 critical services (nominal, number of people is deciding threshold for indicative Flood Risk Areas).
- 3,000 non-residential properties (nominal, number of people is deciding threshold for indicative Flood Risk Areas).

6.2 County wide assessment

6.2.1 Past flooding

The flooding of 2000 and 2007 is best represented in the historical record and clearly highlights how significant flooding can be to residents of Nottinghamshire. Since 2011, the availability and accuracy of data has improved. It has been highlighted that the definition of significant harmful consequences required revision following localised harmful events. For this reason, the definition of events post 2011 during which significant harmful consequences occurred has changed to events at which a Major Incident was declared. Flood events during which a Major Incident was declared were July 2013, November 2019 and February 2020.

The historic flood data has shown that several of Nottinghamshire's villages and parts of urban areas have been affected repeatedly by flooding, during which a Major Incident was not declared. For such areas, NCC intend to work closely with partner organisations, such as the Environment Agency, Districts and Boroughs, IDBs and Water Companies to effectively manage the risk and explore appropriate responses further. NCC will take a holistic approach in these areas, for which Flood Hazard and Risk Mapping and producing Flood Risk Management Plans would not be likely to be appropriate or proportional responses to the flood risk.

6.2.2 Future flooding: Possible harmful consequences to people, property and critical services

For the purpose of the PFRA, the EA Surface Water Flood Depth data for 1 in 100 year events greater than 30cm depth was used to identify buildings which were deemed at risk of flooding. Nottinghamshire was spilt into a grid of 1km^2 squares and points (at risk properties) per polygon were counted using GIS tools to display areas at risk of flooding and assess the potential for future harmful consequences.

The thresholds used for this analysis are the same as the national analysis and are reflected in predicted flood risk map outputs:

- Number of people at risk ≥ 200
- Number of Critical Services at Risk ≥ 1
- Number of Non-Residential Properties at Risk ≥ 20

For completeness we have compared our past flooding summary map with the places where flood risk has been identified as a comparison between places where the consequences of flooding in the future might be highest and those settlements that have flooded in the past on Map J. This map should be treated with caution due to the reasons outlined in Chapters 3 and 4 regarding the limitations of the data presented. It shows that several of the settlements that have been affected by flooding in Nottinghamshire do not cross the thresholds that have been used nationally to identify places where flood risk is an issue. However, this may be due to the assessment methodology not assessing the risk of Main River flooding, as can be seen by historic flood records within the Trent corridor not being comparable to future flood risk predictions.

A cluster analysis has been carried out to identify clusters of places where flood risk is an issue. The clusters contain 5 or more touching 1km grid squares that cross the threshold above. There are four clusters in Nottinghamshire as shown in Map M. These cover Worksop, the surrounds of Mansfield (covering Mansfield, Mansfield Woodhouse, Sutton-in-Ashfield and the north of Kirkby-in Ashfield), Arnold and Carlton.

These areas have not been considered further as a Flood Risk Area because they are notably below the national significance thresholds in terms of the number of people affected. NCC will address local flood risk as appropriate in the Local Flood Risk Management Strategy.

7 Next steps

7.1 Flood Risk Regulations (2009)

The PFRA has not identified any Flood Risk Areas and so it will not be necessary to undertake Flood Risk and Hazard Mapping or prepare a Flood Risk Management Plan.

As the LLFA, NCC will need to repeat the process of preparing a PFRA and identifying Flood Risk Areas for submission in 2029, as part of a six-year cycle. To inform the next round of Preliminary Flood Risk Assessment, the Local Flood Risk Management Strategy and our duty to Investigate flood incidents, NCC will continue to record data on flood incidents in Nottinghamshire to maintain our current database whilst looking to improve the ways in which data is collected. NCC has taken on the lead for data collection on flood incidents for the Local Resilience Forum meaning that data will be shared between RMA's and collated by NCC.

7.2 Working to reduce flood risk for residents of Nottinghamshire

The NCC FRM team continue to work towards the objectives set out within the Local Flood Risk Management Strategy with an aim to reduce flood risk for vulnerable residents. To date, the NCC FRM team has secured and supported external funding of over £120m towards flood alleviation schemes across the County and will continue to seek external funding opportunities wherever possible.

New and innovative approaches are being implemented within FRM schemes including NFM measures which temporality store water within the upper catchment and SUDS measures which capture surface water within the urban settings. Combining these measures with engineered FRM schemes shows that NCC take a catchment wide, holistic approach to flood risk management within Nottinghamshire.

Community resilience to flooding will continue to be built upon to ensure that those at risk of flooding are prepared. Through schemes such as our school's education programme and the Community Flood Signage Scheme, which allows trained members of the community to close roads during flood events, NCC continues to empower residents to act in the interest of their community during flood events.

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Appendix A: Information available for the PFRA

A1. Historic flooding information

Organisation(s)	Information provided	
County Council	Highways	• Highways drainage assets – Bridges and culverts and database of those with flooding issues • Critical services used to inform winter maintenance work • Community Flood Action Groups • Known schemes since flooding of 2007 • Flood photos • Flood related Customer Contact Centre calls Gulley Emptying policy/ hotspots/ general information • Report on climate change impacts on highways Parish, Town Council and Elected Member survey of drainage hotspots
	Emergency Planning	• COMAH sites • Humanitarian Centres • Rest Centres • Designated Filling Stations • Pipelines
	Sustainability and climate change	• Local Climate Impacts Profile and spreadsheet East Midlands Climate Change Predictions
	Waste and Minerals	• Strategic Flood Risk Assessment not made available in project timescales
	General GIS	• Including OS Mastermap, Local Land and Property Gazetteer, that related to Highways, Schools, roads, railways, environmental and cultural heritage sites
District and Borough Councils*		• Assets • List of properties that applied for grants following flooding • Flood related Customer Contact centre calls • Outline, Scoping and/ or Detailed Water Cycle • Studies • Level 1 and potentially Level 2 Strategic Flood Risk Assessment(s) • Flood feasibility reports and studies

Organisation(s)	Information provided	
		• Historic flooding locations e.g. from 2007 • Site specific Flood Risk Assessments done for Councils • Post flood reports including Overview and Scrutiny • List of problem areas and estimated costs of solutions • Survey of drainage hotspots
Environment Agency		• River Witham Catchment Flood Management Plan • River Trent Catchment Flood Management Plan • Fluvial Trent Strategy • Greater Nottingham SFRA • Flood Map and Main Rivers • Detailed River Network • Areas Susceptible to Surface Water Flooding • National Receptor Dataset • Flood Map for Surface Water • Areas Susceptible to Groundwater Flooding • Indicative Flood Risk Areas • Historic Flood Map • PFRA data CD
Severn Trent Water Ltd		• DG5 Register
Internal Drainage Boards*		• Internal Drainage districts • Assets • Flooding records/ incidents (may be in Engineers • Reports) • Flood feasibility reports and studies
British Waterways		• Asset and flooding information
Nottinghamshire Fire and Rescue Service		• Flooding incidents
Highways Agency (A1 Plus)		• Flooding locations

Organisation(s)	Information provided	
Nottingham City Council		• Nottingham Surface Water Management Plan Draft

This table shows data provided, some of which has been deferred for use in the Local Flood Risk Management Strategy, as appropriate
* Not all these datasets were provided by all our Districts and Boroughs or IDBs

A2 Data used to inform future flood risk predictions

Mapping product	Coverage	Comment
Areas Susceptible to Surface Water Flooding	National	The first generation product released by the Environment Agency. This dataset was used in the first PFRA report (2011). Shows areas that may be affected by surface water flooding. Is based on a bare earth ground model and does not take into account the effect of drainage systems. The modelling is based on a two dimensional ground model that routes water over the surface. Following the principle of „topography rules" water will collect along natural valleys and depressions. Hence whilst such mapping primarily shows where surface water flooding might happen, it can also show locations where flooding from Ordinary Watercourses and groundwater might occur. Mapping is not suitable for identifying individual properties themselves that could flood.
Flood Map for Surface Water	National	The second generation product released by the Environment Agency. This data was used to inform the 2023 PFRA review. Shows areas that may be affected by surface water flooding. Is based on a ground model that includes buildings and does take into account the effect of drainage systems. The modelling is based on a two dimensional ground model that routes water over the surface. Following the principle of „topography rules" water will collect along natural valleys and depressions. Hence whilst such mapping primarily shows where surface water flooding might happen, it can also show locations where flooding from Ordinary Watercourses and groundwater might occur. Mapping is not suitable for identifying individual properties themselves that could flood.

Mapping product	Coverage	Comment
Areas Susceptible to Groundwater Flooding	National	Broadscale mapping shows groundwater flood areas on a 1km^2 grid. Shows areas that might be susceptible to flooding from consolidated aquifers e.g. chalk, sandstone and permeable superficial deposits. Does not show areas that might be affected specifically by groundwater rebound.
Flood Map for rivers and the sea	National	Shows areas that could be affected by flooding from watercourses and the sea. Flood Zones are compatible with Planning Policy Statement 25 and show the undefended case for Flood Zone 3 (1% AEP) and Flood Zone 2 (0.1% AEP). Also contains flood storage areas, raised defences and areas benefiting from major defences. Can be viewed on the Environment Agency website.
GIS analysis of the likelihood of surface water flooding undertaken for the River Witham CFMP	Local	The GIS analysis "provides an assessment of the likelihood of surface water flooding relative to other parts of the catchment. The results give a broad picture and do not necessarily mean that a specific area will experience flooding." The assessment only covers the part of Nottinghamshire that is in the Witham CFMP area. The mapping identifies parts of the Upper Witham catchment in Nottinghamshire as being at low risk of surface water flooding.
Analysis of the risk for groundwater flooding undertaken for the River Witham CFMP	Local	The assessment used the Defra "groundwater emergence zones" "along with physical, hydrological and environmental data sets to establish the broad level of risk across the CFMP area for groundwater flooding". The assessment only covers the part of Nottinghamshire that is in the Witham CFMP area. The mapping identifies parts of the Upper Witham catchment in Nottinghamshire as being at low risk of groundwater flooding.
Local studies undertaken for Newark and Sherwood District Council, Bassetlaw District Council and Newark Area IDB	Local	Information on modelled flood levels, extents and/ or the actual extent of past flooding and flow conveyance routes is available in some instances through the post flood investigative reports. This information has already been considered where it exists through such detailed studies which in turn have made locally detailed recommendations for flood risk management actions. It is noted that such detailed studies are highly reliant on the input data available for any modelling that takes place and also that techniques for flood estimate and modelling have changed over time.
District and Borough Council SFRA	Local	Reports created by district and Borough Councils to inform FRM in the area.

Appendix B: Summary of Past Flooding in Nottinghamshire

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Significant harmful consequences?	Comments
Unknown	Elston	Ordinary Watercourse	6	Newark and Sherwood DC: Elston Flood Assessment report		Date of flooding is unknown
1983	Clarborough	Ordinary Watercourse	2	Bassetlaw DC: Hydraulic Catchment Studies (Clarborough)		
1998	Whatton and Aslockton	River Smite (now Main River at Whatton and Aslockton)	Approximately 80	Newark Area IDB: Whatton and Aslockton Flood Study Easter 1998 floods report		Estimated probability
2000	Attenborough, Averham, Beckingham, Besthorpe, Bleasby, Burton Joyce, Carlton-On-Trent, Caythorpe, Collingham, East Stoke, Edwinstowe, Farndon, Fiskerton, Girton, Grassthorpe, Gunthorpe, High Marnham, Holme, Hoveringham, Kelham, Laneham, Littleborough, Lowdham, Morton, Newark On Trent, North Clifton, South Muskham, Staythorpe, Stoke Bardolph, Walkeringham, Winthorpe	Main River, Ordinary Watercourse, Surface runoff	318	Newark and Sherwood DC, LCLIP media database	Yes	The estimated number of flooded properties varies depending on source

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Significant harmful consequences?	Comments
2004	Balderton, Beckingham, Bingham, Carlton-On-Trent, Collingham, Edingley, Newark On Trent, Stapleford, Worksop	Surface runoff	11	Newark and Sherwood DC, LCLIP media database		Source of flooding is based upon what was recorded – there may have been other sources not recorded
2007	Annesley Woodhouse, Bagthorpe, Balderton, Beckingham, Bilsthorpe, Bingham, Bircotes, Bleasby, Blidworth, Brinsley, Bulcote, Burton Joyce, Calverton, Carlton-On-Trent, Carlton In Lindrick, Caunton, Clarborough, Clayworth, Coddington, Colston Bassett, Cromwell, Cuckney, East Drayton, East Markham, East Stoke, Edingley, Edwinstowe, Egmanton, Epperstone, Fackley, Farndon, Fiskerton, Gamston, Gringley on the Hill, Halam, Harworth, Headon, Hockerton, Hucknall, Huthwaite, Jacksdale, Kelham, Kirkby in Ashfield, Kirklington, Lambley, Langold, Laxton, Little Carlton, Lound, Lowdham, Mansfield, Market Worksop, Milton, Moorhouse, Newark On Trent, Normanton on Trent, North Leverton, North Wheatley, Norwell, Oldcotes, Ollerton, Ompton, Oxton, Pleasley, Radcliffe on Trent, Ragnall, Rampton, Ranskill, Retford, Rhodesia, Rockley, Rolleston, Ruddington, Selston, Shireoaks, Skegby, South Clifton, South Leverton, Southwell, Stanley, Staythorpe, Sturton le Steeple, Sutton in Ashfield, Sutton On Trent, Syerston, Teversal, Thurgarton, Treswell, Trowell, Tuxford, Underwood, Walkeringham, Weston, Whaley Thorns, Woodborough, Worksop	Main River, Ordinary Watercourse, Surface runoff	1,411	Ashfield DC, Bassetlaw DC, Mansfield DC, Newark and Sherwood DC, Newark Area IDB, LCLIP media database, Upper Witham IDB	Yes	The estimated number of flooded properties varies depending on source

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Significant harmful consequences?	Comments
2008	Carlton, Clarborough, Clayworth, Eaton, Gunthorpe, Harworth, Hayton, Lambley, Mansfield, Oldcotes, Retford, Sutton, West Stockwith, Wiseton, Worksop	Main River, Ordinary Watercourse, Surface runoff	2	Gaite Group of IDBs, LCLIP media database		Numbers of flooded properties for the majority of settlements affected were not included in records or records referred to "several properties" rather than exact numbers
2012	Arnold, Aslockton, Bingham, Burton Joyce, Calverton, Carlton, Carlton on Trent, Colwick, Costock, Cropwell Butler, East Leake, Edngley, Edwalton, Girton, Gotham, Keyworth, Kimberley, Lowdham, Mansfield, Netherifeld, North Wheatley, Rempstone, Rolleston, Stanford on Soar, Sutton Bonnington, Sutton in Ashfield, Syerston, Tollerton, West Bridgford, Woodborough, Worksop	Main River, Ordinary Watercourse, Surface runoff	72	NCC Flooding History Database		
2013	Arnold, Bingham, Blidworth, Burton Joyce, Calverton, Carlton, Caythorpe, Coddington, East Bridgford, Eastwood, Elton, Farnsfield, Fiskerton, Gedling, Hucknall, Kimberly, Lowdham, Mapperley, Netherfield, Newark on Trent, Newthorpe, Nuthall, Ollerton, Owthorpe, Oxton, Papplewick, Radcliffe on Trent, Ravenshead, Southwell, Sutton in Ashfield, Thurgaton, Trwoell, Wtnall, Woodthorpe	Main River, Ordinary Watercourse, Surface runoff	428	NCC Flooding History Database	Yes	

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Significant harmful consequences?	Comments
2014	Mansfield	Surface runoff	1	NCC Flooding History Database		
2015	Mansfield, Worksop	Surface runoff	2	NCC Flooding History Database		
2016	Balderton, Burton Joyce, Carlton, Gotham, Mansfield, Rainworth, Shireoaks, Sutton Bonnington, Thoroton, west Bridgford	Ordinary Watercourse, Surface runoff	50	NCC Flooding History Database		
2018	Arnold, Bramcote, Clarborough, Edwalton, Hucknall, Mapperley, Mapperley Plains, Normanton on Soar, Radcliffe on Trent, Retford, Southwell, Sutton in Ashfield, Sutton on Trent, Willoughby on the Wolds	Ordinary Watercourse, Surface runoff	53	NCC Flooding History Database		
2019	Arnold, Balderton, Beckingham, Bingham, Bircotes, Bulcote, Burton Joyce, Church Laneham, Clarborough, Collingham, Cossall, Costock, Cropwell Bishop, Darlton, East Leake, East Markham, Eaton, Egmanton, Gateford, Gotham, Jacksdale, Kimberley, Laneham, Lowdham, Mansfield, Mission, Mooregreen, Newton, Normanton on Trent, North Wheatley, Norwell, Radclifee on Trent, Ragnall, Retford, Rhodesia, Ruddington, Scrooby,	Main River, Ordinary Watercourse, Surface runoff	526	NCC Flooding History Database	Yes	

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Significant harmful consequences?	Comments
	Shireoaks, South Wheatley, Sutton Bonnington, Tollerton, Walkeringham, West Bridgford, Weston, Woodthorpe, Workop					
2020	Awsworth, Beeston, Bingham. Bramcote, Burton Joyce, Chilwell, Colston Bassett, Colwick, Cotgrave, Cropwell Butler, East Leake, Eastwood, Edwalton, Gedling, Gotham. Hucknall, Kirkby in Ashfield, Lambley, Linby, Lowdham, Ollerton, Orston, Plumtree, Radcliffe on Trent, Redhill, Rempstone, Retford, Ruddington, Stapleford, Sutton Bonnington, Tollerton, Toton, Trowell, West Bridgford, Widmerpool, Woodboorugh, Worksop	Main River, Ordinary Watercourse, Surface runoff	375	NCC Flooding History Database		
2022	Worksop	Surface runoff	108	NCC Flooding History Database		

*Events only included where there is reasonable information on flood consequences. The number of properties is intended to serve as an indication only.

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