Lichfield District Council Level 2 Strategic Flood Risk Assessment

Final Report

January 2018

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Contract

This report describes work commissioned by Ashley Baldwin, on behalf of Lichfield District Council, by an email dated 27th October 2017. Joanne Chillingworth and Roberta Whittaker of JBA Consulting carried out this work.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to Lichfield District Council.

Acknowledgements

We would like to acknowledge the assistance of:

- Lichfield District Council;
- Staffordshire County Council;
- Environment Agency;
- Severn Trent Water; and
- Canal and River Trust.

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Executive Summary

Introduction and Context

This Level 2 Strategic Flood Risk Assessment (SFRA) 2017 document undertakes a Level 2 assessment of the three sites identified for potential allocation by Lichfield District Council. It builds upon the Level 1 SFRA (2014) for Lichfield originally published by South Staffordshire, Cannock Chase, Lichfield and Stafford.

It involves the site-specific assessment for new proposed development sites required as part of the process of exploring the potential of non-strategic sites to accommodate growth in the emerging District Local Plan. This 2017 Level 2 SFRA has updated information on any policy and legislation since the 2014 Level 1 SFRA was published.

SFRA objectives

The Planning Practice Guidance advocates a tiered approach to risk assessment and identifies the following two levels of SFRA:

- Level One: where flooding is not a major issue in relation to potential development sites and where development pressures are low. The assessment should be sufficiently detailed to allow application of the Sequential Test.
- Level Two: where land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development creating the need to apply the NPPF's Exception Test. In these circumstances, the assessment should consider the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

The objectives of this Level 2 SFRA update are to:

1. Provide individual flood risk analysis for potential development sites using the latest available flood risk data, thereby assisting the Council in applying the Exception Tests to its proposed site allocations in preparation of its Local Plan.
2. Where available re-run existing hydraulic modelling to account for the effects of climate change and any residual risk. Where flood risk information is unavailable or limited, conduct appropriate hydraulic modelling where possible to determine the flood risks to the proposed development sites.
3. Using available data, provide information and a comprehensive set of maps presenting flood risk from all sources for each proposed development site.
4. Where the Exception Test is required provide recommendations for making the site safe throughout its lifetime.
5. Take into account most recent policy and legislation in the NPPF, PPG, and other relevant documents. Using these documents provided, updating information on the requirements for site-specific FRAs, considerations for suitable surface water management methods and opportunities to reduce flood risk to the existing communities.

Level 2 SFRA outputs

The Level Two assessment includes detailed assessments of the proposed sites. These include:

- An assessment of all sources of flooding including fluvial flooding, surface water flooding, groundwater flooding, mapping of the functional floodplain and the potential increase in fluvial flood risk due to climate change and blockage scenarios.
- An assessment of existing flood warning, including an assessment of safe access and egress during an extreme event.
- Advice and recommendations on the likely applicability of sustainable drainage systems for managing surface water runoff.
- Advice on appropriate policies for sites which could satisfy the first part of the Exception Test and on the requirements necessary for a site-specific Flood Risk Assessment, supporting a planning application to pass the second part of the Exception Test.

Summary of Level 2 SFRA

As part of the Level 2 SFRA, detailed site summary tables have been produced for three sites provided by Lichfield District Council, taken forward to a detailed assessment.

The summary tables set out the flood risk to each site, including maps of Flood Zones and climate change, as well as extent, depth and velocity of flooding as well as hazard mapping for the 100-year + 50% climate change defended event. Each table also sets out the NPPF requirements for the site as well as guidance for site-specific FRAs. A broadscale assessment of suitable SuDS options has been provided, giving an indication where there may be constraints to certain sets of SuDS techniques. This assessment is indicative and more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. It may be possible that those SuDS techniques highlighted as possibly not being suitable can be designed to overcome identified constraints.

For two of the three sites located along the River Trent, the Environment Agency's River Trent 1D ISIS model was used to model latest climate change allowances. For the Footherley Lane, Footherley Hall site which was not covered by EA detailed hydraulic models, but where OS Mapping indicated a drain (Footherley Brook) running adjacent to the site, 2D generalised Jflow modelling was conducted. However, this could only be carried out where the catchment area of the drain was present on the FEH CD-ROM (to derive catchment hydrology) and where the drain was represented in the LIDAR data, and therefore flood risk from the small unnamed drain in the south-west of the site will still need to be confirmed as part of a site-specific FRA.

To accompany each site summary table, there is an Interactive Geo-PDF map, with all the mapped flood risk outputs per site. This is displayed centrally, with easy-to-use ‘tick box’ layers down the right-hand side and bottom of the mapping, to allow navigation of the data.

The following points summarise the Level 2 assessment:

- Two sites are covered by detailed Environment Agency hydraulic models: Land north of Dark Lane, Alrewas and Colton Road, Station Works are covered by the River Trent 2005 1D ISIS-only model.
- 2D generalised modelling using Jflow was undertaken on Footherley Brook where no modelling previously existed for Footherley Lane, Footherley Hall. However, detailed hydraulic modelling using channel topographic survey would be required at a site-specific level to confirm the flood risk to this site.
- Two out of the three sites (Land north of Dark Lane, Alrewas and Footherley Lane, Footherley Hall) are at fluvial flood risk. The degree of flood risk varies, with the Alrewas site only being impacted by Flood Zone 2 and Footherley Lane, Footherley Hall being more consistently impacted on its western boundary. Therefore, these sites will require more detailed investigations on sequential site layouts, SuDS possibilities, safe access and egress etc.
- Land north of Dark Lane, Alrewas and Colton Road, Station Works have a minor risk of surface water flooding. Footherley Lane, Footherley Hall is at a greater risk from surface water flooding, with more areas of ponding in the higher return period events. Surface water tends to follow topographic flow routes, for example along the watercourses or isolated pockets of ponding where there are topographic depressions. Surface water should be considered when assessing safe access and egress to and from the site.
- Climate change mapping indicates that flood extents will increase. As a result, the depths, velocities and hazard of flooding may also increase. The significance of the increase tends to depend on the topography of site and the percentage allowance used.
- Footherley Lane, Footherley Hall is located in Groundwater Source Protection Zone 3. This means that special consideration needs to be taken with SuDS. A suitable level of treatment should be ensured prior to discharging, along with establishing an understanding of constraints to sites and how SuDS can be designed to overcome these from relevant bodies (e.g. LLFA).
- A strategic assessment was conducted of SuDS options using regional datasets. Therefore, a detailed site-specific assessment of suitable SuDS techniques would need to be undertaken at site-specific level to understand which SuDS option would be best.
- At 'Land north of Dark Lane, Alrewas and 'Colton Road, Station Works', there is the potential for safe access and egress to be impacted by fluvial or surface water flooding. Consideration should be made to these sites as to how safe access and egress can be provided during flood events, both to people and emergency vehicles.
- Please note, at the time of this report's submission, all three sites that underwent a Level 2 Assessment were:

- Land north of Dark Lane, Alrewas
- Colton Road, Station Works
- Footherley Lane, Footherley Hall

- These three sites all have a site-specific Flood Risk Assessment prepared and have been granted planning permission.

Recommendations

Assessing Flood Risk and Developments

- The NPPF supports a risk-based and sequential approach to development and flood risk in England, so that development is located in the lowest flood risk areas where possible; it is recommended that this approach is adopted for all future developments within the district.
- A site-specific FRA is required for all developments over 1ha in Flood Zone 1; for developments less than 1 ha in Flood Zone 1 where there is a change to vulnerability classification or where the development could be affected by sources of flooding; and for all developments located in an area which has been highlighted as having critical drainage problems. The FRA should be proportionate to the degree of flood risk, as well as the scale, nature and location of the development.
- It is recommended that the impact of climate change to a proposed site is considered as part of a FRA and that the percentage increases which relate to the proposed lifetime of the development and the vulnerability classification of the development is accounted for. This should be informed by latest Environment Agency guidance and requirements of Lichfield District Council.
- At site-specific level, for any developments shown to be at residual flood risk, for example from a breach or overtopping (e.g. reservoir, canal, perched watercourse), it is recommended that a detailed hydraulic modelling study is carried out using Environment Agency guidance to assess the residual risk.
- Opportunities to reduce flood risk to wider communities could be sought through the regeneration of Brownfield sites, through reductions in the amount of surface water runoff generated on a site. The functional floodplain should be protected from development and returned to greenfield status (where possible).
- The Local Planning Authority (LPA), Environment Agency and Lead Local Flood Authority (LLFA) should be consulted to confirm the level of assessment required and to provide any information on any known local issues.
- When assessing sites not identified in the district plan (windfall sites), developers should use evidence provided in this SFRA to apply the Sequential Test as well as provide evidence to show that they have adequately considered other reasonably available sites.
- The FRA should demonstrate that developments do not increase the likelihood or intensity of flood risk to third party development.
- To demonstrate the Exception Test has been passed, flood resilience design and emergency planning must be accounted for.

Future Developments

Development must seek opportunities to reduce the overall level of flood risk at the site, for example by:

- Reducing volume and rate of surface water runoff based on local planning policy and LLFA Guidance
- Locating development to areas with lower flood risk
- Creating space for flooding
- Integrating green infrastructure into mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

The Local Planning Authority should consult the National Planning Practice Guidance and Environment Agency's 'Flood Risk Standing Advice (FRSA) for Local Planning Authorities',

published in March 2014, when reviewing planning applications for proposed developments at risk of flooding.

At the planning application stage, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances, published by the Environment Agency in February 2016), inform development zoning within the site and prove, if required, whether the Exception Test can be passed.

Promotion of SuDS

- Wherever possible, SuDS should be promoted.
- It is essential that developers consider sustainable drainage at an early stage of the development process – ideally at the master-planning stage. This will assist with the delivery of well designed, appropriate and effective SuDS.
- A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals. New or re-development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- Development should aim to achieve Greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible.
- Where possible developments must utilise the most sustainable form of drainage systems, in accordance with the SuDS hierarchy.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration.
- Where sites lie within or close to Groundwater SPZs or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration. Further restrictions may still be applicable, and guidance should be sought from the LLFA.
- Developers need to ensure that new development does not increase the surface water runoff rate from the site and should therefore contact the LLFA and other key stakeholders at an early stage to ensure surface water management is undertaken and that SuDS are promoted and implemented, designed to overcome site-specific constraints.
- The LPA will need to consider drainage schemes for major applications, but it is advised developers utilise the LLFA's policies and guidance to develop their drainage scheme for minor applications.
- Where SUDS are provided as part of a development, applicants should detail how it will be maintained in the long term.

Infrastructure and Access

- Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard should be identified. None of the sites assessed in this Level 2 assessments are protected by formal flood defences, though this should be a consideration for any future windfall sites which may be located near to flood defences.
- Safe access and egress for residents and emergency and service vehicles will need to be demonstrated at all development sites.

Future flood management in Lichfield District

Staffordshire County Council's Local Flood Risk Management Strategy identifies policies and procedures to assist them with achieving and delivering the LFRMS. As the Local Lead Flood Authority (LLFA) Staffordshire County Council will set out to achieve these by adopting a leadership role in FRM in Staffordshire, working in collaboration with key stakeholders and partners, including Lichfield District Council, to enable capacity building and transparent knowledge-sharing across the County, and to ensure SuDS are effectively accounted for in new developments. Cross-authority working should also include community engagement, to manage expectations about what can be achieved from a funding perspective and to help communities to become more self-resilient.

Use of SFRA data

It is important to recognise that the SFRA has been developed using the best available information at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

The SFRA should be periodically updated when new information on flood risk, flood warning or new planning guidance or legislation becomes available. New information on flood risk may be provided by Lichfield District Council, Staffordshire County Council (in its role as LLFA), the Highways Authority, Severn Trent Water, South Staffordshire Water and the Environment Agency. It is recommended that the SFRA is reviewed internally on an annual basis, allowing a cycle of review, followed by checking with the above bodies for any new information to allow a periodic update.

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Contents

List of Figures

List of Tables

Abbreviations and Glossary of Terms

Term	Definition
1D model	One-dimensional hydraulic model
2D model	Two-dimensional hydraulic model
AEP	Annual Exceedance Probability
Brownfield	Previously developed parcel of land
CC	Climate change - Long term variations in global temperature and weather patterns caused by natural and human actions.
CDA	Critical Drainage Area - A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.
CFMP	Catchment Flood Management Plan- A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
CIRIA	Construction Industry Research and Information Association
Cumecs	The cumec is a measure of flow rate. One cumec is shorthand for cubic metre per second; also m^3/s.
Defra	Department for Environment, Food and Rural Affairs
Designated Feature	A form of legal protection or status reserved for certain key structures or features that are privately owned and maintained, but which make a contribution to the flood or coastal erosion risk management of people and property at a particular location.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
DTM	Digital Terrain Model
EA	Environment Agency
EU	European Union
FEH	Flood Estimation Handbook
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG (Welsh Assembly Government).
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Floods and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river
FRA	Flood Risk Assessment - A site specific assessment of all forms of flood risk to the site and the impact of development of the site to flood risk in the area.
FRM	Flood Risk Management
FWMA	Flood and Water Management Act
FZ	Flood Zones
GI	Green Infrastructure – a network of natural environmental components and green spaces that intersperse and connect the urban centres, suburbs and urban fringe

Term	Definition
Greenfield	Undeveloped parcel of land
Ha	Hectare
Indicative Flood Risk Area	Nationally identified flood risk areas, based on the definition of 'significant' flood risk described by Defra and WAG.
ISIS/ ISIS-TUFLOW	1-dimensional hydraulic modelling software/ 1d-2d hydraulic modelling software
JBA	Jeremy Benn Associates
LFRMS	Local Food Risk Management Strategy
LIDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority - Local Authority responsible for taking the lead on local flood risk management
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NPPF	National Planning Policy Framework
NRD	National Receptor Database
Ordinary Watercourse	All watercourses that are not designated Main River. Local Authorities or, where they exist, IDBs have similar permissive powers as the Environment Agency in relation to flood defence work. However, the riparian owner has the responsibility of maintenance.
OS NGR	Ordnance Survey National Grid Reference
PFRA	Preliminary Flood Risk Assessment
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial flooding	Flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
Qbar	The mean annual flow from a catchment. This is approximately the 2.3-year return period event.
PPG	Planning Practice Guidance
PPS25	Planning and Policy Statement 25: Development and Flood Risk – superseded by the NPPF and PPG
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Return Period	Is an estimate of the interval of time between events of a certain intensity or size, in this instance it refers to flood events. It is a statistical measurement denoting the average recurrence interval over an extended period of time.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection - Defences are provided to reduce the risk of flooding from a river and within the flood and defence field standards are usually described in terms of a flood event return period. For example, a flood embankment could be described as providing a 1 in 100-year standard of protection.
Stakeholder	A person or organisation affected by the problem or solution, or

Term	Definition
	interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
SuDS	Sustainable Drainage Systems - Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques
Surface water flooding	Flooding as a result of surface water runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing what is known as pluvial flooding.
SWMP	Surface Water Management Plan - The SWMP plan should outline the preferred surface water management strategy and identify the actions, timescales and responsibilities of each partner. It is the principal output from the SWMP study.
TUFLOW	2-dimensional hydraulic modelling software
RoFfSW	Risk of Flooding from Surface Water
WFD	Water Framework Directive

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1 Introduction

1.1 Purpose of the Strategic Flood Risk Assessment

> ***"Local Plans should be supported by a strategic flood risk assessment and develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as Lead Local Flood Authorities and Internal Drainage Boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid, where possible, flood risk to people and property and manage any residual risk, taking account of the impacts of climate change".*** (National Planning Policy Framework, paragraph 100)

This Level 2 Strategic Flood Risk Assessment (SFRA) 2017 document undertakes a Level 2 assessment of three sites identified for potential allocation by Lichfield District Council. It builds upon the work undertaken in the Level 1 SFRA for South Staffordshire, Cannock Chase, Lichfield and Stafford, originally published in June 2014, which was an update to a 2008 Level 1 undertaken for the individual districts. This document is only specific to the district of Lichfield. It involves the site-specific assessment for three new site options required as part of the process of exploring the potential of non-strategic sites to accommodate growth in the emerging District Local Plan. The 2014 Level 1 SFRA should be considered in conjunction with this Level 2 SFRA, particularly as the Level 1 presents guidance for developers and the application of SUDS.

1.2 Levels of SFRA

The Planning Practice Guidance (PPG) advocates a tiered approach to risk assessment and identifies the following two levels of SFRA:

- Level One: where flooding is not a major issue in relation to potential development sites and where development pressures are low. The assessment should be sufficiently detailed to allow application of the Sequential Test.
- Level Two: where land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development creating the need to apply the National Planning Policy Framework's (NPPF) Exception Test. In these circumstances, the assessment should consider the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

This update fulfils the requirements of a Level 2 SFRA.

1.3 SFRA Objectives

The objectives of this 2017 Level 2 SFRA are to:

1. Provide individual flood risk analysis for potential development sites using the latest available flood risk data, thereby assisting the Council in applying the Exception Tests to its proposed site allocations in preparation of its Local Plan.
2. Where available, re-run existing hydraulic modelling to account for the effects of climate change.
3. Using available data, provide information and a comprehensive set of maps presenting flood risk from all sources for each proposed development site.
4. Where the Exception Test is required provide recommendations for making the site safe throughout its lifetime.
5. Take into account most recent policy and legislation and make recommendations for site-specific FRAs, suitable surface water management methods and opportunities to reduce flood risk to the existing communities.

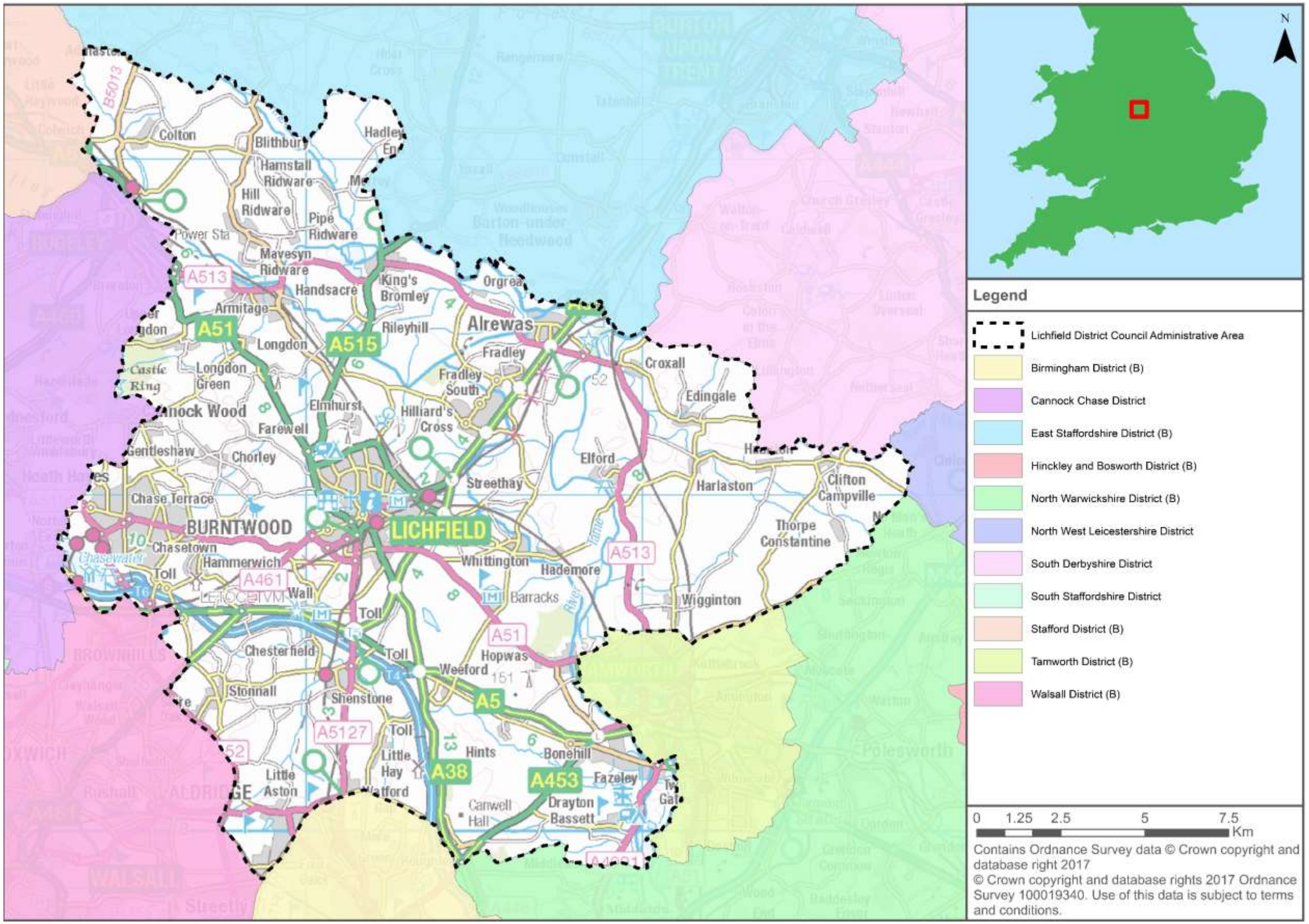
1.4 SFRA user guide

Table 1-1: SFRA user guide

Section	Contents
1. Introduction	Provides a background to the study, defines objectives, outlines the approach adopted and the consultation performed.
2. The Planning Framework and Flood Risk Policy	Includes information on the implications of recent changes to planning and flood risk policies and legislation, as well as documents relevant to the study.
3. The Sequential, risk based approach	Describes the Sequential Approach and application of Sequential and Exception Tests.
4. Climate change	Outlines the latest EA guidance on climate change and how it has been adopted in this L2 SFRA.
5. Sources of information used in preparing the L2 SFRA	Outlines what information has been used in the preparation of this Level 2 SFRA, e.g. technical datasets.
6. Screening of potential development sites	Outlines the sites carried forward to a review of flood risk and an overview of the outputs from the flood risk screening process.
7. Level 2 Assessment Methodology	Outlines the sites taken forward to the L2, what is provided in the site summary tables and associated mapping, and the hydraulic modelling methodology.
8. Summary of Level 2 assessment	Summary of SFRA findings
9. Recommendations	Summary of recommendations.
Appendix A: Level 2 assessment - Site summary tables and Geo-PDF mapping	Overview table of flood risk at each site assessed in the L2 and Geo-PDF mapping showing the flood risk.
Appendix B: Technical supporting information	Technical supporting information on 2D modelling techniques and mapping datasets.

Hyperlinks to external guidance documents/ websites are provided in blue throughout the SFRA.

Figure 1-1: Map of study area



2 The Planning Framework and Flood Risk Policy

2.1 Introduction

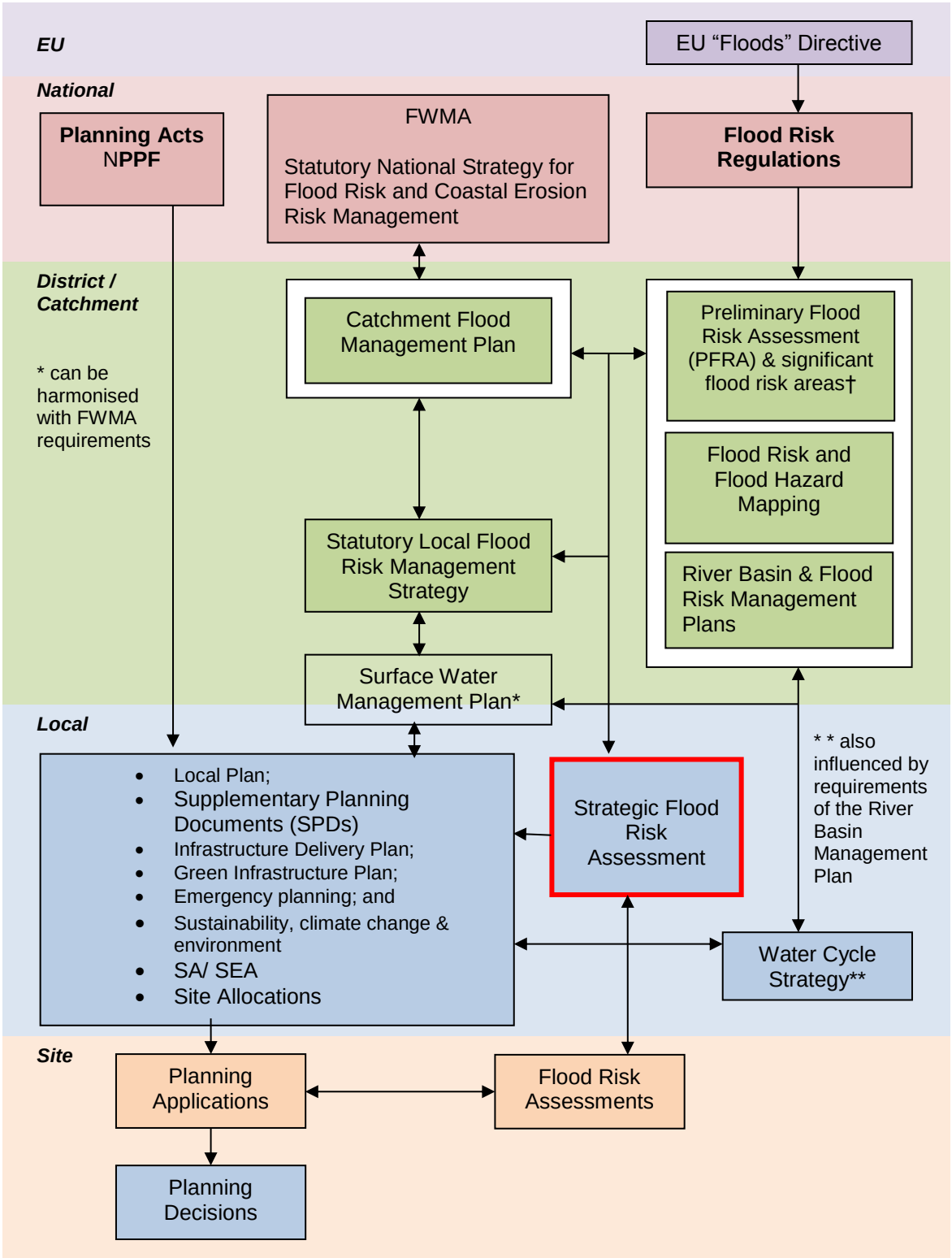
The overarching aim of development and flood risk planning policy in the UK is to ensure that the potential risk of flooding is taken into account at every stage of the planning process. This section of the Level 2 SFRA provides an overview of the planning framework, flood risk policy and flood risk responsibilities, given the changes since the previous publications. In preparing the subsequent sections of this SFRA, appropriate planning and policy amendments have been acknowledged and taken into account.

SFRAs contain information that should be referred to in responding to the Flood Risk Regulations and the formulation of local flood risk management strategies and plans. SFRAs are also linked to the preparation of Catchment Flood Management Plans (CFMPs), Surface Water Management Plans (SWMPs) and Water Cycle Strategies (WCSs).

Figure 2-1 outlines the key strategic planning links for flood risk management and associated documents. It shows how the Flood Risk Regulations and Flood and Water Management Act, in conjunction with the Localism Act's "duty to cooperate", introduce a wider requirement for the mutual exchange of information and the preparation of strategies and management plans.

There are a number of Risk Management Authorities which operate in Lichfield District; the key Risk Management Authorities, alongside their responsibilities, are summarised in Table 2-1.

Figure 2-1: Strategic planning links and key documents for flood risk



† See Table 2-1 for roles and responsibilities for preparation of information

Table 2-1: Roles and responsibilities in Staffordshire under FWMA 2010

Risk Management Authority (RMA)	Strategic Level	Operational Level
Environment Agency	National Statutory Strategy Reporting and supervision (overview role)	• Preliminary Flood Risk Assessment (per River Basin District)* • Managing flooding from Main Rivers and reservoirs and communication flood risk warnings to the public, media and partner organisations. • Identifying Significant Flood Risk Area* • Enforcement authority for Reservoirs Act 1975 • Managing Regional Flood and Coastal Committees (RFCCs) and supporting funding decisions, working with LLFAs and local communities. • Emergency planning and multi-agency flood plans, developed by local resilience forums • Acting consistently with LFRMS in realising Flood Risk Management (FRM) activity and have due regard in the discharge of function of the strategy. • Designating authority of infrastructure with a significant impact on flood risk from surface water and groundwater.
Lead Local Flood Authority (Staffordshire County Council)	Input to National Strategy Formulate and implement the Staffordshire Local Flood Risk Management Strategy	• Power for enforcing and consenting works for ordinary watercourses. • Managing local sources of flooding from surface runoff and groundwater and carrying out practical works to manage flood risk from these sources where necessary. • Preparing and publishing a PFRA and • Identifying Flood Risk Areas • Investigating certain incidents of flooding in the County in Section 19 Flood Investigations • Keeping asset registers of structures and features, which have a significant effect on local flood risk. • Acting consistently with LFRMS in realising FRM activity and have due regard in the discharge of other functions of the strategy • Designating authority for Infrastructure with a significant impact on flood risk from surface runoff and groundwater
Lower Tier Authorities (Lichfield District Council)	Input to National and Local Authority Plans and Strategy	• District Councils have the powers to carry out works on ordinary watercourses to reduce flood risk • Preparation of a Local Plan to guide development. • Acting consistently with LFRMS in realising FRM activity and have due regard in discharge of other functions. • The competent determining authority for planning applications and have the ultimate decision on the suitability of a site in relation to flood risk and management of surface water run-off. • Responsibilities for emergency planning as a responder to a flood event. • Own and manage public spaces which can potentially be used for flood risk management.

** Environment Agency did not prepare a PFRA; instead they exercised an exception permitted under the Regulations*

2.1.1 Riparian ownership

A riparian owner is the person who owns the land on which, or adjacent to, a watercourse flows through. The law presumes, in the absence of any other evidence, that the land adjoining the watercourse includes the watercourse to its mid-point; therefore, there may be more than one riparian owner of a watercourse.

Anyone with a watercourse in or adjacent to their land has rights and responsibilities as a riparian owner. The Environment Agency, LLFA and other risk management authorities have permissive powers to work on watercourses under their jurisdiction, however, they are not required to do so.

Under land drainage law, watercourses cannot be obstructed, and the riparian owner must accept water flowing onto their land.

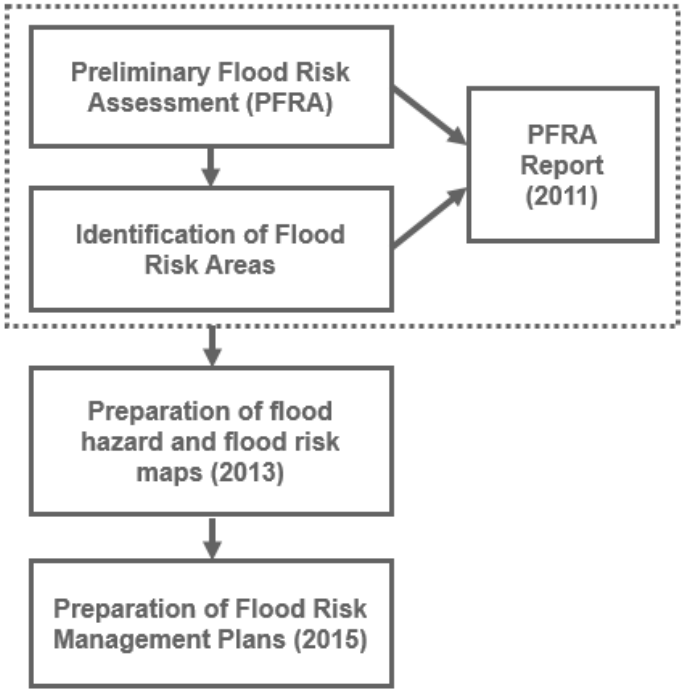
Riparian owners also have a role in risk management activities, for example by maintaining river beds/ banks, controlling invasive species and allowing the flow of water to pass without obstruction. More information can be found in the Environment Agency publication 'Living on the Edge' (2012).

2.2 Flood Risk Regulations (2009)

The Flood Risk Regulations (2009) are intended to translate the current EU Floods Directive into UK law and place responsibility upon all Lead Local Flood Authorities (LLFAs) to manage localised flood risk. Under the Regulations, the responsibility for flooding from rivers, the sea and reservoirs lies with the Environment Agency; however, responsibility for local and all other sources of flooding rests with LLFAs. The LLFA is Staffordshire County Council.

Figure 2-2 illustrates the steps that have / are being taken to implement the requirements of the EU Directive in the UK via the Flood Risk Regulations.

Figure 2-2: Flood Risk Regulation Requirements



Under this action plan and in accordance with the Regulations, LLFAs have the task of assessing flood risk from local sources over a six-year cycle, beginning with the preparation of a Preliminary Flood Risk Assessment (PFRA) report. The next cycle of the Flood Risk Regulations has now begun (2015 – 2021).

2.2.1 Staffordshire Preliminary Flood Risk Assessment (PFRA), 2011

The PFRA document that covers Staffordshire was published by the LLFA in 2011, and gives an overview of local flood risk in Staffordshire based on a review of records of flooding and data derived from modelling of potential future flooding. It reports on significant past and future flooding from all sources except from Main Rivers and Reservoirs, which are covered by the Environment Agency, and sub-standard performance of the adopted sewer network (covered under the remit of United Utilities and Severn Trent Water).

The PFRA is a high-level screening exercise and considers floods which have significant harmful consequences for human health, economic activity, the environment and cultural heritage. The Regulations require the LLFA to identify significant Flood Risk Areas, and therefore the PFRA identifies such areas and if they are considered to be nationally significant, as defined by Defra.

Based on this analysis, no areas were identified in Staffordshire that meet the national criteria to be designated as Flood Risk Areas (clusters with a total of more than 30,000 people affected by local sources of flooding). This could be revised in future however, given that the PFRA is due to be updated in late 2017.

2.2.2 River Basin Flood Risk Management Plans, 2016

Under the Flood Risk Regulations (2009), the Environment Agency exercised an 'Exception' and did not prepare a PFRA for risk from rivers, reservoirs and the sea. This then made it a requirement for the Environment Agency to prepare and publish a Flood Risk Management Plan (FRMP). The FRMP process adopts the same catchments as used in the preparation of River Basin Management Plans, in accordance with the Water Framework Directive (Section 2.8 contains further information on the Water Framework Directive and the River Basin Management Plans).

Lichfield District Council falls within the Humber River Basin District FRMP (March 2016). The FRMP explains the risk from flooding from all sources alongside how risk management authorities will work with communities to manage flood risk from 2015 to 2021. The FRMP draws on previous policies and actions identified in Catchment Flood Management Plans and also incorporates information from Local Flood Risk Management Strategies (it should be noted that FRMPs do not supersede Catchment Flood Risk Management Plans). Each River Basin District is composed of a group of sub-areas or catchments. The FRMP summarises the flooding affecting each area and describes the measures to be taken to address the risk in accordance with the Flood Risk Regulations.

2.3 Flood and Water Management Act, 2010

The Flood and Water Management Act (2010) (FWMA) aims to create a simpler and more effective means of managing both flood risk and coastal erosion and implements Sir Michael Pitt's recommendations following his review of the 2007 floods. The FWMA received Royal Assent in April 2010, and designated upper tier local authorities as LLFAs. Duties for Staffordshire County Council as LLFA include:

- Develop, maintain and apply a Local Flood Risk Management Strategy for Staffordshire under the Act, in consultation with local partners. This Strategy acts as the basis and discharge of duty for Flood Risk Management co-ordinated by Staffordshire County Council, and outlines how they will manage flood risk, identify areas vulnerable to flooding and target resources where they are needed most
- When appropriate and necessary, investigate and report on flooding incidents, i.e. Section 19 reports (no Section 19 reports were identified covering the sites considered in this Level 2 assessment)
- Establish and maintain a register of structures or features which, in their opinion, are likely to have a significant effect on flood risk in the LLFA area
- When appropriate, exercise powers to designate structures and features that affect flood risk, requiring the owner to seek consent from the authority to alter, remove or replace it
- When appropriate, perform consenting of works on ordinary watercourses

The FWMA also makes it clear that the LLFA has powers to manage flood risk from surface water and groundwater and has the lead responsibility for managing/ regulating flood risk from 'ordinary watercourses' (i.e. smaller ditches, brooks), unless there is an Internal Drainage Board (IDB). The LLFA are the regulatory body for changes within ordinary watercourses, with responsibility for managing flood risk and actual maintenance for ordinary watercourses (including development of bylaws) sitting with riparian owners, e.g. the district/ borough councils, landowner, farmers etc. If a riparian owner wishes to alter a watercourse then consent from the LLFA is required, otherwise the LLFA has the power to take enforcement action. The Environment Agency are responsible for 'Main Rivers'.

The FWMA will also update the Reservoirs Act 1975 by reducing the capacity of reservoir regulation from 25,000m^3 to 10,000m^3. Phase 1 has been implemented in 2013 requiring large raised reservoirs to be registered to allow the Environment Agency to categorise whether they are 'high risk' or 'not high risk'.

2.3.1 Staffordshire Local Flood Risk Management Strategy (LFRMS), 2015

Staffordshire County Council as a LLFA is responsible for developing, maintaining, applying and monitoring a Local Flood Risk Management Strategy for Staffordshire. The Strategy is used as a means by which the LLFA co-ordinates Flood Risk Management on a day to day basis. The Strategy also sets measures to manage local flood risk. The six key strategic objectives of the Strategy for managing flood risk include:

- Develop a strategic understanding of flood risk from all sources;
- promote effective management of drainage and flood defence systems;
- support communities to understand flood risk and become more resilient to flooding;
- manage local flood risk and new development in a sustainable manner;
- achieve results through partnership and collaboration;
- be better prepared for flood events, and;
- secure and manage funding for flood risk management in a challenging financial climate.

2.4 National Planning Policy Framework

The National Planning Policy Framework (NPPF) was issued in 2012 to replace the previous documentation as part of reforms to make the planning system less complex and more accessible, and to protect the environment and promote sustainable growth. It replaces most of the Planning Policy Guidance Notes (PPGs) and Planning Policy Statements (PPSs) that were referred to in the previous version of the SFRA. The NPPF sets out the Government's requirements for the planning system and provides a framework within which local people and councils can produce distinctive local and neighbourhood plans to reflect the needs and properties of their communities. The NPPF must be taken into account by local planning authorities when preparing Local Plans and for applicants preparing planning submissions.

Planning Practice Guidance (PPG) was published in 2014 and sets out how the NPPF should be implemented. NPPG: Flood Risk and Coastal Change advises on how planning can account for the risks associated with flooding and coastal change in plan making and the application process. It sets out Flood Zones, the appropriate land uses for each zone, flood risk assessment requirements, including the Sequential and Exception Tests and the policy aims for developers and authorities regarding each Flood Zone. Further details on Flood Zones and associated policy is provided in Table 3-1 and throughout this report. The Sequential and Exception tests are covered in greater detail in Chapter 3.

The Sequential Test

"The Sequential Test ensures that a sequential approach is followed to steer new development to areas with the lowest probability of flooding. The flood zones, as refined in the Strategic Flood Risk Assessment for the area, provide the basis for applying the Test. The aim is to steer new development to Flood Zone 1 (areas with a low probability of river or sea flooding). Where there are no reasonably available sites in Flood Zone 1, local planning authorities in their decision making should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2 (areas with a medium probability of river or sea flooding), applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 (areas with a high probability of river or sea flooding) be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required".

(National Planning Practice Guidance, paragraph 019)

The Exception Test

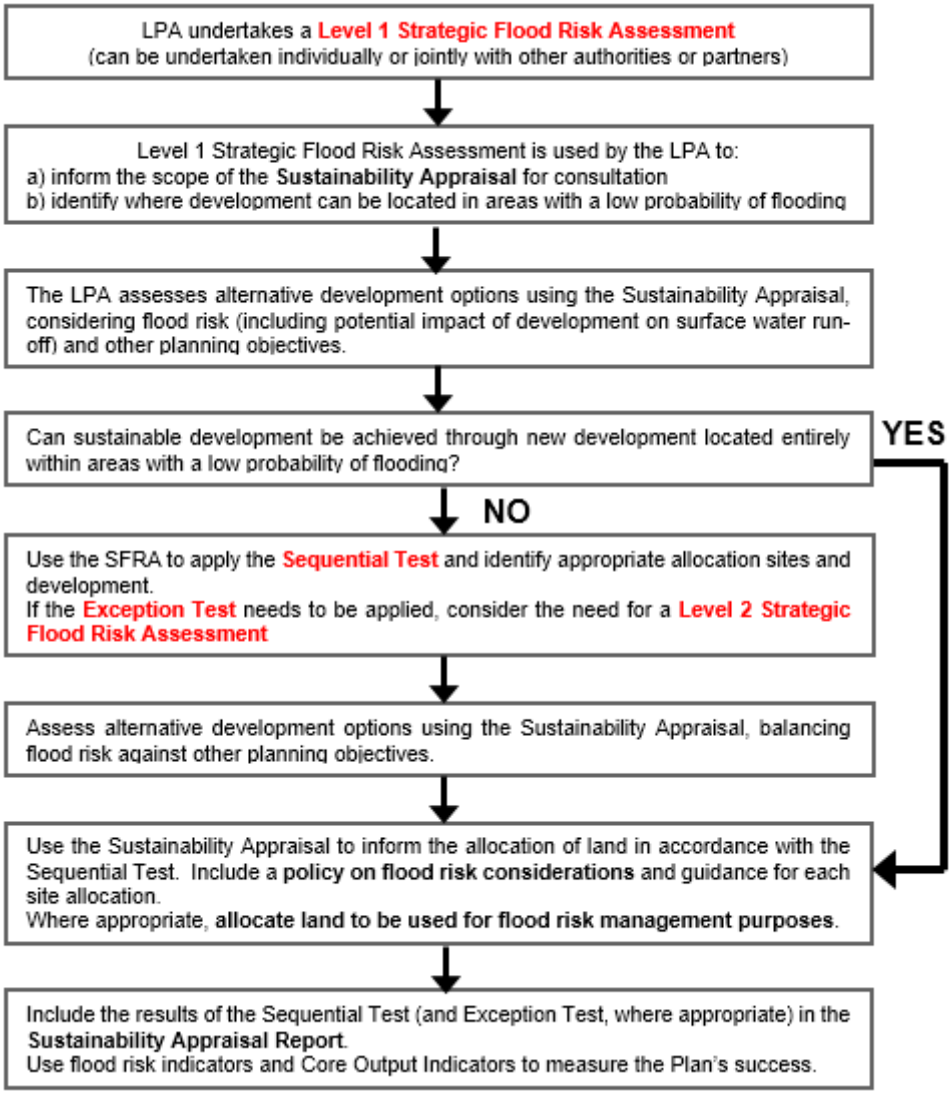
"The Exception Test, as set out in paragraph 102 of the NPPF, is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

Essentially, the two parts to the Test require proposed development to show that it will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.".

(National Planning Practice Guidance, paragraph 023)

A description of how flood risk should be taken into account in the preparation of Local Plans is outlined in Diagram 1 contained within the Planning Practice Guidance (Figure 2-3).

Figure 2-3: Flood risk and the preparation of Local Plans†



† Based on Diagram 1 of NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 004, Reference ID: 7-005-20140306) March 2014

2.5 Planning, surface water and SuDS

On 18 December 2014 a Written Ministerial Statement laid by the Secretary of State for Communities and Local Government set out changes to the planning process that would apply for major development from 6 April 2015.

Major developments are defined as

- residential development: 10 dwellings or more, or residential development with a site area of 0.5 hectares or more where the number of dwellings is not yet known; and
- Non-residential development: provision of a building or buildings where the total floor space to be created is 1,000 square metres or more or, where the floor area is not yet known, a site area of 1 hectare or more.

When considering major planning applications, Local Planning Authorities (LPAs) should consult the LLFA on the management of surface water in order to satisfy that:

- the proposed minimum standards of operation are appropriate
- there are clear arrangements for on-going maintenance over the development's lifetime, through the use of planning conditions or planning obligations.

In March 2015 the LLFA was made a statutory consultee which came into effect on 15 April 2015. As a result, Staffordshire County Council, is required to provide technical advice on surface water drainage strategies and designs put forward for new major developments[1].

2.5.1 Defra Non-Statutory Technical Standards for SuDS

On March 23 2015, the Department for Environment, Food and Rural Affairs (Defra) published the Non-Statutory Technical Standards for SuDS. The standards should be used in conjunction with the NPPF and NPPG. These standards cover the following

- Flood risk outside the development
- Peak flow control
- Volume control
- Flood risk within the development
- Structural integrity
- Designing for maintenance considerations
- Construction

2.5.2 C753 CIRIA SuDS Manual (2015)

The C753 CIRIA SuDS Manual (2015) replaces and updates the previous version (C697) providing up to date guidance on planning, design, construction and maintenance of SuDS. The document is designed to help the implementation of these features into new and existing developments, whilst maximising the key benefits regarding flood risk and water quality. The manual is divided into five sections ranging from a high-level overview of SuDS, progressing to more detailed guidance with progression through the document. It is recommended that developers and the LPA utilise the information within the manual to help design SuDS which are appropriate for a development.

2.5.3 Surface Water Management Plans

Surface Water Management Plans (SWMPs) outline the preferred surface water management strategy in a given location. SWMPs are undertaken, when required, by LLFAs in consultation with key local partners who are responsible for surface water management and drainage in their area. SWMPs establish a long-term action plan to manage surface water in a particular area and are intended to influence future capital investment, drainage maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

The SWMP that covers areas in the district of Lichfield is:

- Southern Staffordshire Surface Water Management Plan Phase 1 & 2 (2011)

Since the production of the 2014 Level 1 SFRA, there have been numerous documents published relating to surface water management and SuDS including:

- Staffordshire Updated SuDS guidance (spread out across several smaller documents) (2015)
- Staffordshire County Council SuDS Handbook (2017)
- The SuDS Manual (C753), published in 2007, updated in 2015
- DEFRA Non-statutory technical standards for sustainable drainage systems, 2015
- The House of Commons: Written Statement HCWS161 on Sustainable Drainage Systems, 2014

The 2014 Level 1 SFRA reviews existing SuDS policy and highlights the main general principals to be followed in the application of SuDS. *"The surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a developed site are no greater than rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect."*

2.6 Catchment Flood Management Plans

Catchment Flood Management Plans (CFMPs) are a high-level strategic plan providing an overview of flood risk across each river catchment. The Environment Agency use CFMPs to work with other key-decision makers to identify and agree long-term policies for sustainable flood risk management.

1 https://www.gov.uk/government/consultations/planning-application-process-statutory-consultee-arrangements

There are six pre-defined national policies provided in the CFMP guidance and these are applied to specific locations through the identification of 'Sub-areas'. These policies are intended to cover the full range of long-term flood risk management options that can be applied to different locations in the catchment.

The study area is covered by the River Trent CFMP. Lichfield falls within the sub-areas 6, Mid Staffordshire and Lower Tame and 7, West Staffordshire.

The preferred policy by Sub-area are as follows:

- Sub area 6 - Policy 6 - Areas of low to moderate flood risk where we will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits.
- Sub area 7 - Policy 4 - Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.

2.7 Water Cycle Studies

Climate change is predicted to present unprecedented new challenges, such as more frequent and extreme rainfall events and rising global temperatures, which are expected to exert greater pressure on the existing infrastructure. Planning for water management therefore has to take these potential challenges into account. A large number of new homes for instance may cause the existing water management infrastructure to be overwhelmed which would result in adverse effects on the environment, both locally and in wider catchments.

Water Cycle Studies assist local authorities to select and develop sustainable development allocations so that there is minimal impact on the environment, water quality, water resources, and infrastructure and flood risk. This can be achieved in areas where there may be conflict between any proposed development and the requirements of the environment through the recommendation of potential sustainable solutions.

Lichfield District Council, in partnership with Southern Staffordshire Councils, have contributed to the Southern Staffordshire Outline Water Cycle Study (2010) and the later addendum in 2011. These documents highlight the requirement to improve the water quality most significantly on a number of watercourses, including these included in the study sites: Footherley Brook and River Trent.

2.8 Water Framework Directive

The EU Water Framework Directive (WFD) seeks to integrate and enhance the way in which water bodies are managed throughout Europe by the preservation, restoration and improvement of the water environment. In England, the Environment Agency is responsible for the delivery of the WFD objectives.

The WFD aims to achieve at least 'good' status for all water bodies; the default deadline for achieving this objective is by 2021 although, in some cases, where it is deemed more appropriate, less stringent objectives have been set with extended deadline of 2027 or beyond. The WFD requires the production of Management Plans for each River Basin District. These plans assess the pressures facing the water environment in each district. Each District is composed of a group of catchments termed river basins to which all water bodies are assigned.

Any adverse impacts can cause a waterbody's ecology to deteriorate and prevent environmental improvements from being undertaken. Nevertheless, in-channel works can also be beneficial if they can be designed to help achieve environmental improvements included in the RBMP, thus enhancing the water environment for plants and animals. Any activity which has the potential to have an impact on the ecology of a waterbody will need consideration in terms of whether it could cause deterioration in its Ecological Status or Potential.

2.8.1 Humber River Basin Management Plan (RBMP), 2015

The Humber River Basin Management Plan (2015) is prepared under the WFD and assesses the pressures facing the water environment in the Humber River Basin District. The 2009 version has been updated in December 2015.

There are several challenges which can impact progress towards cleaning and protecting natural assets including:

- Physical modifications

- Pollution from waste water
- Pollution from towns, cities, transport and rural areas
- Changes to the natural flow and level of water; and,
- Negative effectives of invasive non-native species.

To achieve the environmental objectives set out by the WFD. The RBMP summarises the ongoing measures which seek to prevent the deterioration in status and improve the quality of the water environment.

2.9 United Kingdom's exit from the European Union

On 23rd June 2016, the advisory referendum on whether the United Kingdom should remain a member of the European Union (EU) resulted in a majority vote in favour of leaving the EU. At the time of writing, the process of the UK leaving the EU raises several areas of uncertainty which may impact upon the future applicability of this study, including the future status of EU directives relating to water, for example the Water Framework Directive and the Habitats Directive.

Given these increased uncertainties, it becomes even more important that water companies, planners and regulators co-operate and share information, and to attempt to account for uncertainty in their planning.

3 The sequential, risk-based approach

3.1 Flood Zones

The NPPF guidance identifies the following Flood Zones (see Table 3-1). These apply to both Main River and Ordinary Watercourses.

Table 3-1: Flood Zone descriptions

Zone	Probability	Description
Zone 1	Low	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
		All land uses are appropriate in this zone.
		For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment.
Zone 2	Medium	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1% - 1%) or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1% – 0.5%) in any year.
		Essential infrastructure, water compatible infrastructure, less vulnerable and more vulnerable land uses (as set out by NPPF) as appropriate in this zone. Highly vulnerable land uses are allowed as long as they pass the Exception Test.
		All developments in this zone require an FRA.
Zone 3a	High	This zone comprises land assessed as having a greater than 1 in 100 annual probability of river flooding (>1.0%) or a greater than 1 in 200 annual probability of flooding from the sea (>0.5%) in any year Developers and the local authorities should seek to reduce the overall level flood risk, relocating development sequentially to areas of lower flood risk and attempting to restore the floodplain and make open space available for flood storage.
		Water compatible and less vulnerable land uses are permitted in this zone. Highly vulnerable land uses are not permitted. More vulnerable and essential infrastructure are only permitted if they pass the Exception Test.
		All developments in this zone require an FRA.
Zone 3b	Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone in discussion with the LPA and the Environment Agency. The identification of functional floodplain should take account of local circumstances.
		Only water compatible and essential infrastructure are permitted in this zone and should be designed to remain operational in times of flood, resulting in no loss of floodplain or blocking of water flow routes. Infrastructure must also not increase flood risk elsewhere.
		All developments in this zone require an FRA.

3.2 The sequential, risk-based approach

This approach is designed to ensure areas with little or no risk of flooding (from any source) are developed in preference to areas at higher risk, with the aim of keeping development outside of medium and high flood risk areas (Flood Zones 2 and 3) and other sources of flooding, where possible.

The sequential approach can be applied both between and within Flood Zones.

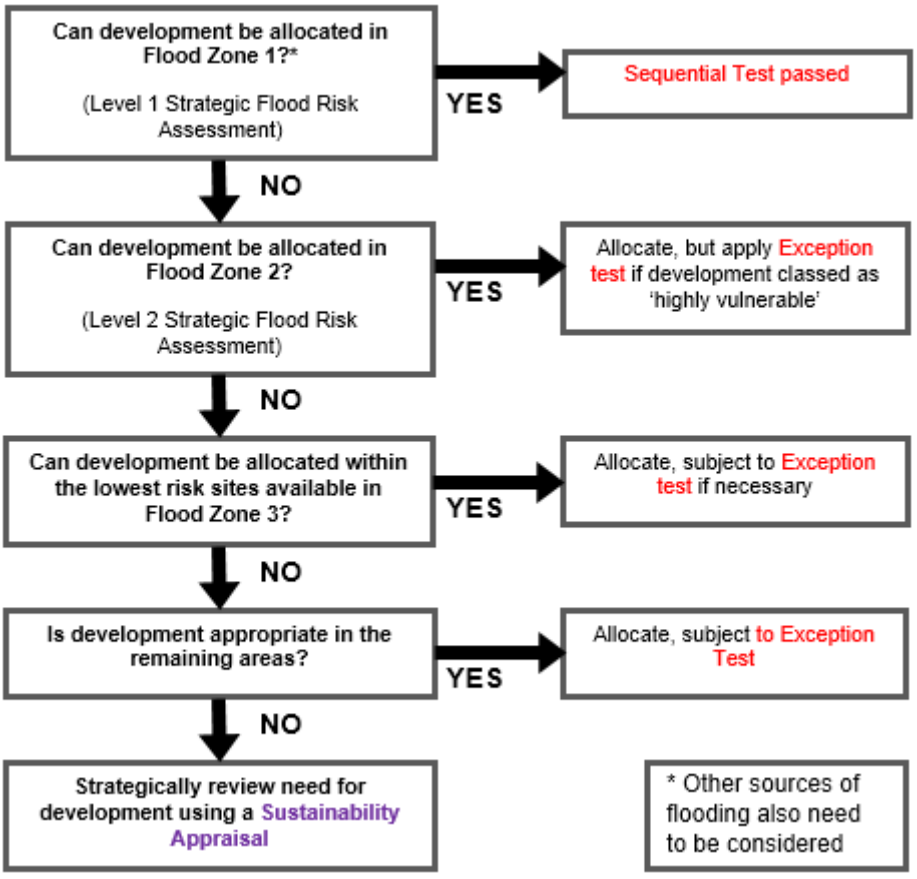
It is often the case that it is not possible for all new development to be allocated on land that is not at risk from flooding. In these circumstances the Flood Zone maps (that show the extent of inundation assuming that there are no defences) are too simplistic and a greater understanding of the scale and nature of the flood risks is required.

3.3 Applying the Sequential Test and Exception Test in the preparation of a Local Plan

When preparing a Local Plan, the Local Planning Authority should demonstrate it has considered a range of site allocations, using SFRAs to apply the Sequential and Exception Tests where necessary.

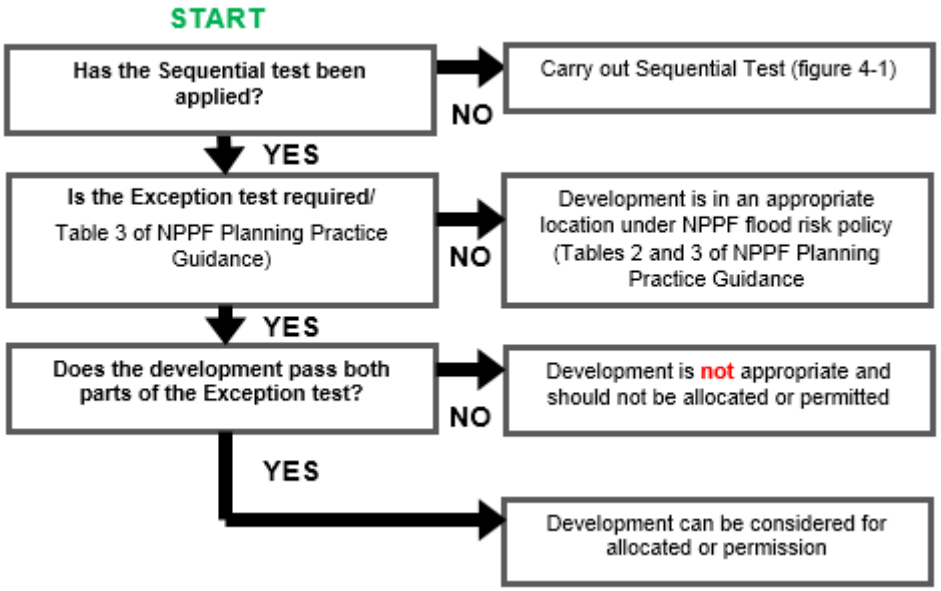
The Sequential Test should be applied to the whole Local Planning Authority area to increase the likelihood of allocating development in areas not at risk of flooding. The Sequential Test can be undertaken as part of a Local Plan Sustainability Appraisal. Alternatively, it can be demonstrated through a free-standing document, or as part of strategic housing land or employment land availability assessments. NPPF Planning Practice Guidance for Flood Risk and Coastal Change describes how the Sequential Test should be applied in the preparation of a Local Plan (Figure 3-1).

Figure 3-1: Applying the Sequential Test in the preparation of a Local Plan



The Exception Test should only be applied following the application of the Sequential Test and as set out in Table 3 of the NPPF Planning Practice Guidance: Flood Risk and Coastal Change. The NPPF PPG describes how the Exception Test should be applied in the preparation of a Local Plan (Figure 3-2).

Figure 3-2: Applying the Exception Test in the preparation of a Local Plan



3.4 Applying the Sequential Test and Exception Test to individual planning applications

3.4.1 Sequential Test

Local circumstances must be used to define the area of application of the Sequential Test (within which it is appropriate to identify reasonably available alternatives). The criteria used to determine the appropriate search area relate to the catchment area for the type of development being proposed. For some sites this may be clear, in other cases it may be identified by other Local Plan policies. A pragmatic approach should be taken when applying the Sequential Test.

Lichfield District Council, with advice from the Environment Agency, are responsible for considering the extent to which Sequential Test considerations have been satisfied, and will need to be satisfied that the proposed development would be safe and not lead to increased flood risk elsewhere.

The Sequential Test does not need to be applied for individual developments under the following circumstances:

- The site has been identified in development plans through the Sequential Test.
- Applications for minor development or change of use (except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site).

It is normally reasonable to presume and state that individual sites that lie in Zone 1 satisfy the requirements of the Sequential Test; however, consideration should be given to risks from all sources and areas with critical drainage problems.

3.4.2 Exception Text

If, following application of the Sequential Test it is not possible for the development to be located in areas with a lower probability of flooding the Exception Test must then be applied if deemed appropriate. The aim of the Exception Test is to ensure that more vulnerable property types, such as residential development can be implemented safely and are not located in areas where the hazards and consequences of flooding are inappropriate. For the Test to be satisfied, both of the following elements have to be accepted for development to be allocated or permitted:

1. It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared.

   LPAs will need to consider what criteria they will use to assess whether this part of the Exception Test has been satisfied, and give advice to enable applicants to provide evidence to demonstrate that it has been passed. If the application fails to prove this, the LPA should consider whether the

use of planning conditions and / or planning obligations could allow it to pass. If this is not possible, this part of the Exception Test has not been passed and planning permission should be refused[2] .

2. A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

   The site-specific FRA should demonstrate that the site will be safe and the people will not be exposed to hazardous flooding from any source. The following should be considered[3:]

   - The design of any flood defence infrastructure.
   - Access and egress.
   - Operation and maintenance.
   - Design of the development to manage and reduce flood risk wherever possible
   - Resident awareness.
   - Flood warning and evacuation procedures.
   - Any funding arrangements required for implementing measures.

The NPPF and PPG provide detailed information on how the Test can be applied.

This SFRA has produced new flood risk mapping datasets. For example, where no detailed hydraulic models were available, but where a drain (Footherley Brook) was shown to be present on OS mapping in the vicinity of the site, 2D generalised modelling using Jflow was undertaken. The various mapping approaches are discussed further in Chapter 7. The additional flood risk mapping datasets and Level 2 Summary Tables will assist Lichfield District Council in Sequential Testing decisions and will help the Council to apply the Exception Test. Actual flood risk

If it has not been possible for all future development to be situated in Zone 1 then a more detailed assessment is needed to understand the implications of locating proposed development in Zones 2 or 3. This is accomplished by considering information on the "actual risk" of flooding. The assessment of actual risk takes account of the presence of flood defences and provides a picture of the safety of existing and proposed development. It should be understood that the standard of protection afforded by flood defences is not constant and it is presumed that the required minimum standards for new development are:

- residential development should be protected against flooding with an annual probability of river flooding of 1% (1 in 100-year chance of flooding) in any year; and
- residential development should be protected against flooding with an annual probability of tidal (sea) flooding of 0.5% (1 in 200-year chance of flooding) in any year*.

The assessment of the actual risk should take the following issues into account:

- The level of protection afforded by existing defences might be less than the appropriate standards and hence may need to be improved if further growth is contemplated.
- The flood risk management policy for the defences will provide information on the level of future commitment to maintain existing standards of protection. If there is a conflict between the proposed level of commitment and the future needs to support growth, then it will be a priority for the Flood Risk Management Strategy to be reviewed.
- The standard of safety must be maintained for the intended lifetime of the development. Over time the effects of climate change will erode the present-day standard of protection afforded by defences and so commitment is needed to invest in the maintenance and upgrade of defences if the present-day levels of protection are to be maintained and where necessary land secured that is required for affordable future flood risk management measures.
- The assessment of actual risk can include consideration of the magnitude of the hazard posed by flooding. By understanding the depth, velocity, speed of onset and rate of rise of floodwater it is possible to assess the level of hazard posed by flood events from the respective sources. This assessment will be needed in circumstances where consideration is given to the mitigation of the consequences of flooding or where it is proposed to place lower vulnerability development in areas that are at risk from inundation.

2 NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 037, Reference ID: 7-056-20140306) March 2014

3 NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 038, Reference ID: 7-056-20140306) March 2014

3.5 Residual flood risk

Residual risk refers to the risks that remain in circumstances after measures have been taken to alleviate flooding (such as flood defences). It is important that these risks are quantified to confirm that the consequences can be safely managed. The residual risk can be:

- The effects of a flood with a magnitude greater than that for which the defences or management measures have been designed to alleviate (the 'design flood'). This can result in overtopping of flood banks, failure of flood gates to cope with the level of flow or failure of pumping systems to cope with the incoming discharges.
- Failure of the defences or flood risk management measures to perform their intended duty. This could be breach failure of flood embankments, failure of flood gates to operate in the intended manner or failure of pumping stations.

The assessment of residual risk demands that attention be given to the vulnerability of the receptors and the response to managing the resultant flood emergency. In this instance attention should be paid to the characteristics of flood emergencies and the roles and responsibilities during such events. Additionally, in the cases of breach or overtopping events, consideration should be given to the structural safety of the dwellings or structures that could be adversely affected by significant high flows or flood depths.

Developers should include an assessment of the residual risk where developments are in areas benefitting from defences. They should consider both the impact of breach, including the effect on safe access and egress, as well as potential for flood risk to increase in the future due to overtopping. Any improvements to defences should ensure they are in keeping with wider catchment policy.

The breach modelling undertaken by the Environment Agency should be used as a starting point for breach modelling as part of detailed site-specific flood risk assessments. The assessments should identify rapid inundation zones, the speed of onset of flooding, the depth, hazard and extent of flood water.

Level 2 SFRAs are intended to help local authorities apply the Exception Test. A key element of the Exception Test is to consider whether the site will be safe for its lifetime. As part of the Level 2 summary tables, the actual and residual risk to the site, has been considered, alongside guidance for developers on site-specific Flood Risk Assessments.

3.6 Impact of additional development on flood risk

When allocating land for development, consideration must be given to the potential cumulative impact of development on flood risk. The increase in impermeable surfaces and resulting increase in runoff increases the chances of surface water flooding if suitable mitigation measures, such as SuDS, are not put in place. Additionally, the increase in runoff may result in more flow entering watercourses, increasing the risk of fluvial flooding downstream.

Consideration must also be given to the potential cumulative impact of the loss of floodplain as a result of development. The effect of the loss of floodplain storage should be assessed, at both the development and elsewhere within the catchment and, if required, the scale and scope of appropriate mitigation should be identified.

Whilst the increase in runoff, or loss in floodplain storage, from individual developments may only have a minimal impact on flood risk, the cumulative effect of multiple developments may be more severe without appropriate mitigation measures.

The cumulative impact of development should be considered at the planning application and development design stages and the appropriate mitigation measures undertaken, within an appropriate FRA, to ensure flood risk is not exacerbated, and in many cases the development should be used to improve the flood risk.

Maintenance and upkeep of SuDS have been neglected in the past as a result of lack of clarity over where responsibility for it lies. Therefore, is it important that maintenance and upkeep for mitigation measures, such as SuDS, has been set out as part of a drainage strategy and that management funding for the lifetime of the development has been agreed.

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4 Climate change

4.1 Revised Climate Change Guidance

The Environment Agency published updated climate change guidance on 19 February 2016, which must now be considered in all new developments and planning applications. The Environment Agency can give a free preliminary opinion to applicants on their proposals at pre-application stage. There is a charge for more detailed pre-application planning advice. The LLFA should be contacted for advice on flood risk from local watercourses, surface, or groundwater.

4.2 Peak River Flows

The peak river flow allowances show the anticipated changes to peak flow by river basin District which the subject watercourse resides. Once this is determined, guidance on uplift in peak flows are assigned for three allowance categories, Central, Higher Central and Upper End which are based on the 50th, 70th and 90th percentiles respectively. The allowance category to be used is based on the vulnerability classification of the development and the flood zones within which it resides.

These allowances (increases) are provided for three climate change 'epochs':

- Total potential change anticipated for '2020s' (2015 to 2039)
- Total potential change anticipated for '2050s' (2040 to 2069)
- Total potential change anticipated for '2080s' (2070 to 2115)

One or two of the percentiles are provided for each combination of vulnerability and flood zone, which in the latter case provides a 'range' of allowances. The allowances for the Humber River Basin District are provided in Table 4-1.

Table 4-1: Peak river flow allowances for the Humber River Basin District

Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Upper end	20%	30%	50%
Higher central	15%	20%	30%
Central	10%	15%	20%

4.2.1 High++ allowances

High++ allowances only apply in assessments for developments that are very sensitive to flood risk and that have lifetimes beyond the end of the century. Further information is provided in the Environment Agency publication, Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities.

4.2.2 Which peak river flow allowance to use?

The flood zone and flood risk vulnerability classification should be considered when deciding which allowances apply to the development or the plan. The guidance states the following

Flood Zone 2

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure		✓	✓
Highly vulnerable		✓	✓
More vulnerable	✓	✓	
Less vulnerable	✓		
Water compatible	None		

Flood Zone 3a

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure			✓
Highly vulnerable	Development not permitted		
More vulnerable		✓	✓
Less vulnerable	✓	✓	
Water compatible	✓		

Flood Zone 3b

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure			✓
Highly vulnerable	Development not permitted		
More vulnerable			
Less vulnerable			
Water compatible	✓		

4.3 Peak rainfall intensity allowance

Increased rainfall affects river levels and land and urban drainage systems. The table below shows anticipated changes in extreme rainfall intensity in small and urban catchments.

For Flood Risk Assessments, both the central and upper end allowances should be assessed to understand the range of impact.

Table 4-2: Peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

Staffordshire County Council set out how they, as LLFA, expect climate change allowances to be used in FRAs and drainage strategies in their Surface Water Guidance document. For SuDS design purposes the central estimate of 20% should be used to assess the performance of the drainage system and ensure it can cope with the critical duration design rainfall event. The 'upper end' of 40% should be used in sensitivity analysis to assess the potential flood risk implications both on and off-site in the critical duration design rainfall event. When using the upper end figure, it must be ensured that surface water is wholly contained on site and that flood hazard is within acceptable tolerances.

4.4 Using climate change allowances

To help decide which allowances to use to inform the flood levels that the flood risk management strategy will be based on for a development or development plan allocation, the following should be considered:

- likely depth, speed and extent of flooding for each allowance of climate change over time considering the allowances for the relevant epoch (2020s, 2050s and 2080s)
- vulnerability of the proposed development types or land use allocations to flooding
- 'built in' resilience measures used, for example, raised floor levels
- capacity or space in the development to include additional resilience measures in the future, using a 'managed adaptive' approach

4.5 Representing climate change in the L2 SFRA

Climate change modelling for the watercourses in Lichfield District was undertaken based on the new climate change guidance. The existing Environment Agency hydraulic model of the River Trent was run for the 2080s period for the Central, Higher Central and Upper End allowance categories. Where no detailed model exists, a 2D generalised model was produced and run for the same allowances. Mapping of the climate change modelling outputs are provided in the Level 2 Geo-PDFs of each site (see Appendix A).

4.6 Adapting to climate change

PPG Climate Change contains information and guidance for how to identify suitable mitigation and adaptation measure in the planning process to address the impacts of climate change. Examples of adapting to climate change include

- Considering future climate risks when allocating development sites to ensure risks are understood over the development's lifetime
- Considering the impact of and promoting design responses to flood risk and coastal change for the lifetime of the development
- Considering availability of water and water infrastructure for the lifetime of the development and design responses to promote water efficiency and protect water quality
- Promoting adaptation approaches in design policies for developments and the public realm for example by building in flexibility to allow future adaptation if needed, such as setting new development back from watercourses
- identifying no or low-cost responses to climate risks that also deliver other benefits, such as green infrastructure that improves adaptation, biodiversity and amenity, for example by leaving areas shown to be at risk of flooding as public open space

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5 Sources of information used in preparing the L2 SFRA

This chapter discusses all the datasets used in the Level 2 SFRA to assess the sites against flood risk.

5.1 Flood Zones

The data used to prepare the fluvial mapping for this study is based on the results from hydraulic models, either provided by the Environment Agency or prepared for the purposes of this SFRA. Existing hydraulic models used include:

- River Trent 2005 1D ISIS-only model

5.1.1 Flood Zones 2 and 3a

Flood Zones 2 and 3a have been taken from the Environment Agency's Flood Zones. The reason for the Flood Zones being derived in this way where there was a detailed hydraulic model was available was because mapped outlines were not provided by the Environment Agency with provision of the model. Re-running of the hydraulic model to produce these Flood Zones would have produced inconsistency with the existing Environment Agency Flood Zones (which were derived from the same model) due to changes in Lidar and subjectivity of mapping 1D mapping techniques.

Where no detailed hydraulic models were available, but where a drain was shown to be present on OS mapping in the vicinity of the site, 2D generalised modelling using Jflow was undertaken.

For the purpose of the Level 2 SFRA, the following return periods were modelled using Jflow.

- 20-year (to inform Flood Zone 3b)
- 100-year (to inform Flood Zone 3a)
- 100-year + Climate Change (+20%, +30% and +50% to account for 2080s allowances)
- 1,000-year (to inform Flood Zone 2).

Although 2D modelling was undertaken for the 20-year, 100-year and 1,000-year return periods, to maintain consistency across the assessment, the Environment Agency's Flood Zone 2 and 3a were used, due to differences in LIDAR and mapping techniques, which will have led to different flood extents.

5.1.2 Flood Zone 3b

Flood Zone 3b has been identified as land which would flood with an annual probability of 1 in 20 years (5% AEP). Usually, where detailed hydraulic models exist, the modelled 20-year defended flood extent is used to inform Flood Zone 3b; however, mapped outlines were not provided by the Environment Agency with provision of the model and re-running of the hydraulic model to produce these Flood Zones produced inconsistencies with the existing Environment Agency Flood Zones due to changes in LIDAR and 1D mapping techniques.

It was therefore decided to set Flood Zone 3b as equal to Flood Zone 3a, and there it is an 'Indicative Flood Zone 3b'. The extents should be confirmed by developers as part of site-specific Flood Risk Assessments.

Although modelling was undertaken for the 20-year return period using Jflow for the Footherley Hall site where no Environment Agency hydraulic models were provided, to maintain consistency across the assessment, the Environment Agency Flood Zone 3a was also taken to be an indicative Flood Zone 3b.

5.2 Climate change

Three climate change allowances were modelled by re-running the Environment Agency's detailed model of the River Trent, upscaling the 100-year flow event by the relevant climate change factor. These runs represented the Central (100-year +20%) Higher Central (100-year +30%) and Upper End (100-year +50%) climate change allowances for the 2080s epoch.

The site covered by Environment Agency Flood Zones but not by the model detailed above, was modelled for climate change as part of this SFRA using Jflow. The mapping provides a strategic assessment of climate change risk; developers should undertake detailed modelling of climate change allowances as part of a site-specific FRA, following the climate change guidance set out by the Environment Agency.

5.3 Surface Water

Mapping of surface water flood risk at the sites in Lichfield District has been taken from the Risk of Flooding from Surface Water (RoFSW) dataset, published online by the Environment Agency.

Category	Definition
High	Flooding occurring as a result of rainfall with a greater than 1 in 30 chance in any given year (annual probability of flooding 3.3%)
Medium	Flooding occurring as a result of rainfall of between 1 in 100 (1%) and 1 in 30 (3.3%) chance in any given year.
Low	Flooding occurring as a result of rainfall of between 1 in 1,000 (0.1%) and 1 in 100 (1%) chance in any given year.
Very Low	Flooding occurring as a result of rainfall with less than 1 in 1,000 (0.1%) chance in any given year.

The RoFSW is derived primarily from identifying topographical flow paths of existing watercourses or dry valleys that contain some isolated ponding locations in low lying areas.

Although the RoFSW offers improvement on previously available datasets, the results should not be used to understand flood risk for individual properties. The results should be used for high level assessments such as SFRAs for local authorities. If a particular site is indicated in the Environment Agency mapping to be at risk from surface water flooding, a more detailed assessment should be required to more accurately illustrate the flood risk at a site-specific scale. Such an assessment will use the RoFSW in partnership with other sources of local flooding information to confirm the presence of a surface water risk at that particular location.

5.4 Groundwater

Mapping of groundwater flood risk has been based on the Areas Susceptible to Groundwater (AStGWF) dataset. The AStGWF dataset is a strategic-scale map showing groundwater flood areas on a 1km square grid. It shows the proportion of each 1km grid square, where geological and hydrogeological conditions indicate that groundwater might emerge. It does not show the likelihood of groundwater flooding occurring and does not take account of the chance of flooding from groundwater rebound. This dataset covers a large area of land, and only isolated locations within the overall susceptible area are actually likely to suffer the consequences of groundwater flooding.

The AStGWF data is indicative and should only be used in combination with other information, for example local data or historical data. It should not be used as sole evidence for any specific flood risk management, land use planning or other decisions at any scale. However, the data can help to identify areas for assessment at a local scale where finer resolution datasets exist.

5.5 River networks

Main Rivers are represented by the Environment Agency's Statutory Main River layer. Ordinary Watercourses are represented by the Environment Agency's Detailed River Network Layer.

5.6 Flood Warning

Flood Warning Areas are represented by the Environment Agency's Flood Warning Area GIS dataset.

5.7 Reservoirs

The risk of inundation as a result of reservoir breach or failure of a number of reservoirs within the area has been identified from the Environment Agency's Long Term Flood Risk Information website.

5.8 Sewer flooding

Historical incidents of flooding are detailed by Severn Trent Water through their sewer flooding register. The sewer flooding register records incidents of flooding relating to public foul, combined or surface water sewers and displays which properties suffered flooding. This data was requested and is used to describe any sewer flooding in the Level 2 summary tables. Due to licencing and confidentiality restrictions, sewer flooding data has not been represented on the mapping.

5.9 Historic flooding

Historic flooding was assessed using the Environment Agency's Historic Flood Map, as well as any incidents picked up in the flooding register noted in Section 8.8, and aerial photography provided by the Council.

5.10 Flood defences

Flood defences are represented by Environment Agency's AIMS Spatial Defences data set. Their current condition and standard of protection are based on those recorded in the tabulated shapefile data. None of the sites being assessed are formally protected by a flood defence.

5.11 Depth, Velocity and Hazard to people

The Level 2 assessment seeks to map the probable depth and velocity of flooding as well as the hazard to people during the defended Upper End (100-year +50%) climate change allowances for the 2080s epoch. The 100-year +50% flood event has been investigated in further detail because the Level 2 assessment helps inform the Exception Test and usually flood mitigation measures and access/ egress requirements focus on flood events lower than the 1,000-year event (e.g. the 100-year or 100-year plus climate change events). As part of a site-specific FRA, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood depth, velocity and hazard based on the relevant 100-year plus climate change event as part of a site-specific FRA, using the relevant climate change allowance based on the type of development and its associated vulnerability classification. Not all of this information is known at the strategic scale.

For 1D-only hydraulic models, velocity and hazard results are not available from the modelled outputs.

Hazard to people has been calculated using the below formula as suggested in Defra's FD2321/TR2 "Flood Risk to People".

HR = d x (v + 0.5) + DF
Where, HR = (flood) hazard rating;
d = depth of flooding (m);
v = velocity of floodwaters (m/sec); and
DF = debris factor (= 1, conservative estimate of DF as largely urban area)

The different hazard categories are shown in Table 5-1.

Table 5-1 : Defra's FD2321/TR2 "Flood Risks to People" classifications

Description of Flood Hazard Rating	Flood Hazard Rating	Classification Explanation
Very Low Hazard	< 0.75	Flood zone with shallow flowing water or deep standing water"
Danger for some (i.e. children)	0.75 - 1.25	"Danger: flood zone with deep or fast flowing water"
Danger for most	1.25 - 2.00	Danger: flood zone with deep fast flowing water"
Danger for all	>2.00	"Extreme danger: flood zone with deep fast flowing water"

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6 Screening of potential development sites

6.1 Introduction

Three potential development sites were provided by Lichfield District Council for assessment as part of the Level 2 SFRA.

Sites were screened to provide a summary of flood risk to each site, including:

- The proportion of the site in each Flood Zone
- Whether the site is shown to be at risk in the RoFfSW and, if so, the lowest return period from which the site is at surface water flood risk
- Whether the site is within, or partially within, the Environment Agency's Historic Flood Map.

The screening was undertaken using JBA in-house software called "FRISM". FRISM is an internal JBA GIS package that computes a range of flood risk metrics based on flood and receptor datasets, giving a clear spatial picture of flood risk. The site boundaries were queried using FRISM against the flood risk information including Flood Zones, surface water and historic flood map.

Table 6-1 summarises the flood risk to the 3 proposed development sites.

Table 6-1: Site Allocation Flood Risk Screening

Site name	Area (ha)	Proportion of site shown to be at risk (%)							
		Flood Zones				Flood Risk from Surface Water dataset			Historic Flood Map
		Indicative FZ3b	FZ3a	FZ2	FZ1	30yr	100yr	1,000yr	
Land north of Dark Lane, Alrewas	4.75	0%	0%	8%	92%	0%	0%	1%	0%
Colton Road, Station Works	0.40	0%	0%	0%	100%	0%	0%	0%	0%
Footherley Lane, Footherley Hall	1.65	13%	0%	2%	85%	3%	7%	29%	0%

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7 Level 2 Assessment Methodology

7.1 Introduction

Proposed site allocations have been provided by the Council for assessment. This Level 2 SFRA assessment helps to determine variations in flood risk across the potential development sites, identifying site-specific FRA requirements and helping guide local policies to provide sustainable developments, as well as reducing flood risk to existing communities.

Please note, at the time of this report's submission, all three sites that underwent a Level 2 Assessment:

- Land north of Dark Lane, Alrewas
- Colton Road, Station Works
- Footherley Lane, Footherley Hall

These three sites all have a site-specific Flood Risk Assessment prepared and have been granted planning permission.

7.2 Site summary tables

As part of the Level 2 SFRA, detailed site summary tables have been produced for the following sites:

- Land north of Dark Lane, Alrewas
- Colton Road, Station Works
- Footherley Lane, Footherley Hall

The summary tables can be found in Appendix A.

Where available, the results from existing detailed Environment Agency hydraulic models were used in the assessment to provide depth, velocity and hazard information.

Using the model information combined with the Flood Zones, climate change and Risk of Flooding from Surface Water (RoFfSW) extents, detailed site summary tables have been produced for the potential development sites (see Appendix A). Each table sets out the following information:

Basic site information

- Area, type of site, current land use (greenfield/ brownfield), proposed site use

Sources of flood risk

- Existing drainage features
- Fluvial – proportion of site at risk including description from mapping/ modelling
- Surface Water – proportion of site at risk including description from RoFfSW mapping
- Reservoir
- Canal
- Flood History

Flood risk management infrastructure

- Defences – type, SoP, condition if known, and description

Emergency Planning

- Flood Warning Areas
- Access and egress

Climate change

- Summary of climate change allowances and increase in flood extent compared to Flood Zones

- Description of implications to the site

Requirements for drainage control and impact mitigation

- Broadscale assessment of possible SuDS to provide indicative surface water drainage advice for each site assessed for the Level 2 SFRA.
- Groundwater Source Protection Zone
- Historic Landfill Site

NPPF Planning implications

- Exception Test requirements
- Requirements and guidance for site-specific Flood Risk Assessment (including consideration of opportunities for strategic flood risk solutions to reduce flood risk)

Mapping information – description of data sources for the following mapped outputs:

- Flood Zones
- Climate change
- Surface water
- Depth, velocity and hazard mapping

7.2.1 Geo-PDF mapping

To accompany each site summary table, there is an Interactive Geo-PDF map, with all the mapped flood risk outputs per site. This is displayed centrally, with easy-to-use 'tick box' layers down the right-hand side and bottom of the mapping, to allow navigation of the data.

Flood risk information in the Geo-PDFs include:

- Site boundary and Council boundary
- Title bar showing area, grid reference, site name, proposed development use (e.g. residential/ employment) and Flood Zone % coverage
- Flood Zones 2, 3a and 3b (functional floodplain)
- Flood risk from Surface water dataset (30-years, 100-years and 1,000-years)
- Climate change extents – Higher Central and Upper allowances
- Areas Susceptible to Groundwater Flooding
- Modelled 100-year + 50% climate change fluvial depth, velocity and hazard rating
- Flood Warning and Flood Alert Areas
- Historic Landfill
- Defences (embankment, wall, other)
- Main Rivers/ Ordinary watercourses

7.3 Hydraulic Modelling undertaken at sites

The following sections describe the modelling work. It should be noted that no site visits or channel survey work has been undertaken as part of this assessment given the high-level nature of the assessment. It is recommended that developers undertake the necessary detailed site-specific work as part of a Flood Risk Assessment, if data is not already available.

Sites covered by detailed Environment Agency models are as follows:

- Colton Road, Station Works – River Trent 2005 1D ISIS model.
- Land north of Dark Lane, Alrewas – River Trent 2005 1D ISIS model.

7.3.1 Use of 2D generalised modelling

Where there are no Environment Agency detailed hydraulic models covering a site, 2D generalised modelling was undertaken using Jflow, to determine Flood Zone 3a, Flood Zone 3b and Flood Zone 2, as well as the effects of climate change. This was undertaken at site Footherley Lane, Footherley Hall.

Jflow is the modelling technique which was used to produce the National-scale Environment Agency Flood Zones, but the extents mapped as part of this study may differ as more up-to-date data has

been used (for example model software version, ground terrain data, hydrological parameters etc), since those published on the Environment Agency's website. Therefore, the Flood Zones from the Environment Agency have been maintained, but the climate change extents use the Jflow modelling conducted as part of this study.

The watercourse modelled is defined in the LIDAR and is represented on the FEH CD-ROM to allow hydrological inflows to be derived. An appropriate reach has been modelled, rather than the whole watercourse, to ensure sufficient coverage and representation of hydraulics in the local vicinity of the site being assessed. The channel capacity is assumed to be QMED; this is subtracted from the inflow hydrographs derived at defined point locations, and water is then allowed to spread across the LIDAR from these points, following topographic flow routes.

Jflow is suitable for providing an indication of flood risk for decision-making purposes at a strategic scale. It is recommended that developers construct a detailed hydraulic model at this site using channel and structure topographic survey, to confirm flood risk at a site.

Appendix B provides a technical summary of this 2D modelling technique.

7.3.2 Important note on datasets used for the summary table maps

It is important to recognise that for the SFRA, several different sets of data have been used to inform the extent, depth, hazard and velocity for each site.

Flood zones

The extent of flooding, which determines the proportions of the site falling into the different Flood Zones, were determined from:

- Flood Zone 2: based on the Environment Agency's Flood Zone 2.
- Flood Zone 3a: based on the Environment Agency's Flood Zone 3.
- Flood Zone 3b: based on the Environment Agency's Flood Zone 3.

Depth, velocity and hazard

Depth, velocity and hazard mapping for the 1 in 100-year +50% climate change event have been taken from the Environment Agency's detailed 1D hydraulic models, where models are present.

For 1D-only models (e.g. River Trent), depth outputs are available, but velocity and hazard outputs are not available. Therefore to prevent confusion, where velocity and hazard outputs for these areas are not available presented, they show an area of 'NO DATA'. Developers should consider improving or upgrading these models to 1D-2D where deemed appropriate, to derive the level of detail required at a site-specific Flood Risk Assessment level.

Where no EA models exist, these outputs were produced from the 100-year +50% climate change event of the 2D generalised modelling outputs. However, developers should seek to produce a detailed model incorporating channel survey for these areas, including smaller drains which were not covered by 2D modelling at a site-specific Flood Risk Assessment.

Climate change

Climate change extents are derived by upscaling the 100-year defended event from existing 1D hydraulic models for the relevant climate change allowance for the 2080s epoch. Where generalised modelling has been undertaken, the 100-year hydrograph was also upscaled by the relevant climate change factor.

7.4 Note on SuDS Suitability

The hydraulic and geological characteristics of each proposed site allocations were assessed to determine the constraining factors for surface water management. This assessment is designed to inform the early-stage site planning process and is not intended to replace site-specific detailed drainage assessments.

The assessment is based on catchment characteristics and additional datasets such as the AStGWF map and BGS Soil maps of England and Wales which allow for a basic assessment of the soil characteristics on a site by site basis. LIDAR data was used as a basis for determining the topography and average slope across each development site. Other datasets were used to determine other influencing factors on potential SuDS. These datasets include the following:

- Historic landfill sites

- Groundwater Source Protection Zones
- Detailed River Network
- Flood Zones derived as part of this L2 SFRA

This data was then collated to provide an indication of particular groups of SuDS systems which might be suitable at a site. SuDS techniques were categorised into five main groups, as shown in Table 7-1. This assessment should not be used as a definitive guide as to which SuDS would be suitable but used as an indicative guide of general suitability. Further site-specific investigation should be conducted to determine what SuDS techniques could be utilised on a particular development.

Table 7-1: Summary of SuDS Categories

SuDS Type	Technique
Source Controls	Green Roof, Rainwater Harvesting, Pervious Pavements, Rain Gardens
Infiltration	Infiltration Trench, Infiltration Basin, Soakaway
Detention	Pond, Wetland, Subsurface Storage, Shallow Wetland, Extended Detention Wetland, Pocket Wetland, Submerged Gravel Wetland, Wetland Channel, Detention Basin
Filtration	Surface Sand filter, Sub-Surface Sand Filter, Perimeter Sand Filter, Bioretention, Filter Strip, Filter Trench
Conveyance	Dry Swale, Underdrained Swale, Wet Swale

The suitability of each SuDS type for the proposed site allocations has been described in the summary tables, where applicable. The assessment of suitability is broadscale and indicative only; more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. The LLFA should be consulted at an early stage to ensure SuDS are implemented and designed in response to site characteristics and policy factors.

8 Summary of Level 2 assessment

8.1.1 Assessment methods

As part of the Level 2 SFRA, detailed site summary tables have been produced for three sites. These sites are shown to be at risk of fluvial flood risk from watercourses running either through or adjacent to the site.

The summary tables set out the flood risk to each site, including maps of extent, depth and velocity of flooding as well as hazard mapping for the 100-year +50% climate change defended event. Climate change mapping has also been produced for each site to indicate the impact which different climate change allowances may have on the site. Each table also sets out the NPPF requirements for the site as well as guidance for site-specific FRAs. A broadscale assessment of suitable SuDS options has been provided giving an indication where there may be constraints to certain sets of SuDS techniques. This assessment is indicative and more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. It may be possible that those SuDS techniques highlighted as possibly not being suitable can be designed to overcome identified constraints. Where deemed required, culvert blockages were also presented to assess residual risk to sites.

For the site not covered by the EA detailed hydraulic model, 2D generalised Jflow modelling was conducted.

8.1.2 Summary of key site issues

- Two of the three sites being assessed are covered by detailed Environment Agency hydraulic models: Land north of Dark Lane, Alrewas and Colton Road, Station Works are covered by the River Trent 1D-only ISIS model.
- 2D generalised modelling using Jflow was undertaken at one site; Footherley Lane, Footherley Hall. However, detailed hydraulic modelling using channel topographic survey would be required at a site-specific level to confirm the flood risk at this site, including the small unnamed drain in the south-west corner of the site which was not able to be modelled using 2D generalised modelling.
- Two out of the three sites (Land north of Dark Lane, Alrewas and Footherley Lane, Footherley Hall are at fluvial flood risk. The degree of flood risk varies, with the Land north of Dark Lane, Alrewas only being impacted by Flood Zone 2 and Footherley Lane, Footherley Hall being more consistently impacted on its western boundary. Therefore, these sites will require more detailed investigations on sequential site layouts, SuDS possibilities, safe access and egress etc.
- Land north of Dark Lane, Alrewas and Colton Road, Station Works have a minor risk of surface water flooding. Footherley Lane, Footherley Hall is at a greater risk from surface water flooding, with more areas of ponding in the higher return period events. Surface water tends to follow topographic flow routes, for example along the watercourses or isolated pockets of ponding where there are topographic depressions. Surface water should be considered when assessing safe access and egress to and from the site.
- Climate change mapping indicates that flood extents will increase. The significance of the increase tends to depend on the topography of site and the percentage allowance used.
- Footherley Lane, Footherley Hall is located in Groundwater Source Protection Zone 3. This means that special consideration needs to be taken with SuDS. A suitable level of treatment should be ensured prior to discharging, along with establishing an understanding of constraints to sites and how SuDS can be designed to overcome these from relevant bodies (e.g. LLFA).
- A strategic assessment was conducted of SuDS options using regional datasets. Therefore, a detailed site-specific assessment of suitable SuDS techniques would need to be undertaken at site-specific level to understand which SuDS option would be best.
- For Land north of Dark Lane, Alrewas and Colton Road, Station Works, there is the potential for safe access and egress to be impacted by fluvial or surface water flooding. Consideration should be made to these sites as to how safe access and egress can be provided during flood events, both to people and emergency vehicles.

- Please note, at the time of this report's submission, all three sites that underwent a Level 2 Assessment:
    - Land north of Dark Lane, Alrewas
    - Colton Road, Station Works
    - Footherley Lane, Footherley Hall
- These three sites all have a site-specific Flood Risk Assessment prepared and have been granted planning permission.

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9 Recommendations

A review of national and local policies has been conducted against the information collated on flood risk in this SFRA. Following this, several recommendations have been made for the Council to consider as part of their planning policy and flood risk management. These have been summarised below.

9.1 Site allocations

It is recommended that the outputs from this study are used as an evidence base for the allocation of potential development areas, directing new development to areas of lowest risk.

The Council should use the information provided within this SFRA for their Sequential Test decision-making, following which, if land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development, the Exception Test will need to be applied. This is where the Level 2 SFRA supports, as it considers the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

9.2 Assessing Flood Risk and Developments

- The NPPF supports a risk-based and sequential approach to development and flood risk in England, so that development is located in the lowest flood risk areas where possible; it is recommended that this approach is adopted for all future developments within the district.
- A site-specific FRA is required for all developments over 1ha in Flood Zone 1; for developments less than 1 ha in Flood Zone 1 where there is a change to vulnerability classification or where the development could be affected by sources of flooding; and for all developments located in an area which has been highlighted as having critical drainage problems. The FRA should be proportionate to the degree of flood risk, as well as the scale, nature and location of the development.
- It is recommended that the impact of climate change to a proposed site is considered in a FRA and that the percentage increases which relate to the proposed lifetime of the development and the vulnerability classification of the development is accounted for. The Environment Agency and LLFA should be consulted to confirm a suitable approach to climate change in light of the latest guidance and requirements.
- At site-specific level, for any developments shown to be at residual flood risk, for example from a breach or overtopping (e.g. reservoir, canal, perched watercourse), it is recommended that a detailed hydraulic modelling study is carried out using Environment Agency guidance to assess the residual risk. For development applications located in the vicinity of a canal or navigation channel or reservoir, it is recommended that overtopping and / or breach of the structure is considered as part of a site-specific FRA to establish the residual risk to the development.
- Opportunities to reduce flood risk to wider communities could be sought through the regeneration of Brownfield sites, through reductions in the amount of surface water runoff generated on a site. The functional floodplain should be protected from development and returned to greenfield status (where possible).
- The Local Planning Authority, Environment Agency and Lead Local Flood Authority should be consulted to confirm the level of assessment required and to provide any information on any known local issues.
- When assessing sites not identified (windfall sites), developers should use evidence provided in this SFRA to apply the Sequential Test, as well as provide evidence to show that they have adequately considered other reasonably available sites.
- To demonstrate the Exception Test has been passed, flood resilience design and emergency planning must be accounted for including:
    - The development will remain safe and operational under flood conditions;
    - A strategy for safe evacuation and / or safely remaining in the building under flood conditions;
    - Key services will continue to be provided under flood conditions; and
    - Buildings are designed for a quick recovery following a flood.

- The Environment Agency may require developers to consider the impacts of more extreme events in the appraisal of flood resilience design and emergency planning.
- Flood Risk Assessments should demonstrate that developments do not increase the likelihood or intensity of flood risk to third party development. Where possible, proposals should seek to maximise opportunities to reduce flood risk at the site and to communities immediately downstream of the site.
- FRAs should follow the approach recommended by the NPPF (and associated guidance) and guidance provided by the Environment Agency and Lichfield District Council. Guidance and advice for developers on the preparation of site-specific FRAs include:
    - Standing Advice on Flood Risk (Environment Agency)
    - Flood Risk Assessment for Planning Applications (Environment Agency)
    - Site-specific Flood Risk Assessment: CHECKLIST (NPPF PPG, Defra)

9.2.1 Future Developments

Development must seek opportunities to reduce the overall level of flood risk at the site, for example by:

- Reducing volume and rate of surface water runoff based on local planning policy and LLFA Guidance
- Locating development to areas with lower flood risk
- Creating space for flooding
- Integrating green infrastructure into mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

The Local Planning Authority should consult the National Planning Practice Guidance and Environment Agency's 'Flood Risk Standing Advice (FRSA) for Local Planning Authorities', published in March 2014, when reviewing planning applications for proposed developments at risk of flooding.

At the planning application stage, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances, published by the Environment Agency in February 2016), inform development zoning within the site and prove, if required, whether the Exception Test can be passed.

9.2.2 Promotion of SuDS

Planners should be aware of the conditions set by the LLFA for surface water management and ensure development proposals and applications are compliant with the Council's policy.

- Wherever possible, SuDS should be promoted.
- It is essential that developers consider sustainable drainage at an early stage of the development process – ideally at the master-planning stage. This will assist with the delivery of well designed, appropriate and effective SuDS.
- A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals. New or re-development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- Development should aim to achieve Greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible.
- Where possible developments must utilise the most sustainable form of drainage systems, in accordance with the SuDS hierarchy.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough to allow for SuDS techniques that are designed to encourage infiltration.
- Where sites lie within or close to Groundwater SPZs or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration. Further restrictions may still be applicable, and guidance should be sought from the LLFA.

- Developers need to ensure that new development does not increase the surface water runoff rate from the site and should therefore contact the LLFA and other key stakeholders at an early stage to ensure surface water management is undertaken and that SuDS are promoted and implemented, designed to overcome site-specific constraints.
- The LPA will need to consider drainage schemes for major applications, but it is advised developers utilise the LLFA's policies and guidance to develop their drainage scheme for minor applications.
- Where SUDs are provided as part of a development, applicants should detail how it will be maintained in the long term.

9.2.3 Infrastructure and Access

- Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard should be identified. None of the sites assessed in this Level 2 assessments are protected by formal flood defences, though this should be a consideration for any future windfall sites which may be located near to flood defences.
- Safe access and egress for residents and emergency and service vehicles will need to be demonstrated at all development sites

9.3 Use of SFRA data and future updates

It is important to recognise that the SFRA has been developed using the best available information at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

The SFRA should be a 'living document', and as a result should be updated when new information on flood risk, flood warning or new planning guidance or legislation becomes available. New information on flood risk may be provided by Lichfield District Council, Staffordshire County Council, the Highways Authority, Canal and River Trust, Severn Trent Water and the Environment Agency. Such information may be in the form of:

- New hydraulic modelling results
- Flood event information following a future flood event
- Policy/ legislation updates
- Environment Agency flood map updates
- New flood defence schemes etc.

The Environment Agency regularly reviews their flood risk mapping, and it is important that they are approached to determine whether updated (more accurate) information is available prior to commencing a detailed Flood Risk Assessment. It is recommended that the SFRA is reviewed in line with the Environment Agency's Flood Zone map updates to ensure latest data is still represented in the SFRA, allowing a cycle of review and a review of any updated data by checking with the above bodies for any new information.

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Appendices

A Appendix - Level 2 Assessment

A.1 L2 Site Summary Tables

A.2 Geo-PDF Mapping

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Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Colton Road, Station Works
	Area	0.40 hectares
	Current land use	Brownfield
	Proposed land use	Housing
Sources of flood risk	**Existing drainage features**	• The River Trent flows to the west of the site in a south-easterly direction. • Moreton Brook flows to the east of the site in a south-westerly direction to the confluence with the River Trent south of the site. • There is a small unnamed drain to the east of the site which enters a culvert at the B5013 Colton Road and emerges near the Moreton Brook and River Trent confluence.
	Fluvial	**Proportion of site at risk** **FZ3b** | **FZ3a** | **FZ2** | **FZ1** 0% | 0% | 0% | 100% Flood risk to the site is associated with the River Trent, which flows to the west of the site, the Moreton Brook to the east of the site and the unnamed drain to the east of the site and west of the A51 and railway line. Neither FZ2 or FZ3a extend into the site; however, both Flood Zones closely track the easterly site boundary due to flow paths through the rail embankment, with FZ2 presenting some potential access and egress issues with the flood extent surrounding the site. The Moreton Brook has not been formally modelled as part of the River Trent model, so this may need to be considered in further detail as part of a site-specific FRA, in order to confirm the flood extents on the site's side of the railway and interactions with the Trent at the confluence.
	Surface Water	**Proportion of site at risk (RoFfSW)** **30-year** | **100-year** | **1,000-year** 0% | 0% | 0% The site itself is not shown to be at risk of surface water flooding. The surface water risk surrounding the site is influenced by the topographic low to the east of the site and to any gaps in the railway embankment, which may affect access and egress. These areas seem relatively sparse in the 30 and 100-year surface water events but increase to fill the topographic lows and gaps in the railway embankments in the 1,000-year surface water events.
	Reservoir	The site is not shown to be at risk of reservoir flooding.
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past. The Southern Staffordshire Surface Water Management Plan (2011) identifies surface water flooding to be a problem in the Rugeley area and broadly identifies the risk of surface water flooding in this area to be every 1-2 years.
Flood risk management infrastructure	**Defences**	**Defence Type** | **Standard of Protection** | **Condition** - | - | - This site is not protected by any formal flood defences.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Colton Road, Station Works			
	Area	0.40 hectares			
	Current land use	Brownfield			
	Proposed land use	Housing			
	Residual risk	The small unnamed drain which flows into the B5013 culvert near the south-western corner of the site may need to be considered by developers at a site-specific level, in case water backing up could encroach into the site.			
Emergency planning	**Flood warning**	The site is not covered by the Environment Agency's Flood Warning Service.			
	Access and egress	In all surface water events, dry access and egress to the south and west of the site is not possible. Dry access and egress via Colton Road to the north-west of the site is possible in the 30-year and 100-year surface water events. However, dry access and egress is significantly reduced and may not be possible in the 1,000-year surface water event. In both FZ3a and FZ2, dry access and egress to the south and west of the site is not possible. Dry access and egress via Colton Road to the north west of the site is possible in FZ3a but not in FZ2.			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Humber	20%	30%	50%
	% of site at risk		4%	4%	5%
	Implications for the site	Climate change scenarios show an increase in flooding across Colton Road, encroaching marginally into the eastern boundary of the site. Note that although there is flow through the railway embankment covering the extent of the Moreton Brook and filling the topographic low points associated with the unnamed drain to the east of the site, these watercourses have not been explicitly modelled and therefore the risk from these watercourses will need to be confirmed at site-specific level.			

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Colton Road, Station Works
	Area	0.40 hectares
	Current land use	Brownfield
	Proposed land use	Housing

Requirements for drainage control and impact mitigation	**Broad scale assessment of possible SuDS**	• Geology at the site consists of:
		  ○ Bedrock – Sandstone and conglomerate, interbedded
		  ○ Superficial – Sand and gravel
		• The site is not located within Groundwater Source Protection Zone.
		• Source control techniques are likely to be suitable for this site.
		• Mapping suggests groundwater flooding may be an issue at the site, as such infiltration techniques may not be suitable. This should be confirmed by on site ground investigation.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.
		• The site is not designated by the Environment Agency as previously being a landfill site.
		• The South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014) highlights the need for SuDS measures on any new developments.
		• A Flooding Information Request report for this site from Staffordshire County Council suggests that infiltration will not be achievable for this site, however this would need to be confirmed by developers.

NPPF and planning implications	**Exception Test requirements**	The Sequential Test will need to be passed before the Exception Test is applied. The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test. The South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014) suggests appropriate measures to restrict inappropriate developments in the Trent corridor.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Colton Road, Station Works
	Area	0.40 hectares
	Current land use	Brownfield
	Proposed land use	Housing
	Requirements and guidance for site-specific Flood Risk Assessment	• In the South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014), guidance from Lichfield District Council states: 'Proposed development should be guided away from the extended floodplain (outside the functional flood) for both the Rivers Tame and Trent. These floodplains are important features in terms of flood risk management. Any development in these areas would have detrimental effect on flood risk in Lichfield, and would increase flood risk downstream'. • Please note, at the time of issue, this site has had a site-specific FRA prepared and has been granted planning permission. • Consultation with the Local Authority, Local Lead Flood Authority and the Environment Agency should be undertaken at an early stage. • Developers will need to consider the risk of flooding both from the Moreton Brook and the unnamed drain to the east of the site, as there is currently no detailed modelling of these watercourses. • Onsite attenuation schemes would need to be tested against the appropriate watercourse(s) to ensure flows are not exacerbated downstream within the catchment. • New or re-development should adopt exemplar source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff. • Assessment for runoff should include allowance for climate change effects. • Safe access and egress will need to be demonstrated.

Mapping Information	
Flood Zones	Flood Zones 2 and 3a are based on the Environment Agency's Flood Zone 2 and 3. Flood Zone 3b is marked as 'indicative' as it is set as equal to the Environment Agency's Flood Zone 3a extent. This is because there were discrepancies in using the modelled 25-year Trent 1D extent when compared against Flood Zone 3a, most likely due to updated 1D mapping processes and LIDAR since the Flood Zones and hydraulic model were created. The extent of Flood Zone 3b should be confirmed by developers as part of a site-specific Flood Risk Assessment, if required, given the site is shown not to be located in the Flood Zones.
Climate change	The climate change allowances for the '2080s' scenarios were modelled using the Environment Agency's detailed 1D River Trent ISIS hydraulic model.
Surface Water	The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Colton Road, Station Works
	Area	0.40 hectares
	Current land use	Brownfield
	Proposed land use	Housing
Depth, velocity and hazard mapping		Depth grids have been derived from the Environment Agency's detailed 1D River Trent ISIS hydraulic model, using the 100-year event with 50% climate change event (Upper end for 2080s). As the River Trent model is 1D-only, velocity and hazard outputs are not produced by the modelling and therefore no data is available.
Reservoir		The Environment Agency's long-term flood risk information, flood risk from reservoirs dataset was used to define areas at risk from reservoirs.

Site ID: Colton Road, Station Works

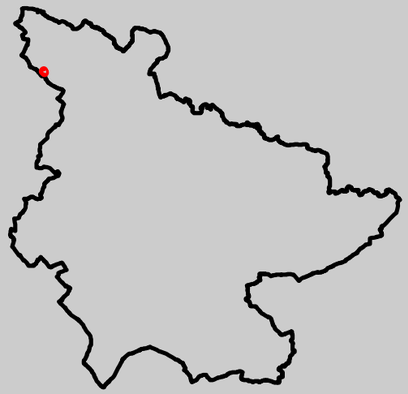
OSNGR: 404787 , 319235 Area: 0.4 ha Brownfield

Flood Zone Coverage	FZ3b : 0%	FZ3a: 0%	FZ2: 0%	FZ1: 100%

Proposed Development Details:
Housing

LEVEL 2 SITE SUMMARY TABLES

LICHFIELD DISTRICT COUNCIL
STRATEGIC FLOOD RISK ASSESSMENT



LEGEND

Flood Risk

Flood Zones
- Indicative Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoFfSW 30-year Extent
- RoFfSW 100-year Extent
- RoFfSW 1000-year Extent

Areas Susceptible to Groundwater Flooding
- >= 75%
- >= 50% <75%
- >= 25% <50%
- < 25%

Upper End Climate Change event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 -1.00
- 1.00 -1.50
- 1.50 - 2.00
- 2.00 -2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00
- NODATA

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- NO DATA

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all
- NO DATA

Please refer to Main Report and Site Summary Table for further information on the datasets

0 0.0125 0.025 0.05 km

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LEGEND

Authority Information
- Council Boundary
- Potential Site Allocations
- Main Rivers
- Detailed River Network

Defences
- Embankment
- Wall
- Other

Flood Warning and Flood Alert Areas
- Flood Warning Area
- Flood Alert

Reservoir Inundation Map
- Reservoir Inundation

Other
- Source Protection Zones

Mapping

Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables

Site details	**Site Code**	Footherley Lane, Footherley Hall
	Area	1.65 hectares
	Current land use	Mixed Greenfield and Brownfield
	Proposed land use	Housing
Sources of flood risk	**Existing drainage features**	• Footherley Brook runs along the west boundary of the site in a northerly direction. • There is a small unnamed drain that extends from the middle of the site into the Footherley Brook in the south-west corner of the site.
	Fluvial	**Proportion of site at risk**

FZ3b	FZ3a	FZ2	FZ1
13%	0%	2%	86%

Flood risk to the site is associated with the Footherley Brook, which flows along the west boundary of the site in a northerly direction. The western portion of the site is located in FZ3 with a larger extent extending into the site in FZ2. This fluvial risk does not consider the small unnamed drain that extends into the site from the Footherley Brook in the south-west corner, which may need to be considered in a site-specific Flood Risk Assessment. The eastern half of the site is not at fluvial flood risk due to the higher topography.

Surface Water — **Proportion of site at risk (RoFfSW)**

30-year	100-year	1,000-year
3%	7%	29%

The surface water flood risk affecting the site is associated with the Footherley Brook to the western boundary of the site and pond located on the site. The surface water extent encroaches further east onto the site in the larger surface water events.

Reservoir	The western half of the site is shown to be within the reservoir inundation flood extents from Little Aston Pool and to a lesser extent, Barr Beacon No. 2. However, risk of flooding from reservoirs is considered low.
Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past. Footherley Hall Shenstone FRA (2014) reports observed flooding on 2 occasions in the period 2005-2014 but that only the low-lying garden area has been flooded.

Flood risk management infrastructure — **Defences**

Defence Type	Standard of Protection	Condition
-	-	-

This site is not protected by any formal flood defences.

Residual risk	There are no structures currently shown at the site. However, there could be a risk of culvert blockage to the site, as the Footherly Brook flows under Footherley Lane to the north of the site, which could impound water on the upstream side, increasing flood risk back towards the site. It is recommended any residual risk is considered at site-specific Flood Risk Assessment stage.
Flood warning	The site is not covered by the Environment Agency's Flood Warning Service.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Footherley Lane, Footherley Hall			
	Area	1.65 hectares			
	Current land use	Mixed Greenfield and Brownfield			
	Proposed land use	Housing			
Emergency planning	**Access and egress**	Dry access and egress via Footherley Lane to the east is possible in both FZ3a and FZ2. Dry access and egress via Footherley Lane to the east is also possible in all surface water events, and additionally may be possible to the north on Footherley Lane in the 30-year surface water event.			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Humber	20%	30%	50%
	% of site at risk		33%	34%	34%
	Implications for the site	Fluvial extents from climate change do not increase significantly when compared with FZ3a because the floodplain is constrained, with the eastern half of the site at higher ground. Depths, velocity and hazard may however increase.			

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Footherley Lane, Footherley Hall
	Area	1.65 hectares
	Current land use	Mixed Greenfield and Brownfield
	Proposed land use	Housing

Requirements for drainage control and impact mitigation	**Broad scale assessment of possible SuDS**	• Geology at the site consists of:
		  ○ Bedrock – Sandstone and conglomerate, interbedded.
		  ○ Superficial – Sand and gravel
		• The site is located within Groundwater Source Protection Zone 3.
		• Source control techniques could be suitable for this site; however, this would need to be confirmed by the EA due to the location of the site within Source Protection Zone 3.
		• Mapping suggests groundwater flooding may be an issue at the site; as such, infiltration techniques may not be suitable. This should be confirmed by on site ground investigation.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.
		• The site is not designated by the Environment Agency as previously being a landfill site.
		• A Flooding Information Request report for this site from Staffordshire County Council suggests that infiltration will not be achievable for this site; however, this would need to be confirmed by developers.

NPPF and planning implications	**Exception Test requirements**	The Sequential Test will need to be passed before the Exception Test is applied. The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Footherley Lane, Footherley Hall
	Area	1.65 hectares
	Current land use	Mixed Greenfield and Brownfield
	Proposed land use	Housing

	Requirements and guidance for site-specific Flood Risk Assessment	• Please note, at the time of issue, this site has had a site-specific FRA prepared and has been granted planning permission.
		• Consultation with the Local Authority, Local Lead Flood Authority and the Environment Agency should be undertaken at an early stage.
		• 2D generalised modelling has been used to demonstrate flood risk from the Footherley Brook at this site. Developers should confirm flood risk to the site by conducting detailed hydraulic modelling using channel topographic survey.
		• The unnamed drain in the south west corner of the site has not been explicitly modelled and therefore the risk from this watercourse may need to be confirmed at site-specific level.
		• Residual risk from culvert blockages may need to be considered as part of a site-specific FRA, for example the risk from Footherley Lane culvert.
		• Resilience measures will be required if buildings are situated in the flood risk area along the site's western boundary. Raising Finished Floor Levels above the design event may remove the need for resilience measures.
		• Onsite attenuation schemes would need to be tested against the appropriate watercourse(s) to ensure flows are not exacerbated downstream within the catchment.
		• New or re-development should adopt exemplar source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
		• Assessment for runoff should include allowance for climate change effects.
		• Safe access and egress will need to be demonstrated.
		• New development must seek opportunities to reduce overall level of flood risk at the site, for example by:
		  ○ Reducing volume and rate of runoff
		  ○ Relocating development to zones with lower flood risk
		  ○ Creating space for flooding.
		• Developers may wish to consider the hydraulic function of the ornamental pond and associated feed watercourse in the site, in terms of local hydraulic characteristics. Removing the ornamental pond may also allow for the removal of local weirs on the Main River, resulting in changes in the local hydraulic characteristics of the river.
		• Green infrastructure could be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

Mapping Information

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Footherley Lane, Footherley Hall
	Area	1.65 hectares
	Current land use	Mixed Greenfield and Brownfield
	Proposed land use	Housing
Flood Zones		Flood Zones 2 and 3a are based on the Environment Agency's Flood Zone 2 and 3. Flood Zone 3b is marked as 'indicative' as it is set as equal to the Environment Agency's Flood Zone 3a extent, in the absence of existing model data. Developers will need to construct a detailed hydraulic model using channel survey as part of a site-specific Flood Risk Assessment in order to confirm Flood Zone 3b at the site.
Climate change		The climate change allowances for the '2080s' were modelled using generalised 2D modelling techniques. This is the same method as that used for the National Flood Zones, but there may be differences in extents when compared against the Flood Zones, due to updated mapping processes and LIDAR used in this new modelling.
Surface Water		The Risk of Flooding from Surface Water dataset has been used to define areas at risk from surface water flooding.
Depth, velocity and hazard mapping		Depth, velocity and hazard mapping for the 1 in 100-year event with 50% climate change (Upper end to 2080s) were derived from 2D generalised modelling techniques.
Reservoir		The Environment Agency's long-term flood risk information, flood risk from reservoirs dataset was used to define areas at risk from reservoirs.

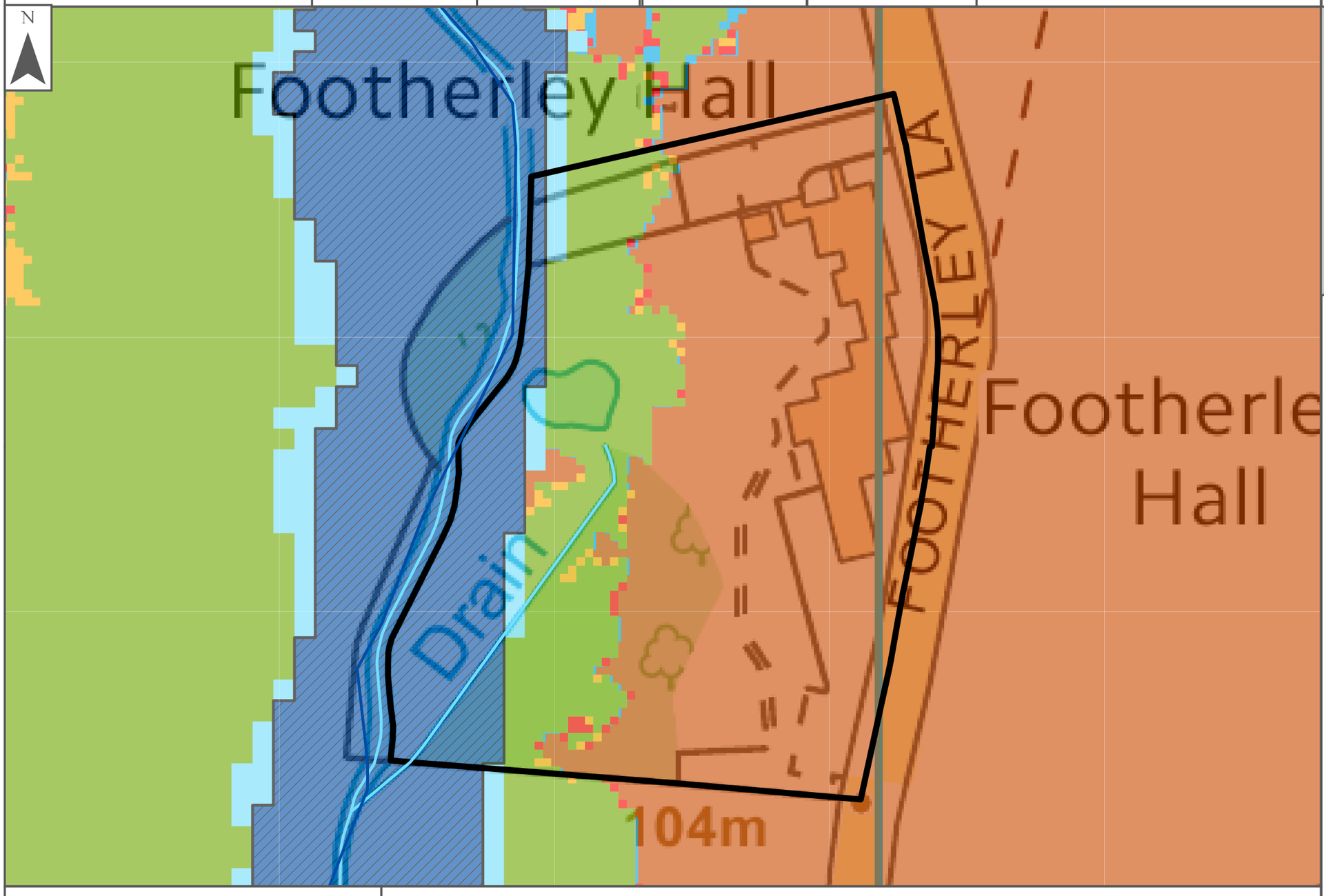
Site ID: Footherley Lane, Footherley Hall

OSNGR: 409955 , 303644 | Area: 1.65 ha | Mixed Greenfield and Brownfield | Proposed Development Details: Housing

Flood Zone Coverage	FZ3b : 13%	FZ3a: 0%	FZ2: 2%	FZ1: 85%

LEVEL 2 SITE SUMMARY TABLES

LICHFIELD DISTRICT COUNCIL STRATEGIC FLOOD RISK ASSESSMENT



0 0.0175 0.035 0.07 km

JBA consulting

LEGEND

Authority Information
- Council Boundary
- Potential Site Allocations
- Main Rivers
- Detailed River Network

Defences
- Embankment
- Wall
- Other

Flood Warning and Flood Alert Areas
- Flood Warning Area
- Flood Alert

Reservoir Inundation Map
- Reservoir Inundation

Other
- Source Protection Zones

LEGEND

Flood Risk

Flood Zones
- Indicative Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoFfSW 30-year Extent
- RoFfSW 100-year Extent
- RoFfSW 1000-year Extent

Areas Susceptible to Groundwater Flooding
- >= 75%
- >= 50% <75%
- >= 25% <50%
- < 25%

Upper End Climate Change event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 -1.00
- 1.00 -1.50
- 1.50 - 2.00
- 2.00 -2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00
- NODATA

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- NO DATA

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all
- NO DATA

Please refer to Main Report and Site Summary Table for further information on the datasets

Mapping

Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables

Site details	**Site Code**	Land North of Dark Lane, Alrewas
	Area	4.75 hectares
	Current land use	Greenfield
	Proposed land use	Housing

Sources of flood risk

Existing drainage features

- The River Trent flows to the north of the site in an easterly direction.
- The Trent and Mersey Canal runs to the west of the site and connects with the River Trent on it's right bank to the north-west corner of the site.
- There is a small unnamed drain entering the right bank of the River Trent approximately 1.7km north of the site.
- Approximately 1.5km to the east of the site, the River Tame joins the River Trent from the south

Fluvial

Proportion of site at risk			
FZ3b	**FZ3a**	**FZ2**	**FZ1**
0%	0%	8%	92%

Flood risk to the site is associated with the River Trent, which flows to the north of the site. FZ3 tracks the northern boundary of the site but does not extend into it. FZ2 increases in extent and extends into the site on the north-west and south-east of the site.

There may also be some interactions at the confluence of the River Tame and Trent, which could have a backwater effect towards the A38.

Surface Water

Proportion of site at risk (RoFfSW)		
30-year	**100-year**	**1,000-year**
0%	0%	1%

The surface water risk affecting the site is limited to isolated topographic lows along the southern and eastern boundaries of the site. However, surface water flooding only affects the site itself during the 1,000-year event. Surface water flood risk affects the roads to the south of the site. This starts with small areas of surface water in the 30-year event with extents growing in the 100-year event with significant surface water flooding to the south of the site in the 1,000-year event.

Reservoir

The whole site and surrounding area is shown to be within the reservoir inundation extents, from Blithfield Reservoir. However, flooding from reservoirs is considered low risk.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Land North of Dark Lane, Alrewas			
	Area	4.75 hectares			
	Current land use	Greenfield			
	Proposed land use	Housing			
	Flood history	The Environment Agency's historic flood map does not show the site as having flooded in the past. A report from Alrewas Parish Council from 2013 on historic flooding in Alrewas shows pictorial evidence of flooding on Micklehome Drive and the A38 northbound carriageway which provide access to the site. In addition, widespread flooding is shown from June 2007 and December 2000 in Alrewas including the confluence of the Trent and Mersey Canal and the River Trent to the north-west of the site; however, exact locations of these photographs are not evident within the report. The report also suggests this widespread flooding within Alrewas occurs every 2-3 years. The Land North of Dark Lane, Alrewas Flood Risk Assessment & Drainage Strategy (2015) report several historical instances of flooding in the village of Alrewas with one instance to south east corner of the site with a reported frequency of 1-2 years.			
Flood risk management infrastructure	**Defences**	**Defence Type**	**Standard of Protection**	**Condition**	
		-	-	-	
		This site is not protected by any formal flood defences.			
	Residual risk	-			
Emergency planning	**Flood warning**	A small area of the site in the south-east corner is covered by the Environment Agency's Flood Warning Area, River Trent at Alrewas and Wychnor (033FWF3TRENT13).			
	Access and egress	Dry access and egress via Dark Lane out of the village is possible in the 30-year surface water event and via Micklehome Drive directly onto the A38 during the 100-year surface water event. However, both of these access and egress routes are cut off in the 1,000-year surface water event. Dry access and egress is possible via Dark Lane in both FZ3 and FZ2.			
Climate Change	**Climate change allowances for '2080s'**	**River Basin District**	**Central**	**Higher Central**	**Upper End**
		Humber	20%	30%	50%
	% of site at risk		20%	29%	43%
	Implications for the site	The climate change events extend into the low-lying areas of the site in the east and north with a progressive increase in extent with the larger climate change events. The climate change events also show a significant increase in flooding along the southern boundary of the site preventing dry access and egress. As the site is affected by surface water flooding from the 1,000-year event, climate change may also increase the extent, depth and frequency of surface water flooding.			

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Land North of Dark Lane, Alrewas
	Area	4.75 hectares
	Current land use	Greenfield
	Proposed land use	Housing

Requirements for drainage control and impact mitigation	**Broad scale assessment of possible SuDS**	• Geology at the site consists of:
		  ○ Bedrock – Mudstone, siltstone and sandstone
		  ○ Superficial – Clay, silt and sand.
		• The site is not located within Groundwater Source Protection Zone.
		• Source control techniques are likely to be suitable for this site.
		• Mapping suggests groundwater flooding may be an issue at the site, as such infiltration techniques may not be suitable. This should be confirmed by on site ground investigation.
		• Detention features may be feasible providing site slopes are <5% at the location of the detention feature. If groundwater is a risk to the site, then a liner may be required to mitigate against potential contamination issues.
		• Filtration systems are probably suitable providing site slopes are <5% and the depth to the water table is >1m. If the site has contamination issues, or at risk from groundwater, then a liner will be required.
		• All forms of conveyance features are likely to be suitable. Where slopes are >5%, features should follow contours or utilise check dams to slow flows.
		• The site is not designated by the Environment Agency as previously being a landfill site.
		• The South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014) highlights the need for SuDS measures on any new developments.
		• A Flooding Information Request report for this site from Staffordshire County Council suggests that infiltration is unlikely to be achievable for this site; however, this would need to be confirmed by developers.

NPPF and planning implications	**Exception Test requirements**	The Sequential Test will need to be passed before the Exception Test is applied. The Exception Test will need to be applied if: • More Vulnerable and Essential Infrastructure development is located in FZ3a and for Highly Vulnerable development located in FZ2. • Highly Vulnerable infrastructure should not be permitted within FZ3a and FZ3b. • More Vulnerable and Less Vulnerable Infrastructure should not be permitted within FZ3b. • Essential Infrastructure in Flood Zone 3b will require the Exception Test. The South Staffordshire, Cannock Chase, Lichfield and Stafford SFRA (2014) suggests appropriate measures to restrict inappropriate developments in the Trent corridor.

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Land North of Dark Lane, Alrewas
	Area	4.75 hectares
	Current land use	Greenfield
	Proposed land use	Housing

	Requirements and guidance for site-specific Flood Risk Assessment	• Please note, at the time of issue, this site has had a site-specific FRA prepared and has been granted planning permission.
		• In the South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014), guidance from Lichfield District Council states: 'Proposed development should be guided away from the extended floodplain (outside the functional flood) for both the Rivers Tame and Trent. These floodplains are important features in terms of flood risk management. Any development in these areas would have detrimental effect on flood risk in Lichfield, and would increase flood risk downstream'.
		• The South Staffordshire, Cannock Chase, Lichfield and Stafford Level 1 SFRA (2014) highlights the importance of preserving the floodplain in Alrewas as 'any constrictions introduced in this area would have significant effects downstream'.
		• Consultation with the Local Authority, Local Lead Flood Authority and the Environment Agency should be undertaken at an early stage.
		• Resilience measures will be required if buildings are situated in the flood risk area along the site's northern boundary. Raising Finished Floor Levels above the design event may remove the need for resilience measures.
		• Onsite attenuation schemes would need to be tested against the River Trent to the north of the site to ensure flows are not exacerbated downstream within the catchment.
		• New or re-development should adopt exemplar source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
		• Assessment for runoff should include allowance for climate change effects.
		• Safe access and egress will need to be demonstrated.
		• New development must seek opportunities to reduce overall level of flood risk at the site, for example by:
		  ○ Reducing volume and rate of runoff
		  ○ Relocating development to zones with lower flood risk
		  ○ Creating space for flooding.
		• Green infrastructure should be considered within the mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.
		• The Southern Staffordshire Outline Water Cycle Study (2010) highlights that 'All flow is received from the pumping station located off Dark Lane, Alrewas which has no spare capacity. It is also located within the floodplain. Due to the levels of potential development being considered in Alrewas and Fradley Village early guidance from Severn Trent Water regarding overall development proposals is essential'.

Mapping Information		

Mapping	**Lichfield District Strategic Flood Risk Assessment Level 2 Detailed Site Summary Tables**	

Site details	**Site Code**	Land North of Dark Lane, Alrewas
	Area	4.75 hectares
	Current land use	Greenfield
	Proposed land use	Housing
Flood Zones		Flood Zones 2 and 3a are based on the Environment Agency's Flood Zone 2 and 3. Flood Zone 3b is marked as 'indicative' as it is set as equal to the Environment Agency's Flood Zone 3a extent. This is because there were discrepancies in using the modelled 25-year Trent 1D extent when compared against Flood Zone 3a, most likely due to updated 1D mapping processes and LIDAR since the Flood Zones and hydraulic model were created. The extent of Flood Zone 3b should be confirmed by developers as part of a site-specific Flood Risk Assessment.
Climate change		The climate change allowances for the '2080s' scenarios were modelled using the Environment Agency's detailed 1D River Trent ISIS hydraulic model.
Surface Water		The Risk of Flooding from Surface Water has been used to define areas at risk from surface water flooding.
Depth, velocity and hazard mapping		Depth grids have been derived from the Environment Agency's detailed 1D River Trent ISIS hydraulic model, using the 100-year event with 50% climate change event (Upper end for 2080s). As the River Trent model is 1D-only, velocity and hazard outputs are not produced by the modelling and therefore no data is available.
Reservoir		The Environment Agency's long-term flood risk information, flood risk from reservoirs dataset was used to define areas at risk from reservoirs.

Site ID: Land north of Dark Lane, Alrewas

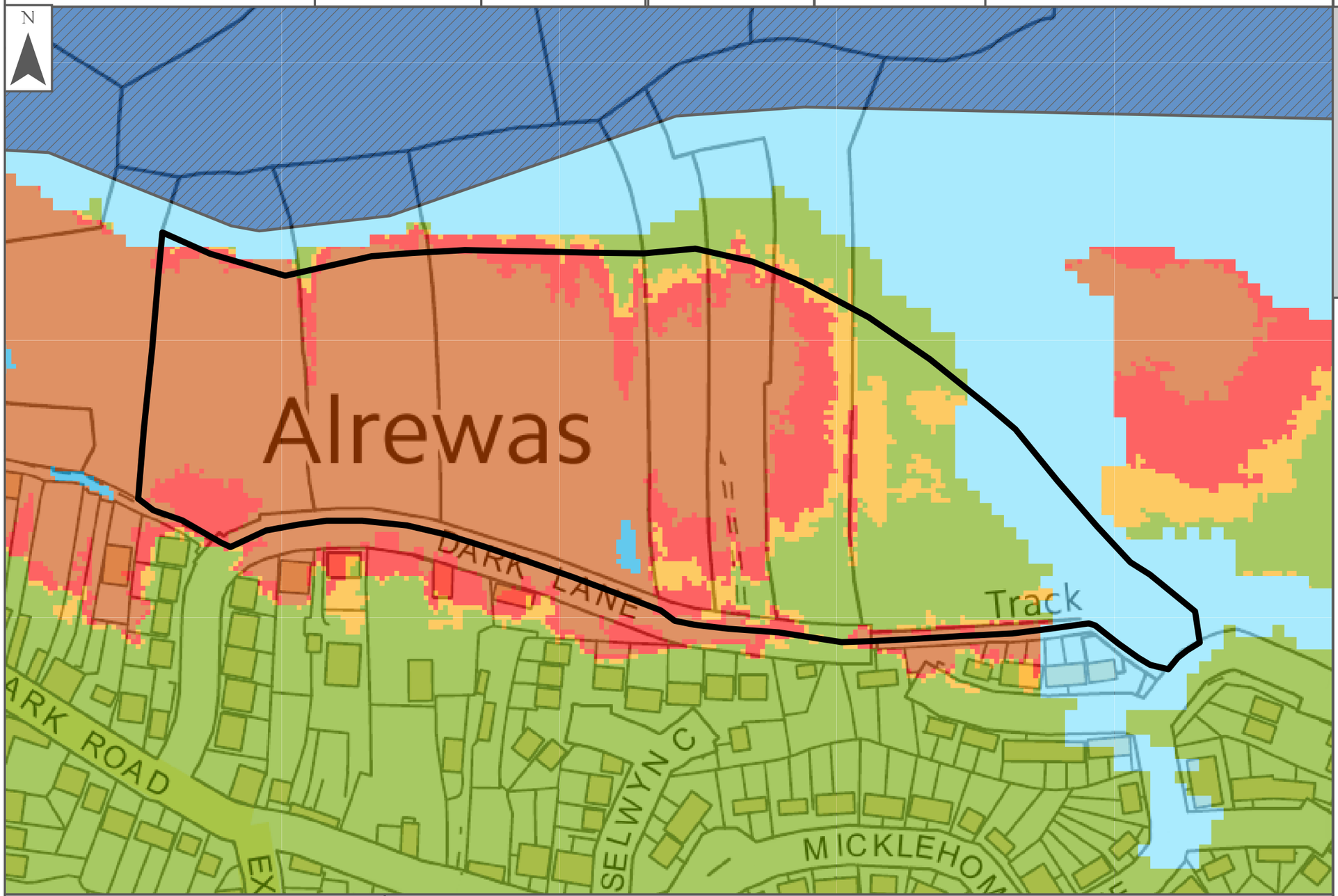
OSNGR: 417451 , 315270 Area: 4.75 ha Greenfield

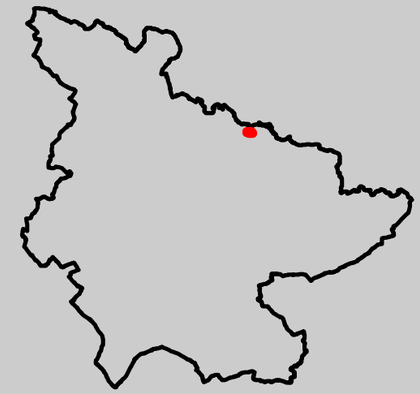
Flood Zone Coverage	FZ3b : 0%	FZ3a: 0%	FZ2: 8%	FZ1: 92%

Proposed Development Details:
Housing

LEVEL 2 SITE SUMMARY TABLES

LICHFIELD DISTRICT COUNCIL STRATEGIC FLOOD RISK ASSESSMENT





LEGEND

Flood Risk

Flood Zones
- Indicative Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

Climate Change
- Climate Change Central
- Climate Change Higher Central
- Climate Change Upper End

Surface Water
- RoFfSW 30-year Extent
- RoFfSW 100-year Extent
- RoFfSW 1000-year Extent

Areas Susceptible to Groundwater Flooding
- >= 75%
- >= 50% <75%
- >= 25% <50%
- < 25%

Upper End Climate Change event

Depth (m)
- 0 - 0.10
- 0.10 - 0.50
- 0.50 -1.00
- 1.00 -1.50
- 1.50 - 2.00
- 2.00 -2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- >4.00
- NODATA

Velocity (m/s)
- 0 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- > 2.0
- NO DATA

Hazard Rating
- Very low hazard - caution
- Danger for some
- Danger for most
- Danger for all
- NO DATA

Please refer to Main Report and Site Summary Table for further information on the datasets

0 0.0325 0.065 0.13 km

JBA consulting

LEGEND

Authority Information
- Council Boundary
- Potential Site Allocations
- Main Rivers
- Detailed River Network

Defences
- Embankment
- Wall
- Other

Flood Warning and Flood Alert Areas
- Flood Warning Area
- Flood Alert

Reservoir Inundation Map
- Reservoir Inundation

Other
- Source Protection Zones

B Appendix - Technical Supporting Information

B.1 2D Modelling Technical Summary

NOTE TO FILE

JBA Project Code	2017s6842
Contract	Lichfield District L2 SFRA
Client	Lichfield District Council
Day, Date and Time	1 December 2017
Author	Roberta Whittaker
Subject	Lichfield District L2 SFRA – 2D generalised modelling

1 Introduction

This document is designed to give an overview of the 2D modelling approach for the strategic modelling used to assess fluvial flood risk to site allocations in the Lichfield District Level 2 SFRA, where no detailed Environment Agency models were available.

2 Modelling Approach

2.1 Introduction to hydraulic modelling

Hydraulic modelling allows simplification of very complex processes, which can enable us to predict flooding caused by events of different return periods. Hydraulic models can be classified according to the number of dimensions in which they represent the spatial domain and flow processes.

One-dimensional models can be useful for studying flood levels and discharges in river systems, and have been applied to flood routing problems at the reach scale. They allow for rapid evaluation of water levels and are best suited for describing flow within channels and through hydraulic structures. They are computationally very efficient but can be potentially expensive in terms of time and data required. The areas between cross-sections are not explicitly represented and a secondary processing step is required in order to map flood inundation.

Two-dimensional models are capable of accurately simulating flow patterns during partial inundation and drainage of the floodplain in order to predict flood risk in these regions. They are therefore best suited for describing the lateral diffusion of shallow water flows over low-lying areas. With two-dimensional models the topography and roughness is described as a continua and they facilitate direct mapping of flood inundation. However, when compared to 1D models, 2D models can be relatively computationally expensive and poor at describing flow through hydraulic structures.

Coupled 1D-2D models can therefore be used to combine the best attributes of each model class to achieve acceptable, computationally affordable predictions of flood extent when compared to typically available verification data.

2.2 2D modelling using JFlow

JFlow® is JBA's proprietary 2D hydraulic model. The model solves the full Shallow Water Equations on a regular square cell grid, and utilises GPU technology to provide parallelised calculations which allows large regions to be modelled efficiently, whilst capturing a wide range of flood hydraulic processes.

The Shallow Water Equations are comprised of two components. The first part is the continuity equation which describes the amount of water that moves in a given amount of time (the given amount of time is known as the timestep). The second component is the momentum equation which describes the rate at which water will move between cells. By solving both of these components at a point in time, the velocity and depth of water at a location can be determined, and by solving these sequentially through time, the passage of a flood wave over an area can be determined.

The inputs to JFlow® are a topographical domain model, which is represented as a grid where each cell of the grid represents a coordinate position with elevation data. Water is then added to the grid as either a hydrograph (river discharge vs time) or as a hyetograph (rainfall depth vs time). A number of additional parameters to the Shallow Water Equations are also input, such as Manning's n, which is a friction coefficient that accounts for losses in momentum caused by water travelling over a surface.

JFlow® determines for each cell, for each timestep in a simulation, a water depth, and a velocity. This is done in three steps. Assuming that for a cell, the water depth and the velocity of the adjacent cell is known, the first step involves determining the volume of water in the cell and the adjacent cell, and calculating the amount of water that can move between those cells (Figure 1). The second step, the inter-cell flux, determines the rate at which the amount of water calculated in step 1 can move, using the velocity of water from the previous cell and the momentum component of the shallow water equations. These two steps then allow the water depth and velocity in the cell to be calculated. Step 3 then repeats

this calculation for all adjacent cells, to determine the direction, speed and volume of flow (Figure 2). This leads to a vector calculation from the cell, in the direction of the greatest hydraulic slope calculated from each of the intercell fluxes.

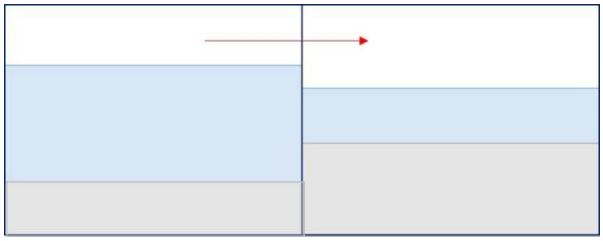


Figure 1: (Step 1 & 2) The Intercell Flux is calculated between two cells. The depth of water in each cell and the height of the terrain determines the volume of water to move. This figure will lead to a movement of water from the left side cell to the right side cell as represented by the red arrow.

The process is performed for all model cells in the domain for an interval of time (the time step), before the time interval is evolved and a new set of water depths in the grid are calculated based on the previous time interval. These steps are then repeated for the duration of the modelled flood event to determine the movement of the flood wave over the model domain.

In order to determine the greatest hazard from flooding, the maximum calculated flood depth for each cell across the time duration is calculated. The final hazard output represents a composition of the highest water depths for each cell, during the flood event. A series of model domains are used to model river reaches, before being amalgamated into a final flood hazard map.

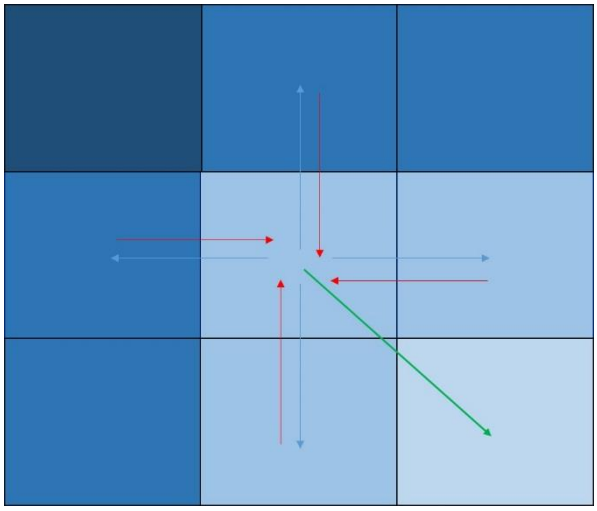


Figure 2: (Step 3) Calculating the intercell flux for all cells and solving to determine the new depth values. After step 1 and 2 are completed (red arrows), all intercell fluxes are calculated for adjacent cells and new values of depth are based on the net values of the intercell fluxes. The resulting sum in this example would see the overall flood wave propagating in the direction of the green arrow in the direction of greatest water slope

2.2.1 Hydrology

In order to run Jflow, hydrological estimates need to be generated for each inflow point. These estimates are based on catchment descriptors extracted from the FEH CD-ROM. Typically, there was an inflow point upstream of each of the site allocations requiring Jflow; however, on longer stretches of watercourse multiple points were used at 100m spacing intervals. The key information within the catchment

descriptors which was used to determine hydrological flows is listed in Table 1. In some cases, the catchment descriptors associated with an inflow point can be extracted from a nearby river or stream, which may cause jumps or falls in the hydrograph values compared with the rest of the reach. In these instances, donor catchments of nearby inflow points were used with adjustments made to the catchment descriptors to represent the new characteristics.

Table 1: Example catchment descriptors

Catchment Descriptor	Explanation
Area	Drainage area km^2
DPLBAR	Mean drainage path length (km)
DPSBAR	Mean slope between nodes (m/km)
FARL	Flood attenuation due to reservoirs and lakes (1.0 for no attenuation)
SAAR	Standard annual average rainfall 1961-1990 (mm)
BFIHOST	Baseflow index from hydrology of soil types
SPRHOST	Standard percentage runoff from soil types
PROPWET	Proportion of time catchment is wet (Soil moisture deficit < 6mm)
URBEXT1990	Urban extent in 1990

Once catchment descriptors had been extracted for each inflow point a JBA tool was used to generate hydrographs for various return periods. Flood Estimation Software (JFes) provides flood estimation for catchments in UK and Ireland. JFes has the capacity to create hydrographs suitable for use in JFlow to produce river hazard maps using catchment descriptors obtained from the FEH CD-ROM as described in the previous section. JFes uses information from the HiFlows-UK dataset to search for donor sites. HiFlows-UK provides flood peak data and station information, for approximately 1,000 gauging stations in the UK. Each point extracted from FEH CD-ROM has a unique ID. The output from the bulk extraction section of JFes produces a file for each requested return period comprising hydrographs for each point with and information about peak flows. The hydrograph is suitable for use in Jflow modelling and requires minimal data manipulation.

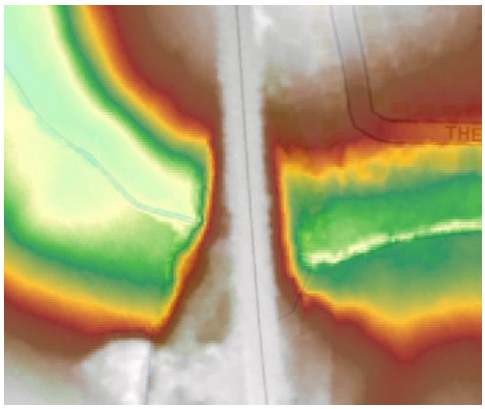
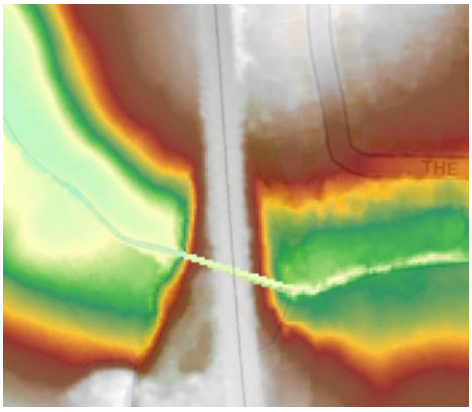
For the purpose of the SFRA the following return periods were modelled.

- 20-year (to inform Flood Zone 3b)
- 100-year (to inform Flood Zone 3a)
- 100-year + Climate Change (+35% and +70% to account for 2080s allowances)
- 1,000-year (to inform Flood Zone 2)

2.2.2 Digital Terrain Model

The Digital Terrain Model (DTM) was created from open LIDAR downloaded from the open.gov.uk website (supplied from Environment Agency). The DTM is a bare earth model but still contains some features such as bridges, subways and embankments which appear as high ground and act as obstacles to flow during the modelling process. This can result in flow accumulating behind which can cause unrealistically high depths and wide extents. In reality, water would flow underneath or around these structures. Where unusual flood extents and depths were observed, the presence or absence of a man-made structure was confirmed by inspecting aerial imagery and the terrain model. If a structure was identified, the high elevations due to man-made obstacles were ‘cut through’ enabling more natural flow (See Figure 3).

Figure 3: DTM cut through example

Original DTM	DTM + Cut through
	

2.2.3 Hydraulic Modelling Assumptions

A number of assumptions were made during the hydraulic modelling process:

- Channel capacity - This was assumed to equal QMED (2-year return period) for all rivers. Particularly in urban areas where channel improvements may have been carried out, this assumption can result in an underestimation of the channel capacity and hence an overestimation of the flood extent. However, studies have shown that unmodified river channel capacities frequently compare well with QMED and so this is deemed an appropriate assumption.
- Manning's *n* - A value of 0.1 was used throughout the study area. This represents a relatively conservative estimate but has been shown to provide acceptable model output in previous studies.
- Structures - Such as bridges and weirs were not explicitly modelled.
- Culverts - These were not explicitly modelled although smaller culverts through large structures such as railway embankments have been crudely cut into the DTM.
- Undefended - All river modelling is undertaken as undefended.
- Climate change hydrology – It has been assumed that hydrology for the 100-year + Climate Change 20%, 50% and 70% is a straight upscale of the 100-year hydrograph.

2.2.4 Outputs

Upon running Jflow, the following outputs were produced for each inflow point:

- Maximum depth
- Maximum velocity
- Maximum hazard

Following completion of the modelling, all outputs from each inflow point were mosaicked into one dataset per return period.

2.2.5 Quality Control

Once the hydraulic model was run for each return period, the resulting depth grid outputs were visually checked and adjustments to the modelling inputs were made where required. The adjustments and checks made include (but are not limited to):

- **Straight edges** – In some cases, straight edges can occur in the flood outlines where the flow is artificially restricted by the modelling domain size. The domain was extended to allow flow to run out naturally where possible.
- **Disconnected flooding** – Flood outlines can be disconnected as a result of a high point in the DTM that restricts the flow. This can be improved by moving an inflow point to the high point in an attempt to fill the break in the flood outline. In some cases, where the channel is not well represented, manual editing of the channel can occur. In all cases the channel was considered with reference to aerial imagery.
- **Cross section edges** - Due to the modelling methods used, straight edges of relatively deeper depths can occur where inflow points are located across the flood outline. This is especially prominent where flow can become constricted behind a road or railway line. To mitigate this, the inflow point was moved upstream further away from the restriction or the cross sections re-angled appropriately.
- **Alignment of points** – Due to the nature of the watercourses and the resolution of the LIDAR creation of inflow points, in some cases these were located outside of the river channel causing unrealistic flood outlines. These points were moved onto the lowest part of the river channel to correct this problem.
- **Restriction of flow due to structures** – The flood depths can be artificially increased by the presence of blockages in the DTM, these can be mitigated by DTM editing (as explained in section 2.1.2)
- **Increase in depth/extent per return** – both visual and automatic checks are undertaken to ensure that flood depths and flood extents increase with return period.
- **Unrealistic output** – in certain circumstances, JFlow can produce erroneous output where flood depths and extents are unrealistically produce. These errors were spotted both visually and through automatic checks.

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