South Worcestershire Councils Level 1 Strategic Flood Risk Assessment

Final Report

August 2019

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South Worcestershire Councils

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Revision history

Revision Ref/Date	Amendments	Issued to
Draft Report v1.0/ December 2018	Draft Report	Angie Matthews (Senior Planning Officer)
Draft Report v2.0/May 2019	Addition of cumulative impact assessment, updated report layout	Angie Matthews (Senior Planning Officer)
Final Report v1.0/August 2019	Addressed stakeholder comments	Angie Matthews (Senior Planning Officer)

Contract

This report describes work commissioned by the South Worcestershire Councils (Wychavon District Council, Malvern Hills District Council and Worcester City Council), by an email dated 12th October 2018 from Wychavon District Council. Lucy Finch of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

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- The South Worcestershire Councils:
    - Wychavon District Council
    - Malvern Hills District Council
    - Worcester City Council
- Worcestershire County Council;
- Environment Agency;
- Canal and Rivers Trust;
- Severn Trent Water;
- Lower Severn Internal Drainage Board;
- Fire and Rescue; and
- Planners at the neighbouring authorities.

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Executive summary

Introduction

The Level 1 Strategic Flood Risk Assessment (SFRA) 2019 document was created with the purpose of supporting the production of the South Worcestershire Development Plan Review and Preferred Options. The study area comprises Wychavon District, Malvern Hills District and Worcester City which, for the purposes of planning, are known as the South Worcestershire Councils (SWCs). The Level 1 SFRA will provide an understanding of the risk from all types of flooding across South Worcestershire and present clear and robust evidence. It will also provide useful information to inform future Infrastructure Planning and Neighbourhood Plans.

Strategic Flood Risk Assessment Objectives

The key objectives of the Level 1 Strategic Flood Risk Assessment are to:

- Inform the South Worcestershire Development Plan Review and Preferred Options by assessing flood risk from all sources, current and future.
- Identify which locations are most and least vulnerable to flooding from all relevant sources.
- Produce a comprehensive set of maps presenting flood risk from all sources that can be used as evidence base for flood management purposes.
- Provide sufficient detail to enable the Sequential Test to be applied to inform allocations of land for development.
- Provide clear advice for developers undertaking site-specific flood risk assessments.
- Take into account climate change.
- Assess the cumulative impact that development will have on flood risk.

SFRA outputs

The following outputs have been produced for this SFRA:

- **Identification of policy and technical updates**.
- Recommendations of the criteria that should be used to assess future development proposals and the **development of a Sequential Test and sequential approach to flood risk**.
- Assessment of the potential increase in **flood risk due to climate change**.
- Review of **historic flood incidents**.
- Appraisal of **all potential sources of flooding**, including Main River, ordinary watercourse, surface water, sewers, groundwater, reservoirs and canals.
- **Mapping** showing distribution of flood risk across all flood zones from all sources of flooding including climate change allowances.
- Reporting on the **standard of protection** provided by existing flood risk management infrastructure.
- Assessment of the **cumulative impact of development**.
- Assessment of **strategic flood risk solutions** that can be implemented to reduce risks.
- **Flood Risk Assessment guidance for developers**.
- Guidance on the use of **Sustainable Drainage Systems**.

Summary of flood risk in South Worcestershire

Parts of South Worcestershire are at risk from the following sources: fluvial, surface water, groundwater, sewers, reservoir inundation and canal overtopping/breaches. This study has shown that the most significant sources of flood risk in South Worcestershire are fluvial and surface water.

- *Fluvial flooding*: The primary fluvial flood risk is along the River Severn, River Teme, River Avon and the tributaries of these rivers. These present fluvial flood risk to rural communities as well as some of the main urban centres, including, but not limited to Worcester, Upton upon Severn, Evesham, Pershore and Tenbury Wells. The floodplains of the watercourses are notably wide along the River Severn downstream of Worcester, the River Avon, the River Teme downstream of Horsham and along the Longdon Brook to the west of Longdon, due to lower lying, flat topography. Major historic flooding events across South Worcestershire occurred in 1998, Autumn 2000, July 2007 and 2014 where several hundred properties were flooded on each occasion.
- *Surface water:* Surface water flooding is most likely caused by intense rainfall. There are many areas in South Worcestershire at risk from surface water flooding. The Risk of Flooding from Surface Water map shows a number of prominent overland flow routes; these predominantly follow topographical flow paths of existing watercourses or dry valleys with some isolated ponding located in low lying areas. The SWMP floodspot data shows that historic flooding events from surface water are widespread throughout South Worcestershire, with notable clusters around Kempsey, Bredon, Westmancote, Overbury, Broadway, Evesham, Bretforton, Crowle and Elmley Castle.
- *Sewer*: The sewers in South Worcestershire are managed by Severn Trent Water. Severn Trent Water provided their Hydraulic Flood Risk Register which denotes 457 properties at risk of sewer flooding in South Worcestershire. The areas with the most recorded events of sewer flooding are Worcester, Malvern and Upton upon Severn.
- *Groundwater:* The Areas Susceptible to Groundwater Flooding map shows that in general, the majority of South Worcestershire is within the <25% susceptibility classification, therefore is at a lower risk of groundwater flooding. Parts of the study area including along the River Severn, River Avon and River Teme fall within the higher susceptibility classifications and are therefore at a higher risk of groundwater flooding. The areas most at risk from groundwater flooding are low-lying areas where the water table is naturally near the surface. The SWMP floodspot data shows that there are very few historic flood events relating to groundwater, however those that are from groundwater sources are largely within Wychavon and are widespread throughout the District.
- *Canals*: There are two canals in South Worcestershire, the Worcester and Birmingham Canal and the Droitwich Canal. These have the potential to interact with other watercourses and become flow paths during flood events or in a breach scenario. There has been one incident of breach on the Worcester and Birmingham Canal in 2008 at Shernal Green and three incidences of overtopping, once in 2007 at Blackpole and twice in 2012 at multiple locations. There has been one incident of breach on the Droitwich Canal in 1930 at Bevere Island and nine incidences of overtopping, five times in 2012 at various locations, three times in 2013 at Porter's Hill Farm and once in 2017 at the junction between the two canals.
- *Reservoirs:* There is a potential risk of flooding from reservoirs both within South Worcestershire and those outside. There are no records of flooding from reservoirs in the study area. The level and standard of inspection and maintenance required under the Reservoirs Act means that the risk of flooding from the reservoirs is

relatively low. However, there is a residual risk of a reservoir breach and this should be considered in any site-specific Flood Risk Assessments (where relevant).

How to use this report

Planners

The SFRA provides **recommendations** regarding **all sources of flood risk** in South Worcestershire which can be used to inform policy on flood risk within the Development Plan Review and Preferred Options. This includes how the cumulative impact of development should be considered.

It provides the latest flood risk data and **guidance to inform the Sequential Test** and provides recommendations for any further work to be done in a Level 2 SFRA that would inform the Exception Test. The SWCs can use this information to apply the Sequential Test to strategic allocations and identify where the Exception Test will also be needed.

The SFRA provides **guidance for developers**, which can be used by Development Management staff to assess whether site specific Flood Risk Assessments meet the required quality standard.

Developers

For sites that are not strategic allocations, developers will need to use this SFRA to help apply the Sequential Test. For all sites, whether strategic allocations or windfall sites, developers will need to apply the Exception Test and use information in a site-specific Flood Risk Assessment to inform this test at planning application stage.

When assessing sites not identified in the Local Plan (windfall sites), developers should use evidence provided in this SFRA to apply the **Sequential Test** and provide evidence to show that they have adequately considered reasonably available sites at lower flood risk.

This is a strategic assessment and does not replace the need for site-specific Flood Risk Assessments where a development is either within Flood Zone 2 or 3 or greater than a hectare in Flood Zone 1. In addition, a Surface Water Drainage Strategy will be needed for all major developments in any Flood Zone to satisfy Worcestershire County Council (the Lead Local Flood Authority (LLFA) for the area).

Developers can use the information in this SFRA, alongside site-specific research to help to scope out what additional work will be needed in a detailed Flood Risk Assessment. To do this they should refer to **Chapter 5** 'Understanding flood in South Worcestershire' and the **flood maps in the appendices**.

At the planning application stage, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (**including applying the latest climate change allowances**, due to be updated by the Environment Agency in 2019), inform master planning and prove, if required, whether the Exception Test can be passed.

Developers need to ensure that new development does not increase surface water runoff from a site. **Chapter 9** provides information on the surface water drainage requirements of Worcestershire County Council as LLFA. Sustainable Drainage Systems should be considered at the earliest stages that a site is developed which will help to minimise costs and overcome any site-specific constraints.

Flood Risk Assessments will need to identify how flood risk will be mitigated to ensure the development is safe from flooding. In high risk areas, the Flood Risk Assessment will also need to consider emergency arrangements, including how there will be safe access and egress from the site.

Developers should contribute to the wider strategic vision for flood risk management and drainage in an area where possible. Any developments located within an area protected by **flood defences**, where the condition of those defences is 'fair' or 'poor', where the future maintenance is uncertain and where the standard of protection is not of the required standard

(either now or in the future) should be identified and the use of developer contributions considered to fund improvements.

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Abbreviations and Glossary of Terms

Term	Definition
1D model	One-dimensional hydraulic model
2D model	Two-dimensional hydraulic model
AEP	Annual Exceedance Probability – The probability (expressed as a percentage) of a flood event occurring in any given year.
AStGWf	Areas Susceptible to Groundwater flooding
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) can cause flooding.
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.
Design flood	This is a flood event of a given annual flood probability, which is generally taken as: fluvial (river) flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year), or; tidal flooding with a 0.5% annual probability (1 in 200 chance each year), against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.
DTM	Digital Terrain Model
EA	Environment Agency
EU	European Union
Exception Test	Set out in the NPPF, the Exception Test is used to demonstrate that flood risk to people and property will be managed appropriately, where alternative sites at a lower flood risk are not available. The Exception Test is applied following the Sequential Test.
FCERM	Flood and Coastal Erosion Risk Management
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 Map for Planning	The Environment Agency Flood Map for Planning (Rivers and Sea) is an online mapping portal which shows the Flood Zones in England. The Flood

	Zones refer to the probability of river and sea flooding, ignoring the presence of defences and do not account for the possible impacts of climate change.
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.
FWA	Flood Warning Area
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a 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
FRMP	Flood Risk Management Plan
FSA	Flood Storage Area
FWMA	Flood and Water Management Act
FWS	Flood Warning System
GI	Green Infrastructure – a network of natural environmental components and green spaces that intersperse and connect the urban centres, suburbs and urban fringe
Greenfield	Undeveloped parcel of land
Ha	Hectare
IDB	Internal Drainage Board
Indicative Flood Risk Area	Nationally identified flood risk areas based on the definition of 'significant' flood risk described by Defra and WAG.
JBA	Jeremy Benn Associates
Jflow	2D generalised hydrodynamic modelling software.
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
NFM	Natural Flood Management
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NRD	National Receptor Database
NRIM	National Reservoir Inundation Mapping

NVZs	Nitrate Vulnerability Zones
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.
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.
PPS25	Planning Policy Statement 25: Development and Flood Risk – superseded by the NPPF and PPG
RBMP	River Basin Management Plan
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.
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.
Riparian owner	A riparian landowner, in a water context, owns land or property, next to a river, stream or ditch.
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.
Risk Management Authority	Operating authorities who's remit and responsibilities concern flood and/or coastal risk management.
RoFfSW	Risk of Flooding from Surface Water (formerly known as the Updated Flood Map for Surface Water (uFMfSW)
Sequential Test	Set out in the NPPF, the Sequential Test is a method used to steer new development to areas with the lowest probability of flooding.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
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.
SPD	Supplementary Planning Document
SPZ	(Groundwater) Source Protection Zone
Stakeholder	A person or organisation affected by the problem or solution or 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.
SWCs	South Worcestershire Councils (Wychavon District, Malvern Hills District and Worcester City Councils)
SWMP	Surface Water Management Plan - A SWMP outlines the preferred surface water management strategy and identify the actions, timescales and responsibilities of each partner.
WFD	Water Framework Directive – Under the WFD, all waterbodies have a target to achieve Good Ecological Status (GES) or Good Ecological Potential (GEP) by a set deadline. River Basin Management Plans (RBMPs) set out the ecological objectives for each water body and give deadlines by when objectives need to be met.

1 Introduction

1.1 Purpose of the Strategic Flood Risk Assessment

JBA Consulting were commissioned by the SWCs to prepare a Level 1 Strategic Flood Risk Assessment (SFRA). The purpose of this study is to provide a comprehensive and robust evidence base to inform the preparation of the South Worcestershire Development Plan Review and Preferred Options. This SFRA and any follow-on Level 2 work will replace the "South Worcestershire SFRA Level 1 and 2", prepared by JBA Consulting in November 2009.

The 2019 SFRA will be used in decision-making and to inform decisions on the location of future development and the preparation of sustainable policies for the long-term management of flood risk.

1.2 Levels of SFRA

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

1. Level 1: where flooding is not a major issue in relation to potential site allocations and where development pressures are low. The assessment should be of sufficient detail to enable application of the Sequential Test.
2. Level 2: where land outside Flood Zones 2 and 3 cannot appropriately accommodate all 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.

This update focusses on a Level 1 SFRA assessment. Should the Councils be unable to place development outside of Flood Zones, a Level 2 assessment may be required in the future.

1.3 SFRA objectives

The key objectives of the Level 1 Strategic Flood Risk Assessment are to:

- Inform the South Worcestershire Development Plan Review and Preferred Options by assessing flood risk from all sources, current and future.
- Identify which locations are most and least vulnerable to flooding from all relevant sources.
- Produce a comprehensive set of maps presenting flood risk from all sources that can be used as evidence base for flood management purposes.
- Provide sufficient detail to enable the Sequential Test to be applied to inform allocations of land for development.
- Provide clear advice for developers undertaking site-specific flood risk assessments.
- Take into account climate change.
- Assess the cumulative impact that development will have on flood risk.

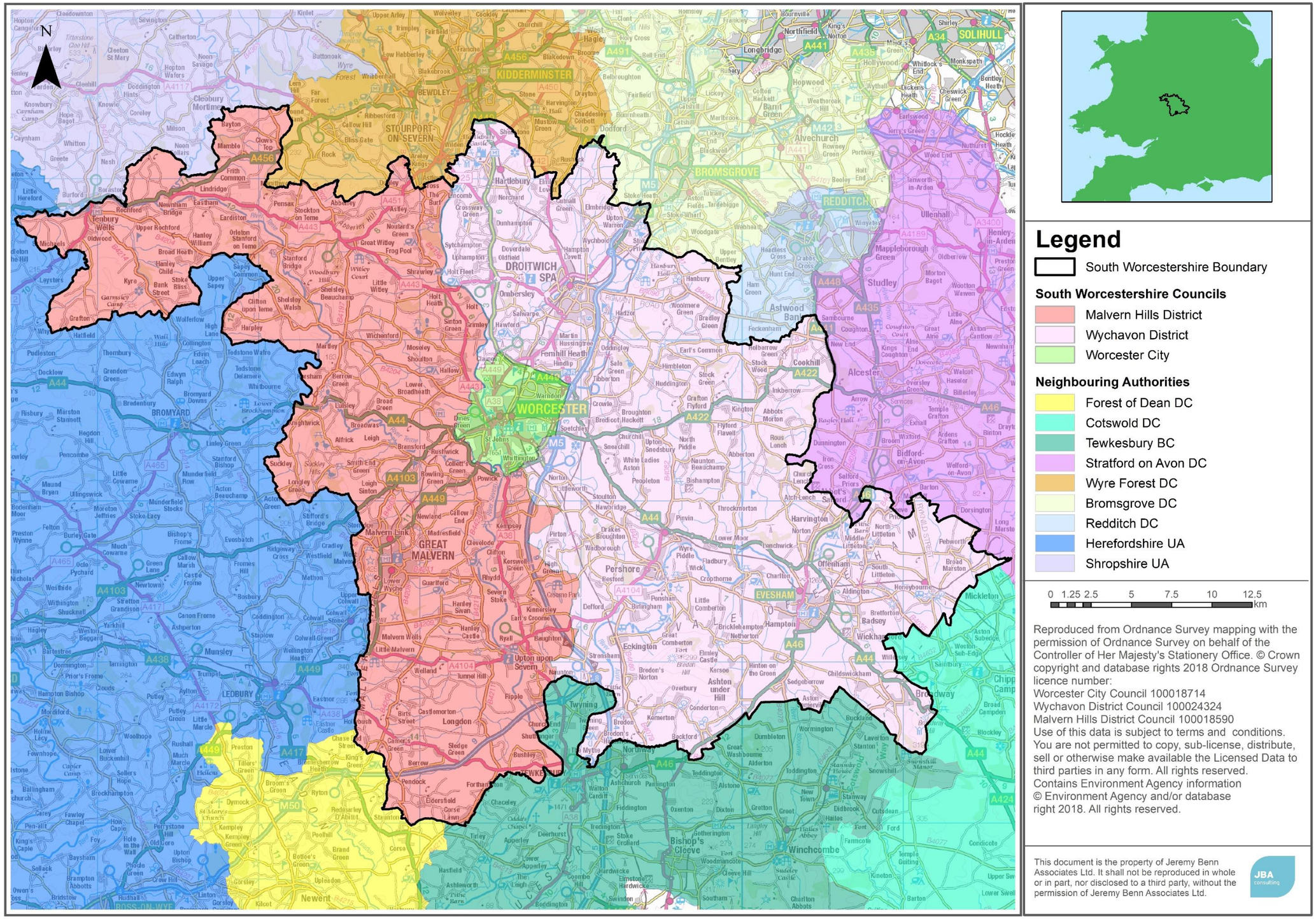
1.4 SFRA Study Area

The SWCs are comprised of Malvern Hills District to the west, Wychavon District to the east and Worcester City in the centre. South Worcestershire covers an area of approximately 1300km^2 and has a population of approximately 304,800 (2014 mid-year population estimates). The main urban areas in South Worcestershire are Worcester City, Pershore, Evesham, Droitwich Spa, Great Malvern, Tenbury Wells and Upton upon Severn.

The main watercourses in South Worcestershire are the River Severn, River Teme, River Avon, Barbourne Brook, River Salwarpe, Badsey Brook, Merry Brook, Carrant Brook, River Isbourne, Kyre Brook, Dick Brook, River Rea, Hatfield Brook and Pool Brook.

An overview of the study area is shown in Figure 1-1.

Figure 1-1 Study Area



1.5 Consultation

SFRAs should be prepared in consultation with other risk management authorities. The following parties (external to the SWCs) have been consulted upon during the preparation of this version of the SFRA:

- Environment Agency
- Worcestershire County Council
- Canal and River Trust
- Worcestershire Highways
- Worcestershire Fire and Rescue
- Severn Trent Water
- Lower Severn Internal Drainage Board (IDB)
- Neighbouring authorities including:
    - Forest of Dean District Council
    - Cotswold District Council
    - Tewkesbury Borough Council
    - Stratford on Avon District Council
    - Wyre Forest District Council
    - Bromsgrove District Council
    - Redditch District Council
    - Herefordshire Council
    - Shropshire Council

1.6 Use of SFRA data

Level 1 SFRAs are high-level strategic documents and do not go into detail on an individual site-specific basis. The primary purpose is to provide an evidence base to inform the preparation of the South Worcestershire Development Plan Review and Preferred Options, and any future flood risk policies.

Developers will still be required to undertake site-specific Flood Risk Assessments to support Planning Applications. Developers will be able to use the information in the SFRA to scope out the sources of flood risk that will need to be explored in more detail at site level.

Hyperlinks to external guidance documents/websites are provided in **green** throughout this SFRA

Advice/notes to users are shown in **amber boxes** throughout this SFRA

On the date of publication, the SFRA contains the latest flood risk information. Over time, new information will become available to inform planning decisions, such as updated hydraulic models (which then update the Flood Map for Planning), flood event information, new defence schemes and updates to policy and legislation. Developers should check with the Environment Agency to confirm latest flood mapping data available.

1.7 Structure of this report

Table 1-1 sets out the structure and content of the SFRA report and associated mapping, alongside how the data can be used, primarily by the SWCs or private developers.

Table 1-1 SFRA report structure

Section	Contents
Executive Summary	Focuses on how the SFRA can be used by planners, developers and neighbourhood planners.
1. Introduction	Provides a background to the study, the Local Plan stage the SFRA informs, the study area, the roles and responsibilities for the organisations involved in flood management and how they were involved in the SFRA. Provides a short introduction to how flood risk is assessed and the importance of considering all sources. Includes this table of the contents of the SFRA.
2. Flood risk policy and strategy	Sets out the relevant legislation, policy and strategy for flood risk management at a national, regional and local level.
3. Planning policy for flood risk management	Provides an overview of both national and existing Local Plan policy on flood risk management. This includes the Flood Zones, application of the Sequential Approach and Sequential/Exception Test process. Provides guidance for the SWCs and Developers on the application of the Sequential and Exception Test for both allocations and windfall sites, at allocation and planning application stages.
4. The impact of climate change	Outlines the latest climate change guidance published by the Environment Agency and how this was applied to the SFRA. Sets out how developers should apply the guidance to inform site specific Flood Risk Assessments.
5. Understanding flood risk in the study area	Provides an overview of the characteristics of flooding affecting the study area and key risks including historical flooding incidents, flood risk from all sources and flood warning arrangements.
6. Flood defences and assets	Provides a summary of current flood defences and asset management. Introduces actual and residual flood risk.
7. Cumulative impact of development and strategic solutions	This section provides a summary of the catchments with the highest flood risk and development pressures, considers opportunities for strategic flood risk solutions and makes recommendations for local planning policy based on these.
8. Guidance for developers	Guidance for developers on Flood Risk Assessments, considering flood risk from all sources.
9. Surface water management and Sustainable Drainage Systems	An overview of Sustainable Drainage Systems, Guidance for developers on Surface Water Drainage Strategies, considering any specific local standards and guidance for Sustainable Drainage Systems (SuDS) from the Lead Local Flood Authority. Includes a broadscale assessment of SuDS suitability across the area.

10. Summary and recommendations	Summarises sources of flood risk in the study area and outlines planning policy recommendations.

Appendices:

- Appendix A: Interactive flood risk maps
- Appendix B: Flood risk screening of SHELAA sites
- Appendix C: Data sources used in the SFRA
- Appendix D: Flood Alert and Flood Warning Areas
- Appendix E: Cumulative Impact Methodology
- Appendix F: Models used in the SFRA

1.8 Understanding flood risk

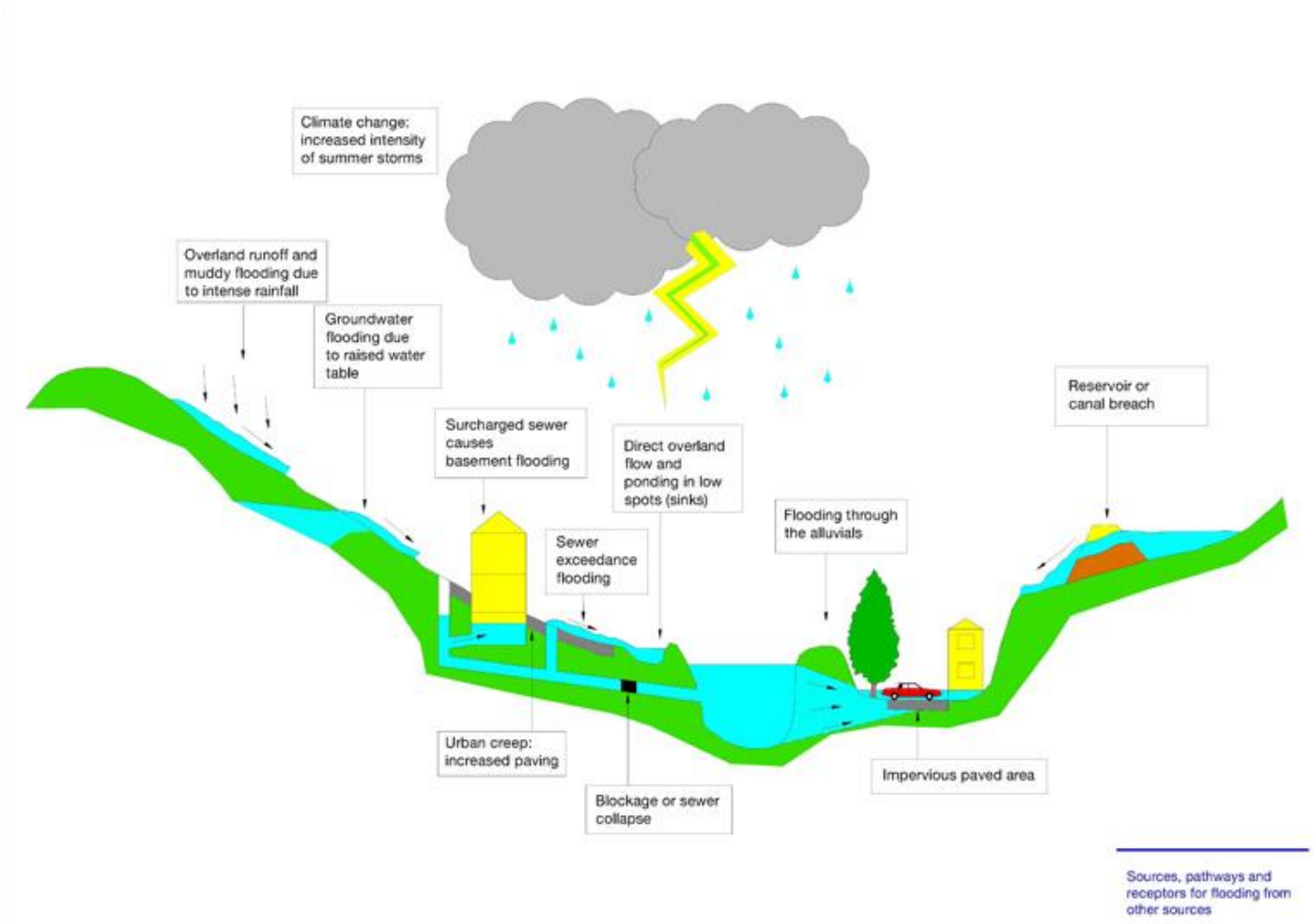
1.8.1 Sources of flooding

Flooding is a natural process and can happen at any time in a wide variety of locations. It constitutes a temporary covering of land not normally covered by water and presents a risk when people and human or environmental assets are present in the area that floods. Assets at risk from flooding can include housing, transport and public service infrastructure, commercial and industrial enterprises, agricultural land and environmental and cultural heritage. Flooding can occur from many different and combined sources and in many different ways. Major sources of flooding include:

- Fluvial (rivers) - inundation of floodplains from rivers and watercourses; inundation of areas outside the floodplain due to influence of bridges, embankments and other features that artificially raise water levels; overtopping or breaching of defences; blockages of culverts; blockages of flood channels/corridors.
- Surface water - surface water flooding covers two main sources including direct run-off from adjacent land (pluvial) and surcharging of piped drainage systems (public sewers, highway drains, etc.)
- Groundwater - water table rising after prolonged rainfall to emerge above ground level remote from a watercourse; most likely to occur in low-lying areas underlain by permeable rock (aquifers); groundwater recovery after pumping for mining or industry has ceased.
- Infrastructure failure - reservoirs; canals; industrial processes; burst water mains; blocked sewers or failed pumping stations.

Different types and forms of flooding present a range of different risks and the flood hazards of speed of inundation, depth and duration of flooding can vary greatly. With climate change, the frequency, pattern and severity of flooding are expected to change and become more damaging. A summary of the different sources of flooding is shown in Figure 1-2.

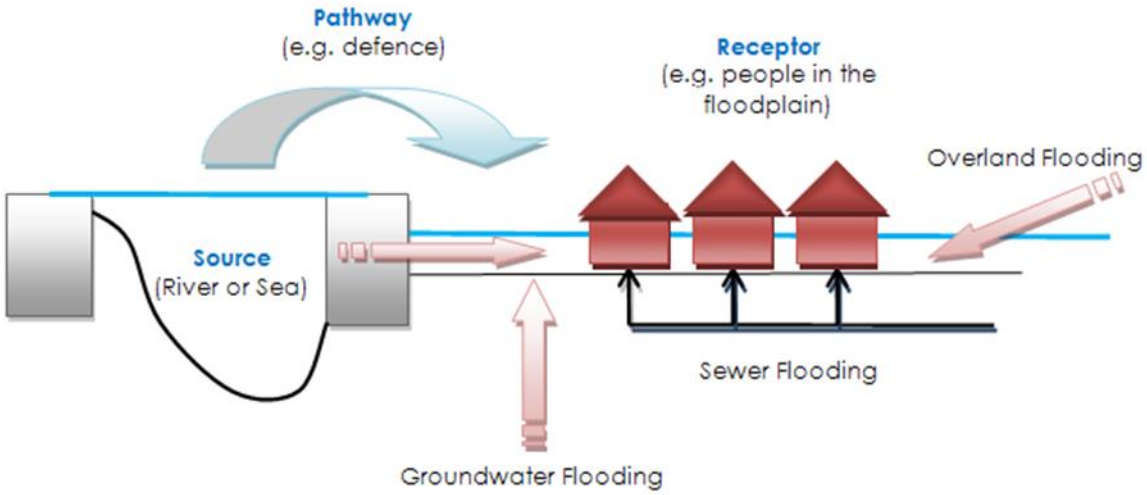
Figure 1-2 Flooding from all sources



1.9 Likelihood and consequence

Flood risk is a combination of the likelihood of flooding and the potential consequences arising. It is assessed using the source – pathway – receptor model as shown in Figure 1-3 below. This is a standard environmental risk model common to many hazards and should be the starting point of any assessment of flood risk. However, it should be remembered that flooding could occur from many different sources and pathways, and not simply those shown in the illustration below.

Figure 1-3 Source-Pathway-Receptor Model



The principal sources are rainfall, snowmelt and high groundwater levels and the most common pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets. The receptors can include people, their property and the environment. All these elements must be present for flood risk to arise. Mitigation measures have little or no effect on sources of flooding, but they can block or impede pathways or increase the resilience of receptors.

The planning process is primarily concerned with the location of receptors, taking appropriate account of potential sources and pathways that might put those receptors at risk. It is therefore important to define the components of flood risk in order to apply this guidance in a consistent manner.

1.9.1 Likelihood

Likelihood of flooding is expressed as the percentage probability based on the average frequency measured or extrapolated from records over a large number of years. A 1% probability indicates the flood level that is expected to be reached on average once in a hundred years, i.e. it has a 1% chance of occurring in any one year, not that it will only occur once every hundred years.

Considered over the lifetime of development, such an apparently low frequency or rare flood has a significant probability of occurring. For example:

- A 1% flood has a 26% (1 in 4) chance of occurring at least once in a 30-year period - the period of a typical residential mortgage.
- And a 49% (1 in 2) chance of occurring in a 70-year period - a typical human lifetime.

1.9.2 Consequence

The consequences of flooding include fatalities, property damage, disruption to lives and businesses, with severe implications for people (e.g. financial loss, emotional distress, health problems). Consequences of flooding depend on the hazards caused by flooding (depth of water, speed of flow, rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure, of the population, presence and reliability of mitigation measures etc). Flood risk is then expressed in terms of the following relationship:

Flood risk = Probability of flooding x Consequences of flooding

1.10 Risk

Flood risk is not static; it cannot be described simply as a fixed water level that will occur if a river overtops its banks or the intensity of a rainfall event that will trigger surface water flooding. It is therefore important to consider the continuum of risk carefully. Risk varies depending on the severity of the event, the source of the water, the pathways of flooding (such as the condition of flood defences) and the vulnerability of receptors as mentioned above.

2 Flood risk policy and strategy

This section sets out the FRM roles and responsibilities for different organisations and relevant legislation, policy and strategy.

2.1 Roles and responsibilities for Flood Risk Management in South Worcestershire

There are a number of different organisations in and around South Worcestershire that have responsibilities for flood risk management, known as Risk Management Authorities (RMAs). These are shown on Table 2-1, with a summary of their responsibilities.

It is important to note that land and property owners are responsible for the maintenance of watercourses either on or next to their properties. Property owners are also responsible for the protection of their properties from flooding. More information can be found in the Environment Agency publication **Owning a watercourse** (2018). Worcestershire County Council have also published a **Guide for Riparian Owners** which highlights rights and responsibilities.

When it comes to undertaking works to reduce flood risk, the Environment Agency and Worcestershire County Council as LLFA do have powers, but limited resources must be prioritised and targeted to where they can have the greatest effect.

Table 2-1 Roles and responsibilities for flood risk management within South Worcestershire

Risk Management Authority	Strategic Level	Operational Level	Planning role
Environment Agency	• Strategic overview for all sources of flooding • National Strategy • Reporting and general supervision	• Main rivers • Reservoirs	• Statutory consultee for development in Flood Zones 2 and 3
Worcestershire County Council as Lead Local Flood Authority (LLFA)	• Preliminary Flood Risk Assessment • Local Flood Risk Management Strategy	• Surface Water • Groundwater • Ordinary Watercourses (consenting and enforcement) • Ordinary watercourses (works)	• Statutory consultee for all major developments
South Worcestershire Councils	• Local Plans as Local Planning Authorities • South Worcestershire Land Drainage Partnership oversees local land drainage issues	• Determination of Planning Applications as Local Planning Authorities • Managing open spaces under Unitary Council ownership • Local land drainage work, such as consenting and	• As left

		enforcement on behalf of the LLFA	
Internal Drainage Board: *Lower Severn IDB*	• Water Level Management Plans	• Ordinary Watercourses within Internal Drainage Districts	• Non-statutory consultee
Water Companies: *Severn Trent Water* *Welsh Water*	• Asset Management Plans supported by Periodic Reviews (business cases) • Develop Drainage and Wastewater management plans	• Public sewers	• Non-statutory consultee
Highways Authorities: *Highways England (motorways and trunk roads)* *Worcestershire County Council (other adopted roads)*	• Highway drainage policy and planning	• Highway drainage	• Internal planning consultee regarding highways and design standards and options

2.2 Relevant legislation

The following legislation is relevant to development and flood risk in South Worcestershire:

- **Flood Risk Regulations (2009)** transpose the EU Floods Directive (2000) into UK law and require the Environment Agency and LLFAs to produce Preliminary Flood Risk Assessments (PFRAs) and identify where there are nationally significant Flood Risk Areas. For the Flood Risk Areas, detailed flood maps and a Flood Risk Management Plan is produced. This is a six-year cycle of work and the second cycle started in 2017.
- **Town and County Planning Act (1990)**, **Water Industry Act (1991)**, **Land Drainage Act (1991)**, Environment Act (2005) and **Flood and Water Management Act (2010)** – as amended and implanted via secondary legislation. These set out the roles and responsibilities for organisations that have a role in FRM.
- **Land Drainage Act (1991)** and **Environmental Permitting Regulations (2016)** also set out where developers will need to apply for additional permission (as well as Planning Permission) to undertake works to an ordinary watercourse or Main River.
- **Water Environment Regulations (2017)** transpose the European Water Framework Directive (2000) into law and require the Environment Agency to produces River Basin Management Plans (RBMPs). These aim to ensure that the water quality of aquatic ecosystems, riparian ecosystems and wetlands reach 'good status'.
- Other environmental legislation such as the Habitats Directive (1992), Environmental Impact Assessment Directive (2014) and Strategic Environmental Assessment Directive (2001) also apply as appropriate to strategic and site-specific developments to guard against environmental damage.

2.3 Relevant flood risk policy and strategy documents

Table 2-2 summarises relevant national, regional and local flood risk policy and strategy documents and how these apply to development and flood risk. These documents may:

- Provide useful and specific local information to inform Flood Risk Assessments within the local area.
- Set the strategic policy and direction for Flood Risk Management (FRM) and drainage – they may contain policies and action plans that set out what future mitigation and climate change adaptation plans may affect a development site. A developer should seek to contribute in all instances to the strategic vision for FRM and drainage in South Worcestershire.
- Provide guidance and/or standards that informs how a developer should assess flood risk and/or design flood mitigation and SuDS.

Table 2-2 National, regional and local flood risk policy and strategy documents

	Document, lead author and date	Information	Policy and measures	Development design requirements	Next update due
National	**Flood and Coastal Management Strategy** (Environment Agency) 2011	No	Yes	No	2019
	National Planning Policy Framework and Guidance (MCHLG) 2018/2015	No	No	Yes	2019 updates to NPPG
	Building Regulations Part H (MCHLG) 2010	No	No	Yes	-
Regional	**River Severn Catchment Flood Management Plan** (Environment Agency) 2009	Yes	Yes	No	-
	Severn River Basin Management Plan (Environment Agency) 2015	No	Yes	No	2021
	Climate Change guidance for development and flood risk (Environment Agency) 2016	No	No	Yes	2019
Local	**Worcestershire SuDS Guidance** (Worcestershire County Council) 2018	No	No	Yes	-
	Worcestershire Surface Water Management Plan (WCC) 2018	Yes	Yes	Yes	-
	Worcestershire Local Flood Risk Management Strategy (WCC) 2016	Yes	Yes	No	2021
	Drainage and Wastewater Management Plan (Severn Trent Water) due 2023	Yes	Yes	No	-

2.4 Key legislation for flood and water management

2.4.1 Flood Risk Regulations (2009)

The **Flood Risk Regulations (2009)**[1] translate the EU Floods Directive into UK law. The EU requires Member States to complete an assessment of flood risk (known as a Preliminary Flood Risk Assessment (PFRA)) and then use this information to identify areas where there is a significant risk of flooding. For these Flood Risk Areas, States must then undertake Flood Risk and Hazard Mapping and produce Flood Risk Management Plans.

The Flood Risk Regulations direct the Environment Agency to do this work for river, sea and reservoir flooding. LLFAs must do this work for surface water, Ordinary Watercourse and Groundwater flooding. This is a six-year cycle of work and the second cycle started in 2017.

The **Worcestershire PFRA** (2011) provides information on significant past and future flood risk from localised flooding in Worcestershire. This was updated in 2017 and there were no nationally significant Flood Risk Areas for surface water, Ordinary Watercourse and groundwater flooding identified in the South Worcestershire area.

The Environment Agency undertook a **PFRA for river, sea and reservoir flooding** and identified nationally significant Flood Risk Areas for these sources in 2018. There were no nationally significant Flood Risk areas for main river or sea flooding identified in the South Worcestershire area.

2.4.2 Flood and Water Management Act (FWMA), 2010

The **Flood and Water Management Act (FWMA)** was passed in April 2010. It aims to improve both flood risk management and the way we manage our water resources.

The FWMA has created clearer roles and responsibilities and helped to define a more risk-based approach to dealing with flooding. This included the creation of a lead role for LAs, as LLFAs, designed to manage local flood risk (from surface water, ground water and ordinary watercourses) and to provide a strategic overview role of all flood risk for the EA.

The content and implications of the FWMA provide considerable opportunities for improved and integrated land use planning and flood risk management by LAs and other key partners. The integration and synergy of strategies and plans at national, regional and local scales, is increasingly important to protect vulnerable communities and deliver sustainable regeneration and growth.

2.4.3 Water Framework Directive & Water Environment Regulations

The purpose of the **Water Framework Directive (WFD)**, which was transposed into English Law by the Water Environment Regulations (2003), is to deliver improvements across Europe in the management of water quality and water resources through a series of plans called River Basin Management Plans (RBMP), which were last published in 2015 and are currently being updated.

1 Flood Risk Regulations (2009): http://www.legislation.gov.uk/uksi/2009/3042/pdfs/uksi_20093042_en.pdf

2.5 Key national, regional and local policy documents and strategies

2.5.1 The National Flood and Coastal Erosion Risk Management Strategy for England (2011)

The **National Flood and Coastal Erosion Risk Management Strategy** for England provides the overarching framework for future action by all risk management authorities to tackle flooding and coastal erosion in England. It was prepared by the Environment Agency with input from Defra.

The Strategy builds on existing approaches to flood and coastal risk management and promotes the use of a wide range of measures to manage risk. It describes how risk should be managed in a co-ordinated way within catchments and along the coast and balance the needs of communities, the economy and the environment.

The Strategy encourages more effective risk management by enabling people, communities, business, infrastructure operators and the public sector to work together to:

- ensure a clear understanding of the risks of flooding and coastal erosion, nationally and locally, so that investment in risk management can be prioritised more effectively;
- set out clear and consistent plans for risk management so that communities and businesses can make informed decisions about the management of the remaining risk;
- manage flood and coastal erosion risks in an appropriate way, taking account of the needs of communities and the environment;
- ensure that emergency plans and responses to flood incidents are effective and that communities are able to respond effectively to flood forecasts, warnings and advice;
- help communities to recover more quickly and effectively after incidents.

The Strategy is currently being updated and was **published for consultation** in May 2019.

2.5.2 River Basin Management Plans

The WFD requires the production of Management Plans for each River Basin District. River Basin Management Plans (RBMPs) aim to ensure that all aquatic ecosystems, riparian ecosystems and wetlands reach 'good status'. To achieve 'good status', a waterbody must be observed to be at a level of ecological and chemical quality.

South Worcestershire falls within the Severn River Basin District. The **River Basin District Management Plan** highlights a number of actions to a number of issues raised either within the districts as a whole or in sub-districts. Key issues include rural and urban diffuse pollution, physical modification, diffuse pollution from agricultural rural land management and point source pollution.

Further information can be found in the **RBMP** and on the **Catchment Based Approach (CaBA) website**.

2.5.3 Flood Risk Management Plans

Flood Risk Management Plans (FRMPs) are part of the six-year cycle of assessment, mapping and planning required under the Flood Risk Regulations. The Environment Agency led the development of the **Severn FRMP**, which was published in 2015. The FRMP summarises the flooding affecting the area and describes the measures to be taken to address the risk in accordance with the Flood Risk Regulations. The FRMPs draw on policies and actions identified in Catchment Flood Management Plans and Local Flood Risk Management Strategies. The Plans will be updated as part of the new cycle of the Flood Risk Regulations and are due to be published in December 2021.

2.5.4 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. South Worcestershire is covered by the **River Severn CFMP** (2009) and within that is covered by four policy units:

- Middle Severn Corridor (including Worcester and upstream of Worcester) is covered by Policy Option 4 – Areas of low, moderate or high flood risk, where flood risk is already being managed effectively but further actions may need to be taken to keep pace with climate change.
- Lower Severn Corridor (downstream of Worcester, including Malvern) is covered by Policy Option 2 – Areas of low to moderate flood risk, where flood risk management actions can generally be reduced.
- Middle Avon and Teme (including Evesham, Pershore and Tenbury Wells) is covered by Policy Option 3 – Areas of low to moderate flood risk where flood risk is generally being managed effectively.
- Telford, Black Country, Bromsgrove, Kidderminster and Coventry Cluster (including Droitwich Spa and the River Salwarpe) is covered by Policy Option 5 – Areas of moderate to high flood risk where further action to reduce flood risk can generally be taken.

In these Policy Options, there are specific 'actions' to manage flood risk in the area. Those most relevant to South Worcestershire are:

- Ensure floodplains are not inappropriately developed. Follow the 'sequential approach' of Planning Policy Statement 25 (which is now superseded but the principles of the approach are embedded into the NPPF) and consider land swapping opportunities.
- Encourage compatibility between urban open spaces, and their ability to make space for rivers to expand as flood flows occur. One example of a flood-compatible use is playing fields. Develop strategies to create 'blue corridors' by developing/redeveloping to link these flood-compatible spaces.
- Encourage rural and urban best practices in land-use and in land-management to restore more sustainable natural floodplains and to reduce run-off.
- Review how effective and sustainable each flood defence is. Review maintenance operations to ensure they are proportionate to flood risk. Focus efforts on protecting communities and making them more resilient to flooding. It should be noted that protecting large areas of agricultural land in the floodplain tends to increase flood risk for downstream communities.
- Develop a better understanding of flooding from surface water, from drainage systems, and from 'non-main' watercourses. Produce a strategy for operation and investment, integrating all these with main rivers. Local authorities to develop a SWMP for Droitwich Spa.
- Raise awareness of flooding among the public and key partners, especially major operators of infrastructure, allowing them to be better prepared. Encourage them all to increase the resilience and resistance of vulnerable buildings, infrastructure and businesses.
- Maintain flood warning systems and seek opportunities to improve effectiveness and coverage.
- Seek ecological improvements.
- Carry out an assessment of the scheme to canalise the River Salwarpe around Droitwich in terms of flood risk.

- Ensure that the run-off from all proposed development is minimised. For example, SuDS must be encouraged and targeted within planning approvals. Encourage the retrofitting of SuDS where surface water flooding is already a problem.

2.5.5 Worcestershire County Council Local Flood Risk Management Strategy (LFRMS) 2016

Worcestershire County Council is responsible for developing, maintaining, applying and monitoring a LFRMS. The most recent Strategy was published in **2016** and is used as a means by which the LLFA co-ordinates Flood Risk Management on a day-to-day basis.

The seven high-level objectives proposed in the Strategy for managing flood risk include:

- Understand and appropriately prioritise flood risk;
- Manage and minimise the likelihood and impact of flooding;
- Develop and manage effective partnerships;
- Inform, develop and implement relevant plans, policies and strategies;
- Secure, maximise and prioritise the appropriate allocation of funding and other resources;
- Deliver sustainable environmental and economic benefits and contribute to the wellbeing of Worcestershire's communities and residents;
- Develop, maintain and implement the LFRMS action plan.

The Action Plan referenced in the Strategy sets out how the objectives will be delivered and by whom. The actions are monitored by a strategic Flood Risk Management Board.

2.5.6 LLFAs, surface water and SuDS

The NPPF states that: 'Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate' (Para 165). When considering planning applications, local planning authorities should consult the LLFA on the management of surface water in order to satisfy that:

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

Worcestershire County Council's requirements for new developers on SuDS are set out on their **website**, alongside supporting documents. At the time of writing this SFRA, documents and policies relevant to SuDS and surface water in South Worcestershire are:

- **SuDS Handbook**
- **Worcestershire Surface Water Management Plan**
- **Worcestershire Local Flood Risk Management Strategy (2015-2021)**
- **2016 Adopted South Worcestershire Development Plan** (SWDP Policy 29: Sustainable Drainage Systems)
- **South Worcestershire Water Management and Flooding Supplementary Planning Document (July 2018)**

2.5.7 Water Cycle Studies

Water Cycle Studies (WCS) – both scoping, outline and detailed – assist Councils to select and develop sustainable development allocations in locations where there is minimal impact on the environment, water quality, water resources, infrastructure, and flood risk. WCS provide the required evidence, and an agreed strategy, to ensure that planned growth occurs within environmental constraints (and where possible contributes to environmental improvements), with the appropriate infrastructure in place in a timely manner so that planned allocations are deliverable. This is undertaken by identifying areas where there may be conflict between any proposed development, the requirements of the environment and by recommending potential solutions to these conflicts. At the time of writing this SFRA, a WCS for the SWCs was being prepared alongside the study.

2.5.8 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 an 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 for Worcestershire County Council is available on their **website**. The SWMP identifies "floodspots", which represent locations where it is known that there has been at least one flood event. This information was used to inform the cumulative impact assessment as part of this SFRA.

At the time of preparing this SFRA, a Flood Risk Management Plan was being prepared for Droitwich by Worcestershire County Council. Other FRMPs in South Worcestershire are being considered and Worcestershire County Council as LLFA should be contacted for more information.

2.5.9 South Worcestershire Water Management and Flooding SPD

The **South Worcestershire Water Management and Flooding Supplementary Planning Document (SPD)** was adopted in July 2018 and sets out the approach of the SWCs to minimising flood risk, managing surface water and achieving sustainable drainage systems. The aims of the SPD are as follows:

- Ensure only appropriate new development is located in areas at risk of flooding through:
    - Requiring that proposals demonstrate the Sequential and Exception tests have been applied where necessary.
    - Ensuring that Site Specific FRAs are undertaken where required with relevant incorporation of climate change.
    - Requiring provision of floodplain compensation where necessary.
    - Ensuring 'vulnerable uses' are not permitted in inappropriate areas.
- Prevent flood exacerbation for all development proposals through:
    - Inclusions of SuDS including permeable paving, planted roofs, filter drains, swales, basins and ponds where appropriate.
    - Provision of on-site storage capacity for surface water attenuation for a storm event up to the 1 in 100 years (1%) probability event including an appropriate allowance for climate change.
    - Use of porous materials to reduce surface water run-off in new developments and applications for changes of use.

- Provision of Green Infrastructure, where necessary, to reduce surface water run-off within developments.
- Requiring, as a minimum for greenfield and brownfield sites, that the post-development surface water run-off rate will not increase.

- Promote effective water management through:
  - Installation of water efficiency devices in new developments including water harvesting, saving and recycling in any new built schemes wherever practical/viable.
- Maintain water quality through:
  - Appropriate water management techniques to, at the very least, maintain existing hydrological conditions and prevent adverse effects on the natural water cycle caused by surface water pollution and discharges to the watercourses and groundwater.
- Reduce negative impacts on, and maximising biodiversity gain and amenity interest through:
  - Establishing coherent ecological networks.
  - Requiring developers to demonstrate that SuDS schemes will benefit water habitat and biodiversity.

3 Planning policy for flood risk management

This section summarises national planning policy for development and flood risk.

3.1 National Planning Policy Framework and Guidance

The revised National Planning Policy Framework (**NPPF**) was published in February 2019, replacing the 2012 version. The NPPF sets out Government's planning policies for England. It must be taken into account in the preparation of local plans and is a material consideration in planning decisions. The NPPF defines Flood Zones, how these should be used to allocate land and flood risk assessment requirements. The NPPF states that:

"Strategic policies should be informed by a strategic flood risk assessment and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards."

Planning Practice Guidance (NPPG) on flood risk was published in March 2014 and sets out how the policy should be implemented. **Diagram 1 in the NPPG** sets out how flood risk should be considered in the preparation of Local Plans.

3.2 The risk-based approach

The NPPF takes a risk-based approach to development in flood risk areas.

3.2.1 The Flood Zones

The definition of the Flood Zones is provided below. The Flood Zones do not consider defences; this is important for planning long term developments as long-term policy and funding for maintaining flood defences over the lifetime of a development may change over time.

The Flood Zones do not take into account surface water, sewer or groundwater flooding or the impacts of canal or reservoir failure. They do not consider climate change. Hence there could still be a risk of flooding from other sources and the level of flood risk will change over time during the lifetime of a development.

The Flood Zones are:

- Flood Zone 1: Low probability – less than a 0.1% chance of river and sea flooding in any given year.
- Flood Zone 2: Medium probability – between a 1% and 0.1% chance of river flooding in any given year or between a 0.5% and 0.1% chance of sea flooding in any given year.
- Flood Zone 3a: High probability – greater than or equal to a 1% chance of river flooding in any given year, or greater than a 0.5% chance of sea flooding in any given year. Excludes Flood Zone 3b.
- Flood Zone 3b: Functional floodplain – land where water has to flow or be stored in times of flood. SFRAs identify this Flood Zone in discussion with the LPA and the Environment Agency. The identification of functional floodplain takes 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.

Important note on Flood Zone information in this SFRA

The Environment Agency Flood Zones do not cover all catchments or ordinary watercourses (only catchments >3km^2). As a result, whilst the Environment Agency Flood Zones may show an area is in Flood Zone 1, it may be that there is actually a degree of flood risk from smaller watercourses not shown in the Flood Zones.

Flood Zones 2, 3a and 3b are identified as land which would flood with an annual probability of 1 in 1000 years, 1 in 100 years and 1 in 20 years respectively. Where detailed hydraulic modelling exists, the undefended 1 in 1,000-year and 1 in 100-year flood extents have been used to represent Flood Zone 2 and 3a respectively and the defended 1 in 20-year flood extent has been used to represent Flood Zone 3b (the 1 in 25-year flood extent was used where the 1 in 20-year was not available).

For areas outside of the detailed model coverage, this is represented by the Environment Agency's Flood Map for Planning Flood Zones 2 and 3 as a conservative indication. Details of where hydraulic models have been used to inform the Flood Zones can be found in Appendix F.

Further work should be undertaken as part of a detailed site-specific Flood Risk Assessment to define the extent of Flood Zone 3b where no detailed modelling exists. Note that the Upton upon Severn modelled outline is based on the highway flood scheme that is currently being implemented at the Marina.

3.2.2 The Sequential Test

Firstly, land at the lowest risk of flooding and from all sources should be considered for development. A test is applied called the Sequential Test to do this.

Figure 3-1 summarises the Sequential Test. The LPA will apply the Sequential Test to strategic allocations. For all other developments, developers must supply evidence to the LPA, with a Planning Application, that the development has passed the test.

The LPA should work with the Environment Agency to define a suitable area of search for consideration of alternative sides in the Sequential Test. 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.

Whether any further work is needed to decide if the land is suitable for development will depend on both the vulnerability of the development and the Flood Zone it is proposed for. **Table 2 of the NPPG** defines the vulnerability of different development types to flooding. **Table 3 of the NPPG** shows whether, having applied the Sequential Test first, that vulnerability of development is suitable for that Flood Zone and where further work is needed.

Figure 3-1 The Sequential Test

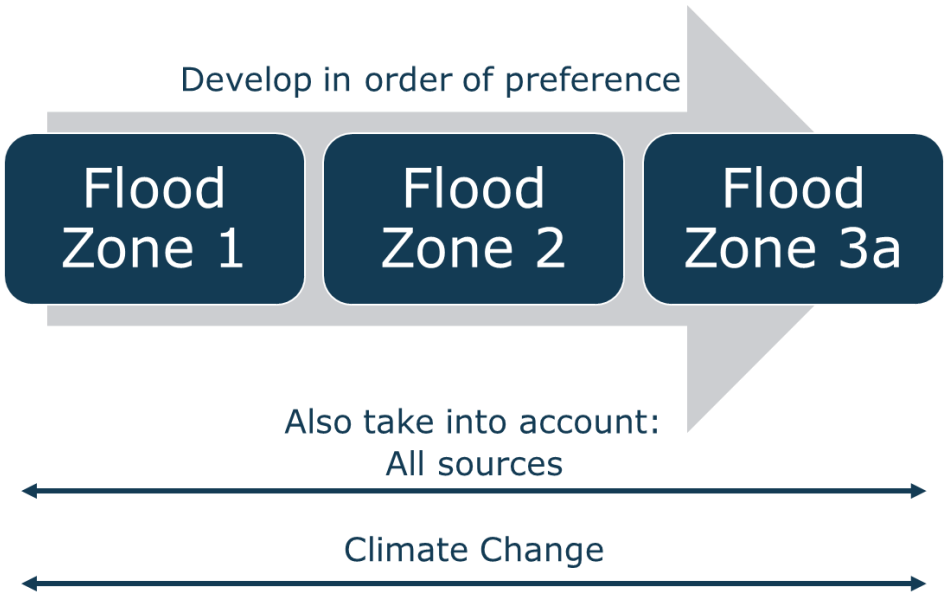
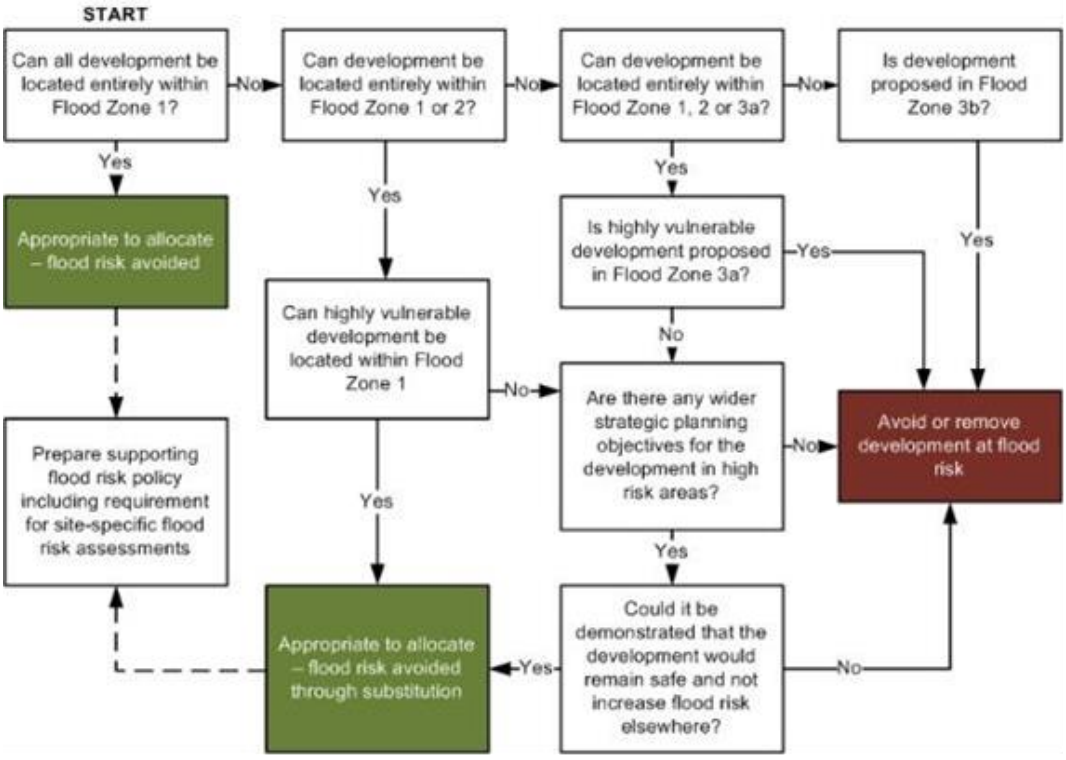


Figure 3-2 illustrates the Sequential and Exception Tests as a process flow diagram using the information contained in this SFRA to assess potential development sites against the EA's Flood Map for Planning Flood Zones and development vulnerability compatibilities.

This is a stepwise process, but a challenging one, as a number of the criteria used and are qualitative and based on experienced judgement. The process must be documented, and evidence used to support decisions recorded.

In addition, the risk of flooding from other sources and the impact of climate change must be considered when considering which sites are suitable to allocate.

Figure 3-2 Local Plan sequential approach to site allocation



3.2.3 The Exception Test

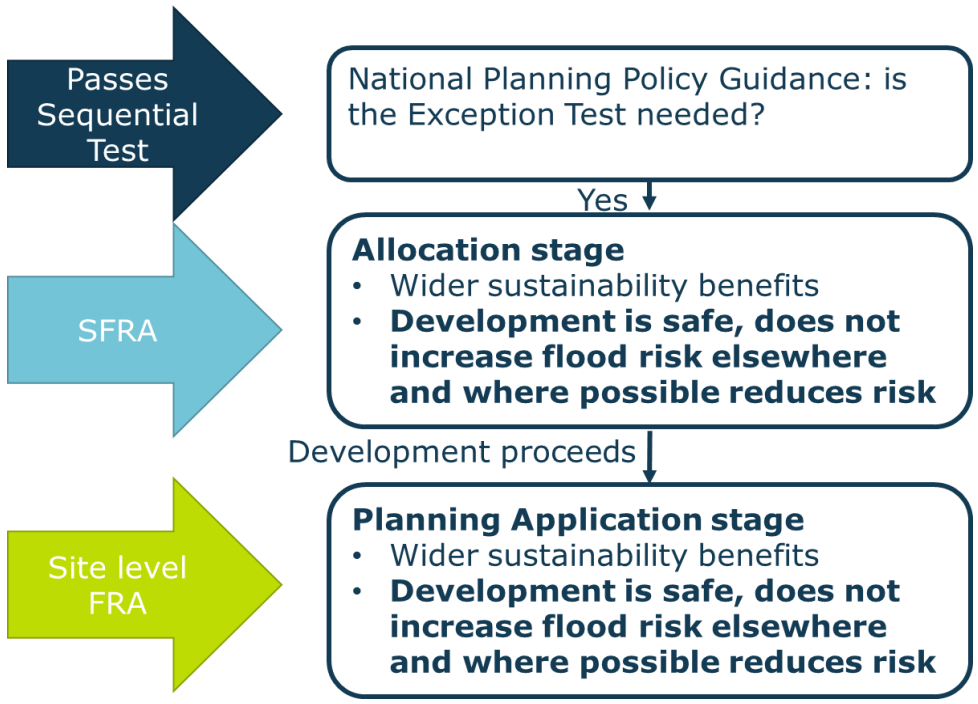
It will not always be possible for all new development to be allocated on land that is not at risk from flooding. To further inform whether land should be allocated, or Planning Permission granted, a greater understanding of the scale and nature of the flood risks is required. In these instances, the Exception Test will be required.

The Exception Test should only be applied following the application of the Sequential Test. It applies in the following instances as set out in Table 3 of the NPPG:

- More vulnerable in Flood Zone 3a
- Essential infrastructure in Flood Zone 3a or 3b
- Highly vulnerable in Flood Zone 2 (this is NOT permitted in Flood Zone 3a or 3b)

Figure 3-3 summarises the Exception Test. An LPA should apply the Exception Test to strategic allocations. For all developments, developers must supply evidence to the LPA, with a Planning Application, that the development has passed the test. This is because when a site-specific Flood Risk Assessment is undertaken, more information on the exact measures that can manage the risk is available.

Figure 3-3 The Exception Test



There are two parts to demonstrating a development passes the Exception Test:

1. *Demonstrating that the development would provide wider sustainability benefits to the community that outweigh the flood risk.*

   Local planning authorities 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 Local Planning Authority 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. *Demonstrating 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.*

   A Level 2 SFRA is likely to be needed to inform the Exception Test in these circumstances for strategic allocations. At Planning Application stage, a site-specific Flood Risk assessment will be needed. Both would need to consider the actual and residual risk and how this will be managed over the lifetime of the development.

Where it is unlikely that the Exception Test can be passed due to few wider sustainability benefits, the risk of flooding being too great, or the viability of the site being compromised by the level of flood risk management work required, then the LPA should consider avoiding the site all together.

3.3 Using the SFRA to apply the Sequential and Exception Tests to the Local Plan

This SFRA provides the main evidence required on flood risk to carry out the Sequential Test. This process also enables those sites that have passed the Sequential Test, and may require the Exception Test, to be identified. A Local Plan Sustainability Appraisal should be used to support any decision to locate development in higher flood risk areas in terms of wider strategic planning objectives.

Appendix B provides an assessment of the flood risk associated with each of the South Worcestershire Strategic Housing and Economic Land Availability Assessment (SHELAA) sites, by illustrating the percentage of a site area within the Flood Zones, surface water flood extent and historic flood map.

It is recommended that planners use the site screening information and other information in this report to apply the Sequential Test alongside wider strategic planning objectives as follows:

1 Using the information on the percentage of sites within the Flood Zones, can development be allocated into the lowest flood risk areas?

2 Using the information on other sources of flooding, can development be allocated into the lowest flood risk areas?

3 Using the information on climate change, is there likely to be a significant increase in flood risk due to climate change? They should form a judgement based on the likely lifetime of a development (e.g. 100 years for residential) as to whether the site is likely to become at unacceptable risk of flooding over time.

Where there are flood defences (shown on the maps in Appendix A), the results of the climate change modelling will not be directly comparable with the Flood Map for Planning, because it does not take the defences into account. Should a site rely heavily on defences for protection, a Level 2 SFRA is recommended that can explore in greater detail what the impact of climate change on flood hazard, depth and velocity over the lifetime of a development to inform the Exception Test, should this be required.

Having applied this analysis, should there be any sites allocated in areas of high flood risk, Table 3 of the NPPG should be consulted to see if the Exception Test would apply, with reference to the flood risk vulnerability of the development. If so, it is recommended that these sites proceed to a Level 2 SFRA to further advise on the likelihood of the allocation passing the Exception Test. In addition, sites that are at high risk of flooding from other sources and/or where there may be significant impacts due to climate change would benefit from Level 2 SFRA.

Once the process has been completed, the LPA should then be able to allocate appropriate development sites through the Local Plan as well as prepare flood risk policy including the requirement to prepare site-specific FRAs for all allocated sites that remain at risk of flooding.

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

3.4.1 Sequential Test

The SWCs, with advice from the Environment Agency, are responsible for considering the extent to which Sequential Test considerations have been satisfied.

Developers are required to apply the Sequential Test to all development sites, unless:

- The site is a strategic allocation and the test has already been carried out by the LPA, or
- The site is a change of use (except to a more vulnerable use), or
- The site is a minor development (householder development, small non-residential extensions with a footprint of less than 250m^2), or

- The site is a development in Flood Zone 1 unless there are other flooding issues in the area of the development (i.e. surface water, ground water, sewer flooding).

The SFRA contains information on all sources of flooding and taking into account the impact of climate change. This should be considered when a developer undertakes the Sequential Test, including the consideration of reasonably available sites at lower flood risk.

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 relates to the catchment area for the type of development being proposed. For some sites this may be clear e.g. school catchments, in other cases it may be identified by other Local Plan policies. For some sites e.g. regional distribution sites, it may be suitable to widen the search area beyond LPA administrative boundaries.

The sources of information on reasonably available sites may include:

- Site allocations in Local Plans;
- Site with Planning Permission but not yet built out;
- Strategic Housing and Economic Land Availability Assessments (SHELAAs)/five-year land supply/annual monitoring reports;
- Locally listed sites for sale.

It may be that a number of smaller sites or part of a larger site at lower flood risk form a suitable alternative to a development site at high flood risk.

Ownership or landowner agreement in itself is not acceptable as a reason not to consider alternatives.

3.4.2 The Exception Test

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 required (as set out in Table 3 of the NPPG). Developers are required to apply the Exception Test to all applicable sites (including strategic allocations).

The applicant will need to provide information that the application can pass both parts of the Exception Test:

- *Demonstrating that the development would provide wider sustainability benefits to the community that outweigh the flood risk.*

  Applicants should refer to wider sustainability objectives in Local Plan Sustainability Appraisals. These generally consider matters such as biodiversity, green infrastructure, historic environment, climate change adaptation, flood risk, green energy, pollution, health, transport etc.

  Applicants should detail the suitability issues the development will address and how doing so will outweigh the flood risk concerns for the site e.g. by facilitating wider regeneration of an area, providing community facilities, infrastructure that benefits the wider area etc.

- *Demonstrating 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 Flood Risk Assessment should demonstrate that the site will be safe, and the people will not be exposed to hazardous flooding from any source.

The FRA should consider actual and residual risk and how this will be managed over the lifetime of the development, including:

- 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, including whether the developer would increase the pressure on emergency services to rescue people during a flood event.
- Any funding arrangements required for implementing measures.

4 Impact of Climate Change

The NPPF sets out that flood risk should be managed over the lifetime of a development, taking climate change into account. This section sets out how the impact of climate change should be taken into account.

Climate change projections show an increased chance of warmer, wetter winters and hotter, drier summers with a higher likelihood of more frequent and intense rainfall. This is likely to make severe flooding happen more often.

4.1 Revised Climate Change Guidance

The Environment Agency published **updated climate change guidance** in 2016 on how allowances for climate change should be included in both strategic and site specific FRAs. The guidance adopts a risk-based approach considering the vulnerability of the development.

In 2018, the government published new UK Climate Projections (UKCP18). The Environment Agency are currently using these to update their climate change guidance for new developments. Developers should check on the government website for the latest guidance before undertaking a detailed Flood Risk Assessment. At the time of writing this report, this was due in late 2019.

The UKCP18 contains high resolution mapping with peak river flow allowances at 1km grid scale that will be released in late 2019. The regional peak river flow allowances in the 2016 guidance may not change but planners and developers may need to consider the finer resolution data where it shows a significant difference to the regional averages.

The UKCP18 high resolution (daily and sub daily) rainfall projections are due to be published in late 2019. Following this, the Environment Agency may update the recommended peak rainfall allowances in their guidance for planners and developers.

4.2 Applying the climate change guidance

To apply the climate change guidance, the following information needs to be known:

- The vulnerability of the development – see the **NPPG**.

When deciding which range of scenarios are appropriate, developers should consider:

- The likely lifetime of the development – in general 100 years is used for residential, but this needs to be confirmed in a FRA.
- The River Basin that the site is in – South Worcestershire is situated in the Severn River Basin District.
- The 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).
- The vulnerability of the development to flooding – see the **NPPG**.
- '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.

4.3 Relevant allowances for South Worcestershire

Table 4-1 shows the peak river flow allowances that apply in South Worcestershire.

Table 4-1 Peak river flow allowances by river basin district

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)
Severn	Upper end	25%	40%	70%
	Higher central	15%	25%	35%
	Central	10%	20%	25%

Increased rainfall affects river levels and land and urban drainage systems. Table 4-3 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.

4.3.1 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 information in the tables below. Note that developments should take into consideration the range of allowances identified for each vulnerability classification.

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	✓		

4.3.2 Nominal climate change allowance for non-major development

For non-major developments, the Environment Agency SHWG area recommends that a model is produced, or an existing model is rerun for climate change. However, in the absence of modelled climate change information, nominal climate allowances as shown in Table 4-2 should be considered as appropriate with any FRA.

Table 4-2 Nominal allowances

Watercourse	20-25%	35-40%	70%
Upper Severn River Wye River Teme	600mm	850mm	1500mm
River Avon Lower Severn	400mm	600mm	1000mm
Tributaries and 'ordinary watercourses'	200mm	300mm	500mm

4.4 Peak rainfall intensity allowance

Increased rainfall affects river levels and land and urban drainage systems. Table 4-3 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 4-3 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%

Important note on Climate Change Mapping in this SFRA

For this SFRA update, the existing hydraulic models provided by the Environment Agency as well as several more detailed models produced for the LLFA were re-run for climate change scenarios to account for the 2016 climate change guidance.

It should be noted that different mapping techniques have been applied, depending on the type of hydraulic model (e.g. 1D-2D or 1D-only). LIDAR ground levels will have updated in some places along with newer model software versions since some of the much older models were originally run, and hence mapped outputs may differ slightly in some areas when compared against the original studies.

Three scenarios were modelled to reflect the three climate change allowances for the '2080s' timeframe in the Severn River Basin District, therefore the 100-year plus 25%, 35% and 70%. The climate change mapping reflects the defended scenario.

Where no detailed hydraulic models are present, Flood Zone 2 has been used as a proxy (Indicative Climate Change Extent). More detailed hydraulic modelling in these areas may be required at site-specific Flood Risk Assessment stage to confirm flood risk and climate change impacts.

This modelling was undertaken to assist the SWCs with the preparation of their Development Plan Review. Developers will need to undertake a more detailed assessment of climate change as part of the planning application process when preparing FRAs.

Climate change mapping has been provided in Appendix A: Geo-PDFs. The Indicative Flood Zone 2 layer provided under the climate change sub-heading should be viewed in conjunction with the modelled climate change outlines. The Indicative Flood Zone 2 extent has been provided where climate change models are not available or could not be run, to serve as an indication of possible extents.

An overview of the models provided and used in this SFRA are shown in Appendix F.

It is recommended that the impact of climate change on a proposed site is considered as part of a detailed Flood Risk Assessment, using the percentage increases which relate to the proposed lifetime and the vulnerability classification of the development as described in Section 4 and in the SHWG Climate Change guidance. The Environment Agency should be consulted to provide further advice for developers on how best to apply the new climate change guidance.

4.5 Requirements for site-specific Flood Risk Assessments

When undertaking a site-specific FRA, developers should:

- Confirm which national guidance on climate change and new development applies by visiting **GOV.UK**.
- Apply this guidance when deciding the allowances to be made for climate change, having considered the potential sources of flood risk to the site (using this SFRA), the vulnerability of the development to flooding and the proposed lifetime of the development. If the site is just outside the indicative climate change extents in this SFRA, the impact of climate change should still be considered because these may get affected should the more extreme climate change scenarios materialise.
- Chapter 8 provides further details on climate change for developers, as part of the FRA Guidance.

4.6 Adapting to climate change

The NPPG sections on climate change contain information and guidance for how to identify suitable mitigation and adaptation measures 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.

5 Understanding flood risk in South Worcestershire

This chapter explores the key sources of flooding in South Worcestershire and the factors that affect flooding including topography, soils and geology. The main sources of flooding are from watercourses, surface water and sewers.

This is a strategic summary of the risk. Developers should use this chapter to scope out the flood risk issues they need to consider in greater detail in a site-specific Flood Risk Assessment to support a Planning Application.

Appendix C contains a list of the sources of data used in the SFRA.

5.1 Historical flooding

South Worcestershire has a history of documented flood events with the majority of events caused by fluvial or surface water flooding. Significant historic flood events are highlighted in Table 5-1.

Worcestershire County Council's SWMP floodspot data represents locations where it is known that there has been at least one flood event. For each floodspot, the total number of properties, businesses and pieces of critical infrastructure is given, and this can be seen in Figure 5-1. Areas with a high number of affected properties, building and pieces of critical infrastructure affected from historic flooding events include Malvern, Evesham, Broadway, Bredon, Childswickham, Kemerton and Lower Moor.

Figure 5-2 shows the same SMWP floodspot data categorised by the source of flooding. The figure shows that the most common source of flooding is surface water flooding.

Table 5-1 Documented Historic Flood Records in South Worcestershire

Location	Date	Record Source	Additional Information
County-wide	March 1947	Recorded flood outlines	Fluvial flooding from the River Severn
Upper Severn	December 1960	Recorded flood outlines	Fluvial flooding from the River Severn to Worcester
River Avon	July 1968	Recorded flood outlines	Fluvial flooding from the River Avon affecting settlements including Evesham and Pershore
Blackminster	1977	Recorded flood outlines	Fluvial flooding at confluence of Littleton Brook and Bretforton Brook
Upton upon Severn	1980/1981/ 1982/1984	Recorded flood outlines	River Severn flooding
Twyning Green, Little Middleton and Nafford	March 1981	Recorded flood outlines	Fluvial flooding from the River Avon
Eckington	December 1981	Recorded flood outlines	Fluvial flooding from the River Avon
County-wide	1985	Recorded flood outlines	Fluvial flooding affecting settlements along the River Avon, Broadway Brook, River Isbourne, Piddle Brook, Bow Brook and Noleham Brook.
Upton upon Severn	December 1985	Recorded flood outlines	Fluvial flooding from the River Severn
County-wide	1990	Recorded flood outlines	Fluvial flooding affecting settlements along the River Severn from Worcester to Tewkesbury, the Bushley Brook and Ripple Brook
Middle Littleton	1992	Recorded flood outlines	Fluvial flooding from the River Avon

Kempsey, Clevelode and Upton upon Severn	1995	Recorded flood outlines	Fluvial flooding from the River Severn
Upton upon Severn	1996/1997	Recorded flood outlines	Fluvial flooding from the River Severn
County-wide	April 1998	Recorded flood outlines	Affecting settlements along the River Avon and Broadway, Hawbridge, Peopleton and Kington
River Severn	October 1998	Recorded flood outlines	Affecting settlements along the River Severn
County-wide	Autumn 2000	Recorded flood outlines	Affecting settlements along the River Severn, Lower Avon and Lower River Teme
Lower Severn	December 2000	Recorded flood outlines	Affecting the Lower Severn from Worcester to Tewkesbury
County-wide	July 2007	Recorded flood outlines **PFRA**	Heavy rainfall causing sewer, pluvial and fluvial flooding from the River Severn from Worcester, River Teme, River Avon, Broadway Brook, River Isbourne, Piddle Brook, Bow Brook and Bushley Brook
County-wide	February 2014	**BBC News**	Pluvial and fluvial flooding due to heavy rainfall
County-wide	February 2016	**Worcester News**	Heavy rainfall affecting settlements including Pershore, Worcester, Evesham, Kempsey and Upton upon Severn
River Avon at Evesham, Strensham, Bredon and Wyre Piddle	March 2018	**Evesham Journal**	Fluvial flooding from the River Avon

Figure 5-1 Historic flooding incidents from SWMP floodspot data by severity

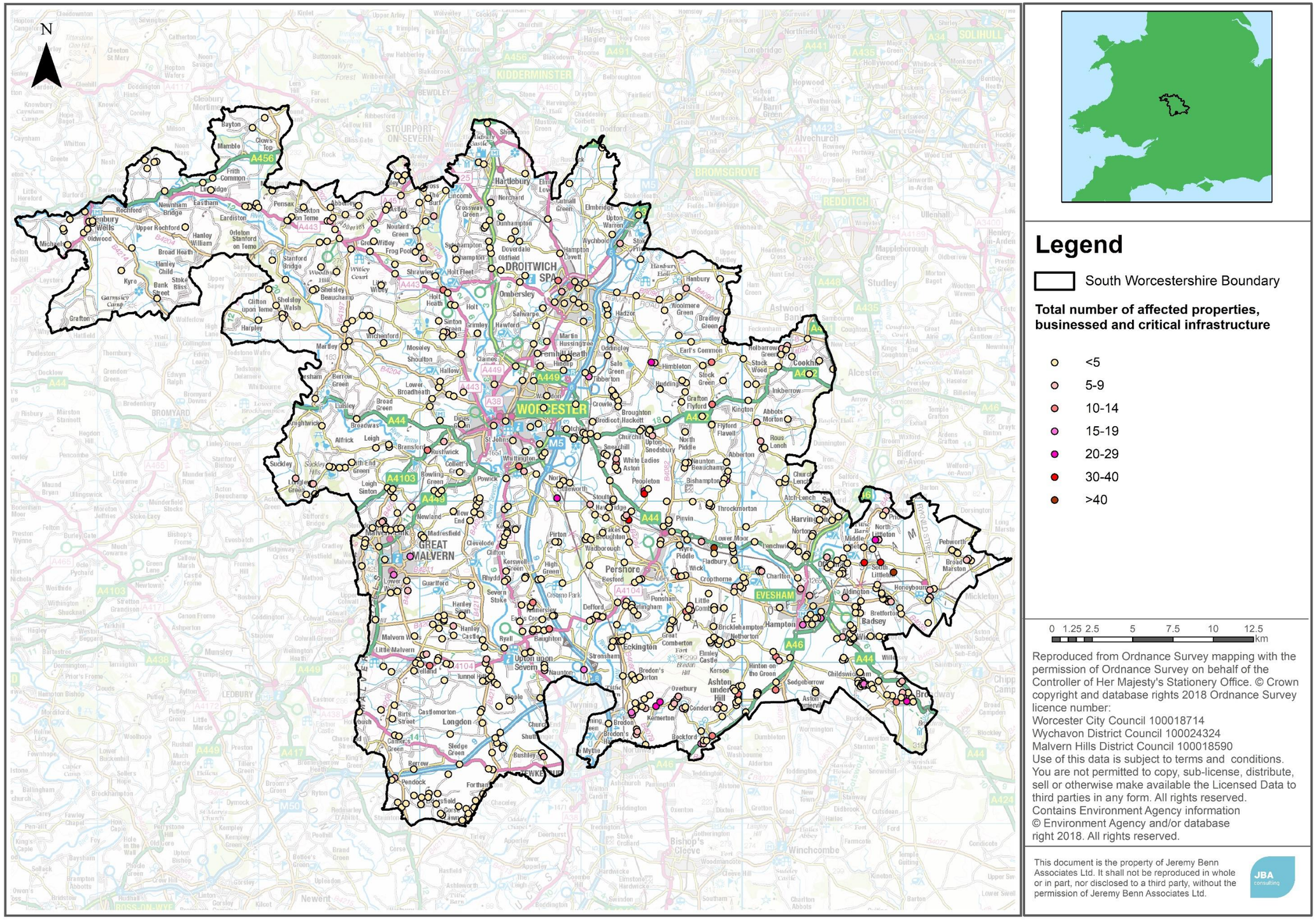
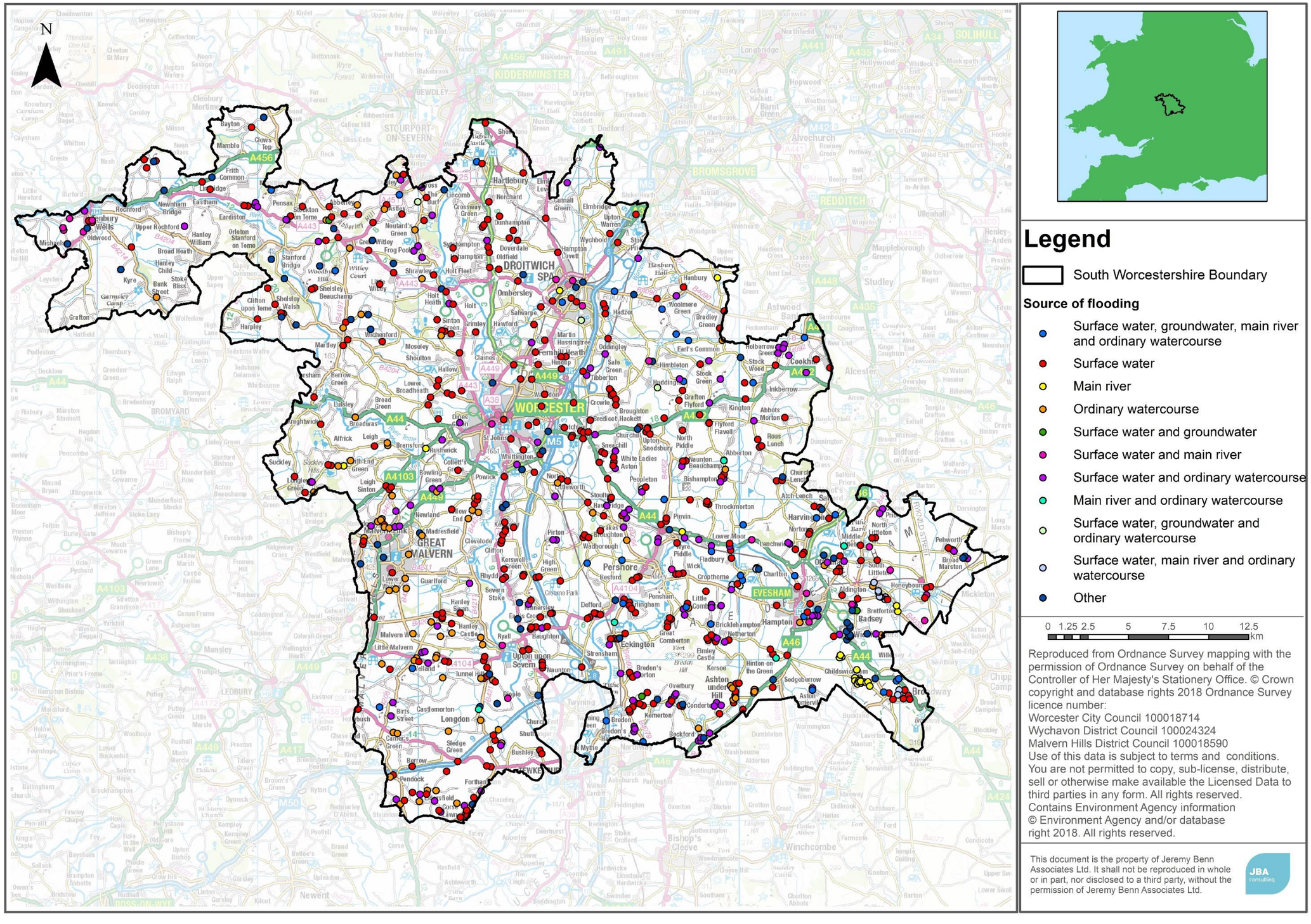


Figure 5-2 Historic flooding events from SWMP floodspot data by flooding source



5.2 Topography, geology, soils and hydrology

The topography, geology and soil are all important in influencing the way a catchment responds to a rainfall event. The degree to which a material allows water to percolate through it, the permeability, affects the extent of overland flow and therefore the amount of run-off reaching the watercourse. Steep slopes or clay rich (low permeability) soils will promote rapid surface runoff, whereas more permeable rock such as limestone and sandstone may result in a more subdued response.

Topography

South Worcestershire has a generally flat, low lying topography with isolated areas of high elevations. Bredon Hill in the south, the Malvern Hills in the west and the hills surrounding the River Teme are the main areas of high elevation within South Worcestershire. The topography of the study area is shown in Figure 5-3.

Geology and soils

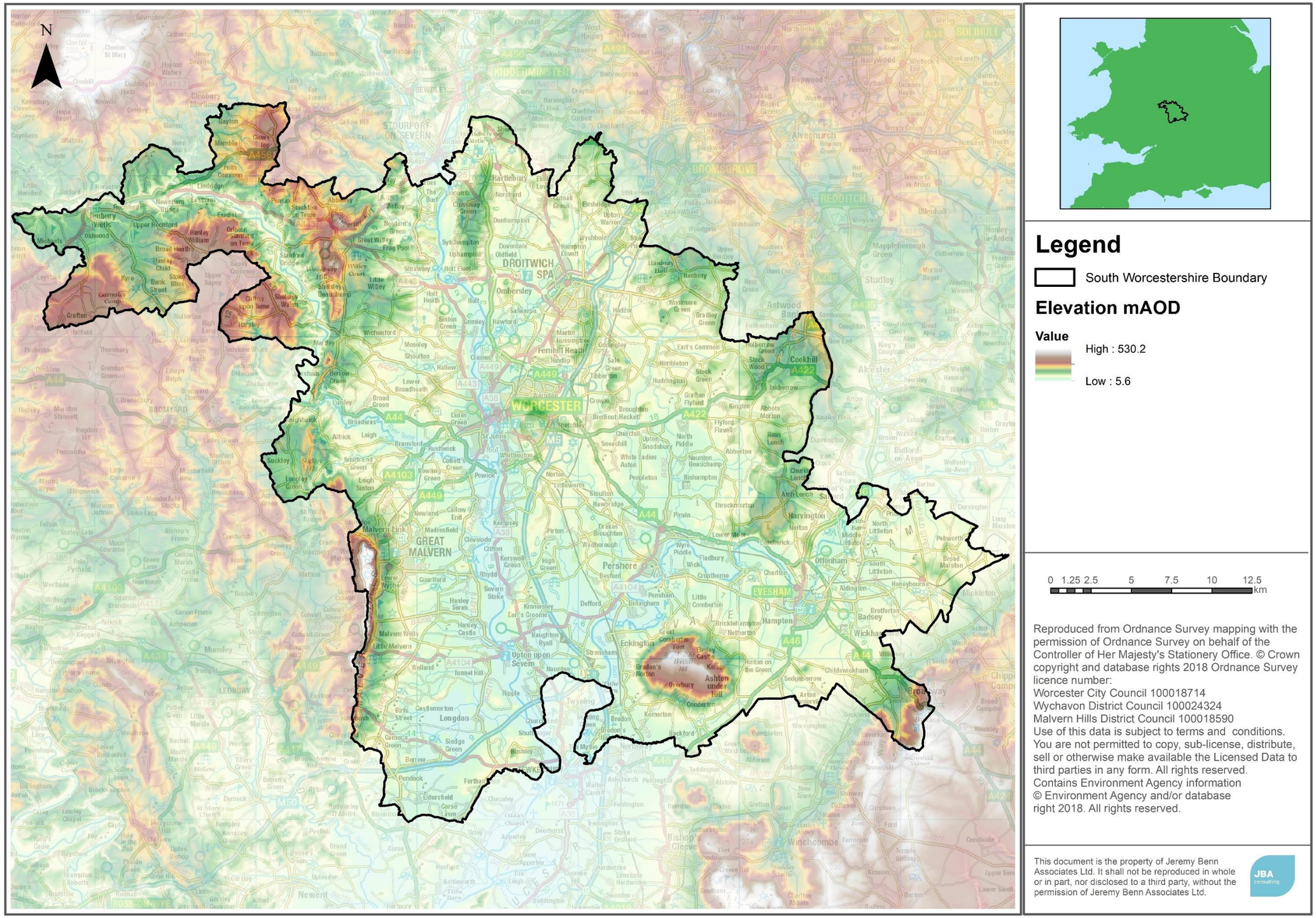
The geology of the catchment can be an important influencing factor on the way that water runs off the ground surface. This is primarily due to variations in the permeability of the surface material and bedrock stratigraphy.

The bedrock geology of South Worcestershire is shown in Figure 5-4. The majority of the study area is made up of undifferentiated Triassic mudstones, siltstones and sandstones, which run through the centre of South Worcestershire. The east is mainly underlain by Lias Group mudstone, siltstone, limestone and sandstone. The north-west of South Worcestershire is underlain by a number of bedrocks, including Lower Devonian mudstone, siltstone and sandstones and Pridoli mudstone, siltstone and sandstones, with narrow bands of undifferentiated Ludlow rocks, undifferentiated Silurian rocks, undifferentiated Wenlock rocks and undifferentiated Llandovery rocks.

The superficial geology of South Worcestershire is shown in Figure 5-5. It shows deposits of clay, silt and sand (alluvium) along the course of the River Teme, and along the course of the River Severn and River Avon within wider areas of sand and gravel (glacial sand and gravel and river terrace deposits). Isolated deposits of till (diamicton, clay with flints) can be found in the east of the study area.

There are a mix of slowly permeable and freely permeable soils within South Worcestershire. These are a mix of slightly acidic, loamy, clayey and sandy soils. The majority of South Worcestershire is covered by soils which have impeded drainage.

Figure 5-3 Topography of South Worcestershire



Legend

South Worcestershire Boundary

Elevation mAOD

Value

High : 530.2

Low : 5.6

0 1.25 2.5 5 7.5 10 12.5 km

Figure 5-4 Bedrock formations in South Worcestershire

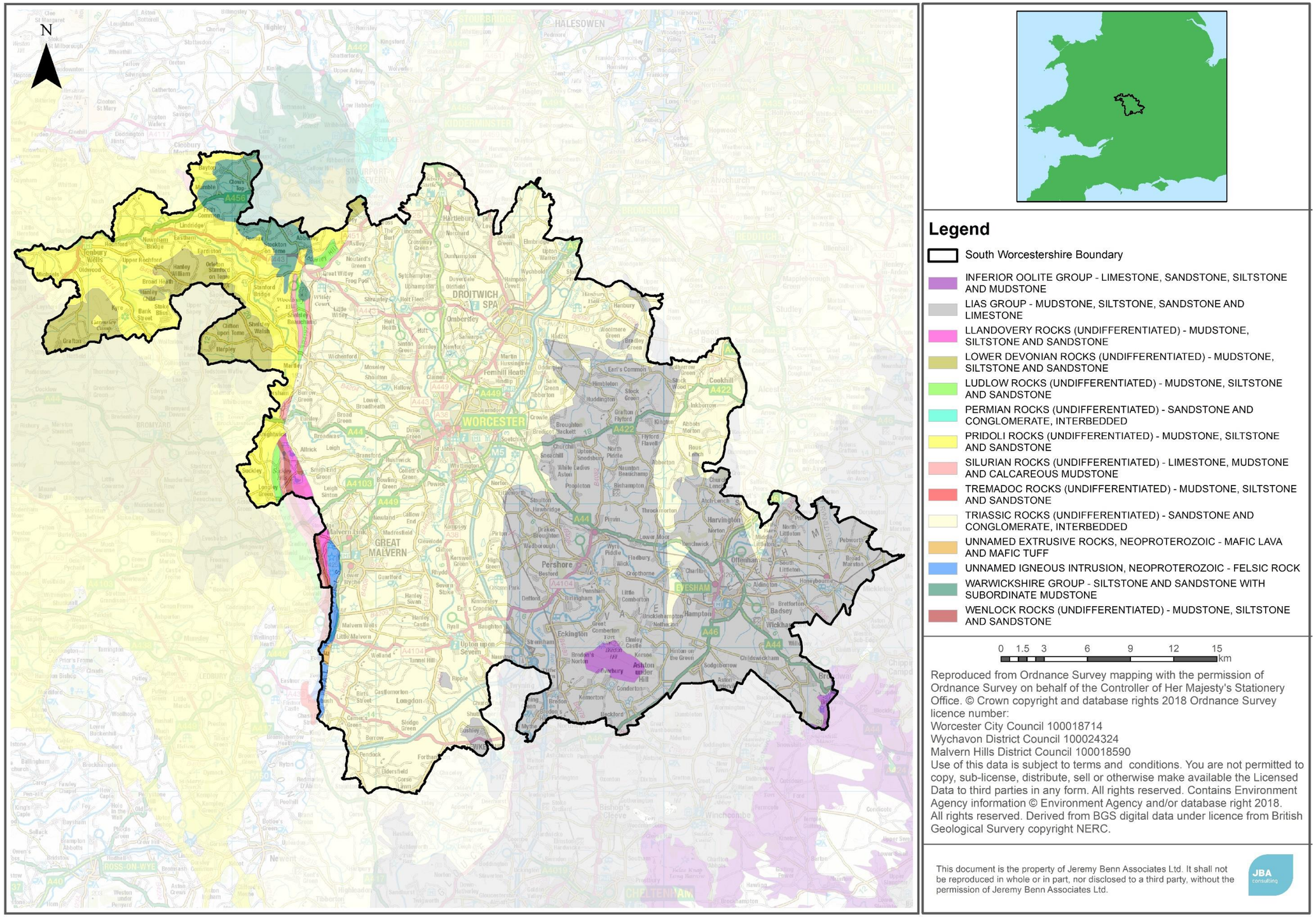
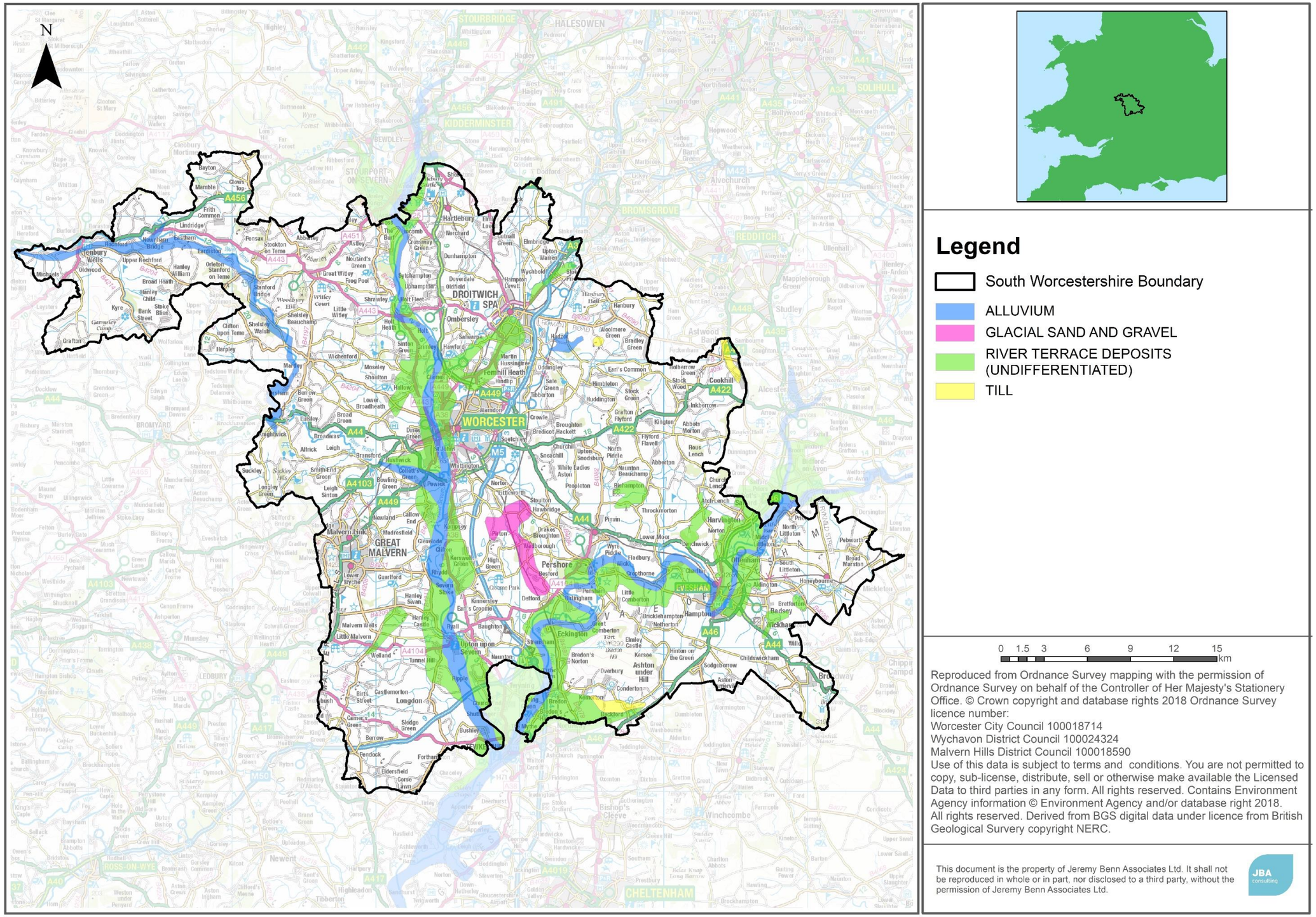


Figure 5-5 Superficial deposits in South Worcestershire



5.3 Hydrology

The principal watercourses flowing through the SFRA study area are:

- River Severn
- River Avon
- River Teme
- River Isbourne
- River Salwarpe
- Piddle Brook
- Bow Brook
- Bushley Brook
- Broadway Brook
- Badsey Brook
- Laughern Brook
- Longdon Brook
- Merry Brook
- Whitsunn Brook

Tributaries of these watercourses include smaller ordinary watercourses and numerous unnamed drains. There are also a number of ponds and lakes within the study area. A summary of the key watercourses in the SFRA are provided in Figure 5-6. Detailed mapping indicating the location of the watercourses can be found in Appendix A.

5.4 Rapid Response Catchments

The Environment Agency has identified Rapid Response Catchments at a national level. These are defined as areas that include rivers or streams (including smaller tributaries and ordinary watercourses) where flooding can occur without a significant period of warning time. The three Rapid Response Catchments in South Worcestershire are the Dick Brook, Badsey Brook and Merry Brook and are shown in Figure 5-7.

Figure 5-6 Key watercourses in South Worcestershire

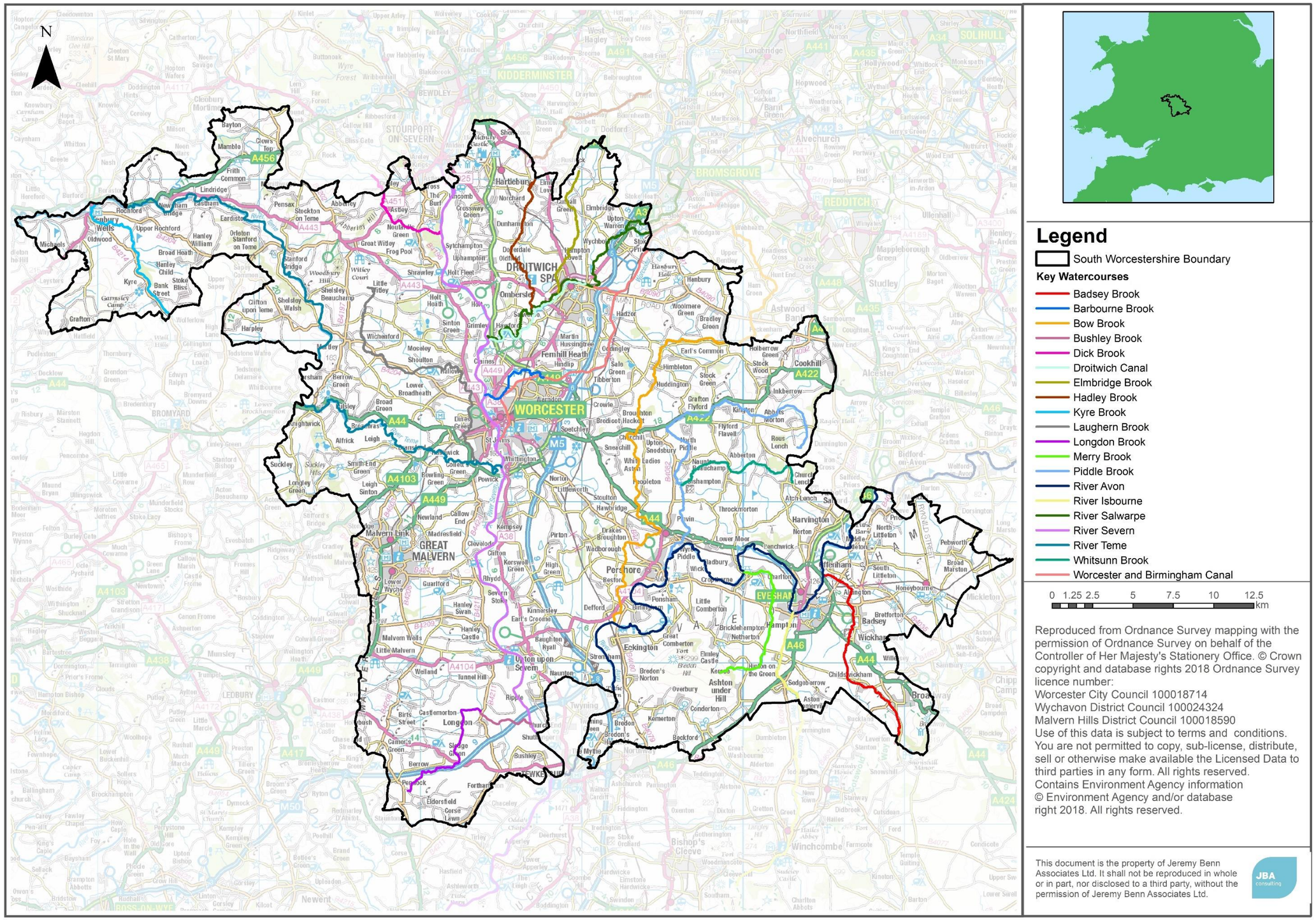
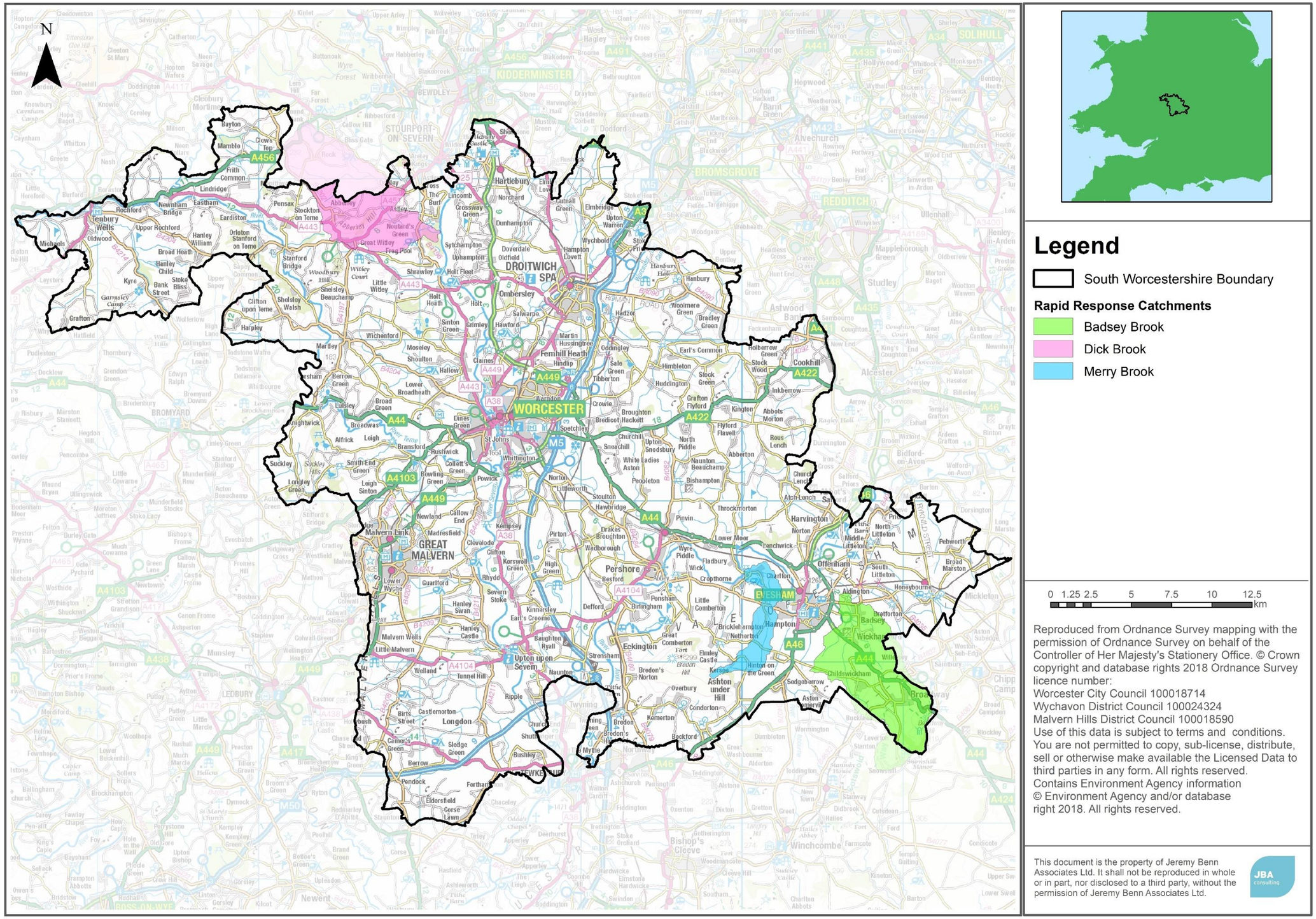


Figure 5-7 Rapid Response Catchments



5.5 Fluvial flood risk

The primary fluvial flood risk in South Worcestershire is along the River Severn, River Teme, River Avon and the tributaries of these rivers. These present fluvial flood risk to rural communities as well as some of the main urban centres including, but not exclusively, Worcester, Upton upon Severn, Evesham, Pershore and Tenbury Wells. The fluvial flood extents are notably wide along the River Severn downstream of Worcester, the River Avon, the River Teme downstream of Horsham and along the Longdon Brook to the west of Longdon due to lower lying, flat topography.

The Flood Zone maps for South Worcestershire are provided in Appendix A: Geo-PDFs, split into Flood Zones 2, 3a and 3b (including an 'Indicative FZ3b' where the Environment Agency's Flood Map for planning Flood Zone 3 acts as FZ3b in the absence of detailed model data). The main settlements in South Worcestershire and their associated flood risk are detailed in Table 5-5. Please note that this table does not cover all locations at risk and the reader should refer to the Appendix mapping for further information on other locations.

5.6 Surface water flooding

Flooding from surface water runoff (or 'pluvial' flooding) is usually caused by intense rainfall that may only last a few hours and usually occurs in lower lying areas, often where the natural (or artificial) drainage system is unable to cope with the volume of water. Surface water flooding problems can be inextricably linked to issues of poor drainage, or drainage blockage by debris, and sewer flooding. This can be made worse by local insufficient drainage capacity. Where discharge is directly to a watercourse, locally high-water levels can cause back-up and prevent water from draining into the drainage system.

The Risk of Flooding from Surface Water mapping (RoFfSW) provided by the Environment Agency shows that a number of communities are at risk of surface water flooding, as discussed in Table 5-5. In general, the RoFfSW shows that surface water predominantly follows topographical flow paths of existing watercourses or dry valleys with some isolated ponding located in low-lying areas. Whilst in the majority of cases the risk is confined to roads, there are notable prominent run-off flow routes around properties, e.g. properties situated at the foot of surrounding hills. The RoFfSW mapping for South Worcestershire can be found in Appendix A.

The floodspot data shown in Figure 5-2 shows the location of historic surface water flooding incidences. Historic surface water events are widespread throughout the study area, however there are some notable clusters around Kempsey, Bredon, Westmancote, Overbury, Broadway, Evesham, Bretforton, Crowle and Elmley Castle.

5.7 Groundwater flooding

In comparison to fluvial flooding, current understanding of the risks posed by groundwater flooding is limited and mapping of flood risk from groundwater sources is in its infancy. Groundwater level monitoring records are available for areas on Major Aquifers; however, for lower lying valley areas, which can be susceptible to groundwater flooding caused by a high-water table in mudstones, clays and superficial alluvial deposits, very few records are available. Additionally, there is increased risk of groundwater flooding where long reaches of watercourse are culverted as a result of elevated groundwater levels not being able to naturally pass into watercourses and be conveyed to less susceptible areas.

Groundwater susceptibility mapping of South Worcestershire has been provided in Appendix A. The floodspot data shown in Figure 5-2 shows the location of historic flooding events relating to groundwater. Groundwater flooding was one of the contributing sources to 42 of the 720 historic floodspot events. These are mainly widespread through Wychavon District, with none within Worcester City and very few in Malvern Hills District. The groundwater flooding events are widespread through

Wychavon District, however there is a small cluster of 3 historic flood events around Cropthorne.

5.8 Flooding from sewers

Sewer flooding occurs when intense rainfall/river flooding overloads sewer capacity (surface water, foul or combined), and/or when sewers cannot discharge to watercourses due to high water levels. Sewer flooding can also be caused by blockages, collapses, equipment failure or groundwater leaking into sewer pipes.

Since 1980, the Sewers for Adoption guidelines mean that new surface water sewers have been designed to have capacity for a rainfall event with a 1 in 30 chance of occurring in any given year, although until recently this did not apply to smaller private systems. This means that sewers will be overwhelmed in larger rainfall and flood events. Existing sewers can also become overloaded as new development adds to the surface water discharge to their catchment, or due to incremental increases in roofed and paved surfaces at the individual property scale (urban creep). Sewer flooding is therefore a problem that could occur in many locations across the study area.

The sewers in South Worcestershire are managed by Severn Trent Water with Welsh Water operating in a small area along the western border of Malvern Hills District. Welsh Water were contacted for their records of historic sewer flooding however there were no incidences within South Worcestershire.

Severn Trent's DG5 register of historic sewer flooding incidents has recently been replaced by the 'At Risk Register', which gives properties a risk based on incident likelihood and impact on customer. Properties defined as at risk on Severn Trent's At Risk Register are set out in Table 5-2.

For confidentiality reasons this data has been supplied on a postcode basis. The dataset was supplied on the 11th December 2018.

Table 5-2 Properties at risk from sewer flooding (Severn Trent Water)

Post code	Locality associated with post code	Number of properties at risk	Post code	Locality associated with post code	Number of properties at risk
WR14 2	Malvern	30	WR3 8	Fernhill Heath	3
WR8 0	Upton upon Severn	25	WR6 5	Broadwas	3
WR14 1	Malvern	22	WR8 0	Ryall	3
WR2 4	Worcester	22	WR4 0	Worcester	3
WR1 2	Worcester	19	WR8 9	Defford	2
WR5 2	Worcester	18	WR8 9	Earls Croome	2
WR2 5	Worcester	17	WR8 9	Baughton	2
WR5 3	Worcester	16	WR9 0	Droitwich	2
WR14 3	Malvern	15	B60 4	Hanbury	2
WR5 1	Worcester	15	B96 6	Stock Green	2
WR3 7	Worcester	13	GL20 6	Uckinghall	2
CV37 8	Broad Marston	10	WR10 1	Pershore	2
WR4 9	Worcester	9	WR2 6	Sinton Green	2
WR12 7	Broadway	9	WR10 2	Wyre Piddle	2
WR13 6	Bismorton	8	WR10 3	Bricklehampton	2
WR3 8	Worcester	8	WR11 1	Evesham	2
WR5 2	Broomhall	7	WR11 5	Evesham	2
WR11 4	Evesham	7	WR11 7	Ashton under Hill	2
WR13 6	Welland	7	WR8 0	Welland	2
WR9 0	Broad Common	6	WR13 5	Malvern	2
GL20 8	Kinsham	6	WR9 7	Tibberton	2

WR8 0	Hanley Swan	6	WR8 0	Longdon Heath	2
WR12 7	Childswickham	5	DY13 0	Astley	1
GL20 7	Little Beckford	5	WR14 4	Upper Welland	1
WR2 4	Powick	5	GL20 7	Bredon	1
WR2 6	Hallow	5	WR10 2	Pershore	1
WR2 6	Lower Broadheath	5	WR10 2	Peopleton	1
WR10 2	Drakes Broughton	5	WR10 2	Pinvin	1
WR9 7	Droitwich	4	WR10 2	Abberton	2
B96 6	Astwood Bank	4	WR10 3	Birlingham	1
WR1 1	Worcester	4	WR5 2	Littleworth	1
WR14 4	Malvern	4	WR5 2	Whittington	1
WR10 3	Great Comberton	4	WR10 3	Little Comberton	1
WR11 3	Evesham	4	WR10 3	Elmley Castle	1
WR5 3	Kempsey	4	WR5 8	Worcester	1
WR7 4	Inkberrow	4	WR11 2	Evesham	1
WR11 7	Honeybourne	4	WR6 6	Martley	1
WR11 7	Wickhamford	4	WR11 3	Badsey	1
WR2 6	Worcester	3	WR7 4	South Littleton	1
WR1 3	Worcester	3	WR8 0	Hanley Castle	1
WR10 3	Eckington	3	WR11 7	Bretforton	1
WR11 7	Badsey	3	WR11 8	Evesham	1
WR11 8	Offenham	3	WR11 8	South Littleton	1
WR9 9	Droitwich	3	DY11 7	Hartlebury	1
WR3 0	Worcester	3			**TOTAL=457**

A total of 457 properties are at risk of sewer flooding within South Worcestershire. The localities at the highest risk include Worcester, Upton upon Severn and Malvern.

5.9 Flooding from canals

Canals do not generally pose a direct flood risk as they are a regulated waterbody. The residual risk from canals tends to be associated with lower probability events such as overtopping and embankment failure (breach and sudden escape of the water retained in the canal channel).

Breaches or embankment failure may be caused by a number of factors including:

- Culvert collapse;
- Overtopping;
- Animal burrowing;
- Subsidence/sudden failure e.g. collapse of former mine workings;
- Utility or development works close to or encroaching onto the footings of a canal embankment.

Flooding from a breach of a canal embankment is largely dictated by canal and ground levels, canal embankment construction, breach characteristics and the volume of water within the canal that can discharge into the lower lying areas behind the embankment. The volume of water released during a breach is dependent on the upstream pound length (i.e. the distance between locks) and how quickly the operating authorities can react to prevent further water loss, for example by the fitting of stop boards to restrict the length of the canal that can empty through the breach, or repair of the breach. The Canal and River Trust monitor embankments at the highest risk of failure.

There are two canals in South Worcestershire, the Droitwich Canal and the Worcester and Birmingham Canal. The Canal and River Trust were consulted to identify any instances of breaches and overtopping of each of the canals.

The Worcester and Birmingham Canal enters South Worcestershire in the north-east of the study area near Wychbold. It travels in a southerly direction to Droitwich Spa, where it splits, and the Droitwich Canal is formed. The Worcester and Birmingham Canal continues south and through Worcester City, where it joins the River Severn at Diglis. There has been one incident of breach on the canal in 2008 at Shernal Green due to culvert collapse.

The Droitwich Canal splits off from the Worcester and Birmingham Canal at Droitwich Spa, it travels south-west to join the River Severn at Hawford. There has been one incident of breach on the canal in 1930 at Bevere Island.

Incidents of overtopping on the Droitwich and Worcester and Birmingham Canals are shown in Table 5-3.

Table 5-3 Incidents of overtopping on canals in South Worcestershire

Date	Canal	Location/information
July 2007	Worcester and Birmingham Canal	Near Blackpole, north Worcester City
April 2012	Droitwich Canal	Junction between Droitwich and Birmingham and Worcester Canals caused by localised rainfall event
June 2012	Droitwich and Worcester and Birmingham Canal	Heavy rainfall caused overtopping at three locations: • Astwood (W&BC) • Shernal Green (W&BC) • Chapel House (DC)
November 2012	Droitwich Canal	Two incidences at Netherwich and Hawford
December 2012	Droitwich Canal	Hawford
November 2013	Droitwich Canal	Three incidences at Porter's Hill Farm
February 2017	Droitwich Canal	Vandalism at the junction between the Droitwich and Birmingham and Worcester Canals causing overtopping

The canals have the potential to interact with other watercourses in the study area, including the Body Brook, Barbourne Brook, Martin Brook, Dean Brook, the River Salwarpe, the River Severn and a number of unnamed watercourse and drains. These have the potential to become flow paths if these canals were overtopped or breached. Any development proposed adjacent to a canal should include a detailed assessment of how a canal breach would impact the site, as part of a site-specific Flood Risk Assessment. Guidance on development near canals is available from the **Canal and River Trust.**

5.10 Flooding from reservoirs

Reservoirs with an impounded volume greater than 25,000 cubic metres are governed by the Reservoir Act 1975 and are on a register held by the Environment Agency. The level and standard of inspection and maintenance required under the Act means that the risk of flooding from reservoirs is very low.

Flooding from reservoirs occurs following partial or complete failure of the control structure designed to retain water in the artificial storage area. Reservoir flooding is very different from other forms of flooding; it may happen with little or no warning and evacuation will need to happen immediately. The likelihood of such flooding is difficult to estimate but is extremely low compared to flooding from other sources. It may not be possible to seek refuge upstairs from floodwater as buildings could be unsafe or unstable due to the force of water from the reservoir breach or failure.

The Environment Agency hold mapping showing what might happen if reservoirs fail. They are currently updating the mapping and new data should be available in late

2019. Developers and Planners should check the **Long-Term Risk of Flooding website** before using the reservoir mapping shown in this SFRA to make sure they are using the most up to date mapping.

There are 26 reservoirs shown to affect South Worcestershire; this includes reservoirs located within the study area and a number of reservoirs outside of the area whose inundation mapping is shown to affect South Worcestershire.

Table 5-4 Reservoirs that may potentially affect South Worcestershire in the event of a breach

Reservoir	Reservoir owner	Is the reservoir located within the study area?	Local Authority Area
British Camp	Severn Trent Water	Yes	Worcestershire
Croome River	The National Trust	Yes	
New Pool, Shrawley	Jeavons-Fellows	Yes	
Warford Pool	Kenrick	Yes	
Witley Court Reservoir	English Heritage	Yes	
Trimpley	Severn Trent Water	No - Wyre Forest District	
Hartlebury Castle Moat and Charlton Pool	Hartlebury Castle Preservation Trust	Yes	
Trimpley Sludge Lagoon	Severn Trent Water	No - Wyre Forest District	
Kyre Pool	Robinson	Yes	
Stackpool	Wyre Forest District Council	No - Wyre Forest District	
Podmore Pool (Broadwater)	Caldwell	No - Wyre Forest District	
Tardebigge	Canal & River Trust	No - Bromsgrove District	
Kidderminster Flood Storage Reservoir	Environment Agency	No - Wyre Forest District	
Top Barn Activity Lake	University of Worcester	Yes	
Pirton Pool	Society of Merchant Venturers	Yes	
Westwood Great Pool	Walker	Yes	
Hundred Pool	Pain	Yes	
Washing Pool	Pain	Yes	
Bittell Upper	Canal & River Trust	No – Bromsgrove District	
Leylandii Norton	Patrick	Yes	
Rotherdale Farm	Spring Hill Farms	Yes	
Hurcott Upper Reservoir	Wyre Forest District Council	Yes	
Eastnor Lake	Eastnor Castle Estates Company	No - Herefordshire	Herefordshire
Bromfield Upper Pool	Trustees of the Plymouth Settled Estate	No - Shropshire	Shropshire
Ragley Hall Lake	Hertford	No - Stratford on Avon District	Warwickshire
Draycote Water	Severn Trent Water	No - Rugby District	

5.11 Flood alert and flood warnings

The Environment Agency is the lead organisation for providing warnings of river flooding. Flood Warnings are supplied via the Flood Warning System (FWS) service, to homes and businesses within Flood Zones 2 and 3.

There are currently 15 Flood Alert Areas (FAA) and 44 Flood Warning Areas (FWAs) covering South Worcestershire. A list of the Flood Alert and Flood Warning Areas and detailed maps are available in Appendix D. The Flood Alert and Flood Warning areas are also included on the Appendix A GeoPDF mapping.

5.12 Summary of flood risk in South Worcestershire

Table 5-5 summarises the key flood risks in South Worcestershire to the main urban areas.

Table 5-5 Summary of Flood Risks in South Worcestershire

Settlement	Fluvial flood risk	Existing defences	Surface water flood risk	Susceptibility to Groundwater flood risk				Reservoir inundation risks	Historic, recorded flood events
				<25%	>=25% <50%	>=50% <75%	>=75%		
Badsey	Badsey is located on the right bank of the Badsey Brook which borders the west and south of the village. An unnamed watercourse flows through the north of the village towards the Badsey Brook which may pose a fluvial flood risk, however it is not included in the Flood Zones due to the catchment size. Parts of Badsey Lane, Mill Lane and the B4035 are located in Flood Zone 3, affecting a property on Mill Lane and farm houses on the bank of the Badsey Brook. Flood Zone 2 extends to reach properties on Seward Road, The Knapp, Manor Close and Badsey Lane.	None	Surface water flooding in the 30-year event in Badsey is largely confined to areas around the Badsey Brook and the unnamed watercourse in the north of the village. A small number of properties are located within the 30-year surface water extent, along Mill Lane, Manor Close, Manor Side and The Drift. There are a number of overland flow routes in the 100-year event, notably along High Street, Seward Road, Synehurst Crescent, Badsey Lane, School Lane and Post Office Lane.	✓	✓			None	Various sources: 1985, 2007 A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Bredon and Mill End	The majority of Bredon is not at risk from fluvial flooding due to the high elevations in the village. Terrain slopes towards the River Avon in the west which poses a fluvial flood risk to Church Street, Dock Lane and Broome Lane. An unnamed watercourse which is not included in the Flood Zones due to the small catchment size flows through the north of Bredon and a watercourse which runs culverted through Bredon could pose a fluvial flood risk to the village.	None	The 30-year surface water flood extent in Bredon and Mill End mainly consists of small isolated areas of ponding; however, High Street is a flow route to the unnamed drain in the south-west of the village. In the 100-year event, Church Street and Dock Lane also become flow routes. Further roads become flow routes in the 1,000-year event including Moreton Lane, College Road, St Giles Road and Farm Lane, and a number of properties fall within the flood extent.		✓	✓	✓	Bredon is partially located within the reservoir inundation extent of Draycote Water reservoir.	Various sources: 1947, 1985, 2000, 2007, 2018 A number of historic flood events highlighted in the SWMP floodspot data from surface water sources.
Broadway	An unnamed watercourse flows past the southern edge of Broadway which then joins the Badsey Brook, which flows past the western edge of the village. This unnamed watercourse could pose a fluvial flood risk; however, it is not included within the Flood Zones. Mill Avenue and The Old Mill lie entirely within Flood Zone 3, with the flood extent also reaching properties on Lifford Gardens, the B4632, Childswickham Road and Pry Farm. Flood Zone 2 extends further, flooding the Broadway Caravan and Motorhome site and backing up significantly behind the old railway line.	~1487m of embankment and flood wall surrounding farm and on West End Lane	High Street, the B4632 and Mill Avenue are significant overland flow routes in the 30-year surface water flooding event and a number of properties are affected including on the B4632, Mill Avenue, The Old Mill, Lifford Gardens, Back Lane and Averill Close. Leamington Road and Springfield Lane become flow routes in the 100-year event. In the 1,000-year event, many roads in the village become overland flow routes and a number of properties are affected with the area between Lifford Gardens and the old railway line where the water backs up significantly.	✓	✓	✓		None	Various sources: 1998, 2007 A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Droitwich Spa	Fluvial flood risk in Droitwich originates from the River Salwarpe, Droitwich Canal, the Body Brook and the Elmbridge Brook. Properties along Swan Drive, Impney Green, Impney Way, the B4090, High Street, Tower Street, Vines Lane, Hanbury Street, Queen Street, Kidderminster Road and Honeymans Gardens are located within Flood Zone 3 of the River Salwarpe and/or the Droitwich Canal. Flood Zone 2 extends further to affect properties on Mallard Place, Heron Place and Waterside. Properties on Paddock Way, Coppice Way, Westwood Road, Hunters Way, Hunters Close, Hunters End and Park Way are within the fluvial flood extents of the Elmbridge Brook. The majority of the town is located at higher elevations than the river channels and are therefore less likely to flood from fluvial sources.	None	The 30-year surface water flood extent is mainly small isolated areas of ponding, however The Holloway, Ombersley Road and Ombersley Street West become overland flow routes. A small number of properties fall within the 30-year surface water flood extent including on Hazel Close, Newland Road, Hunters Way and Woodmans Way. In the 100-year event, Oakland Avenue, Tagwell Road, Stalls Farm Road and Newland Road become notable overland flow routes. The flood extents are notably wide on Newland Road, Maple Grove, Alder Grove and around Queen Street, High Street and Saltway in the north of the town. Many more roads become overland flow routes in the 1,000-year event and properties are largely affected in the Witton, Primsland, Berry Hill areas and along the River Salwarpe and Droitwich Canal in the north of the town.	✓	✓			Droitwich Spa is partially located within the reservoir inundation extents of Tardebigge and Westwood Great Pool reservoirs.	Various sources: 2007 A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Evesham	Evesham is at risk of fluvial flooding from the River Avon, River Isbourne and the Battleton Brook and the Charity Brook which all flow through the centre of the town. The majority of Evesham has a generally flat and low-lying topography making it more likely to flood from fluvial sources. The main fluvial flood risk in the town	None	The surface water flood extent for the 30-year event is largely confined to the areas surrounding the multiple watercourses flowing through the town, with some small isolated areas of ponding and a flow route along School Road. Larger areas of ponding are around the Battleton Brook and	✓	✓	✓		Evesham is partially located within the reservoir inundation extents of	Various sources: 1947, 1968, 1985, 1998, 2001, 2007, 2014, 2016

	is the River Avon. At the upstream end of the town the Flood Zones extend from Common Road and Mill Street on the right bank to Harvey Road, Burford Road and Mansion Gardens on the left bank, affecting roads and properties in between. The B4035, A4184, Nursery Road and fields surrounding the leisure centre all lie within the Flood Zones further upstream the River Avon in the town. A small number of properties lie within the flood extents of the River Isbourne, on Mill Road, the B4084, Mill House and part of the Plant Nursery. The Charity Brook and the upper reaches of the Battleton Brook are not included in the Flood Zones however could pose a fluvial flood risk, particularly as they are both culverted partially through the town.		Bengeworth Brook where they cross the A46 and Broadway Road respectively and in the west of the town along the Merry Brook. In the 100-year event Saxonbury, Kings Road, Broadway Road, the A4184, Bewdley Street and other roads in the town become overland flow routes. Many more roads become flow routes in the 1,000-year event affecting a number of properties. Water from the Battleton Brook backs up behind the A46 and extents are notably wide in this area as well as at the Bengeworth Brook around the A46 and Broadway Road and through the town in the Four Pools and Bengeworth areas.					Ragley Hall Lake, Draycote Water and Leylandii Norton reservoirs.	A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Hartlebury and Waresley	An unnamed watercourse flows through the eastern side of Hartlebury and Waresley towards the Hartlebury Brook in the north which could pose a fluvial flood risk to the villages, however, is not included in the Flood Zones due to the small catchment size. The majority of the villages are located at higher elevations therefore the fluvial flood risk is likely to be low.	None	The majority of Hartlebury does not lie within the 30 and 100-year surface water flood extents with the exception of isolated areas of ponding on Manor Lane, Crown Lane and Waresley Park in Waresley. There a small number of overland flow routes in the 1,000-year event, along Inn Lane, Quarry Bank, the B4193, the A449, Manor Lane and Waresley Lane.	✓	✓	✓	✓	None	One historic flood event highlighted in the SWMP floodspot data from surface water sources.
Harvington	The Harvington Brook flows past the west and south of the village. Parts of Stratford Road, Evesham Road and Anchor Lane lie within the Flood Zones; however, no properties are located within the extents.	Two community level Flood Alleviation Schemes undertaken by Wychavon District Council in 2009 and 2011, and at property level on Leys Road in 2011.	Stratford Road and Leys Road are the two main overland flow routes and there are small isolated areas of ponding elsewhere in the 30-year surface water flood extent. The extents reach a small number of properties in the 100-year event, on the B4088, Brookdale, Leys Road and Station Road. Station Road, Village Street, Ragley Road, Grange Lane and Church Street become flow routes in the 1,000-year event and affects a number of properties in the village.	✓	✓	✓		None	A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Honeybourne	The Gate Inn Brook flows through the centre of the village, which is relatively flat, therefore Honeybourne is more likely to flood from primarily fluvial sources. The Gate Inn pub and parts of High Street, Weston Road, Station Road and Stratford Road are located in Flood Zone 3. Flood Zone 2 extends further to affect properties on Fallow Field and Grange Farm Drive. The Flood Zone extends very wide on the fields to the south and the east of the village.	None	The surface water flood extent is wide along the Gate Inn Brook, affecting properties adjacent to the brook in all AEP events, notably on High Street, Stratford Road, Station Road, Weston Road, Herdwick Drive and Clun Forest Way. Surface water back up behind the railway line in the north of the village in all events. The majority of roads in the village are affected by the 1,000-year surface water flooding event.	✓				None	A number of historic flood events highlighted in the SWMP floodspot data from surface water, and main river sources.
Inkberrow	An unnamed watercourse flows on the eastern edge of Inkberrow, this watercourse is not included in the Flood Zones however could pose a fluvial flood risk to the village.	None	Inkberrow is largely unaffected by surface water flooding in the 30-year and 100-year event, with only isolated areas of ponding, potentially affecting properties along Windmill Lane, Ross Crescent, Appletree Lane and the A422. All roads and a number of properties are affected in the 1,000-year event along Windmill Lane and between the unnamed watercourse and the A422 as water runs off towards the watercourse.	✓				None	Two flood events highlighted in the SWMP floodspot data from surface water, main river, ordinary watercourse and groundwater sources.
Kempsey	Kempsey lies on the left bank of the River Severn and the Hatfield Brook flows through the centre of the village. Properties on Church Street, Court Meadow, Lane's End, Squire's Walk and the A38 are within Flood Zone 3. Flood Zone 2 extends to reach properties on Squire's Close, Lyf's Lane, Chapel Road, Rookery Road, Church Street and Court Meadow.	~338m of embankment off Lane's End	The 30-year surface water flood extent consists of small isolated ponded areas with Old Road North a minor overland flow route. In the 100-year event, parts of the A38 and Old Road South also become flow routes and a small number of properties are affected including on Mercia Way, Centurion Drive and Post Office Lane. In the 1,000-year event Napleton Lane, Post Office Lane, Church Street and Squire's Walk also become flow routes.		✓		✓	None	Various sources: 1947, 1990, 1998, 2000, 2001, 2007, 2016. A number of historic flood events highlighted in the SWMP floodspot data from surface water and other sources.
Malvern	Given the topography of Malvern, it is unlikely to flood from predominantly fluvial sources. A number of small	None	Surface water flooding is the primary flood risk in Malvern, due the topography of the town as water	✓	✓	✓	✓	None	A number of historic flood events

	watercourses run through part of the town including Pool Brook, Whippets Brook, Madresfield Brook, Whitacres Brook and other unnamed watercourses. These are not included in the Flood Zones due to the small catchment size, however they could pose a fluvial flood risk, particularly those which run culverted through the town should blockages occur.		runs off from the surrounding hills and through the town into the various watercourses in the east. There are many overland flow routes in the 100 and 1,000-year events, including the B4503, Church Road, Somers Park Road, A449, B4208, Sandy's Road, Clarence Road, Court Road, Arosa Drive, Geraldine Road and Sling Lane.						highlighted in the SWMP floodspot data from surface water and ordinary watercourse sources.
Offenham	Offenham is located on the left bank of the River Avon and the right bank of the Broadway Brook. The village is largely flat and low lying, particularly in the fields north of the village where the Flood Zone 2 extent is approximately 1km wide. The Flood Zones mainly extends to rural field areas and farm building, however there is a small number of residential properties within the Flood Zones.	None	The majority of surface water flooding in the village is isolated areas of ponding in the 30 and 100-year events which are not seen to affect properties. In the 1,000-year event Main Street, Three Cocks Lane, Ferry Lane, Boat Lane and Myatt Road become flow routes affecting a small number of properties on these roads.			✓	✓	Offenham is partially located within the reservoir inundation extents of Ragley Hall Lake, Draycote Water and Leylandii Norton reservoirs.	Various sources: 1985, 1998, 2007 A number of historic flood events highlighted in the SWMP floodspot data from surface water and ordinary watercourse sources.
Pershore	Pershore lies on the right bank of the River Avon, and the Piddle Brook and Bow Brook flow partially through the north of the town. The extent of the Flood Zones of the River Avon is wide through Pershore. Flood Zones 3 reaches properties on King George's Way, Bridge Street, Nogains and the B4536. Flood Zone 2 extends further affecting properties on Cherry Orchard, Great Calcroft, St Andrew's Road, Farleigh Road, Little Penny Rope, Cornmore and Bredon View Close. Worcester Road, Avon Green, Poplar Avenue and Haines Avenue in neighbouring Wyre Piddle north-east of Pershore lie within the Flood Zones of the Piddle Brook.	~1555m of embankment, flood wall and flood gate on right bank of River Avon, running parallel to Defford Road and Nogains	Surface water flooding in Pershore in the 30-year event is mainly confined to small areas of ponding, with minor flow routes along the A4104, B4536 and B4084. Larger areas of ponding in the 100-year event are seen with an overland flow route along Newlands, New Road, Gig Bridge Lane, Holloway and Head Street. Larger areas of ponding are notable in the fields between the B4083 and the River Avon in the north-east of the town and around Pershore High School.	✓	✓	✓	✓	Pershore is partially located within the reservoir inundation extents of Draycote Water and Leylandii Norton reservoirs.	Various sources: 1947, 1968, 1985, 1998, 2001, 2007, 2016, 2018 A number of historic flood events highlighted in the SWMP floodspot data from surface water and ordinary watercourse sources.
Tenbury Wells	The River Teme flows through the north of Tenbury Wells forming the border of Malvern Hills District and Shropshire. The Kyre Brook flows through the town towards the River Teme. The town is very flat and is at low elevation making it more likely to flood from fluvial sources. The flood extent of the Kyre Brook is fairly well confined to the channel and it is the River Teme that poses the largest fluvial risk. Flood Zone 3 extents to properties on Teme Street, Church Street, Market Street and the B4204. Teme Street and Church Street are entirely located within Flood Zone 2, which also extends to Cralves Mead, St Mary's Close, Bog Lane and Cross Street.	None	Bog Lane, Berrington Road, Cralves Mead, St Mary's Close, Cross Street and Market Street are overland flow routes in the 30-year surface water flooding event, a small number of properties are affected by areas of surface water ponding, on Bromyard Road, and Kyreside. Several more roads become flow routes in the 1,000-year including Church Street, Dark Orchard, The Oaklands and Greenhill Close.	✓		✓	✓	Tenbury Wells is partially located within the reservoir inundation extent of Kyre Pool reservoir.	Various sources: 2007 A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river and ordinary watercourse sources.
Upton upon Severn	Upton upon Severn is at high risk of fluvial flooding due to the flat, low-lying topography of the town. Dunn's Lane, East Waterside, Waterside, the A4104, New Street, Rectory Road are located in Flood Zone 3. Flood Zone 2 extends further to Blackfields Lane, Longfield, Ham View, Court Street, London Lane, Severn Drive, Minge Lane, William Tennant Way, Upton Gardens and The Graftons. The Flood Zone surrounds the town where water spills out of bank just upstream of the town and flows along lower-lying land to the west, bypassing and re-joining the Severn south of the town.	Embankment/flood wall/flood gate around west of town (New Street) and on both banks of the River Severn (Waterside)	Surface water flooding in all events in Upton upon Severn is largely isolated areas of ponding with few notable overland flow routes. The ponded area in the fields to the north-west of the town is very large in the 1,000-year event, however this is largely rural and does not affect properties. A very small number of properties within the town lie within the surface water flood extents.			✓	✓	None	Various sources: 1947, 1980, 1981, 1982, 1984, 1989, 1990, 1995, 1996, 1997, 1998, 2000, 2001, 2007, 2016 A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river and ordinary watercourse sources.
Worcester	The River Severn, Laughern Brook, Duck Brook and the Barbourne Brook flow through Worcester posing a fluvial flood risk to the city.	Embankment/flood wall/flood gate in multiple places in the city, including	There are a few overland flow routes in the 30-year surface water event, including Blackpole Road, St Dunstan's Close, Raleigh Close, Rea Way, Lansdowne Road, the B4636 and Plantation Drive	✓	✓	✓	✓	Worcester is partially located within the reservoir	Various sources: 1947, 1960, 1990, 1998, 2000, 2001, 2007, 2016

	The flood extents of the Barbourne Brook reach parts of Blackpole and Barbourne, notably affecting properties where it becomes culverted in the north-east of Barbourne. The Laughern Brook Flood Zones extends to properties in Dines Green and the western edge of Worcester City. The River Teme flows into the River Severn in the south of the city posing a fluvial flood risk to the area of Lower Wick. The largest fluvial risk in the city is the River Severn. The Flood Zones of the River Severn extend to parts of Cherry Orchard, Diglis, Britannia Square, Barbourne and Northwick. The width of the extent of Flood Zone 2 in the centre of the city along the River Severn is up to 600m.	Astwood, Diglis and Barbourne	as well as many small areas of ponding throughout the city. Larger areas of ponding occur where water backs up behind the A449 and the A38 at Duck Brook, but also in other isolated areas including Kingstone Avenue in Astwood and Williamson Road. Many roads in the city become flow routes in the 1,000-year event and there are large areas of ponding, notably where the Duck Brook meets the A38, where an unnamed watercourse crosses the M5 at Swinesherd, Nunnery Wood Sports Fields, the Barbourne Brook as it crosses the M5 and either side of the A449 and Kingstone Avenue.					inundation extents of New Pool, Tardebigge, Top Barn Activity Lake, Westwood Great Pool and Hundred Pool reservoirs.	A number of historic flood events highlighted in the SWMP floodspot data from surface water, main river and ordinary watercourse sources.
Wychbold	The River Salwarpe flows around the north and west of Wychbold however the majority of the village is located enough distance away from the River Salwarpe and at high enough elevations to not be at risk from fluvial flooding. A very small number of properties fall within the Flood Zones on Mill Lane and Paper Mill Lane.	None	A small number of properties fall within small ponded areas of the 30 and 100-year surface water flood extents, including on Pear Tree Way, Crown Lane and Amphlett Way with flow routes along Crown Lane, Amphlett Way, De Wyche Road and Mill Lane.	✓	✓			Wychbold is partially located within the reservoir inundation extent of Tardebigge reservoir.	Two historic flood events highlighted in the SWMP floodspot data from surface water sources.

6 Flood defences and assets

This chapter provides a summary of existing flood defences and assets in South Worcestershire. Planners should note the areas that are protected by defences where further work to understand the actual and residual flood risk through a Level 2 SFRA may be beneficial. Developers should consider the benefit they provide over the lifetime of a development in a site-specific Flood Risk Assessment.

6.1 Asset management

Risk Management Authorities hold databases of flood risk management and drainage assets:

- The Environment Agency holds a national database that is updated by local teams.
- The LLFA holds a database of significant local flood risk assets, required under Section 21 of the Flood and Water Management Act (2010).
- Highways Authorities hold databases of highways drainage assets, such as gulleys and connecting pipes.
- Water Companies hold records of public surface water, foul and combined sewers. The records may also include information on culverted watercourses.

The databases include assets RMAs directly maintain and third-party assets. The drainage network is extensive and will have been modified over time. It is unlikely that any RMA contains full information on the location, condition and ownership of all the assets in their area. They take a prioritised approach to collecting asset information, which will continue to refine the understanding of flood risk over time.

Developers should collect the available asset information and undertake further survey as necessary to present an understanding of current flood risk and the existing drainage network in a site-specific Flood Risk Assessment.

6.2 Standards of protection

Flood defences are designed to give a specific Standard of Protection (SoP), reducing the risk of flooding to people and property in flood prone areas. For example, a flood defence with a 100-year SoP means that the flood risk in the defended area is reduced to at least a 1% chance of flooding in any given year.

Over time the actual SoP provided by the defence may decrease, for example due to deterioration in condition or increases in flood risk due to climate change. The understanding of SoP may also change over time as RMAs undertake more detailed surveys and flood modelling studies.

It should be noted that the Environment Agency's on-going hydraulic modelling programme may revise flood risk datasets and as a consequence, the standard of protection offered by flood defences in the area, may differ from those discussed in this report.

Developers should consider the standard of protection provided by defences and residual risk as part of a detailed FRA.

6.3 Maintenance

The Environment Agency and Local Authorities have permissive powers to maintain and improve Main Rivers and Ordinary Watercourses, respectively. There is no legal duty to maintain watercourses, defences or assets and maintenance and improvements are prioritised based on flood risk. The ultimate responsibility for maintaining watercourses rests with the landowner.

Highways Authorities have a duty to maintain public roads, making sure they are safe, passable and the impacts of severe weather have been considered. Water Companies have a duty to effectually drain their area. What this means in practise is that assets are maintained to common standards and improvements are prioritised for the parts of the network that do not meet this standard e.g. where there is frequent highways or sewer flooding.

There is potential for the risk of flooding to increase in areas where flood alleviation measures are not maintained regularly. Breaches in raised flood defences are most likely to occur where the condition of a flood defences has degraded over time. Drainage networks in urban areas can also frequently become blocked with debris and this can lead to blockages at culverts or bridges.

Developers should not assume that any defence, asset or watercourse is being or will continue to be maintained throughout the lifetime of a development. They should contact the relevant RMA about current and likely future maintenance arrangements and ensure future users of the development are aware of their obligations to maintain watercourses.

6.4 Major flood risk management assets in South Worcestershire

The Flood Map for Planning contains information on Areas benefiting from defences. This shows areas that benefit from the defences that provide a SoP of at least a 100-year river flood event. It does not show areas that benefit from protection for more frequent events. There are eight 'Areas benefiting from defences' in South Worcestershire, at Sedgeberrow and Hinton on the Green along the River Isbourne and at Upton upon Severn and Worcester along the River Severn. The flood defences on Main Rivers in South Worcestershire are shown in Table 6-1. Figure 6-1 shows the location of assets listed on the Worcestershire County Council Asset Register located within South Worcestershire. These assets include culverts, drains, detention basins and swales. More information on these assets can be obtained by contacting Worcestershire County Council. Information on Environment Agency assets can be found on their **website**.

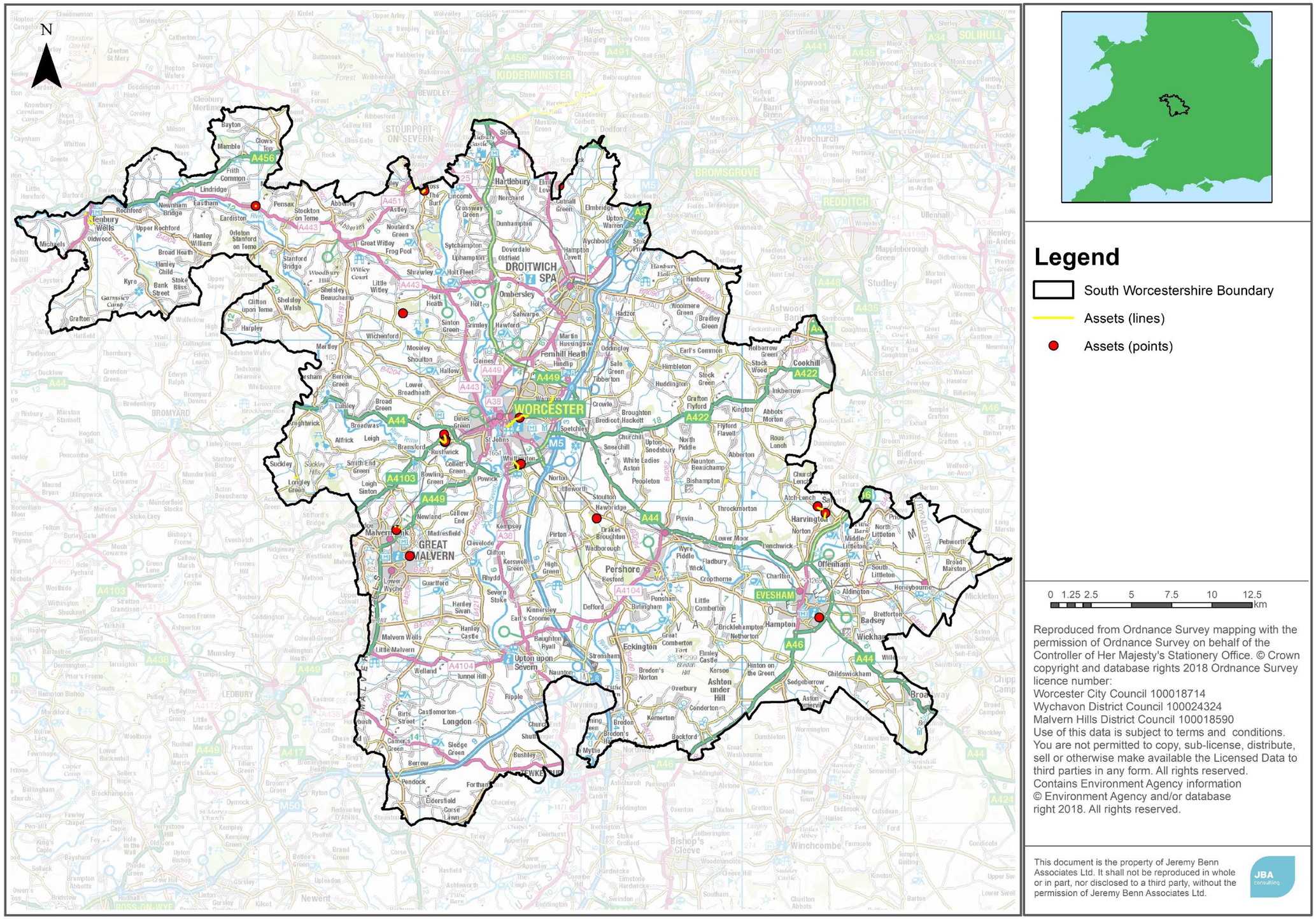
Table 6-1 Formal Flood Defences in South Worcestershire on Main Rivers

Watercourse	Location	NGR	Type	Design SoP	Approximate Length	Condition rating	Comments
River Isbourne	Sedgeberrow	402593, 238733	Embankment/ flood wall/ flood gate	Up to 100	478m	Fair (3) to good (2)	Left bank 350m of flood wall and embankment, right bank 125m of wall/gate/embankment protecting houses on The Hollows and B4078
River Isbourne	Hinton on the Green	402251, 240100	Embankment/ flood wall/ flood gate	Unknown	210m	Fair (3) to good (2)	Right bank, surrounding properties on Corn Mill Bank and Bevans Lane
River Avon	Pershore	394538, 245118	Embankment/ flood wall/ flood gate	Up to 100	1555m	Fair (3) to good (2)	Right bank, running parallel to Defford Road and Nogains
River Avon	Downstream of Pershore	394781, 243273	Embankment	Unknown	4974m	Fair (3)	Left bank 1520m to north of Birlingham, right bank 3452m to east of Birlingham
Badsey Brook	Broadway/ West End	408909, 237247	Embankment/ flood wall	Unknown	1487m	Very good (1)	Predominantly left bank, surrounding farmland on West End Lane
River Severn	Worcester	384379, 255066	Embankment/ flood wall/ flood gate	Up to 100	1165m	Fair (3) to good (2)	Right bank 678m parallel to A443, left bank 487m parallel to Grand Stand Road, North Parade and South Parade
River Severn	Diglis (Worcester)	384794, 253561	Flood wall	Unknown	933m	Fair (3)	Left bank
River Severn	Worcester (confluence with Barbourne Brook)	384035, 256637	Flood wall	Unknown	156m	Good (2)	Left bank
River Severn	Downstream of Worcester to Ryall	-	Embankment/ flood wall/ flood gate	Up to 100	17.6km	Fair (3) to good (2)	Right bank Open Barn Farm to Kempsey, both banks Kempsey, right bank Kempsey to Whitacres Brook, left bank Whitacres Brook to Cliffey Farm, both banks Cliffey Farm to The Vineyard Barn, left

							bank Day House Cottage to Upton upon Severn, both banks north Upton upon Severn, left bank Ryall.
River Severn	Downstream of Upton upon Severn	386874, 236187	Embankment	Up to 5	8872m	Fair (3) to good (2)	Left bank Saxon's Lode to Ripple Nature Reserve, right bank Bushley Brook to Tewkesbury
River Severn	Upton upon Severn	385008, 240446	Embankment/ flood wall/ flood gate	100	758m	Fair (3) to good (2)	Defences on west side of the town (New Street embankment) and north side of the town (Waterside)
Barbourne Brook	Barbourne (Worcester)	385154, 256747	Flood wall	100	41m	Good (2)	Left bank
Barbourne Brook	Barbourne (Worcester)	384549, 256427	Flood wall	Unknown	26m	Good (2)	Left bank, south-west corner of Gheluvelt Park
Unnamed watercourse	Astwood (Worcester)	385907, 256539	Flood wall	Unknown	197m	Fair (3)	Right bank along edge of Astwood Cemetery
Laughern Brook	Worcester	383095, 256264	Flood wall	Up to 5	19m	Fair (3)	Both banks
Unnamed tributary of River Severn	Uckinghall	386739, 237813	Embankment/ flood wall/ flood gate	100	460m	Fair (3) to good (2)	Defences surrounding village through Ferry Lane
Unnamed tributary of Carey's Brook	Powick	383324, 251796	Embankment	75	550m	Fair (3) to good (2)	Embankment around A449, north-east Powick

Source: AIMS dataset, Environment Agency

Figure 6-1 South Worcestershire asset register



6.5 Actual and residual flood risk

A Level 2 SFRA (for strategic allocations) or developer site-specific Flood Risk Assessment will need to consider the actual and residual flood risk due to the presence of flood and drainage assets in greater detail.

6.5.1 Actual flood risk

This is the risk to the site considering existing flood mitigation measures and any planned to be provided through new development. Note that it is not likely to be acceptable to allocate developments in existing undefended areas on the basis that they will be protected by developer works, unless there is a wider community benefit that can be demonstrated.

The assessment of the actual risk should take into account that:

- 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 this 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 and safe guarded that is required for affordable future flood risk management measures.
- 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.

6.5.2 Residual flood risk

Residual risk is the risk that remains after the effects of flood risk infrastructure have been taken into account. 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 larger flood than defences were designed to alleviate (the 'design flood'). This can cause 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 amount of water.
- Failure of the defences or flood risk management measures, such as breaches in embankments or walls, failure of flood gates to open or close or failure of pumping stations.
- Parts of South Worcestershire rely on formal flood defences for protection against fluvial flooding. Consequently, there are areas vulnerable to rapid inundation in the event of a breach/failure. The assessment of the residual risk should take into account:
    - The flood hazard, depth and velocity that would result from overtopping or breach of defences. Flood gate or pumping station failure and/or culvert blockage (as appropriate). The Environment Agency can provide advice at site-specific development level for advice on breach/overtopping parameters for flood models.
    - The design of the development to take account of the highest risk parts of the site e.g. allowing for flood storage on parts of the site and considering

the design of the development to keep people safe e.g. sleeping accommodation above the flood level.

- A system of warning and a safe means of access and egress from the site in the event of a flood for users of the site and the emergency services.

7 Cumulative impact of development, schemes and strategic solutions

This chapter provides a summary of flood alleviation schemes, catchments with highest flood risk and summarises strategic solutions applicable to South Worcestershire.

7.1 Introduction

Under the revised 2018 NPPF, strategic policies and their supporting Strategic Flood Risk Assessments (SFRAs), are required to '*consider cumulative impacts in, or affecting, local areas susceptible to flooding*' (para. 156).

When allocating land for development, consideration should be given to the potential cumulative impact of the loss of floodplain storage volume. Whilst the loss of storage for individual developments may only have minimal impact on flood risk, the cumulative effect of multiple developments may be more severe.

Conditions imposed by the SWCs should allow for mitigation measures so any increase in runoff as a result of development is properly managed and should not exacerbate flood risk issues, either within, or outside of the Council's administrative areas.

The cumulative impact of development should be considered at the planning application and development design stages and the appropriate mitigation measures undertaken to ensure flood risk is not exacerbated, and where possible the development should be used to improve flood risk.

7.2 Cross-boundary issues

The topography of South Worcestershire means that a number of major watercourses, such as the River Avon and River Severn, flow through the study area and into neighbouring authorities. As such, future development both within and outside South Worcestershire can have the potential to affect flood risk to development and surrounding areas, depending on the effectiveness of SuDS and drainage implementation. South Worcestershire has boundaries with the following Local Authorities, which can be seen in Figure 1-1:

- Forest of Dean District Council
- Cotswold District Council
- Tewkesbury Borough Council
- Stratford on Avon District Council
- Wyre Forest District Council
- Bromsgrove District Council
- Redditch District Council
- Herefordshire Council
- Shropshire Council

The effect of proposed development in neighbouring authorities on South Worcestershire has been considered in the cumulative impact assessment.

Growth in neighbouring authorities was considered in the cumulative impact assessment outlined below. GIS shapefiles were provided by five out the eight neighbouring authorities and these were assessed to determine if any neighbouring development would affect flood risk in South Worcestershire.

There is no significant development in neighbouring authorities on catchments draining into South Worcestershire, other than development in Wyre Forest District, however development here will drain into the River Stour (which flows into the River Severn) or

the River Severn itself. Due to the relative size of the catchments draining into the River Severn from upstream, any small-scale developments on these watercourses are unlikely to have a significant impact on flows in the River Severn.

7.3 Cumulative impact assessment

To assess which catchments are at the highest risk of flooding and where the cumulative impact of development may have the biggest effect, historic flood risk and predicted flood risk were assessed. Worcestershire County Council's SWMP floodspot data was used to assess the historic flood risk. Each floodspot represents a location where there has been at least one known flood event and each floodspot identifies the number of properties, buildings and critical infrastructure that are known to have flooded. Predicted flood risk was assessed using the 100-year and 1,000-year surface water flooding extents to determine the percentage of properties at risk of flooding as a result of increased runoff upstream. Further information about the methodology, assumptions and considerations of the cumulative impact assessment can be found in Appendix E.

The WFD catchments and catchments from the FEH CD-ROM were used to define the catchments used in this assessment. The final results of the assessment gave a rating of low, medium or high risk for each catchment. A map of this is shown in Figure 7-1 (along with scheme data which is discussed in section 7.4) and results are outlined below.

The catchments rated as high-risk are:

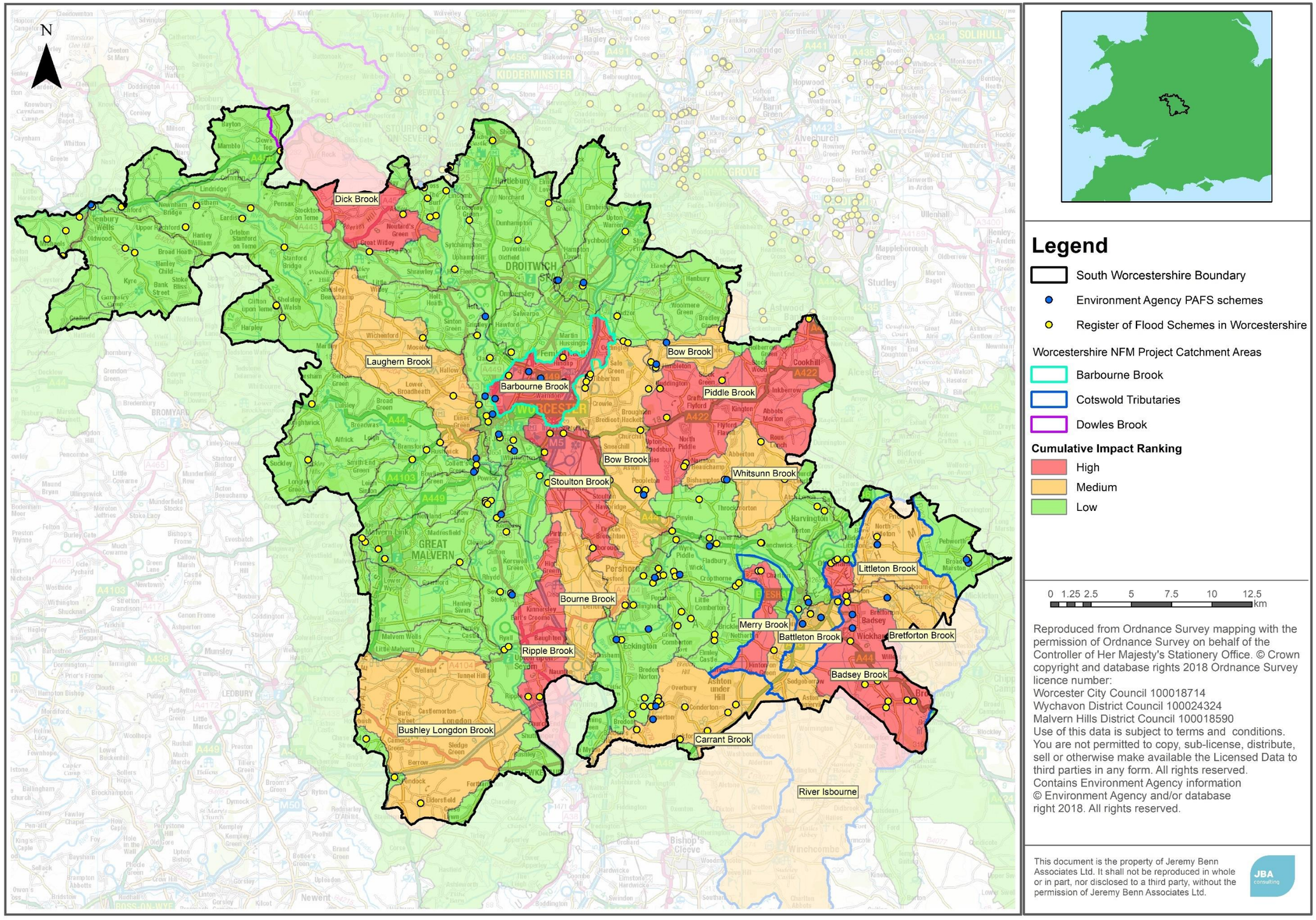
- Dick Brook
- Barbourne Brook, Worcester
- Badsey Brook, including Broadway, Badsey, Childswickham and Offenham
- Merry Brook, draining towards Charlton
- Piddle Brook, including Inkberrow and Flyford Flavell
- Ripple Brook, draining towards Tewkesbury
- Stoulton Brook, south of Worcester, draining towards the Bow Brook

The catchments rated as medium-risk are:

- Battleton Brook, draining towards Evesham
- Bourne Brook
- Bow Brook, Lett's Mill to Shell
- Bow Brook, draining towards Defford
- Bretforton Brook, draining towards Bretforton
- Bushley Longdon Brook, including Welland, Bushley and Longdon
- Carrant Brook, draining towards Tewkesbury
- River Isbourne, draining towards Evesham
- Laughern Brook, draining towards Worcester
- Littleton Brook, including Honeybourne and North, Middle and South Littleton
- Whitsunn Brook, including Church Lench and Bishampton

Policy recommendations for these catchments can be found in Chapter 10.

Figure 7-1 Final risk rating of catchments and schemes in South Worcestershire



7.4 Flood alleviation schemes

Figure 7-1 shows the current programme of LLFA flood alleviation schemes in South Worcestershire and potential flood and environmental schemes from the Environment Agency's Project Application and Funding Service (PAFS). These include schemes currently progressing, such as the Cotswold Escarpment tributaries, Barbourne Brook and Dowles Brook NFM schemes and longer-term pipeline schemes such as the Severn Stoke flood alleviation scheme. More detailed information on some of the major flood alleviation schemes in South Worcestershire are outlined below.

Information on schemes undertaken by the LLFA can be found by contacting Worcestershire County Council and on their **website**, and those undertaken by the Environment Agency can be found through the **programme of FCERM schemes**.

7.4.1 Badsey Brook

The Badsey Brook flood alleviation scheme was opened in October 2018 and comprises of a flood storage area which reduces flood risk to 272 homes and businesses in Broadway, Childswickham and Murcot in Wychavon District following the severe flooding in the areas in 2007 and 2012. The storage area located in Broadway can hold up to 135,000m^3 of water and only allows a set amount of water to flow downstream at times of intense and high rainfall. Further information on the scheme can be found on Worcestershire County Council's **website** and the Environment Agency's **website**.

7.4.2 Upton upon Severn

Upton upon Severn has a long history of flooding, most notably in 2007 and 2014 when access to the town was significantly reduced. The flood alleviation scheme was completed in 2019 with the aim to reduce flooding on key sections of the highway network. The scheme raised over 500 metres of the A4104 in the town by up to 0.8m, meaning that the road will be able to stay open for longer during flood events. The road was also widened and footpaths and drainage from surrounding fields improved. Further information on the scheme can be found on Worcestershire County Council's **website**.

7.4.3 Severn Stoke

The scheme aims to raise the flood bank and install floodgates to reduce flood risk from the River Severn and surface water to 16 properties and key infrastructure with construction planned between 2019-2021.

7.4.4 Property Flood Resilience

Property flood resilience schemes are planned in a number of areas in South Worcestershire, including Evesham, Bretforton, South Littleton, Himbleton, Droitwich and Wickhamford and are expected to be delivered by 2020/2021.

7.5 Strategic solutions

The SWCs have a vision for the future management of flood risk and drainage in South Worcestershire. This concerns flood risk management, alongside wider environmental and water quality enhancement. Strategic solutions may include upstream flood storage, integrated major infrastructure/FRM schemes, new defences and watercourse improvements as part of regeneration and enhancing green infrastructure, with opportunities for natural flood management and retrofitting sustainable drainage systems.

Chapter 2 sets out the strategic plans that exist for South Worcestershire. The list below summarises the key outcomes these are seeking to achieve. This vision needs to be delivered by new development alongside retrofitting and enhancing green infrastructure and flood defence schemes in the existing developed area.

The strategic policy vision from the CMFP and RBMP focusses on ensuring the floodplains are not inappropriately developed and encouraging collaboration and creating new partnerships to reduce the risk of flooding and to enhance the natural environment. Strategic solutions relating to these visions include:

- Safeguard the natural floodplain from inappropriate development and restore the natural floodplain. This could be done by implementing buffer areas around watercourses, de-culverting and removing redundant structures on a watercourse. The Sequential Test should be applied to avoid new development within the floodplain as much as possible.
- Use land management change where possible to reduce runoff rates from the development whilst maintaining or enhancing the capacity of the natural floodplain to retain water.
- Implement upstream catchment management e.g. slow the flow and flood storage schemes (such as that on the Badsey Brook) could be implemented in upper catchment reaches to reduce flooding downstream.
- Consider Natural Flood Management (NFM) measures (including those mentioned above). The Environment Agency have published an **online evidence base** to support the implementation of NFM and included **maps** to show locations for the potential of NFM measures.
- Create 'blue corridors' to link flood compatible spaces.
- Use SFRAs to inform future development and minimise flood risk from all sources.
- Develop flood alleviation schemes.
- Promote and consider SuDS at the earliest stage of development of a site.

8 FRA requirements and guidance for developers

This chapter provides guidance on site specific Flood Risk Assessments (FRAs). These are carried out by (or on behalf of) developers to assess flood risk to and from a site. They are submitted with Planning Applications and should demonstrate how flood risk will be managed over the development's lifetime, considering climate change and vulnerability of users.

The report provides a strategic assessment of flood risk in South Worcestershire. Prior to any construction or development, site-specific assessments will need to be undertaken so all forms of flood risk and any defences at a site are considered in more detail. Developers should, where required, undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances), to inform the sequential approach within the site and prove, if required, whether the Exception Test can be satisfied.

A detailed FRA may show that a site is not appropriate for development of a particular vulnerability or even at all. The Sequential and Exception Tests in the NPPF apply to all developments and an FRA should not been seen as an alternative to proving these tests have been met.

8.1 Principles for new developments

Apply the Sequential and Exception Tests

Developers must provide evidence that the Sequential Test has been passed for windfall developments. If the Exception Test is needed, they must also provide evidence that all parts of the Test can be met for all developments, based on the findings of a detailed Flood Risk Assessment.

Developers should also apply the sequential approach to locating development within the site. The following questions should be considered:

- Can risk be avoided through substituting less vulnerable uses or by amending the site layout?
- Can it be demonstrated that less vulnerable uses for the site have been considered and reasonably discounted? and
- Can layout be varied to reduce the number of people or flood risk vulnerability or building units located in higher risk parts of the site?

Consult with the statutory consultees at an early stage to understand their requirements

Developers should consult with the Environment Agency, Worcestershire County Council as LLFA and Severn Trent Water as the water and sewerage company at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling and drainage assessment and design.

Consider the risk from all sources of flooding and that they are using the most up to date flood risk data and guidance

The SFRA can be used by developers to scope out what further detailed work is likely to be needed to inform a site-specific Flood Risk Assessment. At a site level, developers will need to check before commencing on a more detailed Flood Risk Assessment that they are using the latest available datasets. Developers should apply the 2019 Environment Agency climate change guidance and ensure the development has taken into account climate change adaptation measures.

Ensure that development does not increase flood risk elsewhere

Chapter 9 sets out these requirements for taking a sustainable approach to surface water management. Developers should also ensure mitigation measures do not

increase flood risk elsewhere and that floodplain compensation is provided where necessary.

Ensure the development is safe for future users

Consideration should first be given to minimising risk by planning sequentially across a site. Once risk has been minimised as far as possible, only then should mitigation measures be considered. Developers should consider both the actual and residual risk of flooding to the site.

Further flood mitigation measures may be needed for any developments in 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.

Enhance the natural river corridor and floodplain environment through new development

Developments should demonstrate opportunities to create, enhance and link green assets. This can provide multiple benefits across several disciplines including flood risk and biodiversity/ecology and may provide opportunities to use the land for amenity and recreational purposes. Development that may adversely affect green infrastructure assets should not be permitted. Where possible, developers should identify and work with partners to explore all avenues for improving the wider river corridor environment.

Consider and contribute to wider flood mitigation strategy and measures in South Worcestershire and apply the relevant local planning policy

Wherever possible, developments should seek to help reduce flood risk in the wider area e.g. by contributing to a wider community scheme or strategy for strategic measures, such as defences or natural flood management or by contributing in kind by mitigating wider flood risk on a development site. Developers must demonstrate in an FRA how they are contributing towards this vision.

8.2 Requirements for site-specific Flood Risk Assessments

8.2.1 When is a FRA required?

Site-specific FRAs are required in the following circumstances:

- Proposals of 1 hectare or greater in Flood Zone 1.
- Proposals for new development (including minor development such as non-residential extensions, alterations which do not increase the size of the building or householder developments and change of use) in Flood Zones 2 and 3.
- Proposals for new development (including minor development and change of use) in an area within Flood Zone 1 which has critical drainage problems (as notified to the LPA by the Environment Agency).
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

An FRA may also be required for some specific situations:

- If the site may be at risk from the breach of a local defence (even if the site is actually in Flood Zone 1).
- Where evidence of historical or recent flood events have been passed to the LPA.
- Where the site's drainage system may have an impact on an IDB's system.
- In an area of significant surface water flood risk.

8.2.2 Objectives of site-specific FRAs

Site-specific FRAs should be proportionate to the degree of flood risk, as well as appropriate to the scale, nature and location of the development. Site-specific FRAs should establish:

- Whether a proposed development will be at risk of flooding, from all sources, both now and in the future, taking into account climate change;
- Whether a proposed development will increase flood risk elsewhere;
- Whether the measures proposed to deal with the effects and risks are appropriate;
- The evidence, if necessary, for the local planning authority to apply the Sequential Test; and
- Whether, if applicable, the development will be safe and pass the Exception Test.

FRAs should follow the approach recommended by the NPPF (and associated guidance) and guidance provided by the Environment Agency, the SWCs and Worcestershire County 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);
- FRA Guidance Note (Environment Agency SHWG area);
- **South Worcestershire Water Management and Flooding Supplementary Planning Document**;
- **Site-specific Flood Risk Assessment: CHECKLIST** (NPPF PPG, Defra).

Guidance for local planning authorities for reviewing flood risk assessments submitted as part of planning applications has been published by Defra in 2015 – **Flood Risk Assessment: Local Planning Authorities.**

8.3 Local requirements for mitigation measures

8.3.1 Site layout and design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development.

The NPPF states that a sequential, risk-based approach should be applied to try to locate more vulnerable land uses away from Flood Zones, to higher ground, while more flood-compatible development (e.g. recreational space) can be located in higher risk areas. The sequential approach is followed to steer development into areas with the lowest probability of flooding and any assessment should take into account the flood risk vulnerability of land uses.

Waterside areas, or areas along known flow routes, can act as Green Infrastructure, being used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas and avoid the creation of isolated islands as water levels rise.

8.3.2 Modification of ground levels

Any proposal for modification of ground levels will need to be assessed as part of a detailed flood risk assessment.

Modifying ground levels to raise the land above the required flood level is an effective way of reducing flood risk to a particular site in circumstances where the land does not act as conveyance for flood waters. However, care must be taken as raising land above the floodplain could reduce conveyance or flood storage in the floodplain and could adversely impact flood risk downstream or on neighbouring land. Raising ground levels can also deflect flood flows, so analysis should be performed to demonstrate that there are no adverse effects on third party land or property.

Compensatory flood storage should be provided, and would normally be on a level for level, volume for volume basis on land that does not currently flood but is adjacent to the floodplain (in order for it to fill and drain). It should be in the vicinity of the site and within the red line of the planning application boundary (unless the site is strategically allocated). Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C62430.

Where proposed development results in a change in building footprint, the developer should ensure that it does not impact upon the ability of the floodplain to store or convey water and seek opportunities to provide floodplain betterment.

Raising levels can also create areas where surface water might pond during significant rainfall events. Any proposals to raise ground levels should be tested to ensure that it would not cause increased ponding or build-up of surface runoff on third party land.

8.3.3 Raised floor levels

If raised floor levels are proposed, these should be agreed with the SWCs and the Environment Agency. The minimum Finished Floor Level (FFL) may change depending on the vulnerability and flood risk to the development.

The Environment Agency advises that minimum finished floor levels should be set 600mm above the 100-year plus climate change peak flood level, where the new climate change allowances have been used (see Chapter 4 for the climate change allowances). An additional allowance may be required because of risks relating to blockages to the channel, culvert or bridge and should be considered as part of an FRA.

Allocating the ground floor of a building for less vulnerable, non-residential, use is an effective way of raising living space above flood levels. Single storey buildings such as ground floor flats or bungalows are especially vulnerable to rapid rise of water (such as that experienced during a breach). This risk can be reduced by use of multiple storey construction and raised areas that provide an escape route.

Similarly, the use of basements should be avoided. Habitable uses of basements within Flood Zone 3 should not be permitted, whilst basement dwellings in Flood Zone 2 will be required to pass the Exception Test. Access should be situated 300mm above the design flood level and waterproof construction techniques used.

8.3.4 Development and raised defences

Construction of localised raised floodwalls or embankments to protect new development is not a preferred option, as a residual risk of flooding will remain. Compensatory storage must be provided where raised defences remove storage from the floodplain.

Where development is located behind, or in an area benefitting from defences, the residual risk of flooding must be considered, as set out in Chapter 6.

8.3.5 Developer contributions

In some cases, and following the application of the Sequential Test, it may be appropriate for the developer to contribute to the improvement of flood defence provision that would benefit both proposed new development and the existing local community. Developer contributions can also be made to maintenance and provision of flood risk management assets, flood warning and the reduction of surface water flooding (i.e. SuDS).

8.4 Resistance and resilience measures

The consideration of resistance and resilience measures should not be used to justify development in inappropriate locations.

Having applied planning policy, there will be instances where developments, such as those that are water compatible and essential infrastructure, are permitted in high flood risk areas. The above measures should be considered before resistance and resilience measures are relied on. The effectiveness of these forms of measures are often dependant on the availability of a reliable forecasting and warning system and the use of back up pumping to evacuate water from a property as quickly as possible. The proposals must include details of how the temporary measures will be erected and decommissioned, responsibility for maintenance and the cost of replacement when they deteriorate. The following measures are available:

Permanent barriers: Permanent barriers can include built up doorsteps, rendered brick walls and toughened glass barriers.

Temporary barriers: Temporary barriers consist of moveable flood defences which can be fitted into doorways and/or windows. The permanent fixings required to install these temporary defences should be discrete and keep architectural impact to a minimum. On a smaller scale, temporary snap-on covers for airbricks and air vents can also be fitted to prevent the entrance of flood water.

Community resistance measures: These include demountable defences that can be deployed by local communities to reduce the risk of water ingress to a number of properties. The methods require the deployment of inflatable (usually with water) or temporary quick assembly barriers in conjunction with pumps to collect water that seeps through the systems during a flood.

Flood resilience measures: These measures aim to ensure no permanent damage is caused, the structural integrity of the building is not compromised and the clean up after the flood is easier. Interior design measures to reduce damage caused by flooding can include electrical circuitry installed at a higher level and water-resistant materials for floors, walls and fixtures.

8.5 Reducing flood risk from other sources

8.5.1 Groundwater

Groundwater flooding has a very different flood mechanism to any other and so many conventional flood mitigation methods are not suitable. The only way to fully reduce flood risk would be through building design (development form), ensuring floor levels are raised above the water levels caused by a 1 in 100-year plus climate change event. Site design would also need to preserve any flow routes followed by the groundwater overland to ensure flood risk is not increased downstream.

Infiltration SuDS can cause increased groundwater levels and subsequently may increase flood risk on or off a site. Developers should provide evidence and ensure that this will not be a significant risk.

8.5.2 Surface water and sewer flooding

Developers should discuss public sewerage capacity with the water utility company at the earliest possible stage. It is important that a Surface Water Drainage Strategy (often done as part of a Flood Risk Assessment) shows that this will not increase flood risk elsewhere, and that the drainage requirements regarding runoff rates and SuDS for new development are met.

If residual surface water flood risk remains, the likely flow routes and depths across the site should be modelled. The site should be designed so that these flow routes are preserved and building design should provide resilience against this residual risk.

When redeveloping existing buildings, the installation of some permanent or temporary floodproofing and resilience measures could protect against both surface water and

sewer flooding. Non-return valves prevent water entering the property from drains and sewers. Non-return valves can be installed within gravity sewers or drains within a property's private sewer upstream of the public sewerage system. These need to be carefully installed and must be regularly maintained.

Consideration must also be given to attenuation and flow ensuring that flows during the 100-year plus climate change storm event are retained within the site if any flap valves shut. This should be demonstrated with suitable modelling techniques.

8.5.3 Reservoirs

The risk of reservoir flooding is extremely low. However, there remains a residual risk to development from reservoirs which developers should consider during the planning stage:

- Developers should contact the reservoir owner for information on:
  - the Reservoir Risk Designation;
  - reservoir characteristics: type, dam height at outlet, area/volume, overflow location;
  - operation: discharge rates/maximum discharge;
  - discharge during emergency drawdown; and
  - inspection/maintenance regime.
- The EA and NRW online Reservoir Flood Maps contain information on the extents, depths and velocities following a reservoir breach (note: only for those reservoirs with an impounded volume greater than 25,000 cubic metres are governed by the Reservoir Act 1975). Consideration should be given to the extent, depths and velocities shown in these online maps.

Developers should consult the West Mercia Local Resilience Forum about emergency plans for reservoir breach.

Developers should use the above information to:

- Apply the sequential approach to locating development within the site.
- Consider the impact of a breach and overtopping, particularly for sites proposed to be located immediately downstream of a reservoir. This should consider whether there is sufficient time to respond.
- Assess the potential hydraulic forces imposed by sudden reservoir failure event and check that that the proposed infrastructure fabric could withstand the structural loads.
- Develop site specific emergency plans if necessary and ensure that the future users of the development are aware of these plans.

8.6 Flood warning and emergency planning

Emergency planning covers three phases: before, during and after a flood. Measures involve developing and maintaining arrangements to reduce, control or mitigate the impact and consequences of flooding and to improve the ability of people and property to absorb, respond to and recover from flooding. National Planning Policy takes this into account by seeking to avoid inappropriate development in areas of flood risk and by considering the vulnerability of new developments to flooding.

The NPPF requires site level Flood Risk Assessments to demonstrate that

"d) any residual risk can be safely managed; and

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan."

Certain sites will need emergency plans:

- Sites with vulnerable users, such as hospitals and care homes.

- Camping and caravan sites.
- Sites with transient occupants e.g. hostels and hotels.
- Developments at a high residual risk of flooding from any source e.g. immediately downstream of a reservoir or behind raised flood defences.
- Situations where occupants cannot be evacuated (e.g. prisons) or where it is safer to remain "in-situ" and/or move to a higher floor or safe refuge area (e.g. at risk of a breach).

Emergency Plans will need to consider:

- The characteristics of the flooding e.g. onset, depth, velocity, hazard, flood borne debris.
- The vulnerability of site occupants.
- Structural safety.
- The impact of the flooding on essential services e.g. electricity, drinking water.
- Flood warning systems and how users will be encouraged to sign up for them.
- Safe access and egress for users and emergency services.
- How to manage the consequences of events that are un-foreseen or for which no warnings can be provided e.g. managing the residual risk of a breach.
- A safe place of refuge where safe access and egress and advance warning may not be possible, having discussed and agreed this first with emergency planners. Proposed new development that places an additional burden on the existing response capacity of the Councils will not normally be appropriate.

The **West Mercia LRF** provides Emergency Planning relevant information that is both general and flood specific. This includes practical advice before, during and after flooding has occurred, including preparation, understanding warnings, actions to limit exposure to risk and recovery.

Further information is available from:

- The **National Planning Policy Guidance**
- The Environment Agency and DEFRA's **standing advice for FRAs**
- Environment Agency's **"How to plan ahead for flooding"**
- Sign up for **Flood Warnings** with the Environment Agency
- The **National Flood Forum**
- GOV.UK - Make a Flood Plan guidance and templates

9 Surface water management and SuDS

This chapter provides guidance and advice on managing surface water runoff and flooding.

9.1 Role of the LLFA and Local Planning Authority in surface water management

In April 2015, Worcestershire County Council was made a statutory consultee on the management of surface water and, as a result, provides technical advice on surface water drainage strategies and designs put forward for major development proposals.

When considering planning applications, Worcestershire County Council will provide advice to the Planning Department on the management of surface water. As LPAs, the SWCs should satisfy themselves that the development's proposed minimum standards of operation are appropriate and ensure through the use of planning conditions or planning obligations, that there are clear arrangements for on-going maintenance over the lifetime of the development.

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.

9.2 Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems (SuDS) are designed to maximise the opportunities and benefits that can be secured from surface water management practices.

SuDS provide a means of dealing with the quantity and quality of surface water and can also provide amenity and biodiversity benefits. Given the flexible nature of SuDS, they can be used in most situations within new developments as well as being retrofitted into existing developments. SuDS can also be designed to fit into most spaces. For example, permeable paving could be used in parking spaces or rainwater gardens as part of traffic calming measures.

It is a requirement for all new major development proposals to ensure that sustainable drainage systems for management of runoff are put in place. Likewise, minor developments should also ensure sustainable systems for runoff management are provided. The developer is responsible for ensuring the design, construction and future/ongoing maintenance of such a scheme is carefully and clearly defined, and a clear and comprehensive understanding of the existing catchment hydrological processes and current drainage arrangements is essential.

9.3 Sources of SuDS guidance

9.3.1 C753 CIRIA SuDS Manual (2015)

The **C753 CIRIA SuDS Manual** (2015) provides guidance on planning, design, construction and maintenance of SuDS. 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.

9.3.2 Non-statutory Technical Guidance, Defra (March 2015)

Non-statutory Technical Guidance provides non-statutory standards on the design and performance of SuDS. It outlines peak flow control, volume control, structural integrity, flood risk management and maintenance and construction considerations.

9.3.3 Worcestershire SuDS Handbook

Worcestershire County Council produced their **SuDS Handbook** in 2018 which sets out background context for SuDS design, local SuDS requirements and outlines the three design stages of SuDS.

The SuDS Handbook presents design guidance alongside Local SuDS requirements that developers should meet when proposing SuDS systems on new developments.

The Local SuDS requirements are:

- Worcestershire County Council as LLFA requires all development to provide SuDS for the management of surface water.
- Surface water runoff should be controlled as near to its source as possible through a sustainable drainage approach to surface water management. Ground conditions will need to be confirmed by site investigation and testing. If site investigation indicates that it is possible, then infiltration is the preferred method for disposal of surface water.
- At-surface level SuDS features should form part of an integrated and multifunctional green infrastructure network which provide opportunities for biodiversity, open space and place making opportunities.
- A minimum of 3.0m easements should be provided to and around all SuDS features and a minimum 8.0m easement around any watercourses for maintenance access. This will also help protect and enhance the aesthetic and biodiversity functions of the features.

9.3.4 South Worcestershire Water Management SPD

The **South Worcestershire Water Management and Flooding Supplementary Planning Document (SPD)** was adopted in July 2018 and sets out the approach of the SWCs to minimising flood risk, managing surface water and achieving sustainable drainage systems. Chapter 10 of the document sets out SuDS local requirements and SWDP Policy 29 (SuDS requirements), planning obligations and considerations, SuDS approaches, cost, health and safety, SuDS maintenance, adoption and ecological impact. Appendix 11 summarises SuDS maintenance options to support developers, designers and local authorities consider appropriate arrangements for the on-going maintenance of SuDS over the lifetime of the development.

9.4 Other surface water considerations

9.4.1 Groundwater Vulnerability Zones

The Environment Agency have published new groundwater vulnerability maps in 2015. These maps provide a separate assessment of the vulnerability of groundwater in overlying superficial rocks and those that comprise of the underlying bedrock. The map shows the vulnerability of groundwater at a location based on the hydrological, hydro-ecological and soil propertied within a one-kilometre grid square.

The groundwater vulnerability maps should be considered when designing SuDS. Depending on the height of the water table at the location of the proposed development site, restrictions may be placed on the types of SuDS appropriate to certain areas. Groundwater vulnerability maps can be found under the landscape section of **Defra's interactive mapping.**

9.4.2 Groundwater Source Protection Zones (GSPZ)

The Environment Agency also defines Groundwater Source Protection Zones near groundwater abstraction points. These protect areas of groundwater used for drinking water. The Groundwater SPZ requires attenuated storage of runoff to prevent infiltration and contamination. Groundwater Source Protection Zones can be viewed on the **Environment Agency's website** under the non-statutory land-based designations section.

The vast majority of South Worcestershire is not located within a Groundwater SPZ. Areas within a Groundwater SPZ are predominantly west of the River Severn at Astley, east of the River Severn from Norchard to the confluence with the River Salwarpe and west of the A449 in Malvern.

Depending on the nature of the proposed development and the location of the development site with regards to SPZ's, restrictions may be in place on the types of SuDS used within appropriate areas. For example, infiltration SuDS are generally accepted within Zone 3, whereas in Zones 1 (Inner Protection Zone) or 2 (Outer Protection Zone), the Environment Agency will need to be consulted and infiltration SuDS may only be accepted if the correct treatments and permits are put in place. Any restrictions imposed on the discharge of the site generated runoff by the Environment Agency will be determined on a site by site basis using risk-based approach.

9.4.3 Nitrate Vulnerable Zones

Nitrate Vulnerable Zones (NVZs) are areas designated as being at risk from agricultural nitrate pollution. Nitrate levels in waterbodies are affected by surface water runoff from surrounding agricultural land entering receiving waterbodies. The level of nitrate contamination will potentially influence the choice of SuDS and should be assessed as part of the design process.

The entirety of Worcester City and Wychavon District and parts of the east of Malvern Hills District are located within a surface water NVZ. Offenham to the north-east of Evesham and north of Worcester City to Stourport on Severn are also located within a Groundwater NVZ.

The NVZ coverage can be viewed on the **Environment Agency's online maps**.

9.5 SuDS suitability across the study area

The suitability of SuDS techniques is dependent upon many variables, including the hydraulic and geological characteristics of the catchment.

The permeability of the underlying soils can determine the infiltration capacity and percolation capacities. As such, a high-level review of the soil characteristics has been undertaken using BGS soil maps of England and Wales which allow for a basic assessment of the soil characteristics and infiltration capacity. The results of the assessment are shown in Table 9-1 and mapping of the soil characteristics is shown in Figure 9-1 and Figure 9-2.

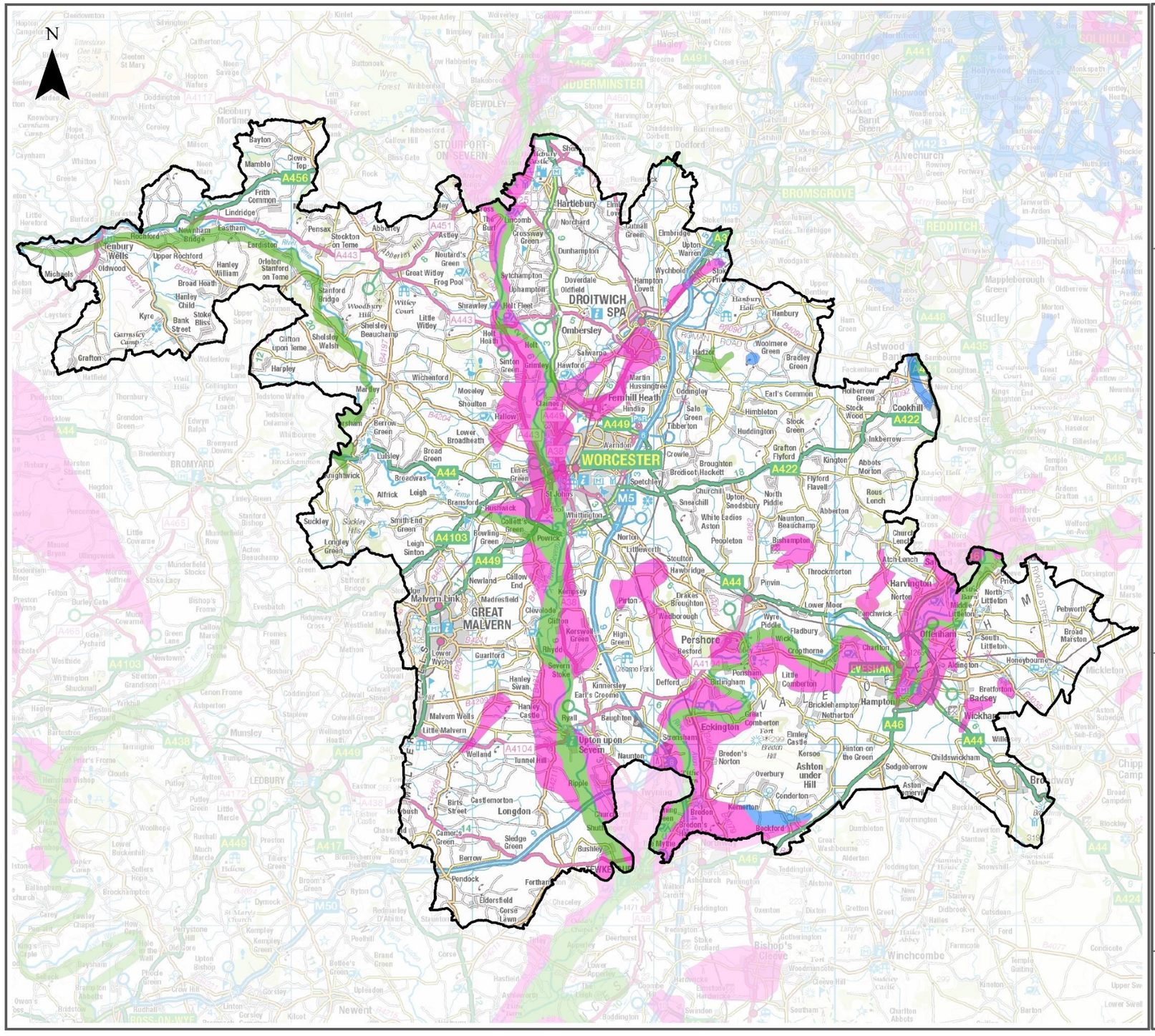
This strategic assessment should not be used as a definitive site guide as to which SuDS would be suitable but rather as an indicative guide of general suitability based solely on soil type. Several other factors can determine the suitability of SuDS techniques including land contamination, the depth and fluctuation of the water table, the gradient of local topography and primary source of runoff etc. When considering NVZs and if areas have pollutants, infiltration may only be suitable where treatment measures are provided, prior to any discharge to surface or groundwaters.

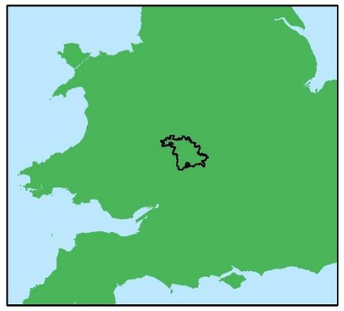
Further site-specific investigation should be conducted to determine what SuDS techniques could be utilised at a particular development. The result of this assessment does not remove the requirements for geotechnical investigation or detailed infiltration testing and does not substitute the results of site-specific assessments and investigations. The LLFA should be consulted at an early stage to ensure SuDS are implemented and designed in response to site characteristics and policy factors.

Table 9-1 General application of SuDS in relation to soil types

General soil type	Description	Infiltration potential	Appropriate SuDS techniques	South Worcestershire
Sand	Brown sand	Good, relatively permeable	Living roofs, basins and ponds (depends on depth of water table), constructed wetlands, balancing ponds, detention basins, retention ponds, filter strips, swales, infiltration devices and soakaways (depends on depth of water table), permeable surfaces, porous paving, gravelled areas, filter drains and tanked systems.	Generally found around the River Teme, River Severn and River Avon.
Sand and gravel	Glacial sand and gravel	Good, relatively permeable	Living roofs, basins and ponds (depends on depth of water table), constructed wetlands, balancing ponds, detention basins, retention ponds, filter strips, swales, infiltration devices and soakaways (depends on depth of water table), permeable surfaces, porous paving, gravelled areas, filter drains and tanked systems.	Isolated area found to the west of Pershore and south-east of Worcester.
Sand and gravel	River terrace deposits	Good, relatively permeable	Living roofs, basins and ponds (depends on depth of water table), constructed wetlands, balancing ponds, detention basins, retention ponds, filter strips, swales, infiltration devices and soakaways (depends on depth of water table), permeable surfaces, porous paving, gravelled areas, filter drains and tanked systems.	Generally found surrounding the River Severn and River Avon with isolated areas around Droitwich Spa and the south of the study area.
Diamicton	Till (also referred to as Boulder Clay)	Variable, mixed permeability	Living roofs, basins and ponds (depends on depth of water table), constructed wetlands, balancing ponds, detention basins, retention ponds, filter strips, swales, infiltration devices and soakaways (depends on depth of water table), permeable surfaces, porous paving, gravelled areas, filter drains and tanked systems. SuDS techniques which rely on infiltration (e.g. infiltration devices, soakaways and permeable surfaces etc.) may/may not be suitable depending on the concentration of clay in the soil.	Small isolated areas found in the east and south of the study area.

Figure 9-1 Soil types in South Worcestershire by general type





Legend

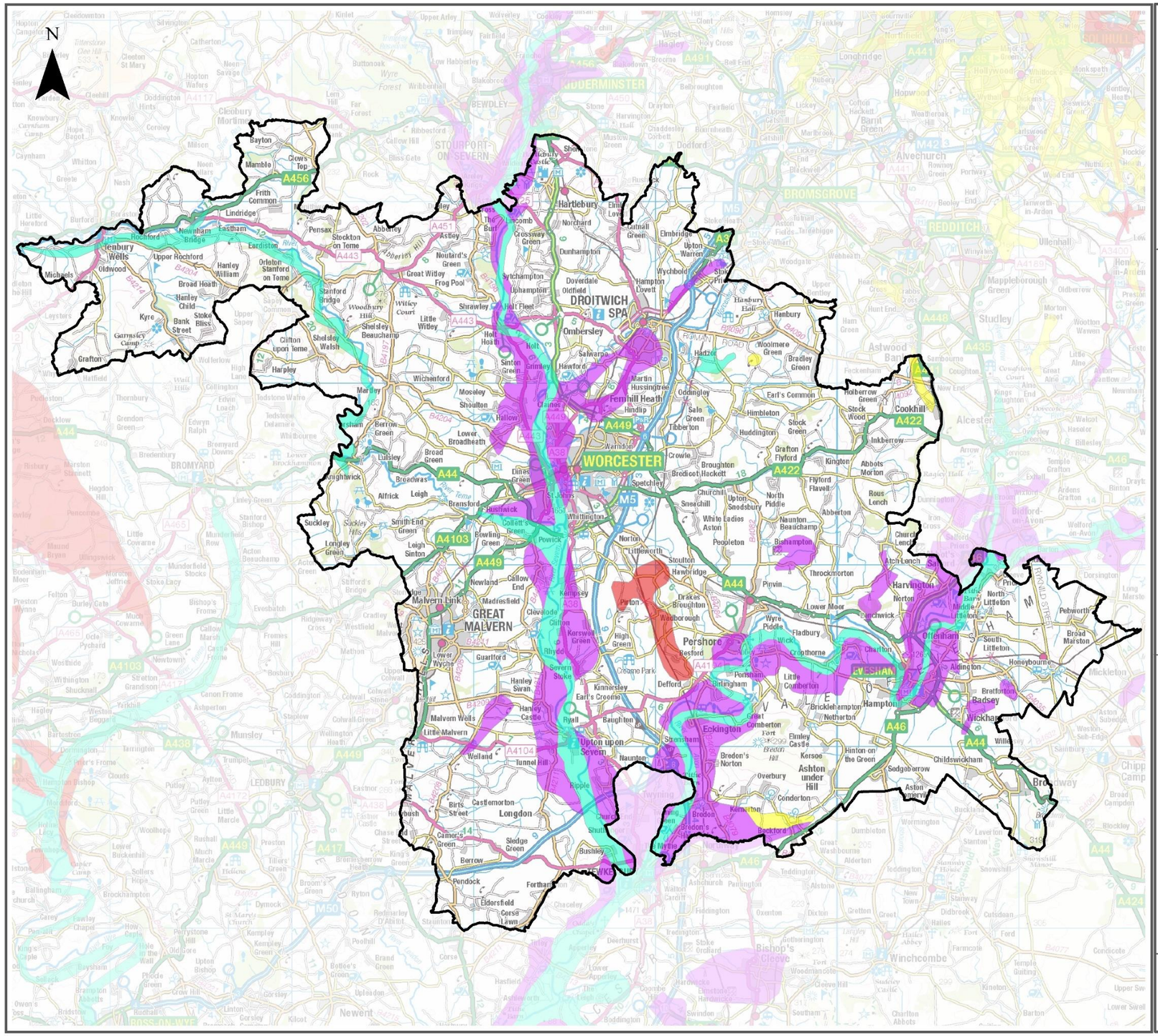
South Worcestershire Boundary

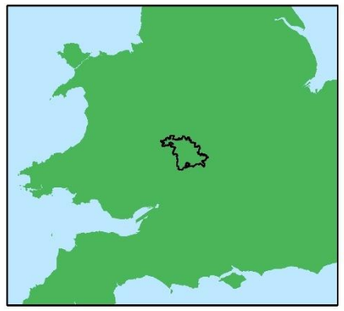
Soil type

- CLAY, SILT AND SAND
- DIAMICTON
- SAND AND GRAVEL

0 1.25 2.5 5 7.5 10 12.5 km

Figure 9-2 Soil types in South Worcestershire by description





Legend

South Worcestershire Boundary

Soil description

- ALLUVIUM
- GLACIAL SAND AND GRAVEL
- RIVER TERRACE DEPOSITS (UNDIFFERENTIATED)
- TILL

0 1.25 2.5 5 7.5 10 12.5 km

10 Summary and recommendations

This Level 1 SFRA delivers a strategic assessment of risk from all sources of flooding in South Worcestershire. It also provides an overview of policy and provides guidance for planners and developers.

10.1 Sources of flood risk

Parts of South Worcestershire are at risk from the following sources; fluvial, surface water, groundwater, sewers, reservoir inundation and canal overtopping/breaches. This study has shown that the most significant sources of flood risk in South Worcestershire are fluvial and surface water.

- *Fluvial flooding*: The primary fluvial flood risk is along the River Severn, River Teme, River Avon and the tributaries of these rivers. These present fluvial flood risk to rural communities as well as some of the main urban centres, including, but not limited to Worcester, Upton upon Severn, Evesham, Pershore and Tenbury Wells. The floodplains of the watercourses are notably wide along the River Severn downstream of Worcester, the River Avon, the River Teme downstream of Horsham and along the Longdon Brook to the west of Longdon due to lower lying, flat topography. Major historic flooding events across South Worcestershire occurred in 1998, Autumn 2000, July 2007 and 2014 where several hundred properties were flooded on each occasion.
- *Surface water:* Surface water flooding is most likely caused by intense rainfall. There are many areas in South Worcestershire at risk from surface water flooding. The Risk of Flooding from Surface Water map shows a number of prominent overland flow routes; these predominantly follow topographical flow paths of existing watercourses or dry valleys with some isolated ponding located in low lying areas. The SWMP floodspot data shows that historic flooding events from surface water are widespread throughout South Worcestershire, with notable clusters around Kempsey, Bredon, Westmancote, Overbury, Broadway, Evesham, Bretforton, Crowle and Elmley Castle.
- *Sewer*: Sewers in South Worcestershire are managed by Severn Trent Water. Severn Trent Water provided their Hydraulic Flood Risk Register which denotes 457 properties at risk of sewer flooding in South Worcestershire. The areas with the most recorded events of sewer flooding are Worcester, Malvern and Upton upon Severn.
- *Groundwater:* The Areas Susceptible to Groundwater Flooding map shows that in general, the majority of South Worcestershire is within the <25% susceptibility classification, therefore is at a lower risk of groundwater flooding. Parts of the study area including along the River Severn, River Avon and River Teme fall within the higher susceptibility classifications and are therefore at a higher risk of groundwater flooding. The areas most at risk from groundwater flooding are low-lying areas where the water table is naturally near the surface. The SWMP floodspot data shows that there are very few historic flood events relating to groundwater, however those that are from groundwater sources are largely within Wychavon and are widespread throughout the District.
- *Canals*: There are two canals in South Worcestershire, the Worcester and Birmingham Canal and the Droitwich Canal. These have the potential to interact with other watercourses and become flow paths during flood events or in a breach scenario. There has been one incident of breach on the Worcester and Birmingham Canal in 2008 at Shernal Green and three incidences of overtopping, once in 2007 at Blackpole and twice in 2012 at multiple locations. There has been one incident of breach on the Droitwich Canal in 1930 at Bevere Island and nine incidences of overtopping, five times in 2012 at various locations, three times in 2013 at Porter's Hill Farm and once in 2017 at the junction between the two canals.

- *Reservoirs:* There is a potential risk of flooding from reservoirs both within South Worcestershire and those outside. There are no records of flooding from reservoirs in the study area. The level and standard of inspection and maintenance required under the Reservoirs Act means that the risk of flooding from the reservoirs is relatively low. However, there is a residual risk of a reservoir breach and this should be considered in any site-specific Flood Risk Assessments (where relevant).

10.2 Recommendations for local planning policy

Reduction of flood risk through site allocations and appropriate site design

- In line with the Sequential Test, locate new development in areas of lowest risk, taking into account all sources of flood risk. If a Sequential Test is undertaken and a site at flood risk is identified as the only appropriate site for development, the Exception Test shall be undertaken, should it apply.
- A Level 2 SFRA should be conducted where the Exception Test is required and also for any site where the ability to provide adequate floodplain compensation is questionable, i.e. employment sites largely affected by Flood Zone 3.
- After application of the Sequential Test (and Exception Test if required), a sequential approach to site design should be used to reduce risk, by placing the least vulnerable parts of the site in the highest flood risk areas.
- Both the actual and residual risk of flooding should be taken into account, by ensuring that appropriate mitigation measures are put in place and that in an extreme event, the users of the development will be safe from flooding.
- Caravans, mobile homes and park homes with permanent residential use should not be permitted in the Functional Floodplain or Flood Zone 3 and opportunities should be taken to relocate these developments to lower flood risk areas.
- Caravans, mobile homes and park homes with seasonal (holiday) use should not be permitted in the Functional Floodplain and are not likely to be permitted in Flood Zone 3, unless the developer can prove the development would pass the Exception Test, which is that it can be made safe from flooding and contributes to wider sustainability benefits. This is only likely to be the case where the proposed site is in an area benefitting from flood defences, where a Flood Evacuation and Warning Plan can be put in place and where other local planning policies promote the development of holiday accommodation in that local area.

Contribute to wider infrastructure improvements

- Assess the condition of existing drainage assets and upgrade, if required, to ensure that the infrastructure can accommodate pressures/flows for the lifetime of the development.
- Contribute to reducing flood risk off site wherever feasible.
- Ensure the whole life costs and maintenance of any engineering works to reduce the flood risk to the site have been accounted for.

Protect and promote areas for future flood alleviation schemes

- Safeguard functional floodplain from future development.
- Develop appropriate policies for brownfield sites which lie in functional floodplain to reduce risk and to provide flood risk betterment.
- Positively contribute towards the wider vision for flood risk management and drainage in South Worcestershire, as set out in the Worcestershire Local Flood Risk Management Strategy and supporting Surface Water Management Plan,

Severn Flood Risk Management Plan and emerging Severn Trent Water Drainage and Wastewater Management Plans.

- Identify opportunities to help fund future flood risk management through developer contributions to reduce risk for surrounding areas.
- Seek opportunities to make space for water to accommodate climate change.

Implement Sustainable Drainage Systems as standard on all developments

- All developments should incorporate SuDS and provide details of adoption, ongoing maintenance and management on all development sites. Proposals will be required to provide reasoned justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in the wider area where practicable.
- Worcestershire County Council as LLFA will review Surface Water Drainage Strategies in accordance with their local requirements for major developments. These should take into account all sources of flooding to ensure that future development is resilient to flood risk and does not increase flood risk elsewhere. Surface Water Drainage Strategies are required for all major developments, regardless of their size and the Flood Zone and catchment they are in to meet the requirements of the LLFA.

Enhance and restore river corridors and habitats

- Natural drainage features should be maintained and enhanced.
- Culverted watercourses should be opened up and new culverting resisted. De-culverting should be considered at the earliest stage of development proposals/planning to avoid financial constraints.
- Identify opportunities for river restoration/enhancement to make space for water.
- Adopt a catchment partnership working approach to promote green infrastructure and natural flood management such as the Barbourne Brook, Cotswold Tributaries and Dowles Brook NFM schemes.

Improve emergency planning and flood awareness

- New developments should not increase the resource burden on emergency responders during an event and should seek betterment for brownfield sites e.g. by providing safe access and egress during a flood/a safe place of refuge.
- Emergency (Flood Warning and Evacuation Plans) will be needed as part of a Flood Risk Assessment for sites within Flood Zone 2 or 3. The key elements of these plans should be communicated to future users of the site. This includes raising awareness of the risk of flooding (even if it is residual) and what to do in the event of a flood.
- Emergency plans need to be integrated into wider Multi Agency Flood Plans and regularly exercised.

Manage the cumulative impact of development

New settlements

Any new settlement area should be accompanied by an overall Surface Water Management Masterplan and Strategy. This should cover:

- How the cumulative effects of potential peak rates and volumes of water from development sites would impact on peak flows, duration of flooding and timing of flood peaks on receiving watercourses. This should be used to develop and

implement appropriate drainage sub catchments and specific runoff rate and volume requirements for each phase of the development.

- The risk of flooding from all sources, including for rainfall events greater than the design standard of the surface water drainage system should be taken into account to ensure there is no flood risk to new properties and that exceedance flows in extreme events are safely routed around those properties.
- The consideration of how SuDS, natural flood management techniques, green infrastructure and green-blue corridors can be designed into the development master plan to facilitate drainage flood risk management and ensure wider benefits such as biodiversity, amenity, water quality and recreation are realised.
- Based on the above, a Drainage Phasing Plan should be developed, based on the SuDS train method (considering firstly how water can be infiltrated/stored at a plot level, then conveyed through the site and any regional storage needs at a settlement level).
- The provision of drainage during the building phase shall be based on the Drainage Phasing Plan to ensure adequate drainage is provided and implemented throughout the development life.
- The LLFA, Environment Agency and LPA should be consulted during the development of the Surface Water Management Masterplan and Strategy.

For the Piddle, Ripple and Stoulton Brook and medium risk catchments the recommended policy is to:

- Incorporate SuDS and provide details of adoption, ongoing maintenance and management on all development sites. Proposals will be required to provide reasoned justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in South Worcestershire where practicable.
- Seek to provide wider betterment by demonstrating in site-specific Flood Risk Assessments and Surface Water Drainage Strategies what measures can be put in place to contribute to a reduction in flood risk downstream. This may either be by provision of additional storage on site e.g. through oversized SuDS, natural flood management techniques, green infrastructure and green-blue corridors and/or by providing a Partnership Funding contribution towards any flood alleviation schemes. Consultation on the site-specific requirements should be undertaken with the LPA and the Environment Agency at the earliest opportunity.
- For the LPA to work closely with the Environment Agency and Worcestershire County Council as LLFA to identify areas of land that should be safeguarded for the future use of natural flood management features.

For high-risk urban catchments, e.g. the Barbourne Brook

All new development (other than minor extensions) in this catchment should:

- Incorporate SuDS and provide details of adoption, ongoing maintenance and management. Proposals will be required to provide reasoned justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in the South Worcestershire where practicable.
- Seek to provide wider betterment by demonstrating in site specific Flood Risk Assessments and Surface Water Drainage Strategies what measures can be put in place to contribute to a reduction in flood risk downstream. This may either

be by provision of additional storage on site e.g. through oversized SuDS, natural flood management techniques, green infrastructure and green-blue corridors and/or by providing a Partnership Funding contribution towards a wider community scheme. Consultation on the site-specific requirements should be undertaken with the LPA at the earliest opportunity.

- A Surface Water Drainage Strategy will be required for all developments in this catchment, regardless of development size.
- Worcestershire County Council as LLFA will review Surface Water Drainage Strategies in accordance with their local requirements for major developments. These should take into account all sources of flooding to ensure that future development is resilient to flood risk and does not increase flood risk elsewhere.
- The SWCs as LPAs will review Surface Water Drainage Strategies for non-major developments.
- The Environment Agency, in consultation with the LPA and WCC, should consider whether to formally designate the catchment as a Critical Drainage area. This would mean that a detailed Flood Risk Assessment would be required for all developments that are proposed, regardless of their size.

For rapid response catchments – Dick, Badsey and Merry Brook the recommended policy is to:

- Ensure that all developments in flood risk areas have taken into account the rapid response nature of the catchments when designing safe access and escape routes, the availability of flood alerts and flood warnings and time people would have to respond and ensure no additional burden is placed on emergency services as part of an agreed emergency flood plan.
- Seek to provide wider betterment by demonstrating in site specific Flood Risk Assessments and Surface Water Drainage Strategies what measures can be put in place to contribute to a reduction in flood risk downstream (and in particular by slowing the flow of water downstream). This may either be by provision of additional storage on site e.g. through oversized SuDS, natural flood management techniques, green infrastructure and green-blue corridors and/or by providing a Partnership Funding contribution towards a wider community scheme. Consultation on the site-specific requirements should be undertaken with the LPA at the earliest opportunity.
- Incorporate SuDS and provide details of adoption, ongoing maintenance and management. Proposals will be required to provide reasoned justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in the study area where practicable.

10.3 Recommendations for further work

10.3.1 Level 2 SFRA

To further inform the site allocations and development of local planning policies, a Level 2 SFRA could be used to:

- Apply the Exception Test should this be required in high flood risk areas,
- Review the possibilities for surface water mitigation measures on sites at high risk of surface water flooding,
- Consider the actual and residual flood risk in greater detail on a site-specific basis,

- Explore flood hazard in greater detail should sites be allocated in high flood risk areas and the Exception Test required,
- Explore in greater detail the impact of climate change in relation to the Flood Zones, and
- Undertake more detailed drainage strategy work as part of a Level 2 SFRA for high and medium flood risk catchments and rapid response catchments, as recommended in the Cumulative Impact assessment for the Level 1 SFRA.

Appendices

A Geo-PDF Mapping

The SFRA appendices are published separately to the main SFRA report.

B Flood risk screening of SHELAA sites

Note on Flood Zone and Surface Water percentages in the site screening

The values quoted in the screening tables in Appendix B shows the percentage of the site at flood risk from that particular Flood Zone/event, *including* the percentage of the site at flood risk as a higher zone.

For example, 50% of a site is in the Flood Zones. Taking each Flood Zone individually, 50% is in Flood Zone 2 but only 30% is in Flood Zone 3a and only 10% is in Flood Zone 3b. In the screening tables this will be displayed as stated above, i.e. the total % of that particular Flood Zone in that site.

If you would like to know how much of the site is in say Flood Zone 2 'only' (i.e. less the overlapping Flood Zone 3), then these percentages can be subtracted, e.g. 50% of the site is in Flood Zone 2, but as 30% of the site is in Flood Zone 3a (which overlaps Flood Zone 2), this leaves 20% of the site in Flood Zone 2 'only'.

Note that the Flood Zones 3a and 3b used in the screening is derived from the 100-year and 20-year model outlines (or 25-year if the 20-year model was not run) respectively which were supplied by the Environment Agency where available. Where no modelled data was available, the Environment Agency Flood Map for Planning Flood Zone 3 was used to give an "Indicative Flood Zone 3b". Therefore, where modelled data is not available, the percentage of a site located in Flood Zone 3b, will be the same as the percentage of the site located in Flood Zone 3a, as the indicative Flood Zone 3 is used in this instance.

The SFRA appendices are published separately to the main SFRA report.

C Data sources used in the SFRA

The SFRA appendices are published separately to the main SFRA report.

D Flood Alert and Flood Warning Areas

The SFRA appendices are published separately to the main SFRA report.

E Cumulative Impact methodology

The SFRA appendices are published separately to the main SFRA report.

F Models used in the SFRA

The SFRA appendices are published separately to the main SFRA report.

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