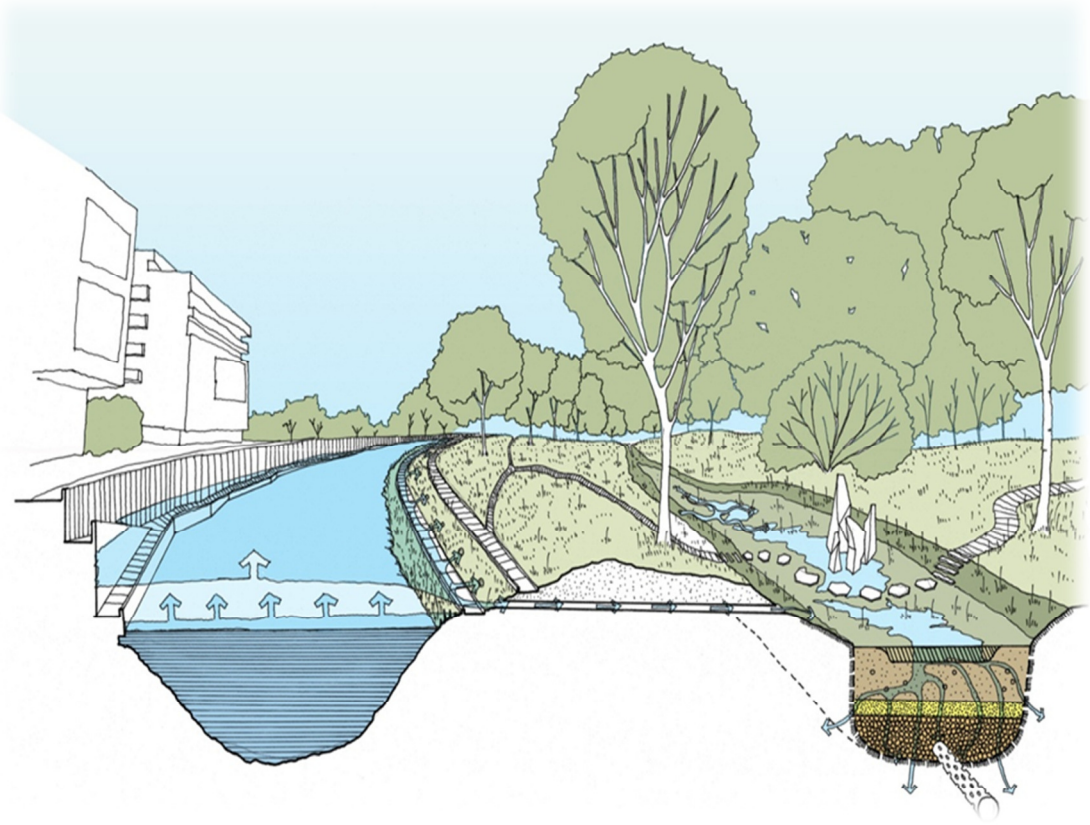

Warwickshire County Council

Surface Water Management Plan Methodology Report

Warwickshire County Council

AECOM

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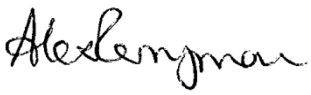
Approved by:  .....

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GIS and Flood Risk Lead

Warwickshire County Council Surface Water Management Plan

Rev No	Comments	Checked by	Approved by	Date
0	First issue to Warwickshire County Council for comment	Kevin Keating	Kevin Keating	08/12/14
1	April 2015 Update – For Discussion with Client (not issued)	Alex Perryman	-	30/04/15
2	Final Draft	Alex Perryman	Chris Paterson	19/05/15
3	Final Issue	Alex Perryman	Chris Paterson	27/05/15
3	Final Issue – Updated Matrix Results (J Parkin)	Alex Perryman	Chris Paterson	26/08/15
3	Minor wording amendments to align with Strategy document	Michael Green	Michael Green	08/09/15

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Job No 60319308 Reference SWMP-Methodology/004 Date Created August 2015

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Abbreviations and Glossary of Terms

AECOM	Architecture, Engineering, Consulting, Operations, and Maintenance
CDAs	Critical Drainage Areas
CI	Critical Infrastructure
Climate Change	A Large-scale, long-term shift in the planet's weather patterns or average temperatures.
CSWRT	Coventry Solihull Warwickshire Resilience Team
Defra	Department for Environment, Food and Rural Affairs
ELR	Employment Land Review
FMfSW	Flood Map for Surface Water
FWMA	Flood and Water Management Act
GARA	Growth and Regeneration Area
GIS	Geographic Information System
LEP	Local Enterprise Partnership
LFRMS	Local Flood Risk Management Strategy
LLFA	Lead Local Flood Authority
MCM	Multi Coloured Manual
NPPF	National Planning Policy Framework
NRD	National Receptors Dataset
OS NGR	Ordnance Survey National Grid Reference
PDF	Portable Document Format
PFRA	Preliminary Flood Risk Assessment
Return Period	An estimate of the likelihood of an event (or interval of time between events of a certain intensity or size) such as a flood or a river discharge.
RMAs	Risk Management Authorities
SFRA	Strategic Flood Risk Assessment
SHLAA	Strategic Housing Land Availability Assessment
Stakeholder	Person and / or organisations affected by the problem / solution, or interested in the problem / solution.
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
uFMfSW	updated Flood Map for Surface Water
WCC	Warwickshire County Council
WSUD	Water Sensitive Urban Design

Executive Summary

The county of Warwickshire has experienced a number of significant flood events in recent times, often with complex flooding interactions from multiple sources. Notable events include January 1992, Easter 1998, August 1999, June 2005, summer 2007, December 2008 and November 2012. Among the various responses to these events, AECOM were appointed by Warwickshire County Council (WCC) as Lead Local Flood Authority (LLFA) to undertake a Surface Water Management Plan (SWMP) and Investment Strategy. The SWMP is tasked with providing a prioritisation process for future flood risk management work. The SWMP will form the risk assessment for WCC's Local Flood Risk Management Strategy (the 'Strategy').

Surface Water Flood Risk:

In the context of this study, surface water flood risk is defined as the following.

- **Pluvial flooding**: High intensity rainfall causes surface water runoff which flows over the ground and accumulates in low-lying areas.
- **Groundwater flooding**: Water in the ground rises up above the ground surface due from within permeable rocks often as a result of prolonged or heavy rainfall.
- **Ordinary watercourse flooding**: When a watercourse (not designated as Main River) cannot accommodate the volume of water flowing in it or the channel becomes blocked, causing water to come out of the channel and flow over the surrounding land.
- **Sewer flooding**: Flooding from a sewer, usually via manholes, due to the capacity being exceeded or due to temporary problems with the system such as blockages, collapses or equipment failures (i.e. pumping stations).

The SWMP objectives are defined as the following.

1. Develop a robust understanding of surface water flood risk across the county of Warwickshire, including a prioritised list of locations at risk of flooding, taking into account the importance of both urban and rural communities, the challenges of population and demographic change and increasing pressures on urban fringes.
2. Develop recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments.
3. Establish new and consolidate existing partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities.
4. Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions.

Warwickshire County Council

5. Develop a robust Action Plan and guidance to deliver change where partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions.

Understanding the different sources of flooding and receptors (e.g. properties, people, environment) across Warwickshire was essential for the SWMP study, and so engagement with different Risk Management Authorities (RMAs) was developed to ensure a comprehensive understanding of flood risk is obtained, and to identify the most appropriate measures for flood risk reduction. Flood history information was obtained from the following sources.

- Districts and Boroughs, and Parish and Town Councils and community groups.
- Stakeholders and organisations:
  - Environment Agency;
  - Severn Trent Water;
  - Network Rail; and
  - Canal and River Trust.

To develop a comprehensive understanding of surface water flood risk in Warwickshire, it is important to capture where surface water flooding has occurred in the past, but to identify where surface water flooding may be more likely to occur in the future.

The Predictive flood risk information is from the Environment Agency's (EA) 'updated Flood Map for Surface Water' (uFMfSW).

The receptors and their associated flood risk vulnerability across Warwickshire have been established using the National Receptors Dataset (NRD), the National Planning Policy Framework (NPPF) and refined using project stakeholder knowledge. To understand which receptors are at greater risk, or where there are greater consequences, a series of standardised quantitative metrics have been established to enable an assessment across the entire study area. Thresholds were developed to understand where there are areas of flood risk and consequences, and analysis of these locations were undertaken in a bespoke project matrix which allowed the scoring, weighting, comparison and ranking of sites. The matrix was developed to identify surface water flooding hotspots (historic and future) that met the following threshold requirements as defined in the Strategy.

1. Flooding that poses a threat to the safety of the public or may directly result in serious injury or death.
2. Five or more residential properties internally flooded.
3. Two or more commercial properties internally flooded.
4. One or more piece of critical infrastructure affected that impact on the wider area.
5. Flooding that places vulnerable individuals or vulnerable communities at risk e.g. hospitals, care and nursing homes, schools, secure units, etc.

6. Where one or more residential property has flooded internally from the same source on five or more occasions within the last five years.

Draft outputs were tested through sensitivity analysis and have been discussed with project stakeholders. Feedback from these workshops was combined with that from the public consultation (January to March 2015), and a ranking of sites across the study area was created, in addition to supporting thematic maps for:

- Historic Surface Water Flood Risk;
- Predictive Surface Water Flood Risk; and
- Combined (Historic and Predictive) Surface Water Flood Risk.

The matrix has been developed to enable both historic and potential future flooding hotspot reporting. For this overall summary, a combined approach has been undertaken (combining both the historic and potential future flooding scores) for each OS tile or combination of OS tiles to provide a top 40 ranking. Note that large locations such as Leamington Spa will have a number of OS tiles at risk of surface water flooding from different sources - these are therefore ranked separately as different flooding locations. Large towns could therefore be named in the list more than once, but it is the specific area or community within the town which is being ranked.

The highest ranked locations will not necessarily have funded flood alleviation schemes. This stage of the SWMP is the risk assessment. The viability of flood alleviation schemes depends not only on the risk, but also on the nature of the flood risk and financial viability of a scheme relative to other areas in England and Wales (since it is necessary to compete with other locations to bid for funding from the national 'pot' of Flood Defence Grant in Aid available).

This report summarises Phases 1 and 2 of the SWMP which have been completed (see Figure 2.1). Subsequent phases of the SWMP process will further investigate the top ranking sites including discussions with project partners and other RMAs such as the EA and Severn Trent Water (STW) to identify areas of risk overlap and develop partnership schemes. Following stakeholder engagement a prioritised list will be developed with conceptual flood risk mitigation options, supporting action plans and investment strategies.

Additional deliverables from this study have included a Microsoft Excel interactive matrix and a set of SWMP Thematic Flood Maps based on the objectives in Section 1.3. The thematic flood maps are reflective of the interactive matrix outputs which can be regularly updated with new information to capture future flooding incidents, updated predictive mapping and details of flood risk management schemes and associated benefits.

An additional Strategic Flood Map has been created (both as a GIS workspace and interactive PDF) which contains all of the data that was collated and used in this commission. The interactive PDF map has been developed to allow WCC and other RMAs to visualise all of the historic flood risk, predictive flood risk and receptor data collated for this study.

1 Introduction

1.1 Purpose of the Assessment

AECOM has been appointed by Warwickshire County Council (WCC) to undertake a Surface Water Management Plan (SWMP) and Investment Strategy for the county of Warwickshire.

WCC require a SWMP and Investment Strategy to provide evidence base for their Local Flood Risk Management Strategy ('the Strategy') and to take a proactive approach to flood risk reduction through informed decision making.

This report has been produced to provide a summary of the methodology and approach of the technical work for Phases 1 and 2 of the SWMP (see Figure 2.1) and forms the risk assessment part of the Strategy.

1.2 Scope of the Assessment

Working in partnership with WCC and key stakeholders, AECOM were required to deliver a SWMP established upon a risk based assessment process to prioritise flooding locations across Warwickshire and develop a greater understanding of key flooding hotspot areas, risks and associated consequences. The partnership will also provide guidance and deliverables that will facilitate subsequent phases of the Defra SWMP wheel (Figure 2.1). The SWMP needs to complement the Strategy and wider WCC Lead Local Flood Authority (LLFA) responsibilities by delivering a strong evidence base and by plotting a route to access potential funding sources for flood risk reduction measures.

Chapter 6 provides a definition of flood risk, the various sources of flooding that have been considered / discounted in this study, and outlines a summary of the techniques used to assess flood risk and associated consequences.

1.3 Study Area Introduction

The study area of the WCC SWMP covers the entire county of Warwickshire. It is bounded to the south by Oxfordshire and Gloucestershire, the west by Worcestershire and the Birmingham conurbation (West Midlands Metropolitan County), the north by Staffordshire and Derbyshire and to the east by Leicestershire and Northamptonshire. Warwickshire is considered an average sized county, spanning 1,975km^2, the shape of county means that it covers an elongated geographical area (nearly 100km), resulting in a wide range of extensive rural landscapes and urban areas.

The majority of Warwickshire's population live in large towns and cities in the centre and north of the county. Market towns are prevalent in the north, such as Nuneaton, Bedworth and Rugby, whilst larger settlements of Warwick, Leamington, Stratford-upon-Avon and Kenilworth are located in the more central and western locations.

Warwickshire has a two-tier structure of local government and contains the following districts and boroughs.

- Stratford on Avon District Council.
- Warwick District Council.
- Rugby Borough Council.
- Nuneaton and Bedworth District Council.
- North Warwickshire District Council.

The City of Coventry is a separate unitary administration and so is therefore excluded from this study.

Figure 2.2 provides a map showing the context of the study area.

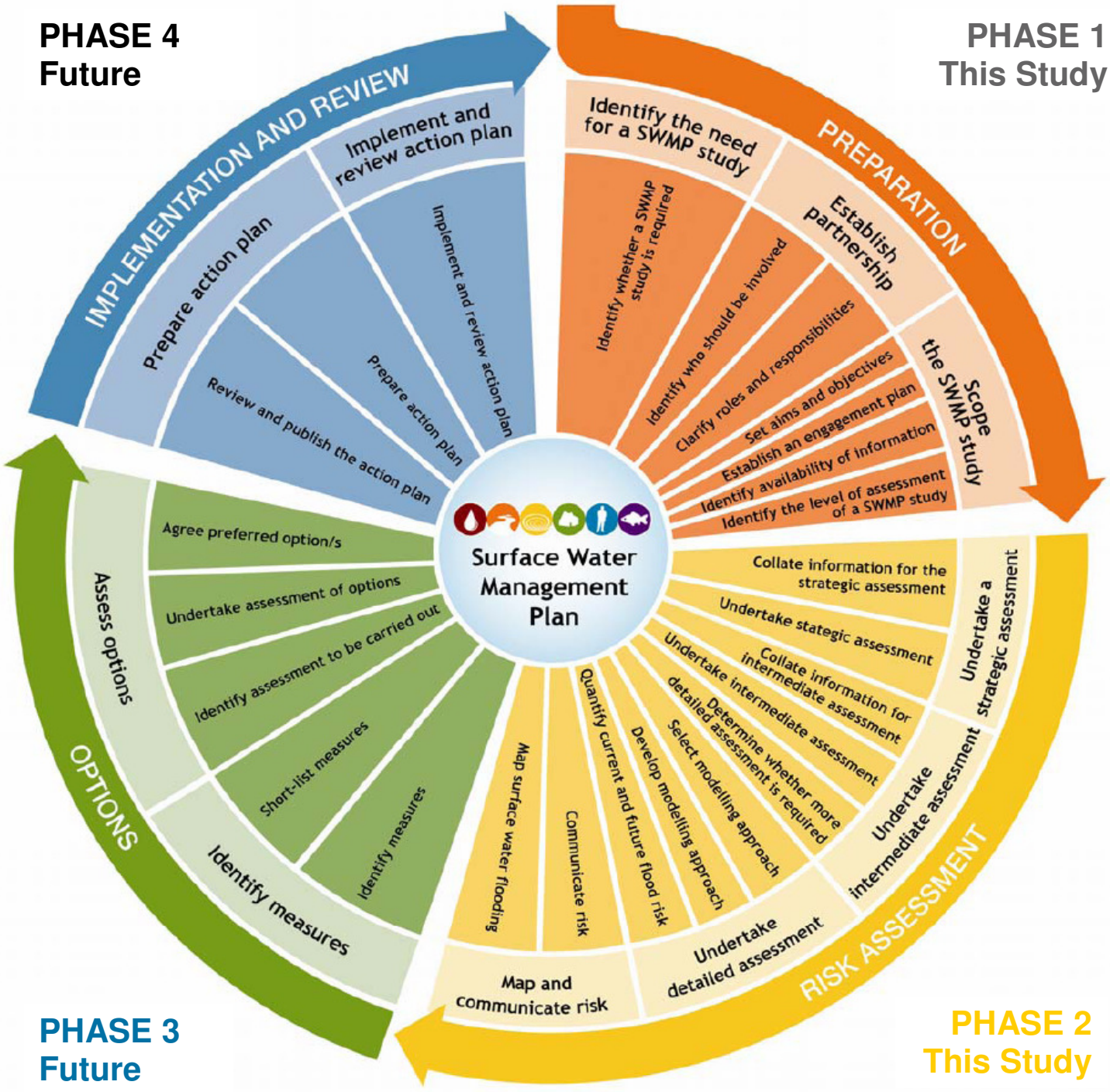


Figure 2.1 – Defra SWMP Wheel

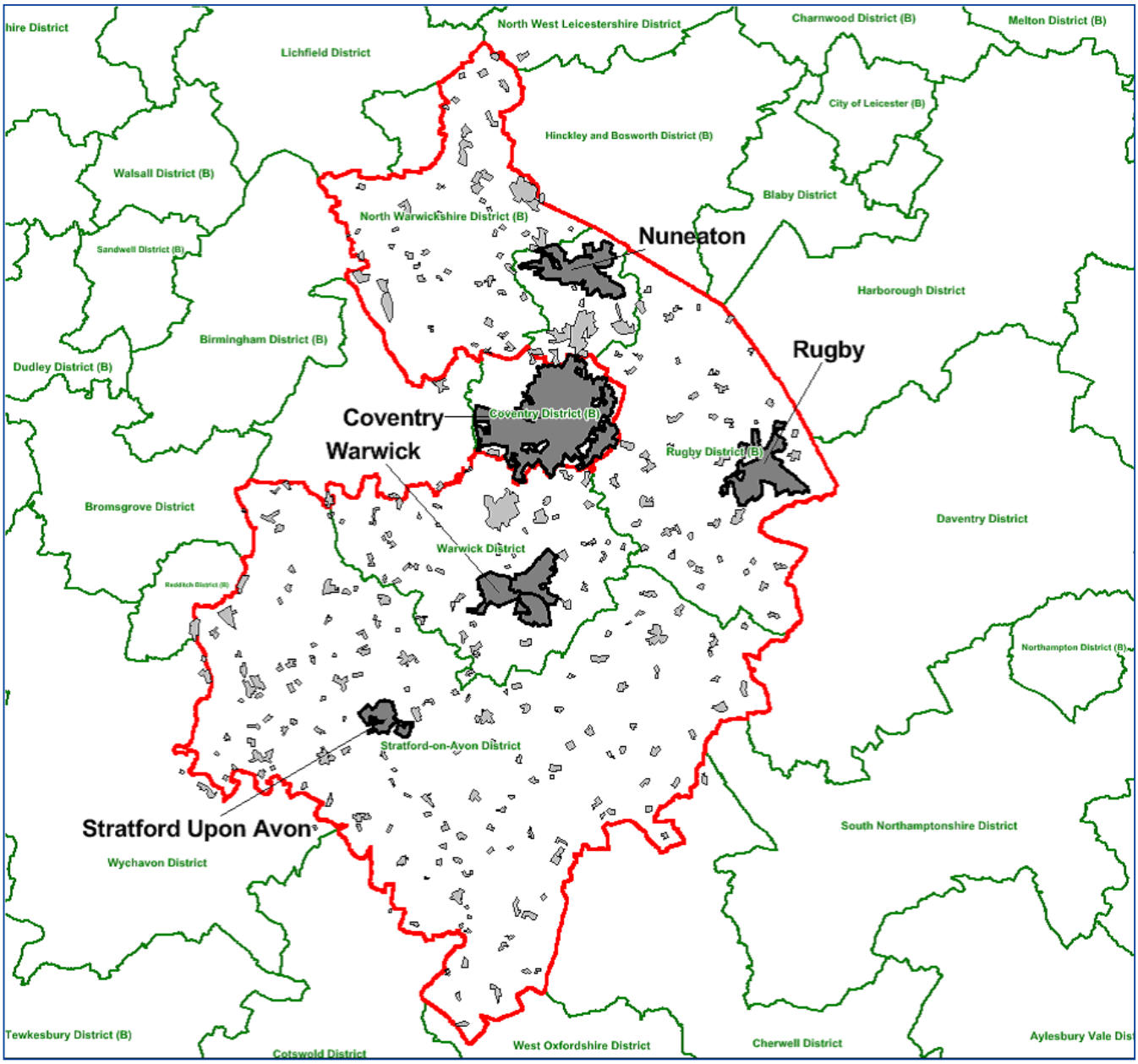


Figure 2.2 – Warwickshire County Council SWMP Study Area Map

1.4 SWMP Introduction

A SWMP outlines the preferred surface water management strategy in a given area. In this context, surface water flooding is defined as the following:

- **Pluvial flooding**: High intensity rainfall causes surface water runoff which flows over the ground and accumulates in low-lying areas.
- **Groundwater flooding**: Water in the ground rises up above the ground surface due from within permeable rocks often as a result of prolonged or heavy rainfall.
- **Ordinary watercourse flooding**: When a watercourse (not designated as Main River) cannot accommodate the volume of water flowing in it or the channel becomes blocked, causing water to come out of the channel and flow over the surrounding land.
- **Sewer flooding**: Flooding from a sewer, usually via manholes, due to the capacity being exceeded.

This SWMP study has been undertaken in consultation with key local partners and stakeholders who are responsible for flood risk management and drainage in the county, including Severn Trent Water and the Environment Agency. The partners have been consulted and engaged to develop an understanding of the locations, causes and effects of surface water flooding, and to develop potential solutions to mitigate the surface water risk for the prioritised hotspots.

This report and the finalised results will provide the evidence base for action plans to manage surface water flood risk in Warwickshire, and will influence future capital investment, asset maintenance, public engagement and understanding, land use planning, emergency planning and future developments.

1.5 Warwickshire Flood Risk Context

The main urban areas are Stratford upon Avon, Warwick, Leamington Spa, Rugby, Nuneaton and Bedworth - centralising the population in the centre and north of the county.

Many rural areas in Warwickshire comprise gentle rolling countryside with low lying river valleys, including the Rivers Avon, Stour, Anker and Tame. The majority of the county is located within the catchment of the River Avon, which drains into the River Severn. The Rivers Tame and Anker drain northern Warwickshire and are part of the wider River Trent catchment.

Fluvial (or "Main River") flood risk in Warwickshire can be significant in both rural and urban locations, often with complex flood flow paths and interactions with surface water flooding. Surface water flooding issues identified in this study will therefore be screened against Main River fluvial flooding to identify where potential partnership flood risk management schemes with the EA may exist. The WCC Level 1 Strategic Flood Risk Assessment (SFRA) 2008 and 2013 update study provides a comprehensive summary of the fluvial watercourses, and Figure 2.3 of this report shows the locations of the significant Main Rivers.

In addition to the gentle rolling valleys, Warwickshire has undulating pockets of high ground and steep slopes (both in the northern and southern areas). Many of these areas have a higher risk of surface water flooding due to overland flows, which can result in significant disruption to many rural communities. Much of the county is underlain by impermeable clay. In urban areas, the complex networks of surface water sewer systems and high proportion of impermeable surfaces can cause significant surface water flood risk issues.

A review of previously published information shows that there have been several notable flood events in recent times. The most recent being in November 2012 where over 300 incidents were reported to WCC (with additional information gathered as part of the data collection exercise for this commission). Examples of significant flooded areas include Aston Cantlow, Fenny Compton, Kenilworth, Gaydon, Nuneaton, Polesworth, Snitterfield, and Warwick (note that many other locations were affected by the November 2012 flood event and have been included in the data gathering exercise and subsequent analysis of this SWMP). Other notable flood events included the Easter 1998 and the summer of 2007 events. Table 2.1 provides a summary of these flood events, with a project data register include in Annex A.

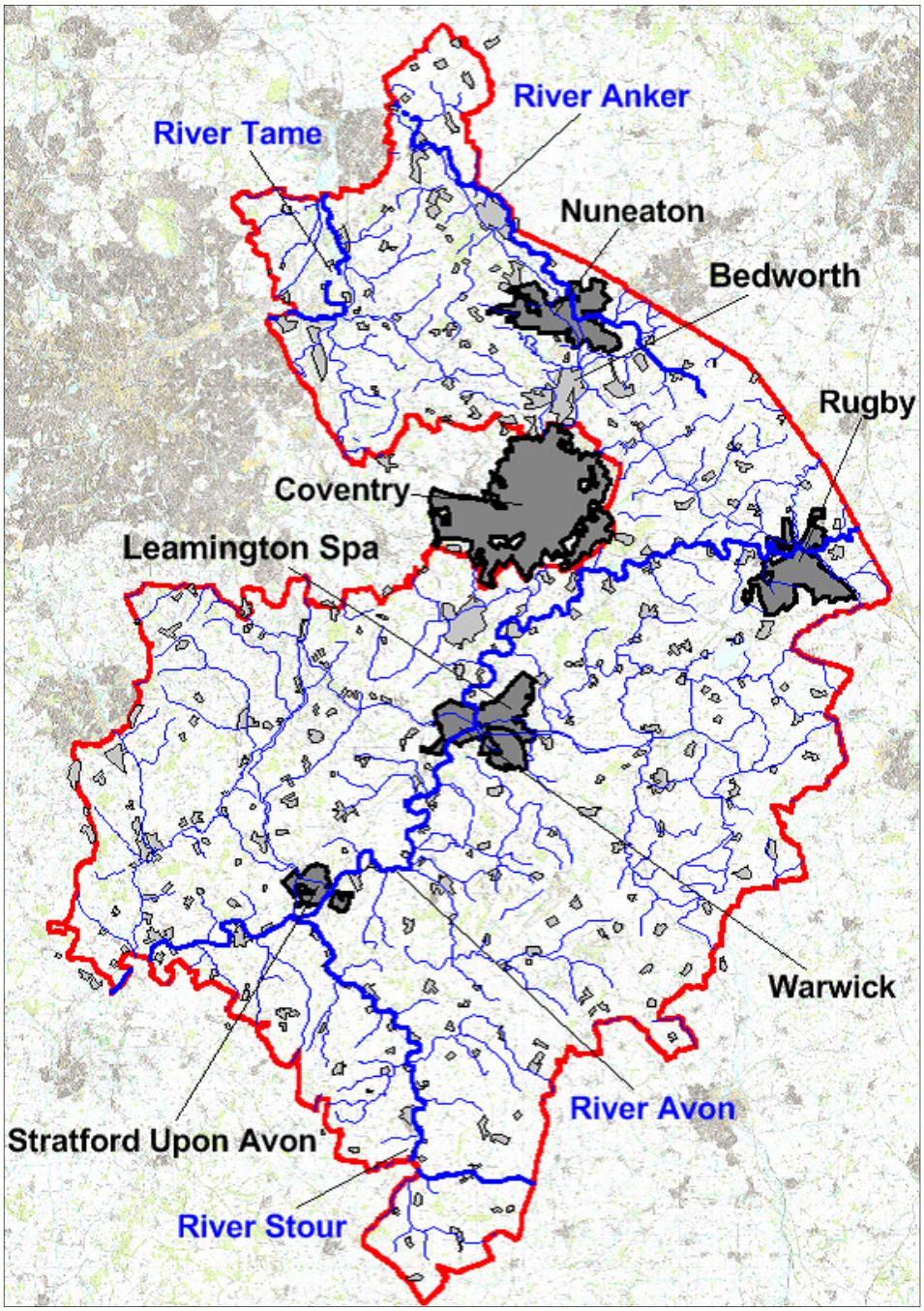


Figure 2.3 – Warwickshire Main Urban Areas and Rivers

Table 2.1 – Warwickshire Flood History Summary

Flood Event	Recorded Duration	Source of Flooding	Number of Properties Flooded
13th January 1992 ***WARWICK AND STRATFORD ON AVON DISTRICTS***	< 1 day	Ordinary Watercourses Sewers Highways Drains Main Rivers	>35 internally (Snitterfield only)
Easter 1998 (9th April) ***SOUTHERN HALF OF COUNTY***	2 days	Ordinary Watercourses Overland Flow Sewers *(surface water and combined)* Highways Drains Groundwater Main River	>480 internally >520 total
9th August 1999 ***WARWICK DISTRICT ONLY***	<24 hours	Sewers *(surface water and combined)*	31 internally 35 total
June 2005 (24th - 28th) ***WARWICK DISTRICT ONLY***	4 days	Sewers *(surface water and combined)* Main River	32 internally 46 total
Summer 2007 (June and July) ***COUNTY -WIDE***	1 - 6 days	Ordinary Watercourses Overland Flow Sewers Highways Drains Main River	>1600 >1750 total
December 2008 ***CENTRAL WARWICKSHIRE***	1 day	Ordinary Watercourses Main River Overland Flow Highways Drains	54 internally 55 total
21st – 25th November 2012	1 – 5 days	Ordinary Watercourses Overland Flow Sewers *(surface water and combined)* Highways Drains Groundwater Main River	Over 300 reported incidents

2 Phase 1 – Preparation

2.1 Introduction

This chapter provides a summary of the approach taken for Phase 1 of the SWMP, the roles and responsibilities, and the development of the aims and objectives. The headings relate to the steps of the SWMP process, as presented in Figure 2.1.

2.2 Identify the need for a SWMP Study

Warwickshire County Council have recognised that the development of a SWMP study would provide a strong evidence base to inform the Strategy, and would facilitate a pro-active approach to flood risk management.

2.2.1 Establish Partnership

The Inception Meeting for this study identified that a key requirement of the SWMP was the need to establish strong project partnerships. Whilst a formal steering group was not established for the WCC SWMP, the principles were applied, and WCC undertook a series of meetings and workshops with partners and stakeholders and provided regular communications to report on progress (see Chapter 6).

Partners and stakeholders consulted included the following:

- Parish and Town Councils and community groups;
- District and Borough Councils;
- Environment Agency;
- Severn Trent Water;
- Canal and River Trust;
- Network Rail; and
- Warwickshire Wildlife Trust.

2.2.2 Scope the SWMP Study

WCC took professional advice and reviewed best practice and SWMPs completed by other local authorities before scoping this SWMP.

WCC decided that a metric-based approach was required in order to provide a means for transparent decision making in the selection of sites for further investigation. This approach also allows an efficient method to update the SWMP study with new datasets in the future.

2.2.3 WCC SWMP Objectives

The WCC SWMP overall project objectives are as follows.

- Develop a robust understanding of surface water flood risk across the county of Warwickshire, including a prioritised list of locations at risk of flooding, taking into account the importance of both urban and rural communities, the challenges of population and demographic change and increasing pressures on urban fringes.
- Develop holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments.
- Establish new and consolidate existing partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities.
- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions.
- Develop a robust Action Plan and guidance to deliver change where partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions.

2.2.4 Guidance

The approach for the WCC SWMP has been guided by the Defra SWMP Technical Guidance[1]. There are normally four phases to a SWMP process, comprising:

- Phase 1 - Preparation;
- Phase 2 - Risk Assessment;
- Phase 3 - Options; and
- Phase 4 - Implementation and Review.

Whilst the current study includes Phases 1 and 2, and initial elements of Phase 3, this report summarises the approach taken for the first two phases – SWMP preparation and risk assessment.

It is important to note that the Defra guidance recommends that the process is continual, with a review and update undertaken periodically, perhaps in tandem with updates to the Strategy, following a major flood event or in response to new major development planning. The approach and tools developed will allow efficient updates to be undertaken.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf

2.2.5 Deliverables

The final deliverables for the SWMP will comprise:

- the methodology report;
- SWMP results and hotspot / objective scoring analysis matrix;
- a shortlist of priority flood risk hotspots; and
- a Strategic Flood Map to present the SWMP results.

3 Phase 2 – Risk Assessment

3.1 Introduction

The chapter provides an overview of the data collation and review, the methodology and the results approach from Phase 2 of the Defra SWMP wheel - Risk Assessment (see Figure 2.1).

Phase 2 comprises two distinct halves. The first is to identify the sources, mechanisms, frequency, extent and consequences of surface water flooding in Warwickshire. The second half of the process relates to the relative assessment of the flood risk problem locations, mapping and identifying the most significant areas, known as 'hotspots'. The second stage includes capturing both predictive and historic flood risk information as well as the local knowledge and experience of partners. This provides a starting point for the identification of locations for a more detailed assessment.

3.2 Phase 2 Overview

The Defra guidance recommends that Phase 2 of the SWMP includes data collection, assessment, mapping and communicating risk stages. Phase 1 identified that the predictive flood risk information for Warwickshire was of sufficient quality for the SWMP study. The historic data varied in spatial content and quality, and a detailed data gathering exercise was required. Each historic dataset was assessed individually and through consultation with WCC, determined which datasets were to be carried forward to the matrix.

To undertake the assessment stage of Phase 2, a metric-based approach was developed and implemented which provides a clear audit trail of the decisions made, and produces outputs in line with the requirements of Phase 2 of the Defra SWMP wheel.

3.2.1 Phase 2 Key Stages

Phase 2 of the Defra SWMP wheel process is summarised below.

1. Establish the approach for data collection and agree flood risk and receptor data sets for inclusion.
2. Undertake data collection and engagement with stakeholders.
3. Develop the matrix using the accrued GIS datasets.
4. Cross reference datasets and undertake technical analysis and sensitivity testing.
5. Present findings in terms of initial hotspot identification to project stakeholders, and assess the performance of the initial objective / metric weighting selection.
6. Adjust weightings, re-run analysis and develop an agreed shortlist of sites to take forward to Phase 3.

4 Phase 2 - Consultation and Data Collection

4.1 Introduction

Credible data is needed to develop a comprehensive understanding of surface water flood risk in Warwickshire. The first stage of Phase 2 of the SWMP therefore includes the collation of such data. Information on the buildings or other assets (called “receptors”) affected by flooding is also important in order to allow the assessment of the consequences of flooding.

4.2 Existing Data Identified

At the start of the Surface Water Management Plan (SWMP), WCC provided its understanding of surface water flooding, as gained from the following sources.

- Ad-hoc historical records of flooding.
- The Preliminary Flood Risk Assessment (PFRA) and SFRAs.
- EA’s national surface water flood mapping published in December 2013.

Existing Historical Records

The initial historic flood risk information held by WCC that was collated at the start of the study was contained in numerous datasets (see data register in Annex A). The data tended to vary in detail, sometimes with limited geographical areas or lacking spatial references and suitable information about the nature of the flooding and receptors affected. To complement this data, information was enhanced through the work of the WCC FRMT via ongoing flood investigation studies. In addition to this, WCC as LLFA have now developed standard ways of reporting and recording flood event data in the future.

Preliminary Flood Risk Assessment and Strategic Flood Risk Assessment

A PFRA was produced for Warwickshire and this identifies areas in which the risk of surface water and groundwater flooding is significant and warrants further examination. The PFRA was prepared by WCC in order to comply with the Flood Risk Regulations 2009 and in accordance with the EA’s Final PFRA Guidance published in December 2010. The PFRA report was published in March 2011.

Environment Agency National Mapping

The EA published their updated Flood Map for Surface Water (uFMfSW) in December 2013. This dataset is the third national surface water map that has been produced by the EA. It represents an improvement over previous surface water flood maps as a result of improved modelling and flood mapping techniques.

This predictive modelling dataset is now well developed and when supported by recorded flood history, provides a good basis for analysis and prioritisation of flood risk locations.

4.2.1 Data Collection and Review

A key objective of the study was to collate as much flooding information as possible, assess its quality and relevance, and combine it within an analysis that would result in the identification and ranking of flood risk locations. The use of GIS software was identified as a useful tool for the analysis and visualisation of the results, flooding and at-risk areas which should assist with spatial planning. Where hard copy data was provided, detailing incidents of surface water flood risk; the information was digitised in GIS so that it could be compared with existing GIS information and integrated into the matrix.

The existing records held by WCC as outlined in Section 4.2 were supplemented with additional information obtained by the following approaches.

- A request for flood history information from:
  - the Districts and Boroughs, Parish and Town Councils and community groups; and
  - project stakeholders (including Severn Trent Water, Network Rail, Canal and River Trust and Warwickshire Wildlife Trust).
- Parish Engagement Workshops - A bespoke flood history questionnaire and map annotation exercise was undertaken as part of the Defra Pathfinder initiative[2]. Comprising of workshops across the county, Parish and Town Council, community group members and key stakeholders were encouraged to identify areas of known flood risk and provide supporting information. To capture information from Parish and Town Councils not attending the Pathfinder workshops, the flood history questionnaire was issued directly to representatives as a follow up exercise. The hard copy data was spatially and digitally uploaded into the GIS software.

Following the initial data gathering exercise and engagement workshops, a gap analysis was undertaken and WCC provided the stakeholders a further opportunity for flood history data to be provided before the technical analysis stage commenced.

Project data was assessed against the data quality scoring system referred to in the Defra SWMP Technical Guidance Document (2010). Additional weightings of data importance were then established through sensitivity testing and stakeholder engagement workshops and incorporated into the project data matrix outlined in Chapter 5.

[2] Launched by Defra in 2012, 13 pilot projects across England were selected to develop innovative projects and flood action groups that will better protect homes and businesses from flooding.

4.2.2 Flood Risk Datasets – Historic

The historic datasets that were used in the technical analysis are presented in Table 5.1 below, with a detailed data register provided in Annex A.

Additional flood history information has been obtained from project stakeholders the EA (fluvial / Main River flooding) and STW (sewer flooding) that will be used to assess flood risk responsibility overlaps and potential flood risk management partnership schemes.

Table 5.1 – Key Historic Data

Stakeholder/Data Source	Data
Defra-funded Community Flood Resilience Pathfinder Workshops	• Historic flood incidents recorded by Parish and Town Council and community group representatives and local stakeholders
WCC	• Ongoing flood incident investigations • Preliminary Flood Risk Assessment flood history data • 2012 flood incident register • Level 1 SFRA studies (2008 and 2013 update) • Highways flood incidents
District and Borough Flood Records	• Historic flood incidents
Network Rail Flood History	• Historic surface water flood incidents that affected Network Rail assets and caused disruption
Canal and River Trust	• Historic surface water flood incidents affecting the canal network

4.2.3 Flood Risk Datasets – Predictive

The predictive flood risk information used was the EA uFMfSW dataset. The 1 in 100 year flood results have been used to assess predicted surface water flooding extent, depth and hazard[3].

[3] Flood Hazard as defined by the Defra Flood Risks to People – Phase Two Document (FD2321/ TR2) (2006)

In addition, the EA second generation mapping (the Flood Map for Surface Water (FMfSW)) has been used during the sensitivity testing of the analysis as an additional check stage. See Section 5.9.1.

4.2.4 National Receptor Dataset

The National Receptors Dataset (NRD) has been used as the primary receptor data. The NRD was used to extract the residential, non-residential and Critical Infrastructure categories (using the Multi Coloured Manual[4] (MCM) codes in the attribute data). Entries such as ponds, reservoirs, post boxes and parks were removed from the dataset as these cannot be categorised into any of the objectives. This follows the same approach detailed in Annex 6 of the PFRA.

4.2.5 Critical Infrastructure

Mapping of Critical Infrastructure in Warwickshire was informed primarily by the NRD. Additional data was obtained from WCC and also Ordnance Survey (OS) Strategic Open Source data including Control of Major Accident Hazard (COMAH) sites, motorways, primary roads, A and B roads and railway lines. Network Rail was also consulted to understand the vulnerability of their local assets and known problem areas. Reference was also made to the Warwickshire PFRA 'critical services' (Annex 6 of the PFRA) to ensure consistency, given that the PFRA also informs the Strategy.

The Critical Infrastructure types were categorised based on the vulnerability to flood risk classifications in Table 2 of the National Planning Policy Framework (NPPF) Planning Practice Guidance Flood Risk and Coastal Change Table[5]. Table 5.2 details the NPPF vulnerability classification, and Critical Infrastructure type. Additional utility data was extracted out of the NRD and placed in the 'More' vulnerable category as the confidence with this dataset was low due to the large volume of data and its associated lack of detail which could skew results if placed into the 'Essential' banding.

Discussions were held with the Coventry Solihull Warwickshire Resilience Team (CSWRT) to refine the approach to Critical Infrastructure and the various categories. The SWMP output will also be discussed with CSW Resilience as there are classified sites within Warwickshire that have not been able to be included within the analysis and mapped outputs.

[4] Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal (Multi-Coloured Manual), Flood Hazard Research Centre, 2013

[5] National Planning Policy Framework, Communities and Local Government, March 2012

Table 5.2 – Critical Infrastructure

Critical Infrastructure Category	Critical Infrastructure Type	
Essential Infrastructure	Road and rail	Water treatment works
Highly Vulnerable	Ambulance station Fire station Police services Police station Hospital / Emergency Responder Pump house Pumping	Sewage pumping Sewage storage Sewage treatment Sludge storage COMAH sites
More Vulnerable	Education First school Further education Further education college High school Higher education Infant school Junior school Middle school Nursery Pre-school education Water Regulating Water Distribution	Primary school Private primary school School Secondary school Technical college University Hospital (including A&E) Medical research Children's nursery Medical education Valve House Water Settling
Utilities	Chimney Cooling Electricity generating Electricity sub station Gas monitoring Gas regulating Radar Radio communications	Telecommunications Telephone exchange Telephone relaying Television communications Ventilating Water distribution Windmill

4.2.6 Growth and Regeneration Area Datasets

Growth And Regeneration Area (GARA) datasets comprised the sources listed in Table 5.3. During the data gathering exercise it was noted that the various Districts and Boroughs were at different stages of their housing and employment allocation requirements for their Core Strategies, and that the terminology for considered and allocation areas varied. A comprehensive approach was therefore adopted for the SWMP, capturing both allocated sites and those still under consideration and combined into a single receptor dataset.

Table 5.3 – Growth and Regeneration Area Component Datasets

Growth and Regeneration Area Component Datasets	
Housing	**Employment**
Strategic Housing Land Availability Assessment (SHLAA) sites	Local Enterprise Partnership (LEP) sites
Allocated Housing Sites	Employment Land Review (ELR) sites
Reasonable Alternative Housing Sites	Strategic Employment Sites
	Allocated Employment Sites
	Alternative Employment Sites

5 Phase 2 - SWMP Flood Risk Assessment

5.1 Introduction

This Chapter outlines the approach to the risk assessment and describes the datasets that were used.

5.2 Definition of Flood Risk

Flood risk is defined in the Flood and Water Management Act (FWMA)[6] (Chapter 3, subsection 1) as "*a risk in respect of an occurrence assessed and expressed (as for insurance and scientific purposes) as a combination of the probability of the occurrence with its potential consequence*".

Flood Risk = (the probability of a flood) x (scale of the consequences)

The effects of flooding can range from environmental damage and pollution, disruption to people's lives (such as travel delays), damage to property (such as business premises and homes), and the risk of injury or death. There are a number of factors that can affect the scale and severity of these consequences which include the following.

- Source and type of flooding.
- Depth and velocity of flood water.
- Duration and rate of onset of flooding.
- Presence or absence of debris in the flood water.
- Degree to which people and/or assets are exposed to the flood water.
- Level and amount of warning people receive.
- Behaviour of people during a flood event.
- Extent and vulnerability of the people and properties affected.

The SWMP study had quantified and assessed relevant consequence factors to identify those areas that should be prioritised for further assessment. Important consequences are the depth of flooding (used to understand where flooding may enter a property, and to understand the risk to life), velocity of flooding (used to understand risk to life), extent of flooding (used to understand locations where communities may be cut off and isolated).

5.3 Historic Flooding Information

Historic flooding information collated for this commission has been used to prioritise historic flooding locations and identify historic flooding 'hotspots' (defined in Section 5.6). Historic

[6] Flood and Water Management Act 2010

data was scored by adopting a count for each property recorded as having been internally flooded by surface water flooding (as per the definition in section 1.4).

5.4 Predictive Flooding Information - Environment Agency Surface Water Flood Maps

The Environment Agency (EA) uFMfSW has been used to as the predictive surface water flooding dataset. Technical details of the uFMfSW and how the maps were produced can be found in the Environment Agency's "What is the updated Flood Map for Surface Water"[7] document. In the context of this SWMP, the 'Medium Risk Probability' data has been used to provide a balanced risk / consequence approach.

Table 6.1 – Surface Water Flood Risk Probability

Surface Water Flood Risk Probability	Rainfall Event	Annual Expected Probability
Very Low	< 1 in 1000 Year	< 0.1%
Low	1 in 1000 to 1 in 100	0.1% to 1%
Medium	1 in 100 to 1 in 30	1% to 3.33%
High	>1 in 30 year	> 3.33%

Note - the uFMfSW provides outputs that detail the predicted surface water flooding depth and velocity. This is important for this study to enable an assessment of flood hazard.

5.5 SWMP Flood Risk Assessment

This chapter describes the approach for the development and application of "metrics" used to quantify surface water flood risk in Warwickshire. Phase 2 of the Defra SWMP process requires the study to rank areas at risk of surface water flooding. The locations at most risk are termed "hotspots" and are potential locations for further detailed assessments, eventually leading to the possible introduction of measures to reduce flood risk. A summary of the process is outlined below in Figures 6.1 and 6.2.

[7] What is the updated Flood Map for Surface Water, 1.0, Environment Agency, November 2103

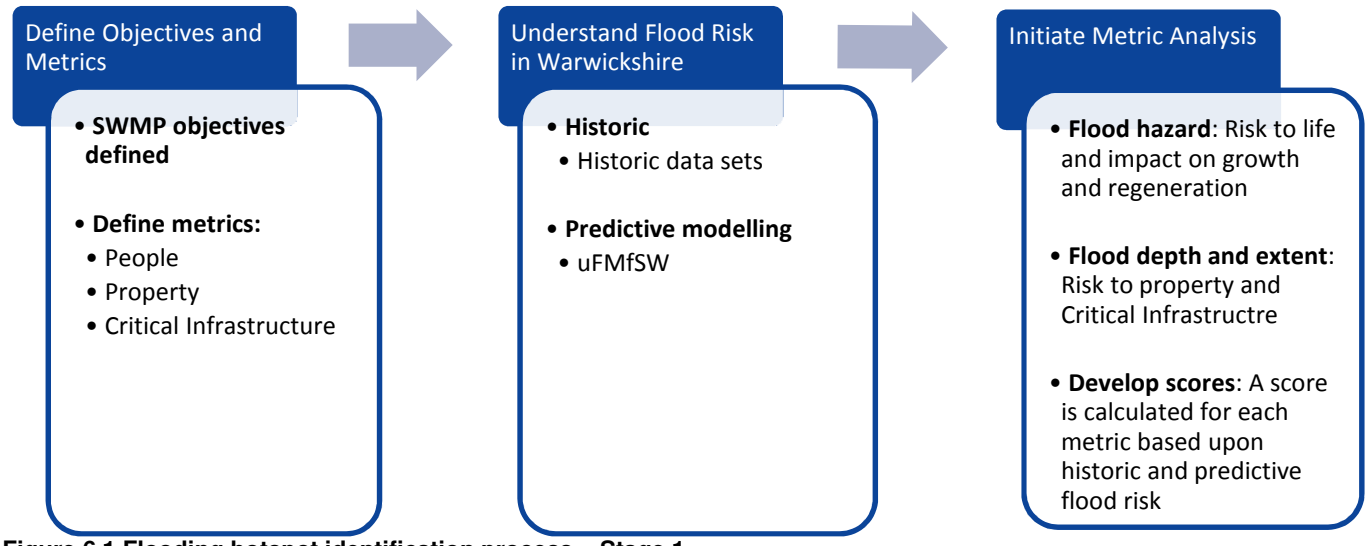


Figure 6.1 Flooding hotspot identification process – Stage 1

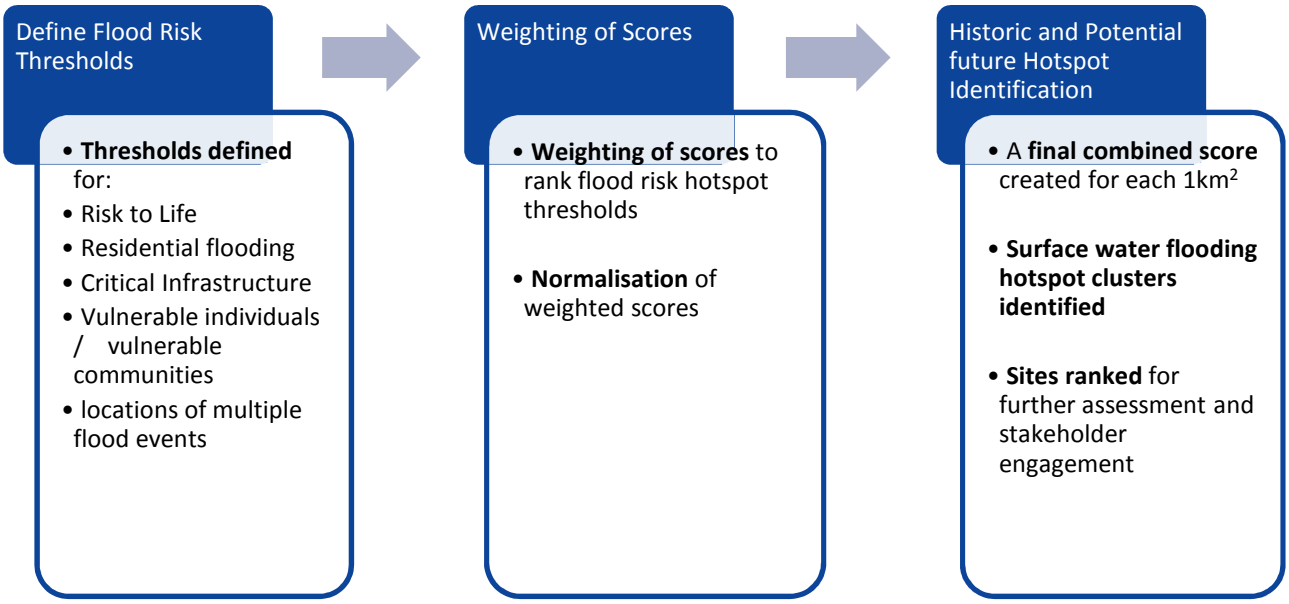


Figure 6.2 – Flooding hotspot identification process – Stage 2

5.5.1 Metrics

To quantify the surface water flood risk and report against the "technical objectives", a series of flood risk metrics have been developed relating to:

- people;
- properties (residential and non-residential);
- growth and regeneration (GARA); and
- critical infrastructure.

5.5.2 Grid Based Assessment

The WCC study area was divided into a grid based upon 1km^2 squares. This approach has been developed for the prioritisation of potential future flooding locations to allow risks to individual receptors to be aggregated and ranked. The grid has been orientated based upon the OS National Grid Reference (OS NGR) system, and allows a detailed level of analysis capable of identifying areas of risk at a community level, in a quick and consistent manner. This is comparable with the approach adopted by the EA during the development of the "Flood Risk Areas" in the PFRA.

Following a sensitivity test, a number of 1km^2 cells were merged together to reflect a single community and a single source or mechanism of flooding (discussed in greater detail in Section 6.33).

Historic and potential future flooding data was cross-referenced with the 1km^2 grid cells and exported to a "project matrix" for scoring, weighting and ranking (discussed in the following sections).

5.6 Surface Water Flooding Historic "Hotspot" (High Priority Site) Identification

Through careful consideration and consultation with fellow LLFAs, WCC have developed the following thresholds for prioritisation of historic flooding events. These thresholds follow closely the areas of locally significant flood risk outlined in the WCC Preliminary Flood Risk Assessment (PFRA) of 2011.

1. Flooding that poses a threat to the safety of the public or may directly result in serious injury or death.
2. Five or more residential properties internally flooded.
3. Two or more commercial properties internally flooded.
4. One or more piece of critical infrastructure affected that, impacts on the wider area*.
5. Flooding that places vulnerable individuals or vulnerable communities at risk e.g. hospitals, care and nursing homes, schools, secure units, etc.
6. Additionally, where one or more residential property has flooded internally from the same source on five or more occasions within the last five years.

**Note*: The trigger thresholds for Critical Infrastructure are based upon their vulnerability classification and comprise:

- 1 instance of Essential Critical Infrastructure; or
- 1 instance of Highly Vulnerable Critical Infrastructure; or

- 1 instance of More Vulnerable Critical Infrastructure; or
- 4 Utilities at risk of internal flooding.

5.6.1 Surface Water Potential Future Flooding "Hotspot" (High Priority Site) Identification Process

For the potential future flooding hotspots, a matrix has been developed in Excel which cross-references the predictive flood risk information with the receptor information. A series of rules have been developed in partnership with WCC to enable a flood risk / consequence score to be developed for each metric, which when combined and weighted, creates an overall risk-consequence score per 1km^2 grid cell which can be ranked to highlight the top priority sites. The rules used within the matrix spreadsheet and individual scoring and weighting approaches have been trialled with WCC during sensitivity testing (see Section 5.9.1), as well as additional testing with project partners at stakeholder workshops.

Additional analysis and scores were developed that, whilst not automatically informing the ranking of sites, provided an additional evidence base to enable informed decisions to be made when quantifying the risk and consequences of locations across Warwickshire. The approach to the scoring, weighting and data thresholds are presented in the sections below.

5.7 Potential Future Flooding - Metric Scoring, Weighting and Thresholds

The following sections provide an overview on the analysis that has been used to prioritise potential future flooding locations.

Flood Hazard

It was important for the Warwickshire SWMP to assess hazard and risk to life in both urban and rural locations, given the large number of rural communities and the consequences of flooding in villages and the connecting roads.

Flood hazard has been assessed at each 1km^2 grid cell and a score derived as follows.

Table 6.2 – Flood Hazard Scoring

Hazard Score	Score
0-0.75	0
0.75-1.25	1.25
1.25-2	1.5
>2	1.75

Flooded Area (sq. km)	Score
0-0.1	1
0.1-0.2	1.1
0.2-0.3	1.2
0.3-0.4	1.3
0.4-0.5	1.4
>0.5	1.5

Flood hazard metric scoring example:

- If a 1km2 grid cell has less than 0.1km2 affected by surface water flooding with a hazard rating of 0.75 - 1.25, then it would have a composite score of 1 x 1.25 = 1.25.
- If a 1km2 grid cell has between 0.3 and 0.4km2 affected by surface water flooding and a hazard rating of >2 it would have a composite score of 1.3 x 1.75 = 2.275.

The hazard scores have been used to develop a thematic map that provides a visual representation of risk to life from surface water flooding across Warwickshire (contained in Annex B). The hazard scores are also presented in the matrix as an additional tool to aid comparison between sites (however they do not directly inform the ranking as initial sensitivity testing showed that there was a risk of skewing results to areas with no receptors).

Risk to Residential and Non-Residential Properties

Discussions with WCC highlighted the importance of capturing the risk to non-residential properties in both urban and rural locations. The metric score to quantify the risk and consequences of flooding of properties within each 1km^2 grid has therefore been informed by both the number of properties affected by flooding and the flood depth. Where properties are shown to be inside the 1 in 100 year uFMfSW flood extent, flood depths have been analysed. When these depths are above 150mm (the assumed threshold elevation of all properties above the surrounding land), a score will be given to each property within the flood extent based upon the predicted depth of flooding as explained in Table 6.3.

Table 6.3 – Flood Depth Scoring

Scoring for Properties	
Depth (metres)	**Score**
0 - 0.15	0
0.15 - 0.3	1
0.3 - 0.6	1.1
0.6 - 0.9	1.2
0.9 - 1.2	1.3
> 1.2	1.4

Property flood depth metric scoring example:

- If a property is within the 0.1 - 0.3m depth banding it will receive a score of 1, whilst a property within the greater than 1.2m depth flood zone will receive a score of 1.4. If these are the only two properties affected by flooding within the 1km^2 grid cell then the total property score will be 1+1.4 = 2.4.

Sensitivity testing demonstrated that the NRD property node points were often located spatially towards the centre of a property, and there was a risk of instances where a surface water flood extent may be shown to affect a building, but not reach the NRD receptor point. Therefore to reduce the likelihood of properties at risk not been correctly identified in the analysis, each residential NRD property receptor node was buffered by 5m, non-residential by 10m and Critical Infrastructure by 10m.

Critical Infrastructure

Scoring the critical infrastructure metric has a number of components. Firstly, it is informed by the flood extent and flood depth (applying the same 150mm threshold as used for property). Secondly, the vulnerability of the various types of critical infrastructure element is considered (as detailed in Table 5.2). These elements are combined to create a weighted score for each type of critical infrastructure.

Table 6.4 provides a summary of the scoring approach. It should be noted that the different types of critical infrastructure are considered to have varying levels of importance / criticality. As a result, the scoring value for flooding of critical infrastructure varies.

Table 6.4 – Critical Infrastructure Scoring

Category	Unit	Score
Road and Rail	** See Notes*	0
Essential Critical Infrastructure	Per occurrence	2
Highly Vulnerable Critical Infrastructure	Per occurrence	1.5
More Vulnerable Critical Infrastructure	Per occurrence	0.6
Utility (More Vulnerable)	Per occurrence	0.1

***Notes**:

I. Score has been set to zero as the results were skewed to areas with no receptors, however the functionality has remained as a sensitivity tool to assess risk to areas such as Brailes, Aston Cantlow and Lea Marston where communities can be cut-off due to flood events. The trigger level for the road and rail was set at 1m length to ensure localised flood risk locations are identified.

II. The ‘essential’, ‘high’ and ‘more’ classifications were extracted from the NRD data and based upon the NPPF classifications.

III. The 0.1 score for Utility (such as telephone masts and radio communications) has been established based upon extensive sensitivity testing and ratio weighting against those receptors in the category above (More Vulnerable) such as schools and nurseries. Scores higher than 0.1 skewed results and resulted in erroneous sites ranking in the top 40.

Critical Infrastructure metric scoring example: If a cell contains the following and they are all shown to be at risk of flooding:

- 2 Essential Critical Infrastructure; and
- 2 More Vulnerable Critical Infrastructure.

The following score would be created: 4 (2x2) + 1.2 (2x0.6) = 5.2 whereby:

- 4 (2x2) represents 2 occurrences of Essential Critical Infrastructure multiplied by the associated score of 2; and
- 1.2 (2x0.6) represents 2 occurrences of More Critical Infrastructure multiplied by the associated score of 0.6.

Growth and Regeneration Areas

The Growth and Regeneration Area (GARA) score was based upon the area of GARA within a 1km^2 cell shown to be at risk of surface water flooding. Sensitivity testing showed that there was a risk of skewed results, and so an appropriate scaled weighting was applied to ensure results were balanced and matched local WCC knowledge.

5.7.1 Normalisation of Scores and Weighting

Following the initial scoring process, all scores were normalised so that each metric has a value between zero and one, whereby zero represented the lowest overall score and one represented the highest score for that particular metric. This was undertaken to convert all the different types of metrics and units into a simple score between zero and one. This allows easier comparison between datasets, and for identification of trends and correlations. Weightings were then applied to each metric to create a total combined score, allowing direct adjustment of the perceived importance of one metric versus another through extensive sensitivity testing.

Note that the score and weighting values outlined in this report and established in the project matrix are able to be edited and refined by the user. Therefore as and when additional datasets become available to WCC, this information can be imported into the project matrix and scores and weightings adjusted based upon data relevance and quality.

The individual normalised scores for each metric were combined and weighted within the matrix to produce a composite score for each 1km^2 grid cell. These scores were ranked and used to inform the Matrix and thematic mapping outputs.

5.8 Potential Future Flooding “Hotspots” (High Priority Site)

The potential future flooding hotspots have been developed to be consistent with the historic flooding hotspots.

1. Flooding that poses a threat to the safety of the public or may directly result in serious injury or death.

2. Five or more residential properties internally flooded.
3. Two or more commercial properties internally flooded.
4. One or more piece of Critical Infrastructure affected that, impacts on the wider area*.
5. Flooding that places vulnerable individuals or vulnerable communities at risk e.g. hospitals, care and nursing homes, schools, secure units, etc.

***Note**:

I. The trigger thresholds for Critical Infrastructure are based upon their vulnerability classification and comprise:

- 1 instance of Essential Critical Infrastructure; or
- 1 instance of Highly Vulnerable Critical Infrastructure; or
- 1 instance of More Vulnerable Critical Infrastructure; or
- 4 Utilities at risk of internal flooding.

5.9 Matrix Outputs

The final scores from the analysis (termed 'matrix scores') were presented in a ranked top 40 list. By incorporating both the historic flood risk information and predicative future flood risk information, the following rankings have been developed to inform the prioritisation of sites for further investigation.

- Historic flooding.
- Potential future flooding.
- Combined (Historic and Potential).

The selection of 40 sites was chosen as a method to capture a wide range of sites, with varying flood risk issues and consequences and to provide a wide focus group to identify schemes for further analysis and locations where stakeholder partnership schemes may be appropriate (as discussed in Chapter 7).

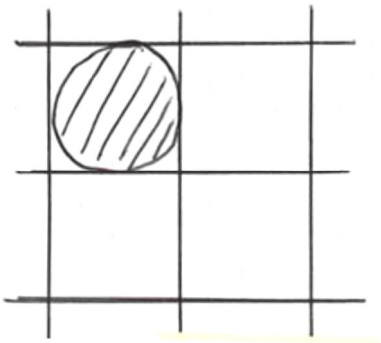
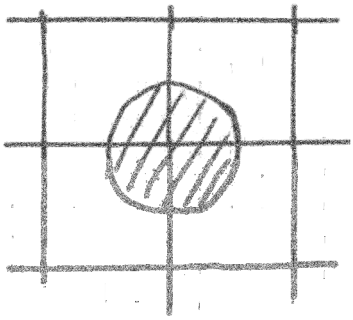
5.9.1 Matrix Sensitivity Analysis

A number of sensitivity tests were undertaken to fine-tune the trigger levels, scoring and weighting and also to assess the effectiveness of the choice of a 1km^2 grid as the basis for the analysis.

The sensitivity tests consisted of adjusting the scoring and weighting parameters and re-running the matrix analysis to assess the resultant changes to the top 40 ranked sites. Observations were made to the changes of the ranked positions of future hotspots, and the reasons for the changes. Through an iterative process and applying local WCC flood risk knowledge, the scorings and weightings were judged to be appropriate.

An additional sensitivity analysis was undertaken on the spatial positioning for the 1km^2 grid. The datum was shifted by 500m horizontally and vertically to provide two sensitivity scenarios, as it is recognised that a flood risk location could be located entirely within a 1km^2 grid cell or could be divided across a number of grid cells – depending upon the datum origin, as highlighted in Table 6.5.

Table 6.5 – 1km^2 Grid Cell Datum Sensitivity Example

Grid Location Example	Flood Risk Location	Notes
1		In this scenario, a theoretical flood risk-consequence issue is shown to be within a single 1km^2 grid cell. This could result in a high score for this cell.
2		In this scenario, a theoretical flood risk-consequence issue is shown to be divided across four 1km^2 grid cells. This could result in a low score in each cell that does not reach minimum trigger levels.

The results showed that whilst there were no significant changes to the ranking of sites, it highlighted the importance of developing 'flood risk clusters' (an approach identified at the project inception). Historic flood risk knowledge was used by WCC to develop a series flood risk clusters – by amalgamating 1km^2 cells where areas were at risk from common sources of flooding. This approach ensured that if flood risk and receptors were divided across 1km^2 grid cells, they would still be accounted for in the matrix analysis and reach the required minimum threshold levels for inclusion.

The quality of the previous FMfSW was generally regarded to be good by WCC and other RMAs in Warwickshire. To check that the updated version was suitable for use in this SWMP, an additional sensitivity test was also undertaken to compare the latest EA surface water flood modelling output (uFMfSW) against the previous generation FMfSW dataset. The result of this showed that whilst there were a number of locations where the flood extents were similar, the uFMfSW mapping provided a better match to areas of known historic surface water flood risk; this was confirmed for use in this analysis.

5.9.2 Post Scheme Matrix Updates

During discussions with WCC an additional requirement of the matrix was identified, which required the ability to amend the number of properties at risk following completion of WCC (or stakeholder) flood alleviation projects. Additional data columns were added to the matrix to enable an 'areas benefiting from defences / schemes' score to be calculated. This allows WCC to capture the benefits of flood alleviation schemes without overriding the original dataset (as there may be instances where risk has been lowered but not completely mitigated and so it is important to understand the residual risk if schemes were to fail).

5.10 Stakeholder Workshop Sensitivity Analysis

Stakeholder workshops were held on the 27th November 2014 with representatives from the Districts and Boroughs, in addition to STW and the EA. The purpose of the workshops was to present a summary of the work undertaken to date, the assumptions made, and the initial results. It was agreed with WCC that feedback on the initial top 20 hotspots (a value chosen to make the process manageable) would be important to assess the performance of the initial scoring and weighting parameters.

During the meeting, the project team discussed how well the analysis was matching areas of known surface water flood risk, and how the ranking reflected the RMAs perception of which areas were at greater risk / had greater consequences. Live trialling of scoring and weighting combinations was undertaken by the team, and the results re-ranked to assess the impact of such changes.

It was observed during the workshop that greater weight needed to be given to the historic flooding locations to avoid skewing the results too far towards national scale modelling in the updated Flood Map for Surface Water.

It was agreed that a more robust method for prioritising historic flooding locations should be utilised in the final analysis, resulting in a flooding hotspot threshold criteria being developed (as outlined in Section 5.6 of this document).

AECOM, in consultation with WCC, combined the stakeholder feedback and results of the live trials with the public consultation feedback and finalised the matrix approach to produce the improved list of the top ranking hotspots presented in Chapter 7 of this report.

6 Results Summary

6.1 Introduction

This Chapter provides a summary of the results from the SWMP analysis.

6.2 Matrix Outputs

Ranked Table

The matrix has been developed to enable both historic and potential future flooding hotspot reporting. For this overall summary, a combined approach has been undertaken (combining both the historic and potential future flooding scores) for each OS tile or combination of OS tiles to provide a top 40 ranking. Note that large locations such as Leamington Spa will have a number of OS tiles at risk of surface water flooding from different sources - these are therefore ranked separately as different flooding locations. Large towns could therefore be named in the list more than once, but it is the specific area or community within the town which is being ranked.

The highest ranked locations will not necessarily have funded flood alleviation schemes. This stage of the SWMP is the risk assessment. The viability of flood alleviation schemes depends not only on the risk, but also on the nature of the flood risk and financial viability of a scheme relative to other areas in England and Wales (since it is necessary to compete with other locations to bid for funding from the national 'pot' of Flood Defence Grant in Aid available).

Outputs from the matrix include the ranked results table and thematic maps displaying a spatial representation of results to allow WCC and the users to readily identify the areas with the greatest risk and consequences to:

- people;
- property (residential and commercial); and
- critical infrastructure.

Table 7.1 provides the top 40 surface water flood risk sites from the SWMP matrix analysis.

Note that the current top 40 ranking shown below in Table 7.1 is subject to further change following review of classified strategic sites of national importance and feedback from the final consultation phase.

The following examples provide a demonstration of how the table should be interpreted.

Firstly, a location may be ranked highly due to a single severe flood risk and consequence score – such as at Snitterfield which is ranked position 1. The SWMP objective normalised scores show that this location has an important historical flood risk score (the highest from the analysis). Alternatively, Kenilworth (ranked 3rd) does not feature significantly high

individual objective scores; however, it is ranked highly in the overall matrix due to the combined risk and consequence scores for a range of SWMP objectives.

Table 7.1 – WCC SWMP Matrix Outputs: Top 40 Combined (Historic and Predictive) Flood Risk Sites

**Dark Red shaded OS Tile names indicate where location has met the SWMP historic Hotspot Threshold for historic flood risk. Tile location can be identified using the OS Tile Finder[8]*

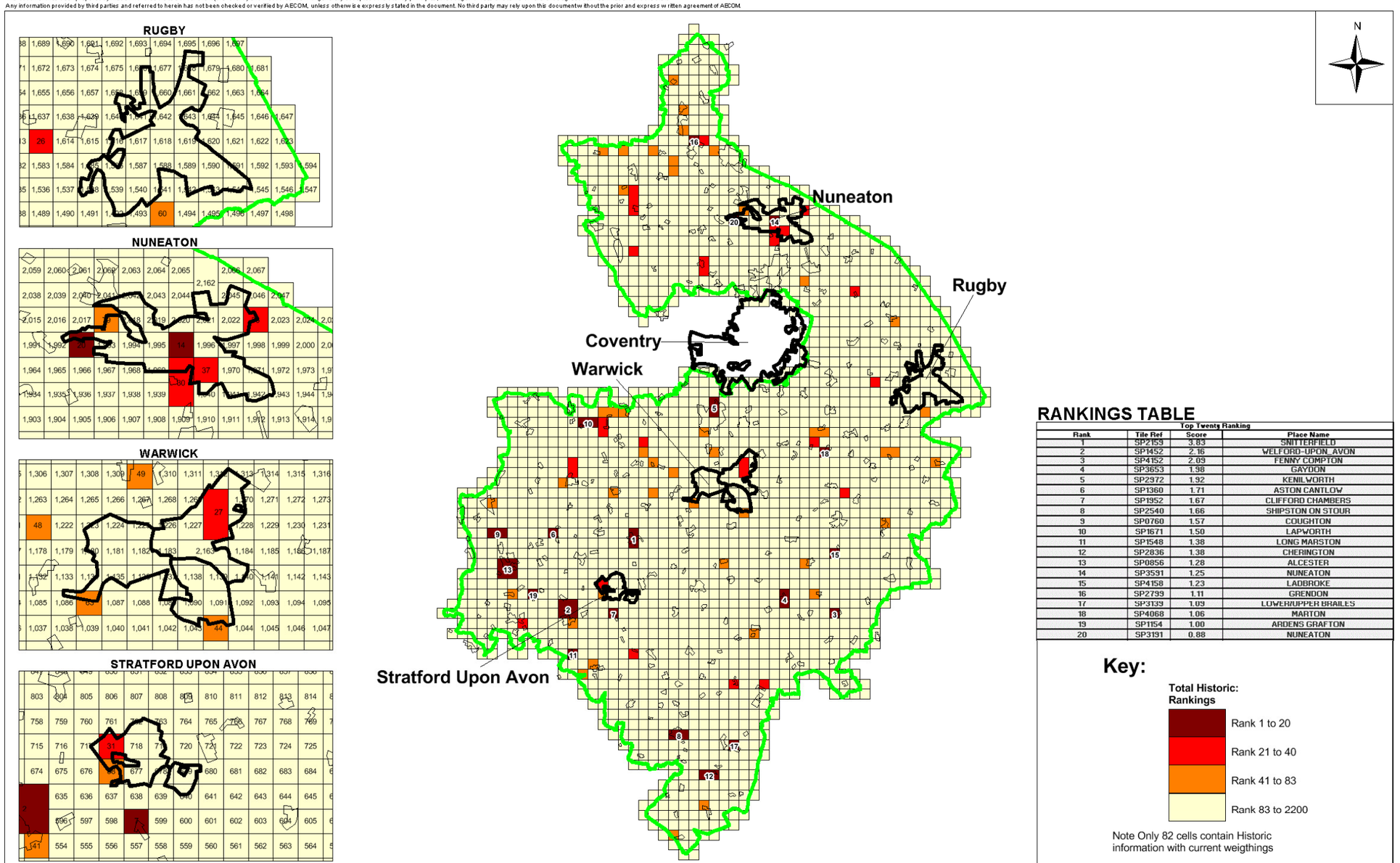
Matrix Ranking				
Rank	***OS Tile Ref**	**Matrix Score**	**Place Name**	**Nature of Flood Risk**
1	SP2159	21.16	SNITTERFIELD	Risk to Life, Main River, Ordinary Watercourse, Surface Water
2	SP2540	14.73	SHIPSTON ON STOUR	Main River, Surface Water, town centre
3	SP2972	14.46	KENILWORTH	Main River, Surface Water, area of Northvale Close
4	SP4152	12.60	FENNY COMPTON	Ordinary Watercourse, Surface Water
5	SP1452	12.23	WELFORD-UPON-AVON	Main River, Ordinary Watercourse, Surface Water, multiple locations
6	SP3653	11.57	GAYDON	Ordinary Watercourse, Surface Water, village centre
7	SP3486	10.00	BEDWORTH	Main River area of Delamere Road (addressed by EA scheme), Surface Water Risk
8	SP1952	9.63	CLIFFORD CHAMBERS	Main River, Ordinary Watercourse, Surface Water
9	SP3266	9.49	ROYAL LEAMINGTON SPA	Ordinary Watercourse, Surface Water, Foul Sewer, area of Gresham Avenue
10	SP3591	9.38	NUNEATON	Ordinary Watercourse, Surface Water, Sewer Capacity, area of Queens Road
11	SP2866	9.25	WARWICK	Surface Water, area of Woodloes Estate
12	SP1360	9.16	ASTON CANTLOW	Main River, Ordinary Watercourse, Surface Water
13	SP0856	9.03	ALCESTER	Main River, Surface Water
14	SP0760	8.83	COUGHTON	Surface Water
15	SP1566	8.39	HENLEY IN ARDEN	Main River, Surface Water
16	SP2799	7.88	GRENDON	Ordinary Watercourse, Surface Water, Sewer Flooding, various locations
17	SP1671	7.83	LAPWORTH	Ordinary Watercourse, Surface Water, multiple locations
18	SP2836	7.70	CHERINGTON	Ordinary Watercourse, Surface Water, village centre
19	SP1548	7.55	LONG MARSTON	Ordinary Watercourse, Surface Water, area of Welford Road
20	SP3139	7.07	LOWER/UPPER BRAILES	Ordinary Watercourse, Surface Water, area of Orchard Close
21	SP3165	6.97	ROYAL LEAMINGTON SPA	Main River, Ordinary Watercourse, Surface Water, town centre
22	SP4158	6.93	LADBROKE	Ordinary Watercourse, Surface Water, village centre
23	SP1955	6.66	STRATFORD-UPON-AVON	Ordinary Watercourse, Surface Water, area of Western Road
24	SP3691	5.99	NUNEATON CENTRE	Main River, Ordinary Watercourse, Surface Water, Sewer Flooding
25	SP2765	5.63	WARWICK	Main River, Ordinary Watercourse, Surface Water, area of Race Course Brook
26	SP4068	5.63	MARTON	Main River, Surface Water
27	SP3191	5.37	GALLEY COMMON	Ordinary Watercourse, Surface Water

[8] http://www.ordnancesurvey.co.uk/business-and-government/help-and-support/products/tile-selector.html

Matrix Ranking				
Rank	***OS Tile Ref**	**Matrix Score**	**Place Name**	**Nature of Flood Risk**
28	SP2886	5.30	FILLONGLEY	Ordinary Watercourse, Surface Water, Foul Sewer
29	SP1154	5.28	ARDENS GRAFTON	Risk to Life, Ordinary Watercourse, Surface Water, area of Little Britain
30	SP4264	4.91	LONG ITCHINGTON	Risk to Life, Ordinary Watercourse, Surface Water, area of Stockton Road
31	SP3589	4.75	BERMUDA	Surface Water
32	SP1855	4.33	STRATFORD-UPON-AVON	Ordinary Watercourse, Surface Water, area of Drayton Avenue
33	SP2192	4.29	WHITACRE HEATH	Main River, Surface Water, Sewer Flooding
34	SP1870	4.24	KINGSWOOD	Surface Water, multiple locations
35	SP2899	4.23	GRENDON	Surface water, proposed growth and regeneration area
36	SP3264	4.17	ROYAL LEAMINGTON SPA	Ordinary Watercourse, Surface Water, centred on Whitnash
37	SP3969	4.15	EATHORPE	Risk to Life, Main River, Ordinary Watercourse, Surface Water
38	SP4575	3.93	LAWFORD HEATH	Risk to Life, Ordinary Watercourse, Surface Water
39	SP2269	3.91	FIVE WAYS	Ordinary Watercourse, Surface Water
40	SP3445	3.79	LOWER/MIDDLE/UPPER TYSOE	Ordinary Watercourse, Surface Water

Thematic Maps

A set of thematic maps have also been produced to complement the matrix ranked table outputs, shown in Figures 7.1 – 7.5. These are also included in Annex B of the PDF version of this report at a larger scale. The thematic maps provide a visual representation of the spatial distribution of the top 40 ranked sites. Note that a Hazard risk thematic map has also been included to provide a visual representation of the risk to life across the study area to inform wider decision making.



RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP2153	3.83	SNITTERFIELD
2	SP1452	2.16	WELFORD-UPON_AVON
3	SP4152	2.09	FENNY COMPTON
4	SP3653	1.98	GAYDON
5	SP2372	1.92	KENILWORTH
6	SP1360	1.71	ASTON CANTLOW
7	SP1952	1.67	CLIFFORD CHAMBERS
8	SP2540	1.66	SHIPSTON ON STOUR
9	SP0760	1.57	COUGHTON
10	SP1671	1.50	LAPWORTH
11	SP1548	1.38	LONG MARSTON
12	SP2836	1.38	CHERINGTON
13	SP0856	1.28	ALCESTER
14	SP3591	1.25	NUNEATON
15	SP4158	1.23	LADBROKE
16	SP2799	1.11	GRENDON
17	SP3139	1.09	LOWER/UPPER BRAILES
18	SP4068	1.06	MARTON
19	SP1154	1.00	ARDENS GRAFTON
20	SP3191	0.88	NUNEATON

Key:

Total Historic: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 83
- Rank 83 to 2200

Note Only 82 cells contain Historic information with current weigthings

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL HISTORIC SCORE 1 IN 100 YEAR EXTENT RANKINGS

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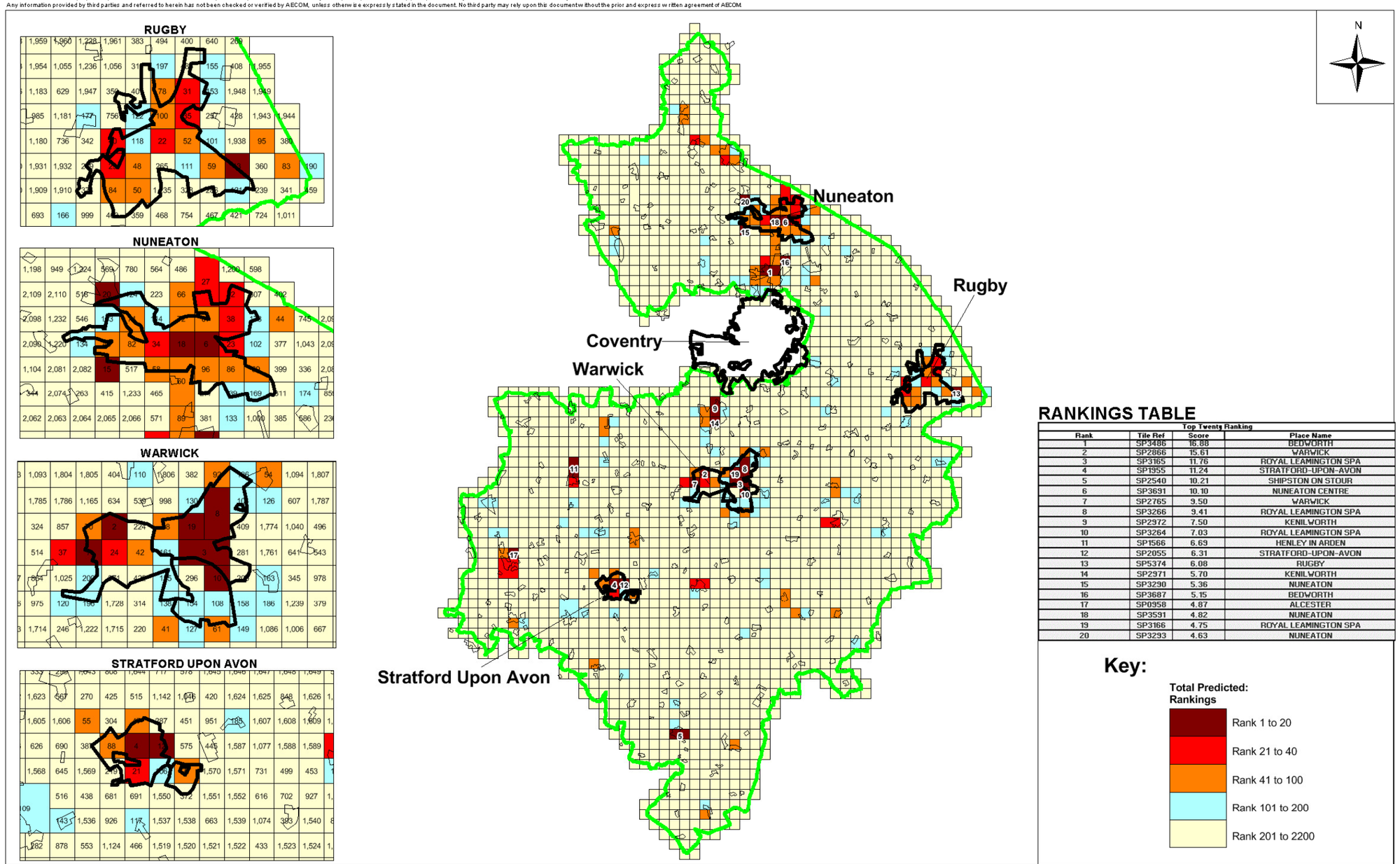
Date:	25/08/2015	Scale at A3:	1:350,000 @ A3
Drawing Number:	60319308_9_v2		A3

Figure 7.1 – Total Historic Surface Water Risk Score



RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP3486	16.88	BEDWORTH
2	SP2866	15.61	WARWICK
3	SP3165	11.76	ROYAL LEAMINGTON SPA
4	SP1955	11.24	STRATFORD-UPON-AVON
5	SP2540	10.21	SHIPSTON ON STOUR
6	SP3691	10.10	NUNEATON CENTRE
7	SP2765	9.50	WARWICK
8	SP3266	9.41	ROYAL LEAMINGTON SPA
9	SP2372	7.50	KENILWORTH
10	SP3264	7.03	ROYAL LEAMINGTON SPA
11	SP1566	6.69	HENLEY IN ARDEN
12	SP2055	6.31	STRATFORD-UPON-AVON
13	SP5374	6.08	RUGBY
14	SP2971	5.70	KENILWORTH
15	SP3290	5.36	NUNEATON
16	SP3687	5.15	BEDWORTH
17	SP0958	4.87	ALCESTER
18	SP3591	4.82	NUNEATON
19	SP3166	4.75	ROYAL LEAMINGTON SPA
20	SP3293	4.63	NUNEATON

Key:

Total Predicted: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 100
- Rank 101 to 200
- Rank 201 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL PREDICTED SCORE 1 IN 100 YEAR EXTENT RANKINGS

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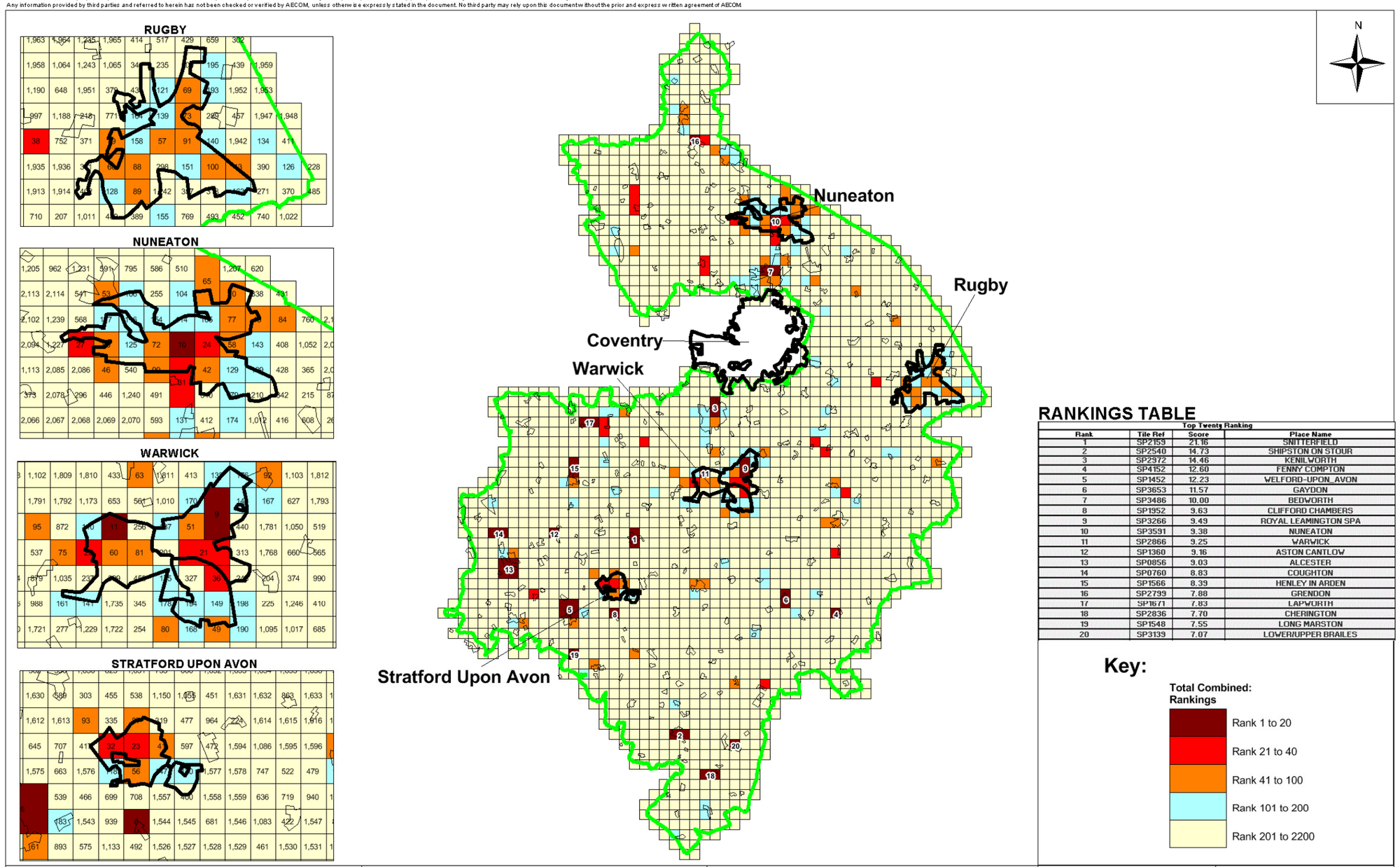
Date:	25/08/2015	Scale at A3:	1:350,000 @ A3
Drawing Number:	60319308_8_v2		A3

Figure 7.2 – Total Predictive Surface Water Risk Score



RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP2159	21.16	SNITTERFIELD
2	SP2540	14.73	SHIPSTON ON STOUR
3	SP2972	14.46	KENILWORTH
4	SP4152	12.60	FENNY COMPTON
5	SP1452	12.23	WELFORD-UPON_AVON
6	SP3653	11.57	GAYDON
7	SP3486	10.00	BEDWORTH
8	SP1952	9.63	CLIFFORD CHAMBERS
9	SP3266	9.49	ROYAL LEAMINGTON SPA
10	SP3591	9.38	NUNEATON
11	SP2866	9.25	WARWICK
12	SP1360	9.16	ASTON CANTLOW
13	SP0856	9.03	ALCESTER
14	SP0760	8.83	COUGHTON
15	SP1566	8.39	HENLEY IN ARDEN
16	SP2799	7.88	GRENDON
17	SP1671	7.83	LAPWORTH
18	SP2836	7.70	CHERINGTON
19	SP1548	7.55	LONG MARSTON
20	SP3139	7.07	LOWER/UPPER BRAILES

Key:

Total Combined: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 100
- Rank 101 to 200
- Rank 201 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL COMBINED SCORE 1 IN 100 YEAR EXTENT RANKINGS

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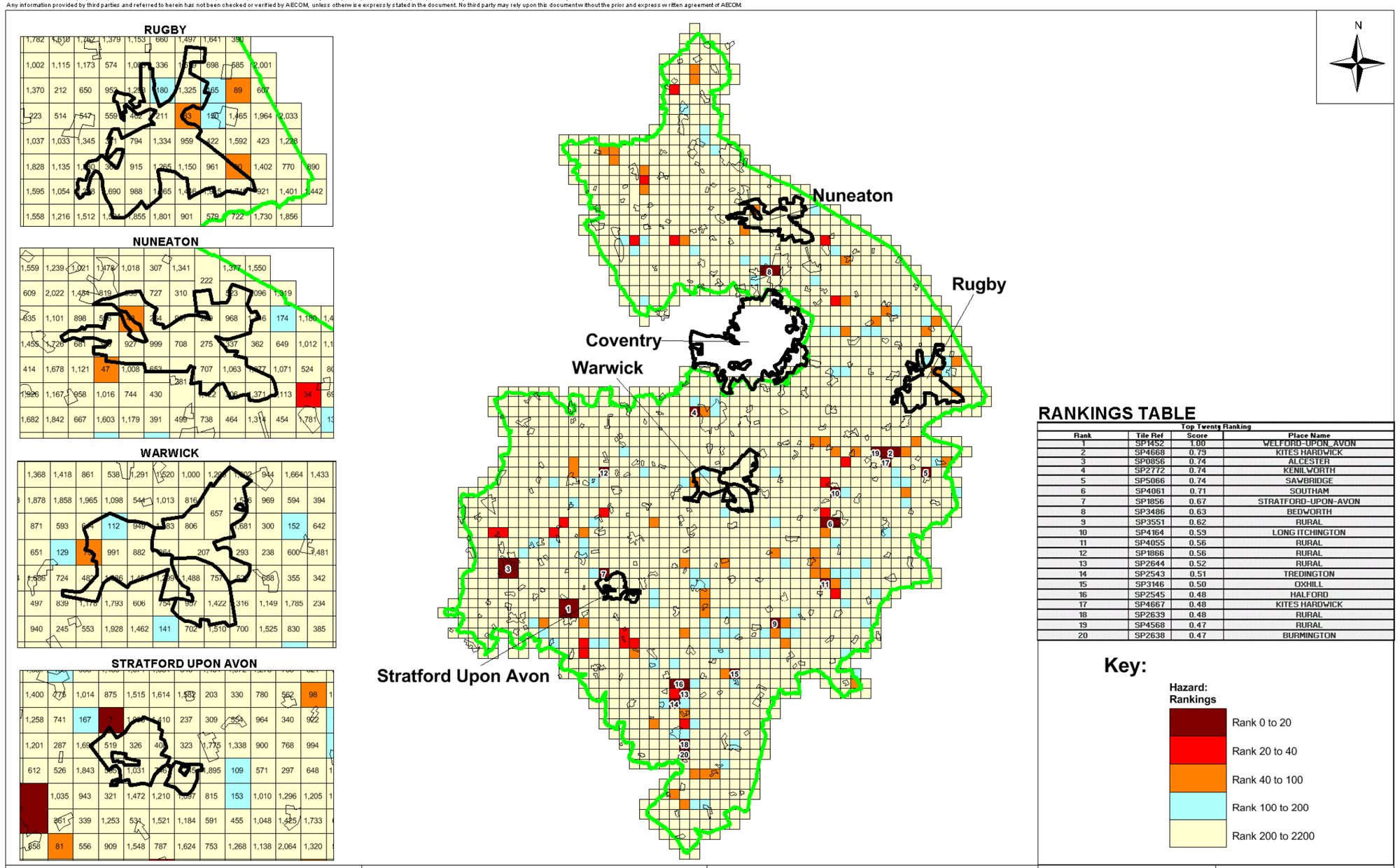
Date:	25/08/2015	Scale at A3:	1:350,000 @ A3
Drawing Number:	60319308_10_v2		A3

Figure 7.3 – Total Combined Surface Water Risk Score



RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP1452	1.00	WELFORD-UPON-AVON
2	SP4658	0.79	KITES HARDWICK
3	SP0856	0.74	ALCESTER
4	SP2772	0.74	KENILWORTH
5	SP5066	0.74	SAWBRIDGE
6	SP4061	0.71	SOUTHAM
7	SP1856	0.67	STRATFORD-UPON-AVON
8	SP3486	0.63	BEDWORTH
9	SP3551	0.62	RURAL
10	SP4164	0.59	LONG ITCHINGTON
11	SP4055	0.56	RURAL
12	SP1866	0.56	RURAL
13	SP2644	0.52	RURAL
14	SP2543	0.51	TREDINGTON
15	SP3146	0.50	OXHILL
16	SP2545	0.48	HALFORD
17	SP4667	0.48	KITES HARDWICK
18	SP2639	0.48	RURAL
19	SP4568	0.47	RURAL
20	SP2638	0.47	BURMINGTON

Key:

Hazard: Rankings

- Rank 0 to 20
- Rank 20 to 40
- Rank 40 to 100
- Rank 100 to 200
- Rank 200 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: HAZARD SCORE
1 IN 100 YEAR EXTENT
RANKINGS

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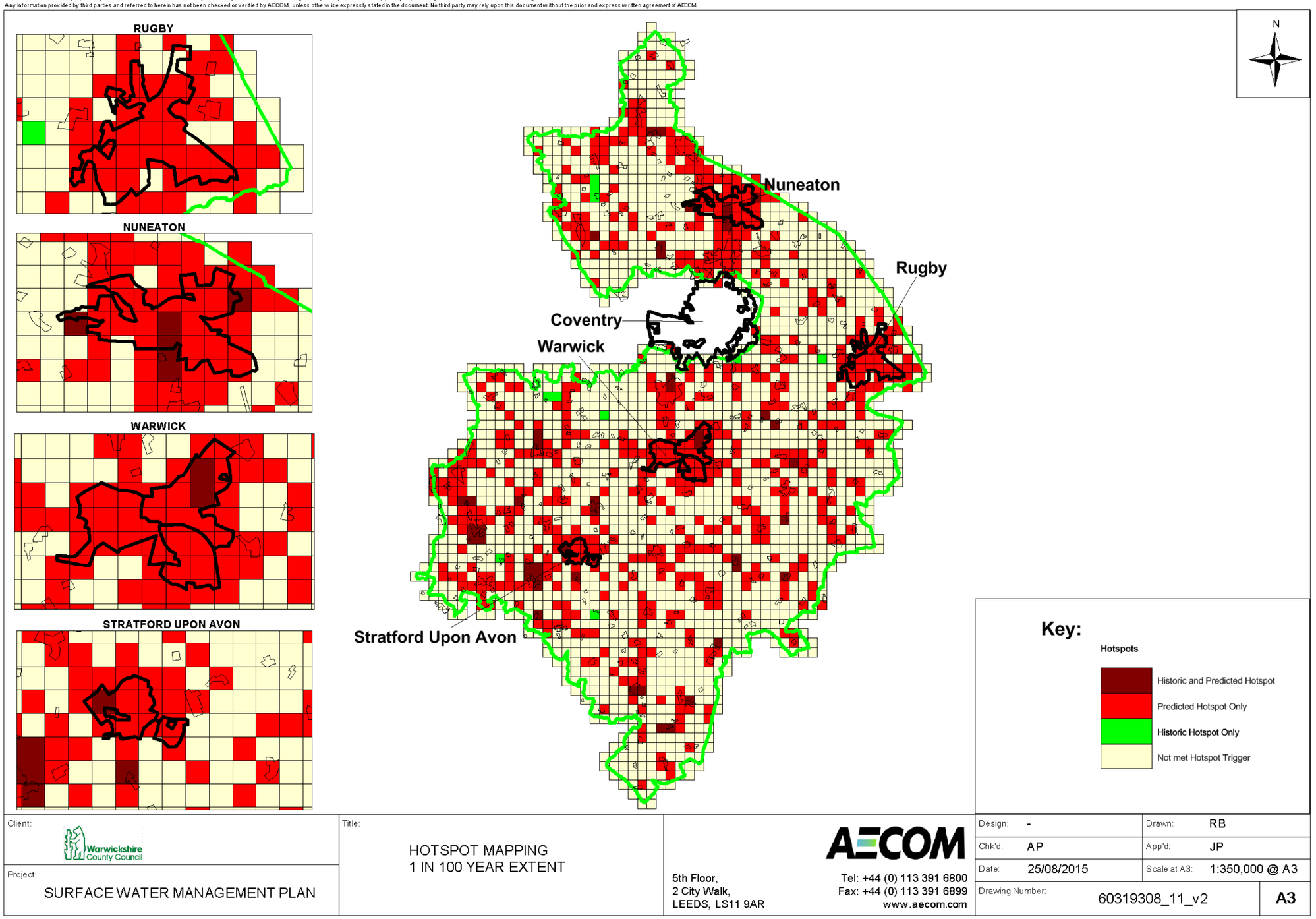
Drawing Number:	60319308_11		A3

Figure 7.4 – Hazard (Risk to Life) Surface Water Risk



Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: HOTSPOT MAPPING
1 IN 100 YEAR EXTENT

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Drawing Number:	60319308_11_v2		A3

Figure 7.5 – Historic and Predictive Flood Risk Hotspots

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6.3 SWMP Strategic Flood Maps

In addition to the matrix ranked outputs and GIS Strategic Flood Maps, the digital and hard copy data that was collated and used in this commission was uploaded into a GIS workspace, and integrated PDF and project matrix. The GIS workspace and interactive PDF has been termed the SWMP Strategic Flood Maps. These allow WCC and other RMAs to visualise all of the historic flood risk information collated for this study, predictive flood risk and receptors. The GIS workspace, and project matrix is designed to be a living database and should be regularly updated with new information to capture future flooding incidents, updated predictive mapping and details of flood risk management schemes. The Strategic Flood Maps will be of particular importance when reviewing the top 40 ranked list during the subsequent stages of the SWMP process to ensure that the cells adjacent to those that rank highly are considered and the wider consequences and benefits taken into account if necessary.

Whilst the main objectives from the SWMP study are to identify the most significant surface water flooding hotspot areas, and to develop action plans and investment strategies, the SWMP Strategic Flood Maps are a useful tool for WCC and other RMAs by providing an evidence base for a wide range of planning documents and decision making processes (examples listed below):

Local Flood Risk Management Strategy

The outputs from the SWMP process will be used as the risk assessment part of the Local Flood Risk Management Strategy (LFRMS) for Warwickshire. Whilst this SWMP has developed a priority list of key surface water flood risk hotspots, there remain many locations across Warwickshire with significant risk and consequences that are outside of this list for initial further consideration at this stage. The SMWP therefore needs to remain a living Appendix of the Strategy and be updated with new datasets and flood history information.

Land Use Planning

The SWMP Strategic Flood Maps will indicate areas where a more detailed study of surface water flooding may be required. Flooding hotspots may indicate areas with drainage problems known as Critical Drainage Areas (CDAs). WCC can therefore use the SWMP information to develop surface water control policies that both steer development away from at risk areas, and reduce risk through the requirement of SuDS and other sustainable designs measures. Annex C provides a summary of potential SuDS techniques that may be appropriate.

Flood Risk Assessments

Whilst the SWMP Strategic Flood Maps are not suitable to inform site specific development related flood risk assessments, they will provide WCC and developers with a useful tool to assess if they need to seek further advice and technical support on surface water flooding when preparing a Flood Risk Assessment to support a planning application (where a proposed site is shown to be within an area subject to problematic surface water flooding).

Emergency Planning and Resilience

The SWMP Strategic Flood Maps are a useful tool to inform emergency planning and resilience. The development of the SWMP was undertaken in parallel with the Community Flood Resilience

Pathfinder project. A key message to communities in Warwickshire delivered as part of the Pathfinder workshops was that flood preparedness and resilience is a crucial first step in coping with a flood event. The SWMP Strategic Flood Maps will allow parishes and local flood action groups to further develop their understanding of local flood risk issues and provide information for community flood risk summary sheets and flood plans.

At a higher level, the SWMP Strategic Flood Maps can be used by emergency responders and resilience teams (such as CSW Resilience) to:

- raise general awareness of surface water flood risk;
- understand where suitable / unsuitable locations are for emergency control centres, evacuation centres and safe evacuation routes;
- understand the potential flood threat to critical infrastructure and to take action to identify the consequence of failure of key sites; and
- Identify the locations of vulnerable sites and groups of vulnerable people such as schools and care homes.

7 Next Steps for the SWMP

7.1 Public Consultation and Finalisation of the Priority List

This SWMP Methodology Report was issued for public consultation between January and March 2015 as an Appendix of the Local Flood Risk Management Strategy. Following the consultation, feedback and comments were reviewed and actioned where appropriate to refine the methodology and technical approach. After which, the ranking of sites has been undertaken and discussed with project partners. From this short list, a priority list has been developed of sites at risk of flooding from surface water. This is now going out for further public consultation in September 2015. Once the Strategy has been adopted by the County Council, this list will used to develop measures and actions in each of the areas at risk of flooding in the next stage of the SWMP and an investment plan will be developed.

7.2 Identification of Partnership Opportunities

During the development of the investment plan, further engagement with other RMAs and stakeholders will take place to identify opportunities for potential partnership schemes and joint funding applications.

Environment Agency

The top ranked surface water flooding hotspots list has been cross referenced with the Environment Agency supplied data including the Main River flood risk GIS data and information from the "Communities at Risk"[9] dataset. A visual comparison of the Communities at Risk dataset has been undertaken against the top 40 location areas. Table 8.1 provides a summary of where there are correlations between the Communities at risk dataset and the top 40 locations. Note that the Communities at Risk dataset was developed as a desktop exercise at a regional level, whereas more detail relevant to Warwickshire and using local historic knowledge has contributed to the Warwickshire SWMP.

It is planned that this table (and supporting SWMP GIS outputs) are used to inform future discussions with the Environment Agency to discuss these locations and to cross reference with current and short, medium and long term action plans and investment strategies.

Table 8.1 – WCC SWMP Top 40 Sites and Environment Agency Communities at Risk Comparison

SWMP Top 40 Sites Rank	Place Name	Environment Agency Communities at Risk Data	
		Correlation with Possible Fluvial Risk	Correlation with Possible Surface Water Risk
1	SNITTERFIELD	✓	✓
2	SHIPSTON ON STOUR	✓	✓
3	KENILWORTH	✓	✓

[9] Midlands Communities at Risk 2013, Environment Agency Midlands, (April 2014)

SWMP Top 40 Sites Rank	Place Name	Environment Agency Communities at Risk Data	
		Correlation with Possible Fluvial Risk	Correlation with Possible Surface Water Risk
4	FENNY COMPTON	×	✓
5	WELFORD-UPON-AVON	✓	✓
6	GAYDON	×	✓
7	BEDWORTH	✓	✓
8	CLIFFORD CHAMBERS	✓	✓
9	ROYAL LEAMINGTON SPA	✓	✓
10	NUNEATON	✓	✓
11	WARWICK	✓	✓
12	ASTON CANTLOW	✓	✓
13	ALCESTER	✓	✓
14	COUGHTON	✓	✓
15	HENLEY IN ARDEN	✓	✓
16	GRENDON	×	✓
17	LAPWORTH	×	✓
18	CHERINGTON	✓	✓
19	LONG MARSTON	×	✓
20	LOWER/UPPER BRAILES	✓	✓
21	ROYAL LEAMINGTON SPA	✓	✓
22	LADBROKE	✓	✓
23	STRATFORD-UPON-AVON	✓	✓
24	NUNEATON CENTRE	✓	✓
25	WARWICK	✓	✓
26	MARTON	✓	✓
27	GALLEY COMMON	✓	✓
28	FILLONGLEY	×	✓
29	ARDENS GRAFTON	×	✓
30	STOCKTON	✓	✓
31	BERMUDA	✓	✓
32	STRATFORD-UPON-AVON	✓	✓
33	WHITACRE HEATH	✓	✓
34	KINGSWOOD	×	✓
35	GRENDON	×	✓
36	ROYAL LEAMINGTON SPA	✓	✓
37	EATHORPE	✓	✓
38	LAWFORD HEATH	×	×
39	FIVE WAYS	×	✓
40	LOWER/MIDDLE/UPPER TYSOE	×	✓

Severn Trent Water

Discussions have also been held with Severn Trent Water to discuss potential opportunities for partnership schemes to address higher priority combined surface water flooding / sewer flooding hotspot locations.

Like with the Environment Agency, it is envisaged that further discussions with Severn Trent Water will be held to assess the top 40 (and wider) sites from this SWMP study and cross-reference against their short, medium and long term action plans and key risk areas. It is envisaged that these stakeholder workshops will be held jointly with multiple RMAs to investigate and develop multi-stakeholder opportunities.

7.3 Action Plans and Investment Strategies

Action plans and investment strategies will be developed in a future study for the priority locations, with a subsequent consultation period to follow. At this stage, the following broad themes for action plans and flood risk mitigation have been identified.

- Stakeholder engagement:
  - between RMAs, Districts and Boroughs and Parish and Town Councils community groups; and
  - public engagement.
- Increase understanding of surface water flood risk:
  - improving the capture and documentation of existing flood risk history data; and
  - developing hydraulic models of critical sites;
- Identify potential surface water management measures including:
  - defining Critical Drainage Areas (CDAs) and associated policies;
  - developing SuDS policies;
  - localised SuDS schemes;
  - Water Sensitive Urban Design (WSUD) / Green Infrastructure solutions;
  - development control policies;
  - soft estate (grass verges etc.) maintenance standards; and
  - partnership schemes with other RMAs (such as improvements and disconnection of surface water drainage from the combined sewer network).

8 Conclusions

The county of Warwickshire has experienced a number of significant flood events in recent times, often with complex flooding interactions from multiple sources. Notable events include January 1992, Easter 1998, August 1999, June 2005, summer 2007, December 2008 and November 2012. Among the various responses to these events, AECOM were appointed by Warwickshire County Council (WCC) to undertake a Surface Water Management Plan (SWMP) and Investment Strategy.

The SWMP defined the following objectives.

1. Develop a robust understanding of surface water flood risk across the county of Warwickshire, including a prioritised list of locations at risk of flooding, taking into account the importance of both urban and rural communities, the challenges of population and demographic change and increasing pressures on urban fringes.
2. Develop holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments.
3. Establish new and consolidate existing partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities.
4. Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions.
5. Develop a robust Action Plan and guidance to deliver change where partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions.

An understanding of the different sources of flooding and receptors across Warwickshire was developed to ensure that a comprehensive understanding of flood risk was obtained. Flood history information was obtained from the following sources.

- Districts and Boroughs, and Parish and Town Councils and community groups.
- Stakeholders and organisations:
  - Environment Agency;
  - Severn Trent Water;
  - Network Rail; and
  - Canal and River Trust.

It was important to capture where surface water flooding has occurred in the past, but also to identify where surface water flooding may be more likely to occur in the future across

Warwickshire, and so predictive flood risk information was obtained from the Environment Agency's 'updated Flood Map for Surface Water' (uFMfSW).

The receptors and their associated flood risk vulnerability across Warwickshire were defined using the National Receptors Dataset (NRD), the National Planning Policy Framework (NPPF) and refined using project stakeholder knowledge.

A bespoke flood risk and receptor matrix was developed to understand which areas are receptors are at greater risk, or where there are greater consequences. Creating a series of metrics and thresholds, analysis was undertaken which allowed the scoring, weighting, comparison and ranking of sites, used to identify surface water flooding, historic and future 'hotspot' locations and develop a ranked output of sites for further investigation.

Draft outputs were tested through sensitivity analysis and have been discussed with project stakeholders. Feedback from these workshops was also combined with that from the public consultation (January to March 2015). Following refinements to the approach and matrix scoring, the top 40 rankings and thematic maps were developed for the following categories:

- Historic surface water flood risk;
- Predictive surface water flood risk; and
- Combined (Historic and Predictive) surface water flood risk.

The matrix has been developed to enable both historic and potential future flooding hotspot reporting. For this overall summary, a combined approach has been undertaken (combining both the historic and potential future flooding scores) for each OS tile or combination of OS tiles to provide a top 40 ranking. Note that large locations such as Leamington Spa will have a number of OS tiles at risk of surface water flooding from different sources - these are therefore ranked separately as different flooding locations. Large towns could therefore be named in the list more than once, but it is the specific area or community within the town which is being ranked.

The highest ranked locations will not necessarily have funded flood alleviation schemes. This stage of the SWMP is the risk assessment. The viability of flood alleviation schemes depends not only on the risk, but also on the nature of the flood risk and financial viability of a scheme relative to other areas in England and Wales (since it is necessary to compete with other locations to bid for funding from the national 'pot' of Flood Defence Grant in Aid available).

Subsequent stages of the SWMP process will investigate the top ranking sites further, including discussing with project partners and other Risk Management Authorities (RMAs) such as the Environment Agency and Severn Trent Water to identify areas of risk overlap and develop partnership schemes. Following stakeholder engagement a prioritised list will be developed with conceptual flood risk mitigation options, supporting action plans and investment strategies.

In addition to the project matrix and thematic maps, additional deliverables from this study have included SWMP Strategic Flood Maps which will allow WCC and other RMAs to visualise all of the historic flood risk information collated for this study, predictive flood risk and receptors. The project matrix, GIS workspace and interactive PDF is designed to be a living database and

should be regularly updated with new information to capture future flooding incidents, updated predictive mapping and details of flood risk management schemes.

Annex A: Data Register

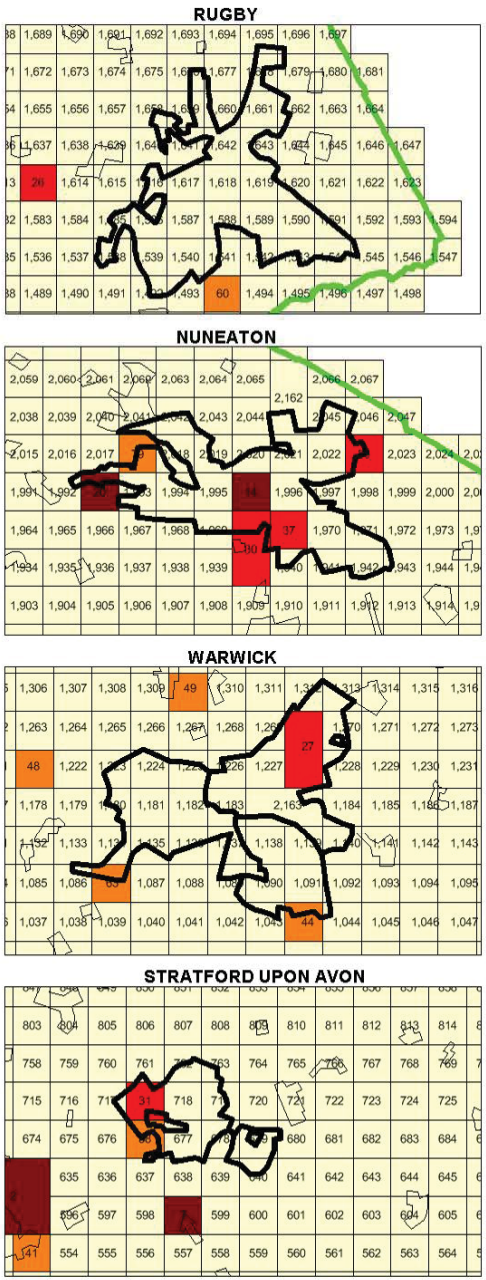
Project Name: Warwickshire Surface Water Management Plan
Project Number: 60319308

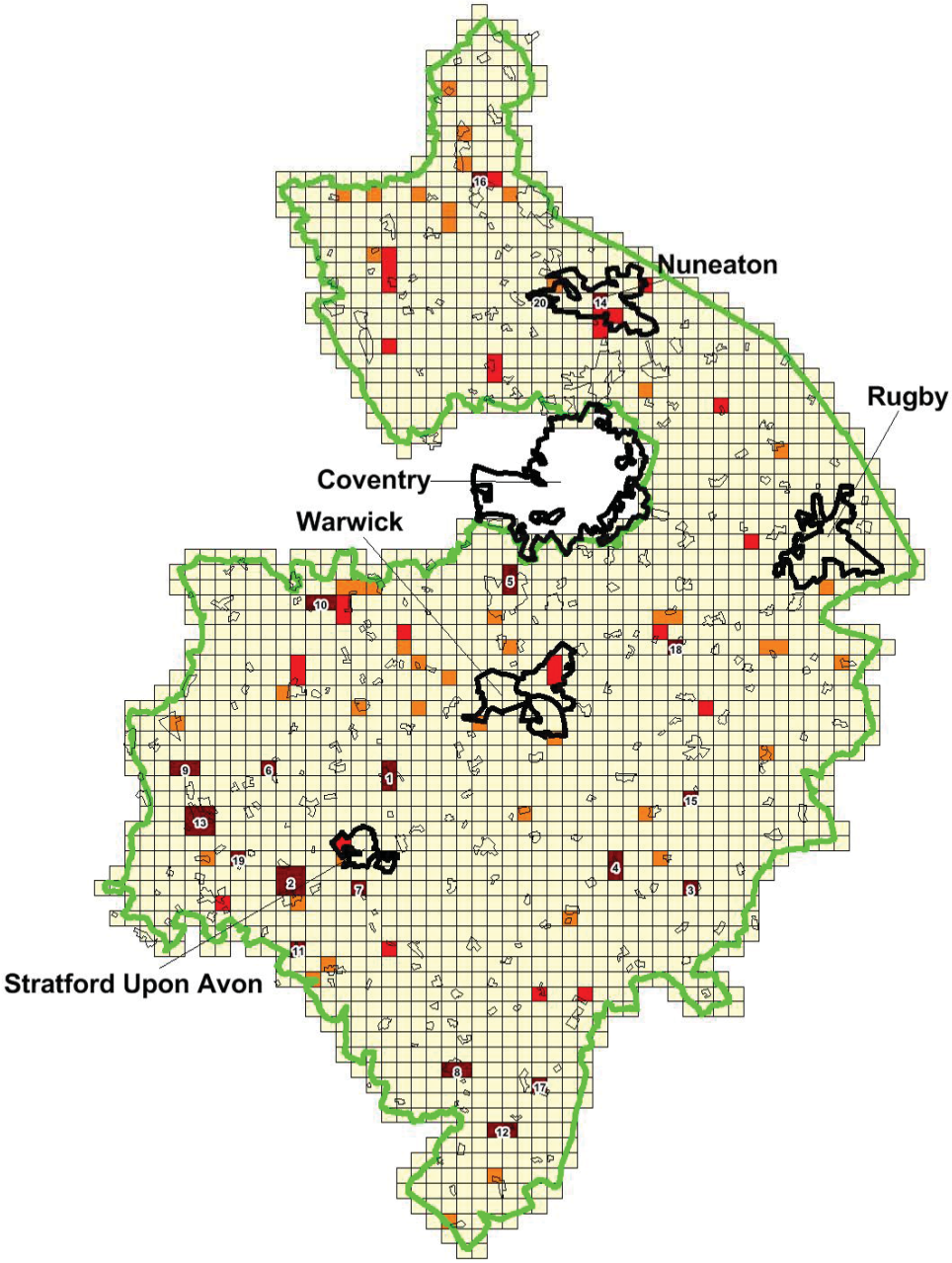
Updated 30/04/2015

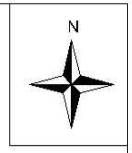
Dataset Description	Format	Source	Requested	Received (Traffic Light Status)	Notes	Date Received	Received From
Environment Agency							
Updated Flood Map for Surface Water (uFMfSW)	GIS	EA	✓	✓	Downloaded Extent. Depth, Velocity & Hazard from WCC Extent, Depth, Velocity & Hazard. Hard drive handed over on 10/07/14 Initial issue with Hazard data - WCC delivered w/c 01/09/14 - Now addressed.	10/07/2014	WCC and EA Geostore
Updated Flood Map for Surface Water (uFMfSW) - Property Counts	GIS	EA	✓	✓	Received from EA	24/07/2014	Michael Thomas
EA Communities at Risk Project data	GIS	EA	✓	✓	This project looked at EA fluvial, pluvial, historic flood data and property counts, and categorized and ranked communities at risk - resulting in an Action Plan. Met EA to learn more about database and to obtain the data	20/05/2014	Michael Thomas
EA Flood Zones	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
EA Standardised Modelling?	GIS	EA	✓	×	Not available for this area.	N/A	
Flood Alert / Warning Areas	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
Historic Flood Outlines	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
National Receptors Dataset	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
Detailed River Network	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
Areas to benefit from New & Reconditioned Flood Schemes	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
ASTGWF	GIS	EA	✓	✓	Tabfile and shapefile format	13/05/2014	EA Geostore
1m LiDAR data	GIS	EA	✓	✓	LiDAR format	13/05/2014	EA Geostore
Communities at Risk Data	GIS	EA	✓	✓	Have the full dataset	28/05/2014	Michael Thomas
Warwickshire County Council							
Properties in FZ2 and or at risk from Surface Water.	Email	WCC	✓	✓	Initial WCC Screening.	28/04/2014	Sacha Barnes
Schools & Landfill Sites CI Data	GIS	WCC	✓	✓	From Sophie Wynne	27/08/2014	Sophie Wynne
Critical Infrastructure Data: Fire Stations (Warwickshire) Police Stations (Warwickshire) A&E Hospitals (Midlands)	GIS	WCC	✓	✓	From Derek Tate (WCC GIS)	18/08/2014	Derek Tate
Public Engagement / Pathfinder Workshop Date List	Email	WCC	✓	✓	-	-	-
OS Mapping: MasterMap Data OS 10k Tiles	GIS	WCC	✓	✓	MasterMap and 10k Tiles MasterMap Data re-obtained on the 08/01/15 due to errors / missing data in original dataset.	03/06/2014	Sacha Barnes - via hard drive
Deprivation and Disadvantage Statistics	Web based	WCC	✓	Available online if needed	Will be used to select priority list from the top 40.	17/04/2014	Paul Rimen
Groundwater Flood Risk Map of England & Wales from ESI.	GIS	WCC	✓	✓	Received 01/08/14	01/08/2014	Jagjit Mahal
Warwickshire County Highways 2007 Flood Incidents	GIS	WCC	✓	✓	Points on paper maps - digitised into MapInfo.	24/04/2014	Sacha Barnes
WCC historic records of flooding	Excel	WCC	✓	✓	Not all of it is geo-referenced. Based on data from PFRA Jan 1992, Easter 1998, Aug 1999, June 2005, June/July 2007, December 2008 (not geo-referenced) Only data from 2012 is geo-referenced / has an address.	24/04/2014	Sacha Barnes
WCC initial screening GIS layer (based on EA Flood Zones and FMFSW Mapping) - including property count data	MapInfo Tab Files	WCC	✓	✓	Based on properties in Flood Zone 2 and / or at risk of flooding from the 1 in 200 year Surface Water Flood Event	24/04/2014	Sacha Barnes
National Land and Property Gazetteer	GIS	WCC	✓	✓	-	03/06/2014	Sacha Barnes - via hard drive
SHLAA data, ELR, Strategic Housing Sites, Strategic Employment Sites & other growth points	GIS	WCC	✓	✓	Received all available data at time of this commission.	03/06/2014	Sacha Barnes - via hard drive
PFRA data - Reports and Spreadsheets	Mixed	WCC	✓	✓	PFRA Data - Reports on Significant Floods: Jan 1992, Easter 1998, Aug 1999, June 2005, June/July 2007, December 2008	28/04/2014	Sacha Barnes
Warwickshire Multiagency Flood Plan	Report	WCC	✓	✓	-	28/04/2014	From Sophie Wynne
Warwickshire SFRA data	Mixed	WCC	✓	✓	-	Project Inception and Various Dates - downloaded from WCC website	WCC
Pathfinder - Flood History Data -All collected	GIS	AECOM / WCC facilitated workshops	✓	✓	Data collected and digitised.	Various Dates.	-
Feedback on Hotspots - Collected as part of Key Partner Stakeholder Engagement Workshops	GIS	AECOM / WCC facilitated workshops	✓	✓	Meeting held on the 27/11/15 with WCC, EA, STW and Districts.	27/11/2015	-
North Warwickshire Proposed priority areas for Defra Flood Resilience Community Pathfinder February 2013	Text & Web links	WCC	✓	✓	Data came via Robert Beggs from North Warwickshire Borough Council	16/05/2014	Robert Beggs
NRD Meta Data?	GIS	WCC	✓	✓	Issues opening this - re:requested. Received on 10/07/14 - Checked. OK	10/07/2014	From Sophie Wynne
SFRA Data PFRA Data Historic Flooding Data	GIS	WCC	✓	✓	Provided at meeting on the 08-10-14	08/10/2014	Michael Green
Supplementary Flood History Data / List of ongoing flood investigations. These have been split into the North and South	Excel	WCC	✓	✓	Sent as two Excel files. Jag notes that: "For some of the locations that are yet to be investigations (particularly in RBC), the given co-ordinates are only in the general area as detailed information has yet to be gathered."	Jag: 22-10-14 Paul: 14-10-14	North provided by Paul Rimen, South provided by Jagjit Mahal
Flood Map for Surface Water	GIS	WCC	✓	✓	Issued on Memory Stick	04/11/2014	Sophie Wynne
LEP DATA	GIS	WCC	✓	✓	Issued on Memory Stick	04/11/2014	Sophie Wynne
Annex 6 of the attached a definition of 'critical services' used in the PFRA guidance	PDF	WCC	✓	✓	Sent by Michael Green to assist with Critical Infrastructure definition.	10/11/2014	Michael Green
Additional Pathfinder Questionnaire Flood History Info	Digitised Paper Copies	WCC	✓	✓	Sent by Sophie Wynne following WCC Flood Summit Meeting	17/10/2014	Sophie Wynne

Received additional information from Paul Rimen and Jag Mahal regarding the locations flood risk management schemes and numbers of properties benefitting from defences	Excel	WCC	✓	✓	Sent by Paul and Jag on the 17th April 2015	17/04/2015	Paul Rimen and Jag Mahal
Districts & Boroughs							
North Warwickshire BC Priority Areas	Word	NWBC	✓	✓	-	16/05/2014	Robert Beggs
Stratford District Council	Word	SDC	✓	✓	Word Doc	14/05/2014	Geoff Turton
Warwick District Flood Incident GIS Locations	GIS	WDC	✓	✓	GIS File - Info very limited though. B = Highway flood locations (impassable at certain times). Y = Areas of flooded properties where flooding has occurred over a number of years.	28/04/2014	Sacha Barnes
Nuneaton & Bedworth	GIS	NBBC	✓	✓	SHLAA, ELR, Strategic Housing Sites, Strategic Employment Sites.	15/07/2014	Simon Daly
Warwick District Council - SHLAA & Local Plan GIS	GIS	WDC	✓	✓	SHLAA data and: a. Employment Allocations b. Housing Allocations c. Major Education Allocations d. Major Employment Commitments e. Major Housing Commitments f. Sub Regional Employment Allocation	08/08/2014	Daniel Robinson
North Warwickshire Borough Council	GIS & Web Links	NWBC	✓	✓	SHLAA data, employment data, priority sites & **WEBLINKS**	08/08/2014	Mike Dittman
Stratford District Council	Web Links	STD	✓	✓	SHLAA data - Paul Harris from SDC stated that the SHLAA data was too numerous and most wasn't relevant so he sent a number of useful links instead.	12/08/2014	Paul Harris
Rugby Borough Council	GIS	RBC	✓	✓	SHLAA data	07/08/2014	Lizzie Betesford
CSW Resilience							
Critical Receptors	Telephone Discussion and Emails	CSW	✓	✓	Engaged with Jacob Forgham - need to discuss with team and MG for useful criteria. Obtained Critical Infrastructure Data from Derek Tate of WCC. CSW Resilience supplied COMAH sites and Prisons locations.	11/08/2014	Jacob Forgham
Severn Trent Water							
Numerous Datasets: Return Period Analysis (RPA) data Flooding Register for Warwickshire Flooding Other Causes dataset.	Multi format Data	Severn Trent Water	✓	✓	Engaged with Paul Petherick and Tim Smith. Tim Smith would like to meet team and Michael. Discuss with Michael at meeting on 29th. Meeting on 10/07/14 - Tim Smith to send the following data through: DG5 GIS data Return Period Analysis data Flooding other causes data Asset data (critical infrastructure sensitive to flood risk) List of current schemes Amp 5 map showing previous schemes Amp 6 potential schemes	24/11/2014	Tim Smith at Severn Trent Water.
Canal & River Trust							
Overtoppings and Breaches data	GIS Shapefiles	CRT	✓	✓	Overtopping and Breach GIS data - plus anecdotal info on surface water problem areas.	04/06/2014	Mike Clayton
Additional Data That May Be Useful:							
Flood incidents / reports from NFU	N/A	NFU	✓	N/A	Engaged with Sarah Fulkner . Discussed approach for liaison with MG at WCC. Decided to consult on Hotspots when creating priority list from top 40 sites.	-	-
Flood incidents / reports from Network Rail	Excel table	Network Rail	✓	✓	Engaged with Steven Raj - NOW RECEIVED	22/07/2014	Raj Steven

Annex B: SWMP Thematic Maps







RANKINGS TABLE

Top Twenty Ranking

Rank	Tile Ref	Score	Place Name
1	SP2159	3.83	SNITTERFIELD
2	SP1452	2.16	WELFORD-UPON-AVON
3	SP4152	2.09	FENNY COMPTON
4	SP3653	1.98	GAYDON
5	SP2972	1.92	KENILWORTH
6	SP1360	1.71	ASTON CANTLOW
7	SP1952	1.67	CLIFFORD CHAMBERS
8	SP2540	1.66	SHIPSTON ON STOUR
9	SP0760	1.57	COUGHTON
10	SP1671	1.50	LAPWORTH
11	SP1548	1.38	LONG MARSTON
12	SP2836	1.38	CHERINGTON
13	SP0856	1.28	ALCESTER
14	SP3591	1.25	NUNEATON
15	SP4158	1.23	LADBROKE
16	SP2799	1.11	GRENDON
17	SP3139	1.09	LOWER/UPPER BRAILES
18	SP4068	1.06	MARTON
19	SP1154	1.00	ARDENS GRAFTON
20	SP3191	0.88	NUNEATON

Key:

Total Historic: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 83
- Rank 83 to 2200

Note Only 82 cells contain Historic information with current weigthings

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL HISTORIC SCORE 1 IN 100 YEAR EXTENT RANKINGS

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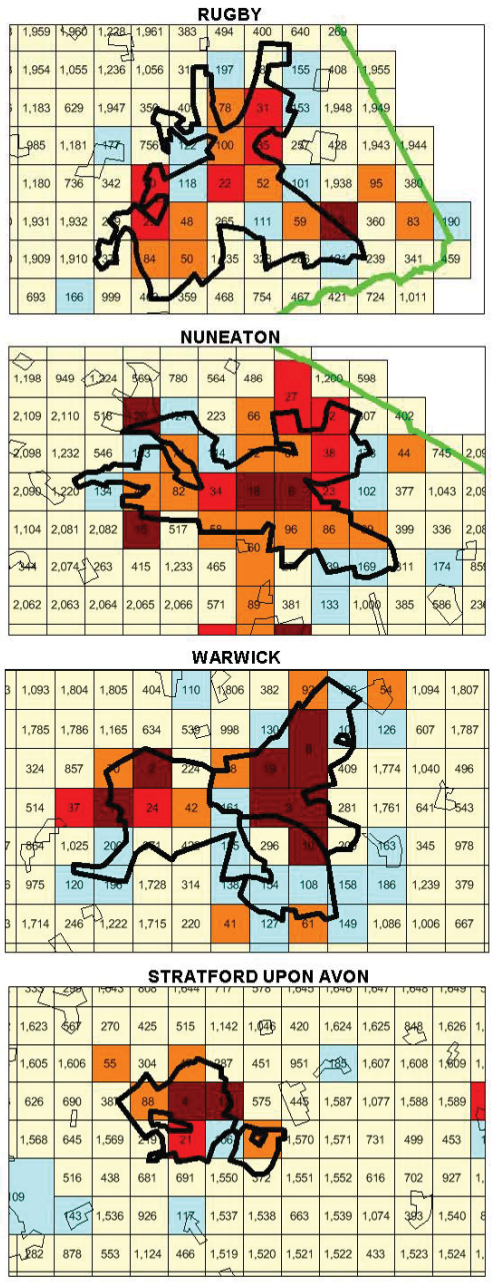

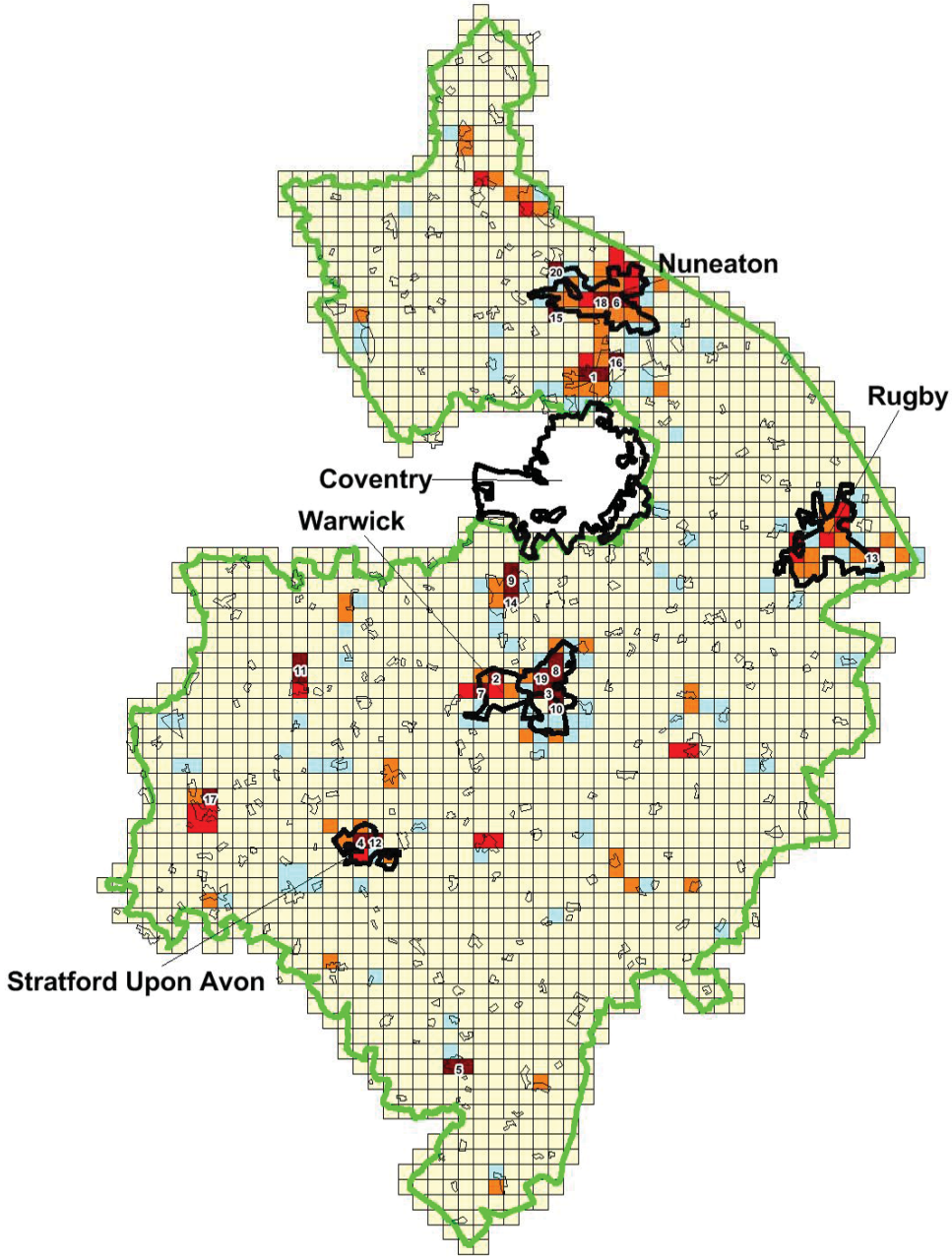

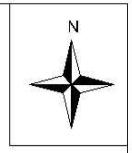

RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP3486	16.88	BEDWORTH
2	SP2866	15.61	WARWICK
3	SP3165	11.76	ROYAL LEAMINGTON SPA
4	SP1955	11.24	STRATFORD-UPON-AVON
5	SP2540	10.21	SHIPSTON ON STOUR
6	SP3691	10.10	NUNEATON CENTRE
7	SP2765	9.50	WARWICK
8	SP3266	9.41	ROYAL LEAMINGTON SPA
9	SP2972	7.50	KENILWORTH
10	SP3264	7.03	ROYAL LEAMINGTON SPA
11	SP1566	6.69	HENLEY IN ARDEN
12	SP2055	6.31	STRATFORD-UPON-AVON
13	SP5374	6.08	RUGBY
14	SP2971	5.70	KENILWORTH
15	SP3290	5.36	NUNEATON
16	SP3687	5.15	BEDWORTH
17	SP0358	4.87	ALCESTER
18	SP3591	4.82	NUNEATON
19	SP3166	4.75	ROYAL LEAMINGTON SPA
20	SP3293	4.63	NUNEATON

Key:

Total Predicted: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 100
- Rank 101 to 200
- Rank 201 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL PREDICTED SCORE 1 IN 100 YEAR EXTENT RANKINGS

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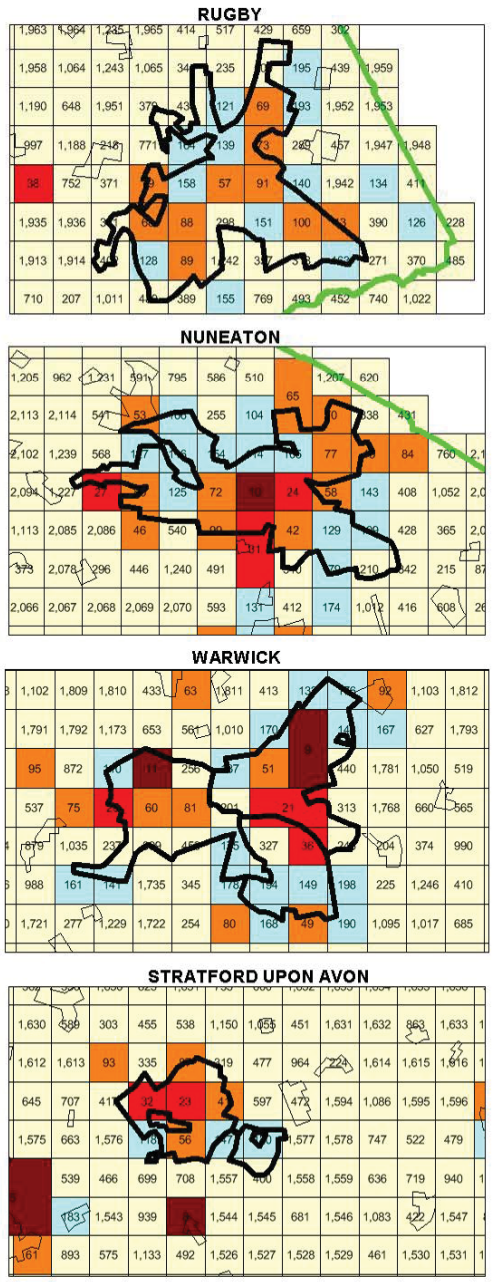

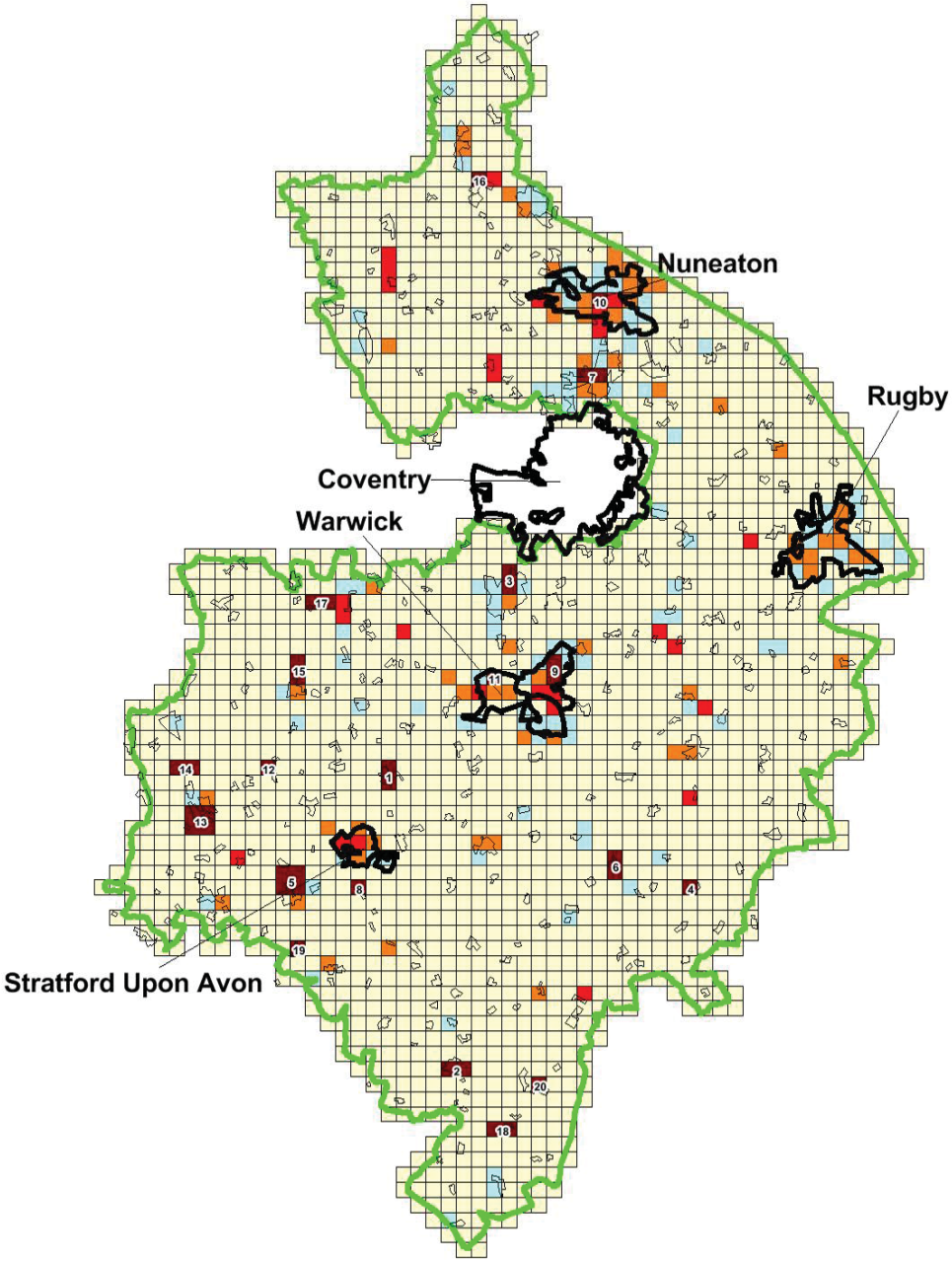

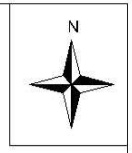

RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP2159	21.16	SNITTERFIELD
2	SP2540	14.73	SHIPSTON ON STOUR
3	SP2372	14.46	KENILWORTH
4	SP4152	12.60	FENNY COMPTON
5	SP1452	12.23	WELFORD-UPON_AVON
6	SP3653	11.57	GAYDON
7	SP3486	10.00	BEDWORTH
8	SP1952	9.63	CLIFFORD CHAMBERS
9	SP3266	9.49	ROYAL LEAMINGTON SPA
10	SP3591	9.38	NUNEATON
11	SP2866	9.25	WARWICK
12	SP1360	9.16	ASTON CANTLOW
13	SP0856	9.03	ALCESTER
14	SP0760	8.83	COUGHTON
15	SP1566	8.39	HENLEY IN ARDEN
16	SP2799	7.88	GRENDON
17	SP1671	7.83	LAPWORTH
18	SP2836	7.70	CHERINGTON
19	SP1548	7.55	LONG MARSTON
20	SP3139	7.07	LOWER/UPPER BRAILES

Key:

Total Combined: Rankings

- Rank 1 to 20
- Rank 21 to 40
- Rank 41 to 100
- Rank 101 to 200
- Rank 201 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: TOTAL COMBINED SCORE 1 IN 100 YEAR EXTENT RANKINGS

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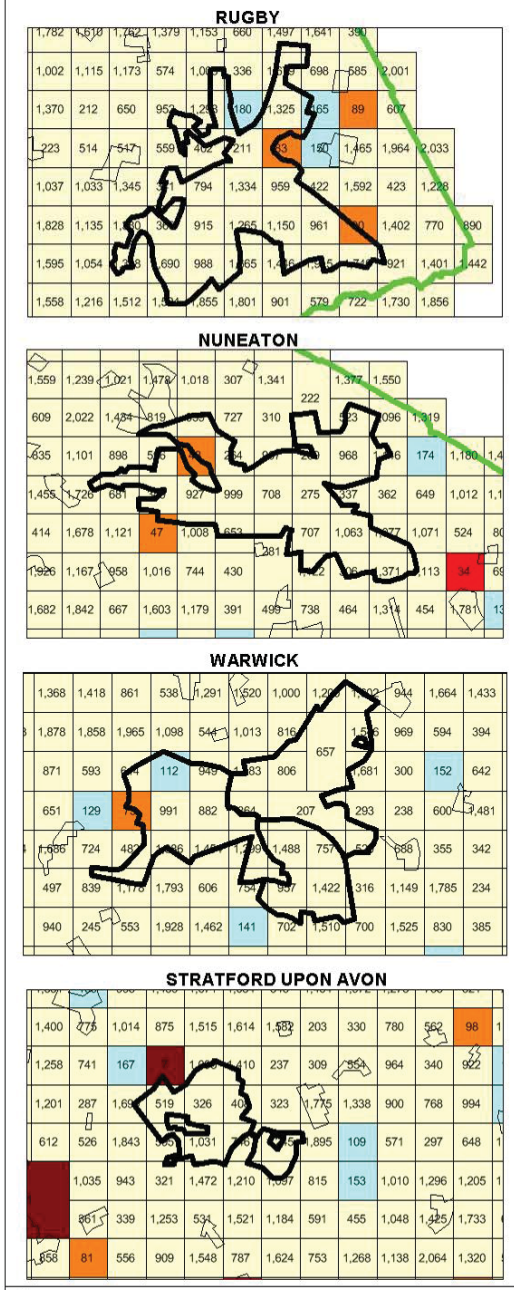

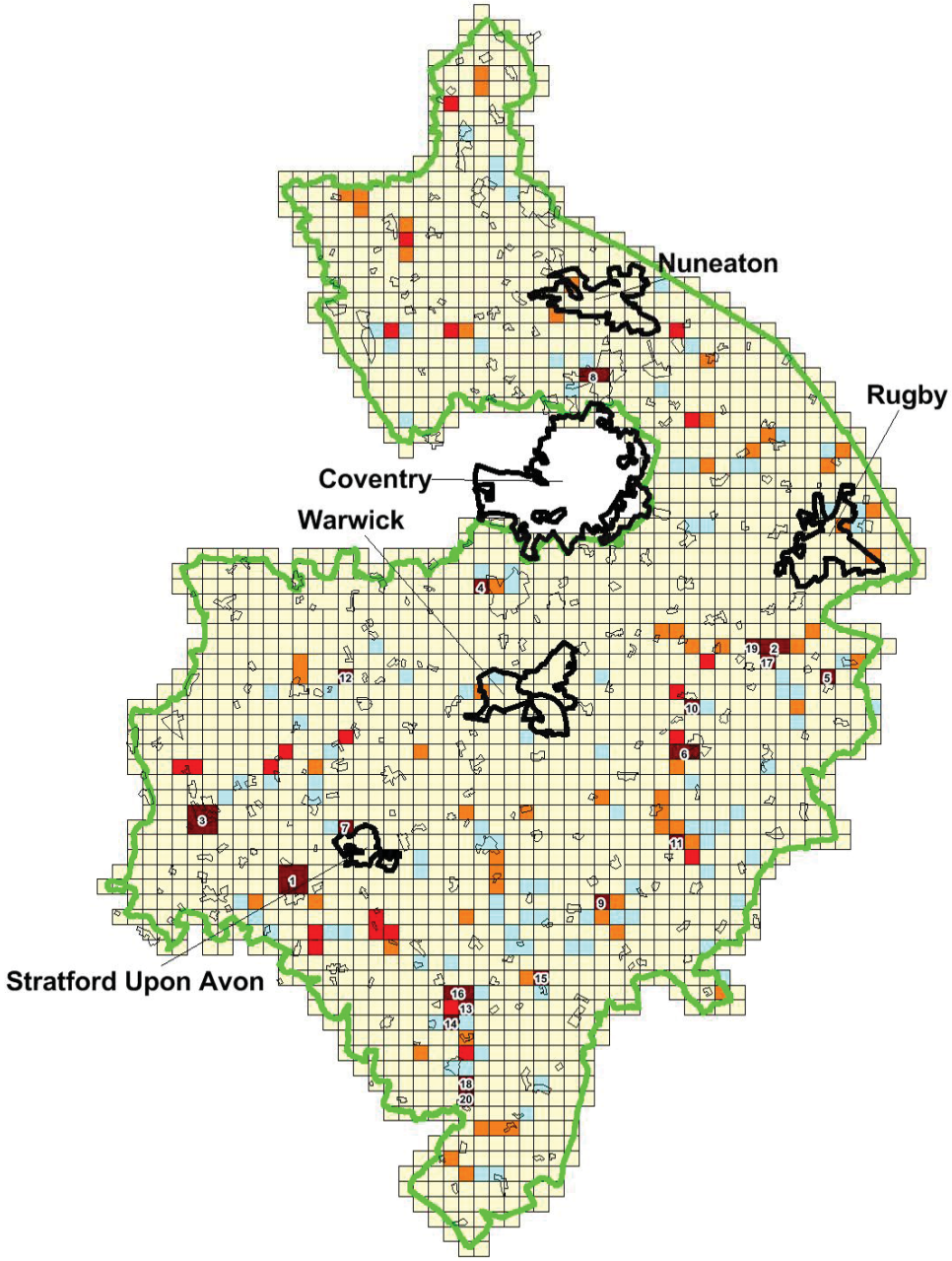

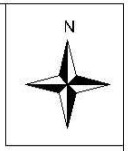

RANKINGS TABLE

Top Twenty Ranking			
Rank	Tile Ref	Score	Place Name
1	SP1452	1.00	WELFORD-UPON-AVON
2	SP4668	0.79	KITES HARDWICK
3	SP0856	0.74	ALCESTER
4	SP2772	0.74	KENILWORTH
5	SP5066	0.74	SAWBRIDGE
6	SP4061	0.71	SOUTHAM
7	SP1856	0.67	STRATFORD-UPON-AVON
8	SP3486	0.63	BEDWORTH
9	SP3551	0.62	RURAL
10	SP4164	0.59	LONG ITCHINGTON
11	SP4055	0.56	RURAL
12	SP1866	0.56	RURAL
13	SP2644	0.52	RURAL
14	SP2543	0.51	TREDINGTON
15	SP3146	0.50	OXHILL
16	SP2545	0.48	HALFORD
17	SP4667	0.48	KITES HARDWICK
18	SP2639	0.48	RURAL
19	SP4568	0.47	RURAL
20	SP2638	0.47	BURMINGTON

Key:

Hazard: Rankings

- Rank 0 to 20
- Rank 20 to 40
- Rank 40 to 100
- Rank 100 to 200
- Rank 200 to 2200

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: HAZARD SCORE
1 IN 100 YEAR EXTENT
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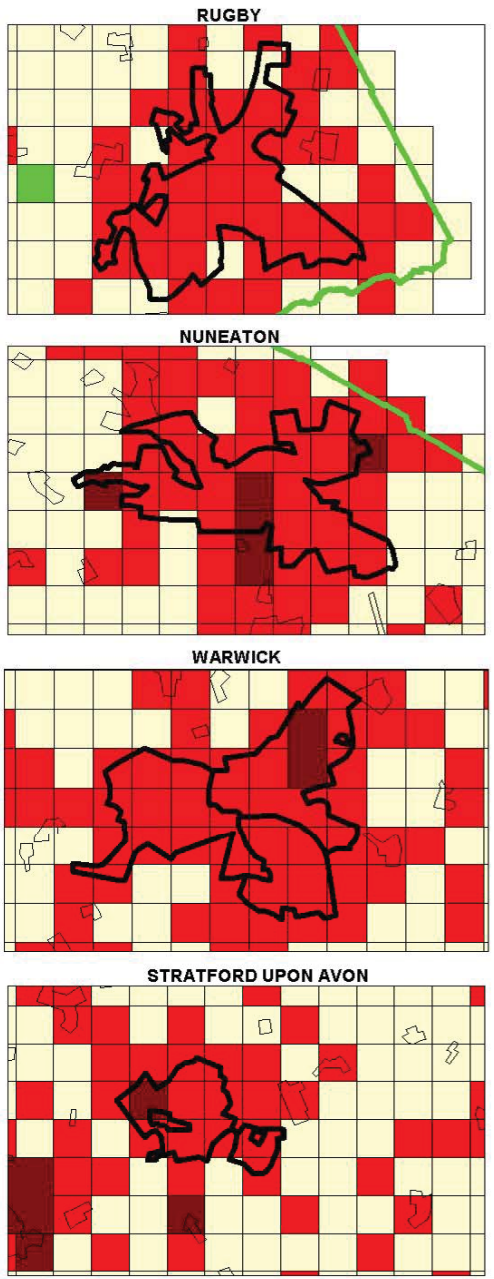

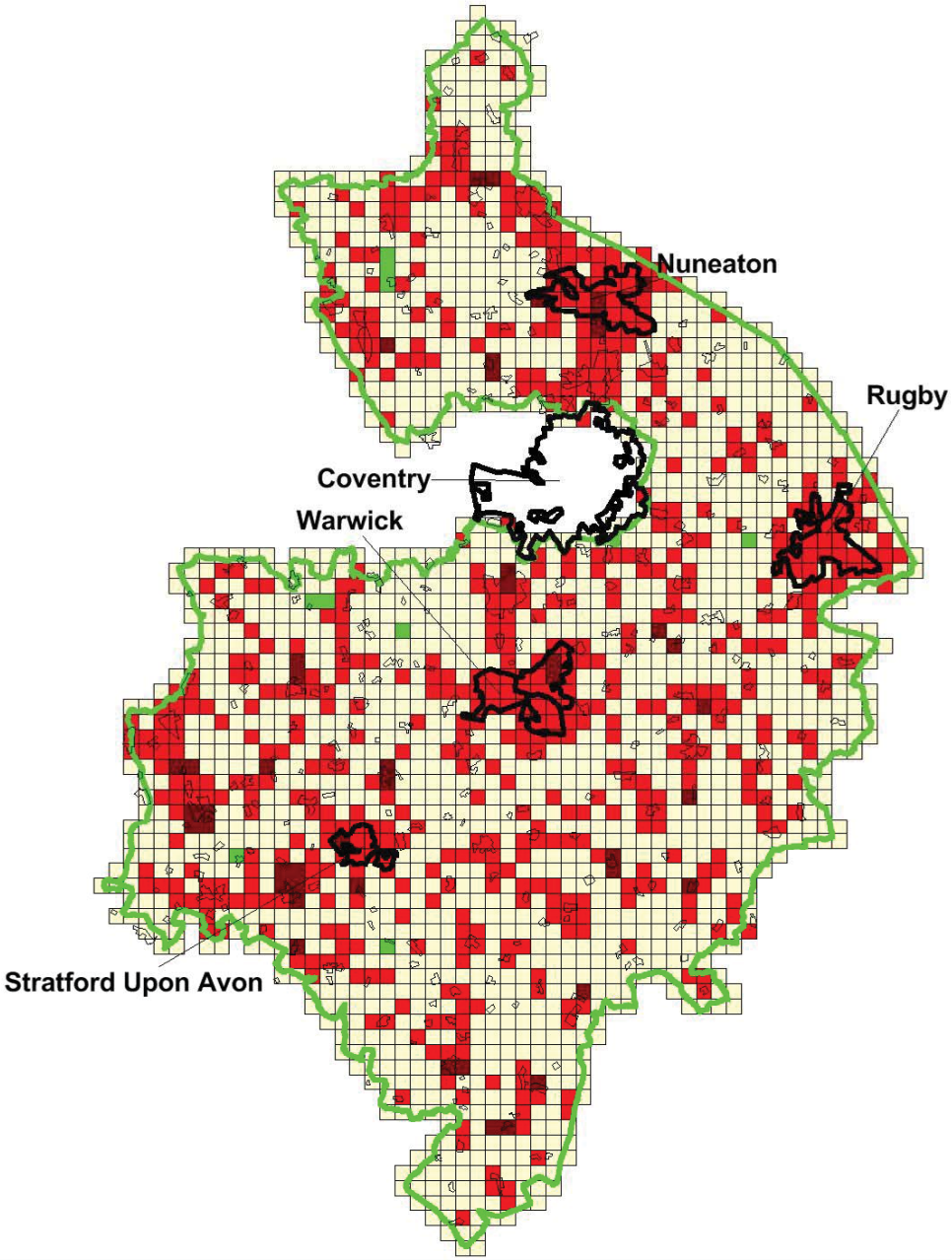

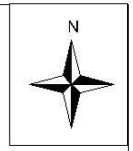

Key:

Hotspots

- Historic and Predicted Hotspot
- Predicted Hotspot Only
- Historic Hotspot Only
- Not met Hotspot Trigger

Client: Warwickshire County Council

Project: SURFACE WATER MANAGEMENT PLAN

Title: HOTSPOT MAPPING
1 IN 100 YEAR EXTENT

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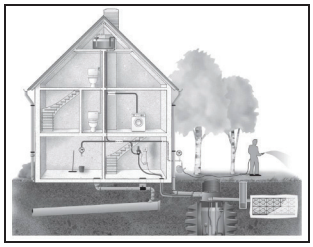
Annex C: Sustainable Drainage Systems (SuDS)

SuDS Type	Photo
Source Control	
Green Roofs Green roofs comprise a multilayered system that covers the roof (or walls) of a building with vegetation over a drainage layer. Green roofs are suitable for most developments.	
Rainwater Harvesting Rainwater harvesting is the collection and storage of rainwater from roofs and other hard surfaces. Rainwater harvesting systems can be used for residential, commercial and industrial developments.	
Water Butts Water butts are a common means of harvesting rainwater for garden use via an inlet connected to roof downpipes. Water butts are best suited to low and medium residential development where the catchment area is limited to the property and ancillary building roof area.	
Permeable Pavements Permeable pavements allow rainwater to infiltrate through the surface and into under-layers where it is temporarily stored before infiltrating into the ground, or released to a watercourse or drainage system. Permeable pavements can be used for a wide variety of developments.	
Soakaways Soakaways store rapid runoff from a single development and allow it to infiltrate into the surrounding soil. Soakaways are not suitable where there is a risk of contamination, where there are unstable ground conditions and where there are poor draining soils. Field investigations are required to determine infiltration rates.	
Site Control	
Filter Strips Filter strips are vegetated strips of land designed to accept runoff and allow it to infiltrate or be filtered by vegetation before being received by a stream or surface water collection system. Filter strips are considered to have a large land requirement, and are not suitable for significant attenuation or if there is risk of ground contamination.	

SuDS Type	Photo
Trenches Trenches are shallow excavations filled with rubble, stone or other void media that create temporary subsurface storage for runoff. There are two types of trenches; filtration trenches are used where soils are impermeable or where the groundwater is vulnerable to pollution and infiltration trenches filter runoff through the stone media and infiltrate it into permeable soils.	
Swales Swales are linear vegetated drainage systems where surface water can be stored to allow infiltration, and/or conveyed to other SuDS components, a stream or river. This type of SuDS design can be used in a wide variety of situations where catchments have small impermeable areas.	
Bioretention Bioretention areas, filters or rain gardens are shallow landscaped depressions designed to capture, filter and treat surface water. Bioretention areas are suitable for various development types including residential plots, car parks, along highways and roads, commercial, and industrial sites and can be retrofitted into existing developments and used where the groundwater is vulnerable.	
Geocellular / Modular Systems Geocellular systems are high void structures which are below ground and used to infiltrate or store runoff before it is discharged to a downstream drainage system. They can be used for a variety of development types including residential, commercial and industrial developments. This type of system can be used where there are contaminated sites.	
Regional Control	
Infiltrations Basins Infiltration basins are vegetated depressions that store runoff for infiltration into the subsurface soil. The suitability of a site must be confirmed by geotechnical investigations.	
Detention Basins Detention basins are dry basins which temporarily store runoff by use of a controlled release which attenuates flow. Detention basins are suitable for use on at a variety of development types including residential, commercial, industrial, contaminated sites and where there is high density infrastructure.	

SuDS Type	Photo
Ponds Ponds are basins which have a permanent pool of water. Ponds can generally be used for most types of developments and redevelopments for both residential and non residential areas.	
Wetlands Wetlands are constructed shallow marsh systems covered almost entirely by aquatic vegetation. Wetlands are suitable for residential, commercial and industrial developments.	

With a variety of SuDs techniques that can be considered for a new development, Table 8.3 outlines the capability of different SuDS techniques and their suitability in terms of providing environmental and water quality benefits. SuDS should be considered on a site-by-site basis to facilitate their effective implementation. Guidance on the planning, design, construction, operation and maintenance of SuDS is detailed in CIRIA's SuDS Manual.

Capability of different SUDS techniques (Extract from CIRIA C697, Table 1.7)

Technique	Description	Management Train Suitability						Water Quantity				Water Quality								Environmental Benefits		
		Prevention	Conveyance	Pre-treatment	Source control	Site Control	Regional Control	Conveyance	Detention	Infiltration	Water Harvesting	Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Water butts, site layout and management	Good housekeeping and design practices.	■	▲		■			▲	▲	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Pervious pavement	Allow infiltration of rainwater into underlying construction/soil.	■			■	▲			■	■	▲	■	■	■	■	■				▲	▲	▲
Filter drain	Linear drains/ trenches filled with a permeable, often with a perforated pipe at the base of the trench.		■		■	▲		■	■				■	■	■	■						
Filter strips	Vegetated strips of gently sloping ground designed to drain water from impermeable areas and filter out silt and other particulates.			■	■			▲	▲	▲		■	■	■	■					▲	▲	▲
Swales	Shallow vegetated channels that conduct and/or retain water (and can permit infiltration when underlined). The vegetation filters particulates.		■		■	■		■	■	▲		■	■	■	■			▲		▲	▲	▲
Ponds	Depressions used for storing and treating water. They have a permanent pool and bankside emergent and aquatic vegetation.					■	■		■	▲	■	■	■	■	■	■	■	■	■	■	■	■
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds.		▲			■	■	▲	■	▲	■	■	■	■	■	■	■	■	■	■	■	■
Detention Basin	Dry depressions designed to store water for a specified retention time.					■	■		■			■	▲	▲	■			■		▲	▲	▲
Soakaways	Sub-surface structures that store and dispose of water via infiltration.				■					■			■	■	■							
Infiltration Trenches	As filter drains, but allowing infiltration through trench base and sides.		▲		■	■		▲	■	■			■	■	■	■						
Infiltration basins	Depressions that store and dispose of water via infiltration.					■	■		■	■			■	■	■	■				▲	▲	▲
Green roofs	Vegetated roofs that reduce runoff volume and rate.	■		■	■				■				■	■	■	■	■	■	■	■	■	■
Bioretention areas	Vegetated areas for collecting and treating water before discharge downstream, or to the ground via infiltration.				■	■			■	■		■	■	■	■	■	■	■	■	■	■	■
Sand filters	Treatment devices using sand beds as filter media.			■		■	▲		■	▲			■	■	■	■	■					
Silt removal devices	Manhole and/or proprietary devices to remove silt.			■								■										
Pipes, subsurface storage	Conduits and their accessories as conveyance measures and/or storage. Water quality can be targeted using sedimentation and filter media.		■			■		■	■			▲	▲	▲								

Key	
■	Recommended
▲	Some opportunities, subject to design