Wiltshire Council

Surface Water Management Plan – Focussed on Chippenham, Trowbridge and Salisbury

Phase I & II - Final Report

November 2011

Prepared for

Wiltshire Council

Where everybody matters

Revision Schedule

Surface Water Management Plan: Phase I & II
November 2011
Final Report

Rev	Date	Details	Prepared by	Reviewed by	Approved by
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Table of Contents

Abbreviations

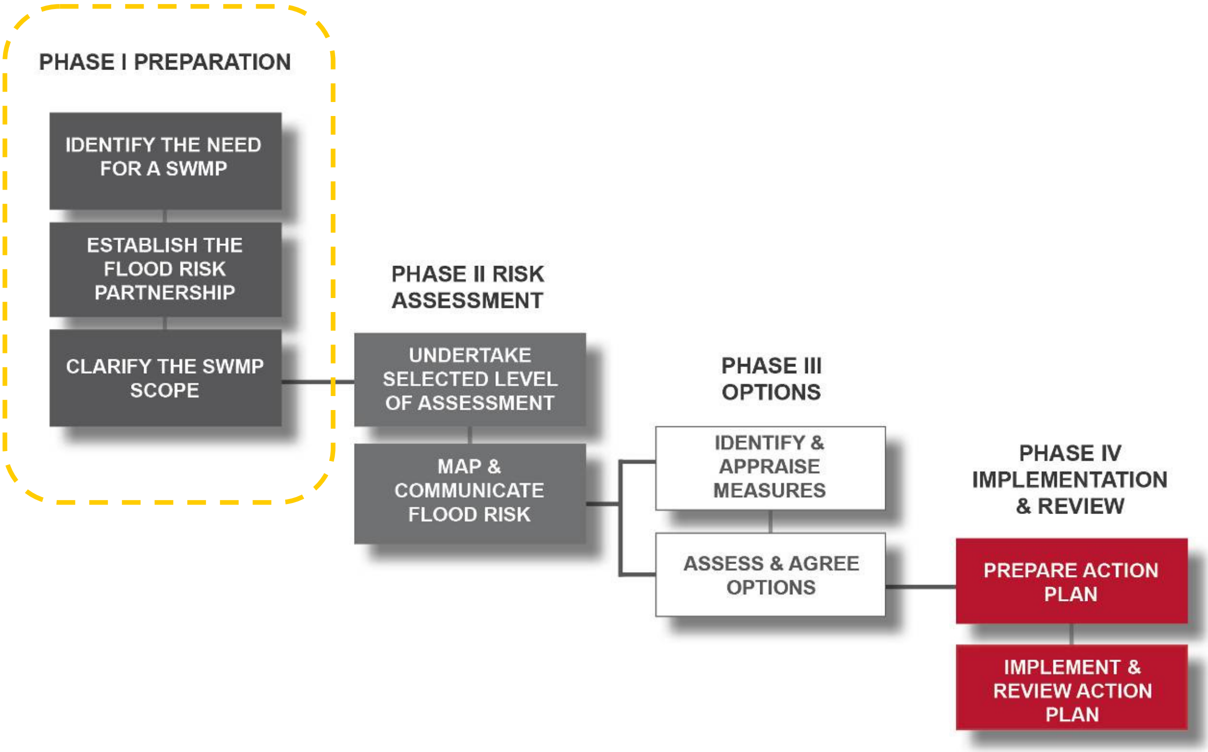
ACRONYM	DEFINITION
AStGWF	Areas Susceptible to Groundwater Flooding
BGS	British Geological Survey
CDA	Critical Drainage Area
CIRIA	Construction Industry Research and Information Association
CFMP	Catchment Flood Management Plan
CLG	Government Department for Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
EA	Environment Agency
IUD	Integrated Urban Drainage
LDF	Local Development Framework
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
LRF	Local Resilience Forum
PPS25	Planning and Policy Statement 25: Development and Flood Risk
RBMP	River Basin Management Plan
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Glossary

TERM	DEFINITION
Aquiclude	Formations that may be sufficiently porous to hold water, but do not allow water to move through them.
Aquifer	Layers of rock sufficiently porous to hold water and permeable enough to allow water to flow through them in quantities that are suitable for water supply.
Aquitard	Formations that permit water to move through them, but at much lower rates than through the adjoining aquifers.
Asset Management Plan	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding.
Critical Drainage Area	Areas of significant flood risk, characterised by the amount of surface runoff that drains into the area, the topography and hydraulic conditions of the pathway (e.g. sewer, river system), and the receptors (people, properties and infrastructure) that may be affected.
Culvert	A channel or pipe that carries water below the level of the ground.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic incapacity within the sewer system. DG5As are properties that have flooded twice in ten years, DG5Bs are properties that have flooded once in 5 years and DG5Cs are properties that have flooded during a severe event between 10 and 20 years.
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floods and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial flooding	Flooding from a river or a watercourse.
Groundwater	Water that is underground. For the purposes of this study, it refers to water in the saturated zone below the water table.
Interfluve	A ridge or area of land dividing two river valleys.
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Rate Support Grant	Funding mechanism from CLG to Local Authorities which provides funding for all Local Authority responsibilities.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood

	occurring, and the consequence of the flood.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.

PHASE I: PREPARATION



1 Identify the need for a SWMP

1.1 Introduction

The principal output from a Surface Water Management Plan (SWMP) is an outline of the preferred strategy for the coordinated management of surface water flood risk within a given location[1]. In this instance, several key locations within the administrative area of Wiltshire Council have been identified as the focus of the SWMP. In the context of the SWMP, surface water flooding incorporates flooding from sewers, drains, groundwater, and runoff from land, small ordinary water courses and ditches occurring as a result of heavy rainfall.

The SWMP Technical Guidance issued by Defra in March 2010 emphasises that SWMPs may not be required in all locations. Studies should be prioritised in areas considered to be at greatest risk of surface water flooding or where partnership working is essential to both understand and subsequently address surface water flooding issues.

The remainder of this chapter provides an overview of the rationale behind the preparation of a SWMP for Wiltshire Council; the history of surface water flooding; the complexity of flooding mechanisms due to drainage system interactions; the fragmented nature of asset management; proposed future urbanisation and redevelopment; and the impacts of existing and emerging policy and legislation.

1.2 History of Surface Water Flooding

According to national research undertaken by Defra[2,] Wiltshire has a significant number of settlements that are susceptible to surface water flooding with up to 16,000 properties estimated to be at risk across the administrative area.

Strategic Flood Risk Assessments were previously undertaken for the individual Local Planning Authorities (LPAs) prior to the amalgamation into the single unitary authority of Wiltshire Council. These documents and subsequent updates[3] identify historical flood incidents including surface water, groundwater and sewer flooding. Surface water and sewer flooding is typically experienced when intense rainfall exceeds the capacity of the existing drainage systems and leads to overland flow and ponding of surface water in low lying areas. Examples of drainage systems being overwhelmed have been identified in several locations across the area in 2006, 2007 and 2008, most notably in Chippenham.

Furthermore, as part of the ongoing work of the Operational Flood Working Groups, smaller settlements have been identified as at risk of flooding from a range of sources and from issues such as gullies easily becoming blocked or a lack of capacity during intense rainfall events.

Under UKCP09, predictions for future rainfall in the South West indicate that whilst annual mean precipitation is unlikely to change, winter mean precipitation and summer mean precipitation are likely to increase and decrease respectively. The projected increase in heavier winter precipitation is likely to increase the risk of exceedance of the urban drainage system and therefore surface water flooding is likely to increase into the future unless steps are taken to manage and mitigate this form of flooding. Table 1-1 provides projected changes based on the 'high emissions' scenario[4].

[1] Defra (March 2010) Surface Water Management Plan Technical Guidance www.defra.gov.uk
[2] National Rank Order of Settlements Susceptible to Surface Water Flooding, Defra 2009
[3] SFRAs can be found at: http://www.wiltshire.gov.uk/environmentandplanning/planninganddevelopment/planningpolicy/planningpolicyevidencebase/strategicfloodriskassessment.htm
[4] Further information can be found at: http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=163

Table 1-1: UKCP09 Projections for South West England (High Emissions Scenario)

Climatic Variable	Year	Projected Change (compared to 1961-1990 baseline under high emissions scenario)		
		10% (very unlikely to be less than)	50% (central estimate)	90% (very unlikely to be greater than)
Annual Mean Precipitation	2020s	-5%	0%	6%
	2050s	-6%	0%	6%
	2080s	-7%	1%	10%
Winter Mean Precipitation	2020s	-2%	6%	18%
	2050s	3%	18%	41%
	2080s	8%	31%	73%
Summer Mean Precipitation	2020s	-24%	-5%	18%
	2050s	-45%	-20%	8%
	2080s	-58%	-30%	4%

1.3 Drainage System Interactions

In the context of SWMPs, surface water flooding incorporates flooding from sewers, drains and groundwater. It also includes runoff from land, small watercourses and ditches occurring as a result of heavy rainfall. These sources may operate independently or through a more complex interaction of several sources.

An initial overview of the flooding issues in Wiltshire identifies areas that are affected by multiple sources of flood risk and complex interactions between urban watercourses, direct surface water ponding, overland flow paths and the surface water sewer system. One such example is the High Street in Chippenham which is susceptible to surcharge of the surface water drainage system, in part associated with high river levels as well as direct surface water flooding from rainfall that contributes to overland flow-paths due to the impermeable nature of the surrounding surfaces.

In order for these flooding mechanisms to be adequately assessed, a holistic approach to surface water management is required. The SWMP approach will seek to ensure that all sources and mechanisms of surface water flood risk are assessed and that solutions are considered in a holistic manner so that measures are not adopted that reduce the risk of flooding from one source to the detriment of another.

1.4 Fragmented Responsibilities

In areas of multiple sources of flood risk and complicated interactions between different sources of flooding, there are likely to be multiple water or drainage regulators, owners and maintainers. In Wiltshire there are a number of partners with responsibility for decisions regarding drainage assets and areas at risk of flooding. These include Wiltshire Council, the Environment Agency and Wessex Water[5].

It is essential that all relevant partners with responsibility for making decisions and taking actions are involved in plans for flood risk management from the outset. A key aim of the

[5] It is noted that Wessex Water is the predominant sewerage undertaker within the Wiltshire administrative area, however, Thames Water and Veolia Water also act as sewerage undertakers in some areas.

SWMP for Wiltshire is to strengthen the partnership between these organisations and ensure inclusivity through all phases of this study and in the future flood risk management of the administrative area.

1.5 Future Development

The Wiltshire Council Core Strategy is being progressed as part of the Local Development Framework. This sets out the vision for the future of the Wiltshire including broad locations for development. It seeks to focus new development, redevelopment and economic growth in a number of key centres, primarily Chippenham, Trowbridge and Salisbury. Further development is to be distributed across the administrative area within smaller settlements but to a lesser extent.

These plans provide an opportunity to address existing issues with surface water management and identify suitable measures to be implemented for future development. The initial stage of the SWMP focuses on the key centres of Chippenham, Trowbridge and Salisbury and identifies potential issues and opportunities. Further settlements are likely to be considered and investigated as required as part of the 'live' nature of the SWMP document.

1.6 Existing and emerging Legislation

Following flooding in July 2007, the Government commissioned Sir Michael Pitt to undertake an independent review into the causes and management of flood risk in the areas affected. The Flood and Water Management Act 2010 is designed to put into place the changes recommended by Sir Michael Pitt in his review and aims to reduce the risk and impact of flooding, improve the Local Authority's ability to manage the risk of flooding, improve water quality and reduce pollution.

The Flood Risk Regulations 2009 came into force in December 2009 and are a set of regulations which translate the EU Floods Directive into law for England and Wales. The Regulations bring the Environment Agency, County Councils and Unitary Authorities together with partners such as water companies to manage flood risk from all sources and to reduce the consequences of flooding on human health, economic activity, cultural heritage and the environment.

All these documents - Sir Michael Pitt's review of the Summer 2007 floods, the subsequent Flood and Water Management Act 2010 and the Flood Risk Regulations 2009, emphasise the need for local authorities to embrace a leadership role for local flood risk management, ensuring that flood risk from all sources, including flooding from surface water, groundwater and small watercourses, is identified and managed as part of locally agreed work programmes.

In accordance with these recommendations and emerging requirements Wiltshire Council has prepared a Surface Water Management Plan.

1.7 Summary

Wiltshire has the potential for significant numbers of properties to be affected by surface water flooding. In addition historical records of flooding from surface water, groundwater and sewer sources highlight past issues. There are multiple and interlinked sources of flooding across the administrative area which require holistic management and solutions and therefore the engagement of multiple responsible organisations from an early stage in the flood risk management process.

In addition, future development planned within the main settlements of Chippenham, Trowbridge and Salisbury alongside smaller development within other settlements requires an understanding of the constraints to surface water managements both now and in the future. It is therefore crucial that issues relating to surface water flooding are addressed when and where new development is proposed to maximise the potential for strategic improvements such as flood storage, SUDS retrofit, and/or upgrades to the drainage system.

Existing and emerging legislation strongly advocates the leadership role of local authorities in local flood risk management and the preparation of SWMPs where there is a clear need.

It is evident that further understanding is required to address surface water flooding issues in Wiltshire at an appropriate level and where required. This will develop a strategy for surface water management that is evidence based, risk based, future proofed and inclusive of stakeholder views and preferences.

2 Establish the Flood Risk Partnership

2.1 SWMP Working Group

In order for the SWMP study, and future flood risk management more generally within Wiltshire to be successful, it is essential that relevant partners and stakeholders, who share the responsibility for necessary decisions and actions, work collaboratively to understand existing and future surface water flood risk in the administrative area.

The SWMP Working Group comprises representatives from the Environment Agency and Wessex Water as well as multi-departmental representation from Wiltshire Council including strategic planning and highways drainage. The group was set up as part of the SWMP process with the aim of ensuring collaborative working across relevant partners and stakeholders. In addition, interaction with work being undertaken for the Preliminary Flood Risk Assessment (PFRA) and the Operational Flood Working Groups within Wiltshire Council is also being undertaken to ensure consistency between different functions with responsibilities for flood risk management.

2.2 Suggested Flood Risk Partnership Members

The SWMP study will build upon the partnerships established through the SWMP Working Group and will seek to incorporate additional partners and stakeholders as they are identified throughout the course of the study. The expected potential extent of the local flood risk partnership for Wiltshire Council is illustrated in Table 2-1.

Table 2-1: Potential Flood Risk Partnership Members

Level	Organisation	Typical Role
Lead Partner	• Wiltshire Council	Responsible for ensuring that objectives are set and met and that partnership approach is adopted
Essential Partners	• Environment Agency	Responsible for Main River flooding. National coordination role ensuring consistency and high standards in SWMP
	• Wessex Water	Responsible for public sewer systems and reduction of sewer flooding. Responsible for 'effectually draining' their area (as defined within the Water Industry Act).
Potential Partner/Stakeholder	• Thames Water • Network Rail • Natural England • British Geological Survey • Highways Agency • British Waterways • Developers • Local Communities and Business	Valuable sources of information on historical flooding, input into planning process, asset/infrastructure owners with responsibilities for other drainage sources.

2.3 Benefits of Collaborative Working

A number of benefits will arise from the collaborative working between partners of the Wiltshire SWMP Working Group, including:

- Greater understanding of urban drainage by a range of organisations;
- A shared understanding of flood risk by the Council, Wessex Water and the Environment Agency;
- Efficiency savings for 'essential partners' through achieving outcomes;
- Appraisal of surface water drainage options;
- Greater certainty for developers concerning appropriate drainage;
- Quicker, more certain decisions on development and infrastructure provision; and
- Overall reduction in flood risk to Wiltshire Council (primarily driven through the later SWMP phases III and IV – dependent upon available funding).

2.4 Project Governance Framework

The Wiltshire SWMP Working Group has a strategic function to contribute to the delivery of the SWMP by establishing a shared understanding of flood risk and agreeing a coordinated approach to reduce the risk.

A project governance framework has been prepared[6]. This document sets out proposed roles and responsibilities for 'essential partner' organisations including Wessex Water and the Environment Agency, as well as the objectives and terms of reference of the Wiltshire SWMP Working Group, and proposed lines of communication.

This document is included in Appendix A and should be consulted for more detailed information regarding the working relationship between key partner organisations throughout the completion of the SWMP and for future flood risk management.

[6] URS Scott Wilson Ltd (January 2011) Project Governance Framework

3 Clarification of SWMP Scope

3.1 Structure

The principal output from an SWMP is an action plan which outlines the preferred strategy for the coordinated management of surface water flood risk within a given area.

The Defra SWMP Technical Guidance identifies four key phases of a SWMP as shown in Figure 3-1.

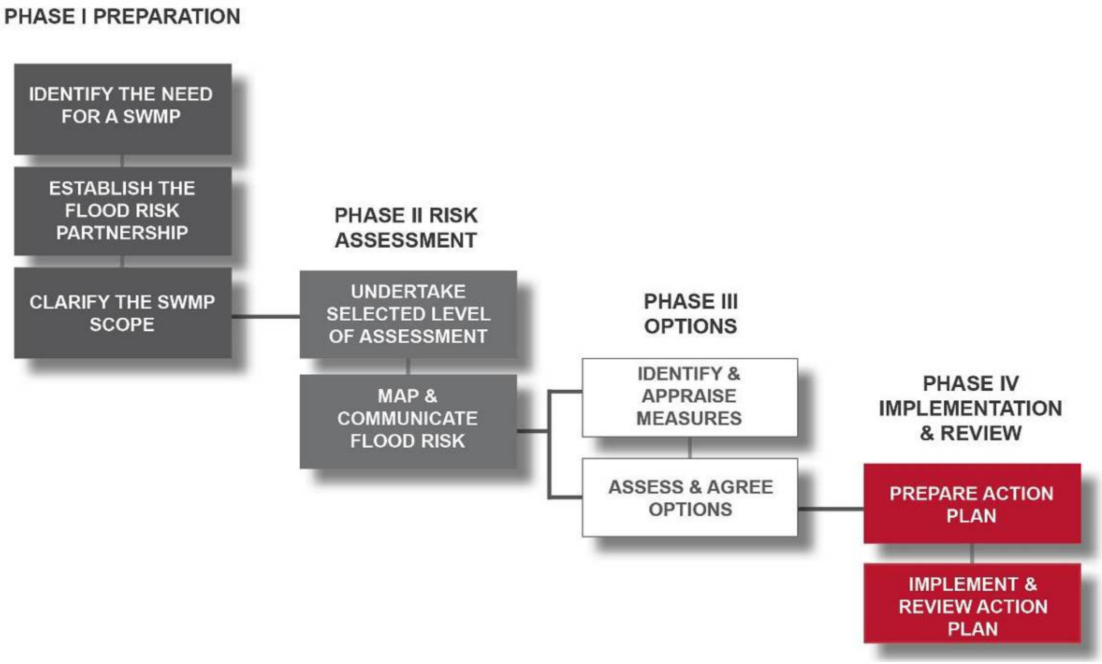


Figure 3-1: Phases of SWMP

The first three phases involve undertaking the ‘SWMP study’, whilst the fourth phase involves producing and implementing the ‘action plan’, founded on the evidence base of the Phase I – III SWMP study.

This report constitutes the Phase I (Preparation) and Phase II (Risk Assessment) SWMP for Wiltshire Council. However, an indicative element of Phase III (Options) has been included as an added value measure within this report. This has been included to help to identify any SWMP ‘early actions’ and to assist with spatial planning. This ensures the outputs from the SWMP study for Wiltshire Council are focused and practical. However, it is stressed that a full Phase III SWMP is beyond the scope of this commission and would require further assessment.

3.2 Aims and Objectives

The following objectives have been developed for each phase of the Wiltshire Council SWMP;

Phase I – Preparation

- Identify the specific needs of the SWMP and the determine the local project drivers;

- Build upon the existing work through the SWMP Working Group to continue to develop a joint understanding of flood risk within the administrative area and overcome the division of responsibility in urban drainage;
- Collate and map existing information regarding flood risk from all sources;
- Determine an appropriate level of assessment for the Wiltshire Council SWMP.

Phase II – Risk Assessment

- Undertake a suitable modelling approach to enable an intermediate assessment of surface water flood risk in the settlements identified;
- Quantify the risks from surface water flooding through the identification of overland flow paths and areas of surface water ponding leading to an assessment of properties and infrastructure at risk;
- Map the results of the pluvial modelling;
- Communicate flood risks to relevant bodies within the local flood risk partnership;
- Provide recommendations for a detailed risk assessment if appropriate.

Phase III – High Level Indicative Options

- Provide initial identification of high level potential options for surface water management in the settlements identified;
- Advise on 'early actions' or practical solutions that can be implemented;
- Advise on the potential for Integrated Drainage Strategies for strategic development sites.

3.3 Linkages with other plans

It is important that the SWMP is not viewed as an isolated document, but one that connects with other strategic and local plans. Figure 3-2 below shows Scott Wilson's interpretation of the drivers behind the Wiltshire SWMP, the evidence base and how the SWMP interacts and supports the delivery of other key spatial planning and investment processes.

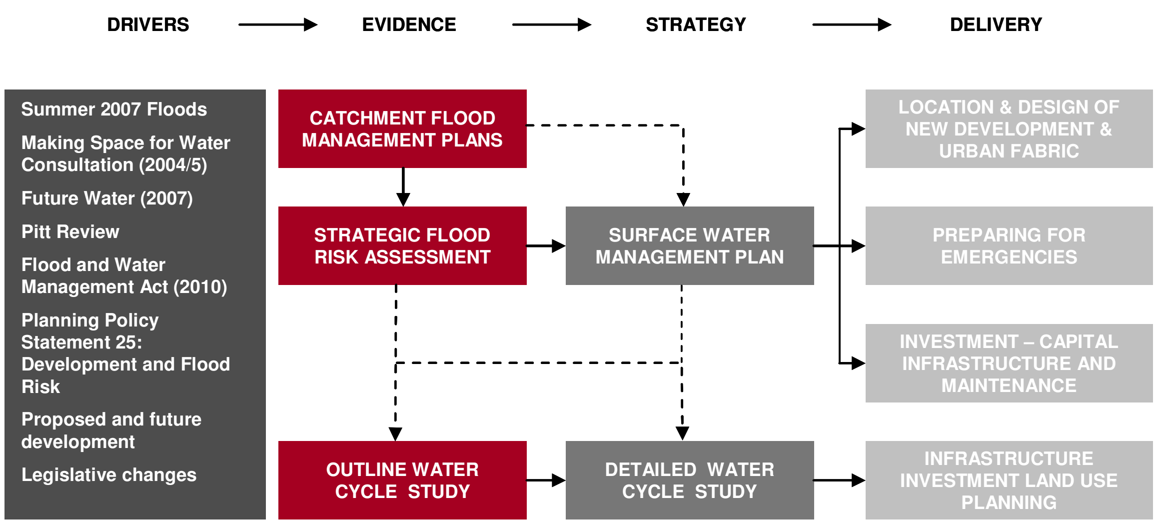


Figure 3-2: Drivers and linkages with other plans.

3.3.1 Environment Agency Plans

River Basin Management Plans

The administrative area of Wiltshire Council spans across three River Basin Districts, these are Thames, South West and Severn. These plans identify the pressures facing the water environment in each district and the actions required to protect and improve the water environment. They have been developed in consultation with a wide range of organisations and individuals. The plans are over a six-year planning cycle with the first cycle ending in 2015. During each cycle further monitoring, planning and consultation will take place and each plan will be updated at the end of each cycle.

Catchment Flood Management Plans

Catchment Flood Management Plans (CFMPs) provide an overview of flood risk across each river catchment and recommend ways of managing current and future risks over the next 50 to 100 years. Three CFMPs cover the administrative area of Wiltshire Council. The two main CFMPs are the Bristol Avon and Hampshire Avon that cover the north and south of the area respectively. The Thames CFMP also covers a smaller area within the north east of the administrative area.

These plans consider inland flooding from rivers, groundwater and surface water including the likely impacts of climate change and the use and management of land. They provide ‘policies’ for management of flood risk depending on impacts identified. They emphasise the role of the floodplain as an important asset for the management of flood risk, the opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally.

The CFMPs will be reviewed periodically on approximately a five year cycle from date of publication to ensure that they continue to reflect changes within the CFMP area.

3.3.2 Wiltshire Council Plans

Wiltshire 2026 Vision and South Wiltshire Core Strategy

Due to changes both within the planning system and the formation of Wiltshire Council, spatial planning within the administrative area is currently being progressed via the Wiltshire 2026 vision and the South Wiltshire Core Strategy. Ultimately, there will be a single Core Strategy that presents the spatial vision, strategic objectives and policies for growth across the whole of Wiltshire until 2026, including locations for proposed new housing, retail and business development.

As plans progress for settlements, the findings of the SWMP should be considered and incorporated in wider spatial planning decisions to provide sustainable development for the future.

Strategic Flood Risk Assessments

Prior to the formation of Wiltshire Council, four individual SFRAs were produced for the former planning areas of Salisbury, Kennet, North Wiltshire and West Wiltshire to inform the spatial planning of new development. An overarching document was also produced to inform the minerals and waste planning process and was updated following the formation of Wiltshire Council. The SWMP builds upon this evidence base with respect to surface water flood risk.

3.4 Stakeholder Engagement

For the purposes of the SWMP a stakeholder is defined as anyone affected by, or interested in, the surface water problem or proposed solution. Stakeholders are often individual homeowners but they can include organisations, the public and communities. Different stakeholders should be engaged with to provide a rounded view of the problem and proposed solution.

It is important that the Council liaise with stakeholders as an on-going process as they have often experienced flooding first hand and can provide invaluable information. Also, to ensure the smooth running and effective implementation of potential mitigation measures (especially those which may lead to local disruption e.g. road works) stakeholder engagement is required from the start.

The SWMP process supports liaison with local stakeholders throughout the process however, it also highlights the importance of managing their expectations. It is recommended that Wiltshire Council follow the guidelines outlined in the Environment Agency's 'Building Trust with Communities'[7] which provides a useful process of how to communicate risk including the causes, probability and consequences to the general public and professional forums such as local resilience forums. Examples of stakeholder communication at differing levels are summarised in Table 3-1.

Table 3-1: Approaches to stakeholder involvement and methods of communication

Type of Involvement	Description	Examples of Methods
Inform	Provide information, for example to help people understand the issue, or to announce a decision.	• Leaflets • Newsletter • Briefing note • Displays • Advertising • Newspapers, TV and radio • Video/DVD • Site visits • Internet
Gather information	Feedback is necessary in order to gain an insight into people's comments, questions and concerns. This can help Wiltshire Council to understand what people know and what they value.	• Staffed displays • Surgeries • Staffed telephone lines • Internet (inviting feedback) • Public meetings • Surveys, questionnaires and interviews
Involve	Provide opportunities for everyone to talk and listen. To understand the issues and concerns of those involved. Although Wiltshire Council makes the final decision, there is a real opportunity for the community to have an influence. There must be things that can change as a	• Workshops • Focus groups • Surgeries • Liaison groups (different groups representing specific interests) • Facilitated meetings (meeting managed by a third party who is unconnected to the issues) • Partnerships provide opportunities for everyone involved to talk and listen

[7] For further information see: http://www.ncl.ac.uk/ihs/research/environment/rehmarc/pdfs/workingwithothers.pdf

	result of their involvement.	• The people taking part share the decision making

The Operational Flood Working Groups have undertaken community engagement through contacting local town and parish councils and have held a 'Flood Fair' to both communicate and gather information on local flood risk issues.

It is suggested that as the SWMP continues to move forward to Phases III and IV (options and implementation stages) that local stakeholders are contacted for their views on flood risk mitigation options and to exchange ideas about what they would like to see as potential outcomes.

3.5 Data Review

One of the key components of a shared understanding of flood risk is the sharing of flood risk data between and across organisations. This section sets out the results of the comprehensive data collection and review.

Data has been collated, recorded and analysed, predominantly by URS Scott Wilson. Data collected has been recorded in a data register (see Table 3-2) which documents the source of the data and its completeness. In line with the SWMP technical guidance (Defra 2009), the quality of the data has been scored using the following classifications:

1. No known deficiencies - not possible to improve in the near future.
2. Known deficiencies – best replaced as soon as new data are available.
3. Assumed – based on experience and judgement.
4. Grossly assumed – an educated guess.

3.6 Level of assessment adopted for SWMP

SWMPs can function at different geographical scales and therefore different levels of detail are used when considering the outputs. Table 3-3 defines the three potential levels of assessment within a SWMP. At a strategic level, Wiltshire Council identified three settlements based on their strategic significance, future growth requirements and potential for surface water flooding. These were Chippenham, Trowbridge and Salisbury. This SWMP will undertake an 'Intermediate Assessment'[8] as defined in Table 3-3 and identify if 'Detailed Assessment' will be required. In addition, further settlements are likely to be identified that will require future investigation through the same level of assessment. The structure of this report has therefore been set up to allow for additional assessments to be incorporated as part of a 'live' document.

[8] For further information and guidance see: http://www.defra.gov.uk/environment/flooding/

Table 3-2: Data register

Category	Data / Information	Source	Provided	Details	Format	Quality Score	Comments / Limitations
Asset Data and Information	Highway drainage records	Wiltshire Council	✓	Office visits to talk to drainage engineers + go through paper records of recorded flood incidents	Various	3	
	'Ordinary watercourses'	Wiltshire Council	✓	Office visits to talk to drainage engineers + go through paper records of recorded flood incidents		3	
	Sewer improvement information	Wessex Water, Wiltshire Council and Third parties (journal entries, industry newsletters)	✓	Chippenham upgrade information	PDF	2	Obtained from industry newsletter and therefore not from reliable source
	River or coastal models and asset data	Environment Agency	✓	Flood outlines for the Salisbury, Chippenham and Trowbridge areas	GIS	1	Includes Main River centrelines, NFCDD and reservoir locations
	Water company assets	Wessex Water	✓	Major (larger than 225mm diameter) public surface and foul water sewer locations and associated infrastructure	GIS	1	
	Information on local watercourses	Wiltshire Council	✓	Office visits to talk to drainage engineers + go through paper records of recorded flood incidents	Various	3	
	Borehole records	Environment Agency/British Geological Survey	✓	Borehole records provided for Chippenham, Trowbridge and Salisbury	Excel	1	
Background Information	OS Mapping data	Local authorities have licence for this data	✓	50,000, 10,000 and OS Mastermap	GIS	1	
	Ground topographical data	Provided by the Environment Agency. Augmented by data from a third party (Bluesky)	✓	Up to 2m resolution Light Detection and Ranging (LiDAR) data	GIS	2	No terrain model available for parts of Chippenham, Salisbury, Trowbridge.
	Areas Susceptible to Surface Water Flooding Mapping	Local Planning Authority	✓	ASTSWF coverage for Wiltshire	GIS	2	High-level approximation of potential surface water flooding, would be superseded by the Intermediate Assessments of this SWMP
	Flood Maps from Surface Water Flooding	Local Planning Authority	✓	FMfSW coverage for Wiltshire	GIS	2	
	Supporting Documents	Environment Agency	✓	Bristol Avon CFMP report, Hampshire Avon CFMP Report, Thames CFMP.	PDF	1	

Category	Data / Information	Source	Provided	Details	Format	Quality Score	Comments / Limitations
	Areas Susceptible to Groundwater Flooding	Environment Agency	✓		GIS	2	
	Abstraction and Discharges	Environment Agency	✓	Locations of licensed abstractions and discharges for Chippenham, Trowbridge and Salisbury	Excel/GIS	1	
	Geological data – artificial, superficial, bedrock, linear features and mass movement	Wiltshire Council has a licence for this data. Augmented by data from the British Geological Survey	✓	Provided for the Salisbury, Trowbridge and Chippenham areas	GIS	1	
Historical Information	Historic flood incident data	All partners should hold this	✓	Environment Agency FRIS data for Salisbury, Trowbridge and Chippenham	Excel	2	Incidents are geo-referenced.
				Historic flood incidents obtained from the various SFRAs	PDF	2	High-level summary of flood incidents
				Salisbury flood incidents records	Hard copy	2/3	Accurate location or address of incidents not always provided
				Chippenham flood records from local newspapers	PDF	2/3	Not directly from a reliable source
	Rainfall data	Environment Agency	✓	Rainfall data for Chippenham, Trowbridge and Salisbury	Excel	1	
	Fluvial flow data	Environment Agency	✓	Flow data for rivers in Chippenham and Trowbridge	Excel	1	
	DG5 Register	Wessex Water	✓			1	Confirmed that no additions to DG5 register in coming year.
Future development information	Strategic Flood Risk Assessment	Local Planning Authority	✓	Level One and Two Reports for former district areas and High Level Summary for Wiltshire Council	PDF	1	
	Housing Land Availability Report	Wiltshire Council	✓		PDF	1	

Category	Data / Information	Source	Provided	Details	Format	Quality Score	Comments / Limitations
	Development proposals Drainage Area Plans	Local Planning Authority Water and sewerage companies	✓	South Wiltshire Core Strategy, Chippenham Core Strategy, Trowbridge Core Strategy, Wiltshire 2026 Consultation Docs,	PDF	1	

Table 3-3: Level of assessment for SWMPs

Level of Assessment	Appropriate Scale	Outputs
Strategic Assessment	Wiltshire Council administrative area	• Broad understanding of locations that are more vulnerable to surface water flooding • Prioritised list for further assessment • Outline maps to inform spatial and emergency planning
Intermediate Assessment	City / Large Town e.g. Chippenham, Trowbridge, Salisbury	• Identify flood hotspots which might require further analysis through detailed assessment. • Identify immediate mitigation measures which can be implemented • Inform spatial and emergency planning
Detailed Assessment	Known flooding hotspots, small towns	• Detailed assessment of cause and consequences of flooding • Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

3.6.1 Strategic Assessment

At a strategic level, there are approximately 18,000 properties at risk from surface water flooding within the administrative area of Wiltshire Council, based on the analysis undertaken as part of the PFRA process. The ten highest ranking settlements within Wiltshire are listed in Table 3-4 with their rank and number of properties at risk from surface water flooding.

Table 3-4: PFRA ranking of settlements and number of properties at risk of surface water flooding assessed using Environment Agency Flood Maps from Surface Water (0.5% annual probability event)

Settlement	Rank	Number of properties at risk	Settlement	Rank	Number of properties at risk
Salisbury	1	1476	Warminster	6	751
Chippenham	2	1192	Calne	7	652
Westbury	3	1174	Corsham	8	642
Trowbridge	4	935	Bradford on Avon	9	445
Devizes	5	866	Melksham	10	387

Wiltshire Council identified a requirement to undertake a SWMP focusing on strategically significant towns (Chippenham, Trowbridge and Salisbury) where significant future development is planned. However, it is recognised that other settlements (e.g. Westbury, Devizes, Warminster and others) should be investigated in the future.

3.6.2 Intermediate Assessment

As shown in Table 3-3, the intermediate assessment is applicable at the town/city scale. It is therefore considered appropriate to adopt this level of assessment to further quantify the risks identified from both the national scale assessment undertaken by Defra in 2009 and the PFRA work undertaken by Wiltshire Council at the strategic level in 2011.

The purpose of this intermediate assessment will be to further identify those parts of the settlements identified that are likely to be at greater risk of surface water flooding and, where required, indicate where a more detailed assessment should be undertaken.

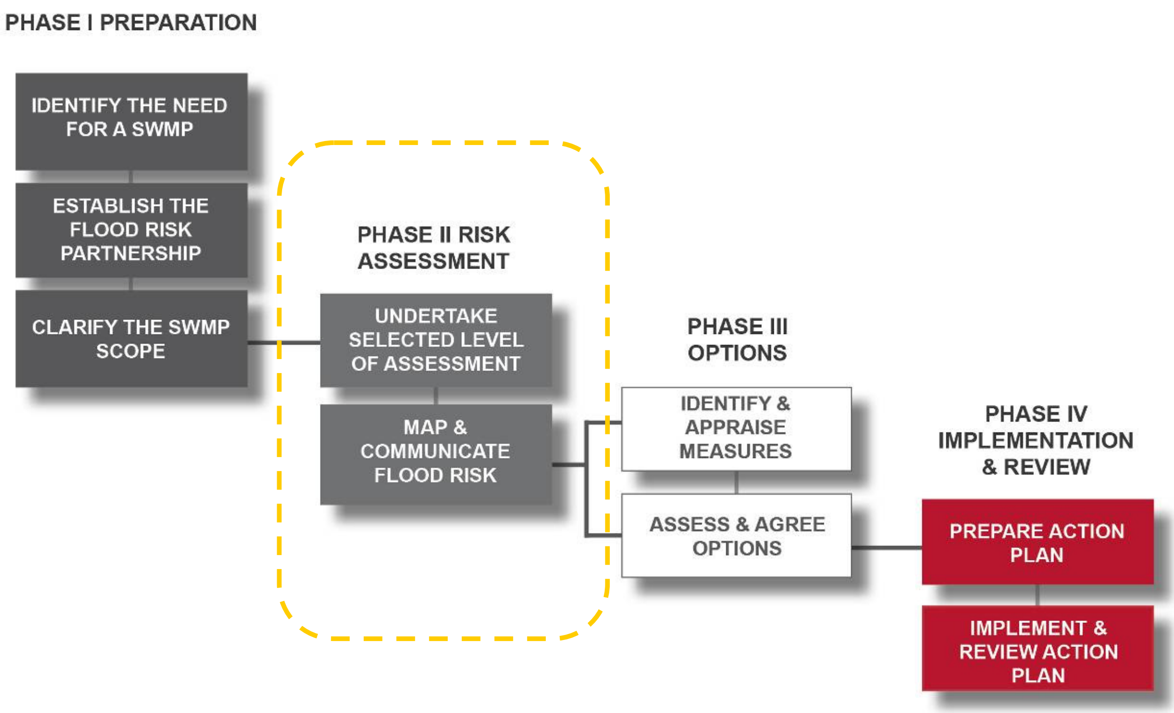
The outputs from this intermediate assessment should be used to update spatial and emergency planning documents and to identify potential mitigation measures including quick win measures which can be implemented to reduce surface water flooding. These may include improved maintenance and clearance of blockages.

3.6.3 Detailed Assessment

As stated in Table 3-3, detailed assessments are used to gain an improved understanding of the causes and consequences of surface water flooding, and to test the benefits and costs of mitigation measures. These are normally informed by intermediate assessments. Detailed assessments typically use integrated modelling of the surface and subsurface drainage system.

It is emphasised that this level of assessment is not included within the current SWMP.

PHASE II: RISK ASSESSMENT



4 Intermediate Assessment

4.1 Overview

The purpose of the Phase II 'Intermediate Assessment' is for the local flood risk partnership to further develop their understanding of the surface water flood risk for the settlements identified as requiring assessment. It is then to subsequently communicate this risk to relevant parties. As defined in Section 3.2, the specific objectives of Phase II are set out below:

- Undertake a suitable modelling approach to enable an intermediate assessment of surface water flood risk for the required settlements;
- Quantify the risks from surface water flooding through the identification of overland flow paths and areas of surface water ponding leading to an assessment of locations and infrastructure at risk;
- Map the results of the pluvial modelling;
- Communicate flood risks to relevant bodies within the local flood risk partnership; and
- Provide recommendations for detailed risk assessment if appropriate.

In order to achieve these objectives, the following elements of work have been undertaken:

- Review of existing data identified and collated in Phase I;
- Site walkovers to enhance model representation of features such as culverts and bridges and to identify potential surface water flood risk issues from initial model runs and high level mitigation options.
- Direct rainfall pluvial modelling;
- Review of data relating to the existing sewer system from Wessex Water; and
- An assessment of the groundwater flooding potential for each settlement.

The findings of these assessments are described in the following chapters. A brief overview of the methodology for assessing surface water flooding from the different sources is provided below.

4.2 Pluvial Flooding

4.2.1 Overview

Pluvial flooding occurs when high intensity rainfall generates runoff which flows over the surface of the ground and ponds in low lying areas. It often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with the additional flow.

4.2.2 National Pluvial Modelling

The Environment Agency has undertaken pluvial modelling at a national scale and produced two sets of mapping. These are termed 'Areas Susceptible to Surface Water Flooding' (AStSWF) and the 'Flood Map from Surface Water' (FMfSW). The following provides a brief overview of their attributes and limitations.

Areas Susceptible to Surface Water Flooding

AStSWF maps indicate where surface water would be expected to flow or pond on a strategic rather than site specific scale. They were produced using a single rainfall event with a 0.5% annual exceedance probability (AEP) and a duration of 6.5 hours. The primary purpose of this mapping is to provide a general indication of areas likely to suffer from surface water flooding at this rainfall AEP. They also assist Local Authorities with emergency planning procedures. The maps are provided in three bandings - 'less', 'intermediate' and 'more' susceptible. It should be noted that this national mapping has the following limitations:

- The mapping does not show the interface between the surface water network, the sewer systems and the watercourses;
- The mapping does not take into consideration surface permeability or infiltration;
- It does not show the susceptibility of individual properties to surface water flooding;
- Map accuracy is strongly influenced by the topographical information (e.g. Digital Terrain Model) available in each area, which is often of worse quality in more rural locations and for some areas of Wiltshire, e.g. Chippenham;
- The modelling assumed a uniform Manning's roughness coefficient of 0.1; and
- The mapping has significant limitations for use in flat catchments.

Flood Maps from Surface Water

As with the AStSWF, the FMfSW indicate where surface water would be expected to flood or to pond. They have been produced for two rainfall events, the 3.33% and 0.5% AEP, 1.1 hour storm duration. The maps show the areas likely to become inundated by 'surface water flooding' (flooding greater than 0.1m deep) and 'deeper surface water flooding' (flooding greater than 0.3m deep). The FMfSW methodology included a number of improvements over the AStSWF mapping in that it included the following:

- More storm events;
- The influence of buildings on surface water flooding by adding them to the topographical Digital Terrain Model;
- The inclusion of assumed infiltration by reducing rainfall in rural areas to 39% and to 70% in urban areas;
- The inclusion of assumed drainage systems by reducing the rainfall in urban areas by a further 12mm/hr; and
- Two values for Manning's coefficient used. These were 0.1 in rural areas and 0.03 in urban areas;

Although the FMfSW provide a more refined indication of surface water flooding than the AStSWF, they still have a number of limitations to their use, as follows:

- A short storm duration was used which may not be the critical storm duration for many larger catchments;
- A single infiltration figure was used for rural or urban areas and no allowance was made for the differing infiltration of different soil types or land covers;

- A uniform rainfall reduction factor for the allowance of a sewer network with no allowance for varying sewer types or for potential blockages;
- A uniform Manning's coefficient applied to all rural or urban areas;
- The topographical information used (i.e. the Digital Terrain Model) remains relatively inaccurate but suitable for use on a strategic scale;
- No allowance was made for smaller structures such as culverts or small bridges that may convey or prevent the flow of surface water.

The above limitations indicate why the FMfSW and AStSWF maps should not be used as the sole evidence for any specific planning decision or to identify individual properties at risk of surface water flooding. They are suitable for use as an indicator for surface water flooding within an area on a more strategic scale, and can identify where further work may be required as part of a site-specific Flood Risk Assessment or similar level of study.

Table 4-1 Comparison of model inputs and parameters for the FMfSW and AStSWF

Properties	AStSWF	FMfSW	Why different/same?
Annual Exceedance Probability Rainfall	0.5%	3.33% and 0.5%	3.33% added to allow a better understanding of lower consequence more frequent events
Storm Duration	6.5 hrs	1.1 hr	1.1 hr profile produced on average higher results than other durations piloted
Rainfall Profile	50% summer	50% summer	Recommended profile from the FEH
Reduction to rainfall amount to represent infiltration	None	Reduction to 39% in rural areas and 70% in urban areas	AStSWF did not consider infiltration
Reduction to rainfall amount to represent sewer flow	None	Reduction of 0mm/hr rural, 12mm/hr urban	AStSWF did not consider the effects of sewers
Manning's 'n'	0.1	0.1 rural, 0.03 urban	Urban value reduces now as buildings are included in DTM. Previously 'n' was increased to account for lack of building representation
DTM	Infoterra bare earth LIDAR and GeoPerspectives	EA 2010 Composite (SAR, EA LIDAR and PGA2 LIDAR) with OS 2009 Mastermap Buildings (DTM raised by 5m)	Access to EA LIDAR available
Model Resolution	5m	5m	Modelling at smaller resolution (for example 2m) was impracticable at a national scale with the model used due to processing demands.
Model Domain Size	5 x 5 km	5 x 5 km	5km provides a reasonable balance between high

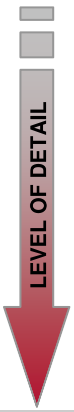
			intensity local storms and larger less intense events
Buildings	Not represented	Represented in the DTM using the 2009 OS Mastermap Buildings layer	Earlier work identified that the presence of buildings improved the routing of flow in urban areas. Use of buildings based upon the DTM elevation plus 5m. Building outlines are best represented by OS Mastermap polygons
Threshold Bands	- 0.1 to 0.3m - 0.3 to 1m - >1m	- >0.1m - >0.3m	Consultation with partners resulted in 2 bands being produced to represent where areas or people may experience difficulties in access/ egress

In the light of the above, this mapping has been used for an initial high-level overview of pluvial flood risk for each settlement and has been used to inform the approach for the intermediate risk assessment.

4.2.3 Settlement Level Pluvial Modelling – Direct Rainfall Approach

In order to continue developing an understanding of the causes and consequences of surface water flooding for key settlements, intermediate level pluvial modelling has been undertaken for a range of rainfall event probabilities. This pluvial modelling has been designed to provide additional information where local knowledge is lacking and forms a basis for future detailed assessments in areas identified as high risk.

A Direct Rainfall approach (see Figure 4-1) using TuFLOW software has been selected whereby rainfall events of known AEP are applied directly to the ground surface and are routed overland to provide an indication of potential flow path directions, maximum flow depths and velocities, and areas where surface water will pond. A full methodology of the pluvial modelling undertaken is included in Appendix B.



Rolling Ball	Surface water flow routes are identified by topographic analysis, most commonly in a GIS package
Direct Rainfall	Rainfall is applied directly to a surface and is routed overland to predict surface water flooding
Drainage Systems	Models representing sewer network system.
Integrated Approach	Representing both direct rainfall and drainage systems in an integrated manner, or linking different models together dynamically

Figure 4-1: Levels of Pluvial Modelling [SMWP Technical Guidance March 2010]

Rainfall events with the following return periods have been modelled:

- 3.33% AEP event
- 3.33% AEP plus Climate Change (+ 30%)
- 1% AEP event
- 1% AEP event plus Climate Change (+ 30%)
- 0.5% AEP event

Flood depth and hazard mapping has been provided for each of the settlements and is included within the appendices for the relevant settlement. Screenshots have been provided within the report for the 1% AEP rainfall event inclusive of climate change for areas identified within each settlement with potential surface water flooding issues.

It is anticipated that these maps should be used for facilitating the engagement of stakeholders on surface water flooding issues, to further inform spatial planning process, to inform future capital investment decisions, to inform emergency planning functions carried out by Local Resilience Forums and to identify whether critical infrastructure is at risk from surface water flooding.

However, the limitations of this modelling should be considered when using the information. The key points are that the intermediate modelling assumes that no water either enters the underground drainage network or infiltrates into the soil surface. In addition, the modelling does not take into account any capacity issues of the local drainage network such as surcharging of manholes which may lead to backing up and further pooling of surface water locally. Further limitations are provided in the 'Data Information and Review' sections for each settlement.

4.3 Sewer Flooding

4.3.1 Overview

Where incidents of sewer flooding occur, this is typically associated with either exceedance of sewer capacity or a blockage/collapse within the sewer system. Design standards for surface water sewers currently require the sewer design to be for a 3.33% AEP (1 in 30 year) storm event. However, some existing sewers are likely to have lower capacity due to their age. Therefore, sewer exceedance, blockage or collapse could lead to localised flooding within and from the sewer network.

Surface water runoff from roads, roofs and other areas typically enters the sewer network and is therefore inherently linked. Detailed modelling of the sewer network is not considered proportionate at the 'Intermediate' level of assessment. However, a qualitative assessment has been undertaken to identify potential areas where exceedance of the surface water sewer network may lead to combined surface water and sewer flooding.

4.3.2 Methodology

Wessex Water has provided details of their sewer assets for each settlement within GIS format and also confirmed that there are no new DG5 register entries that require attention (under the duties of Wessex Water) at present. In order to assess potential surface water flooding issues, the pluvial modelling results have been overlain with the surface water sewer network details. This approach allows a qualitative assessment of areas where pluvial modelling indicates surface water ponding or flow routes. Where surface water sewers exist, it is reasonable to assume that flow depths predicted by the pluvial modelling are likely to be less. However, due to the design capacity of the sewer system, surcharge of the sewer network is still likely to occur where the capacity is exceeded.

In addition, a qualitative assessment has been undertaken to identify where issues may arise where surface water sewers discharge to watercourses. Levels within watercourses may exceed invert levels of the discharge point from the surface water sewer and may lead to temporary backing up within the surface water sewer network leading to localised surcharging and flooding.

4.4 Groundwater Flooding

4.4.1 Overview

Groundwater flooding occurs as a result of water rising up from the underlying aquifer or water flowing from groundwater springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels.

Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. Basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, pluvial and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy[9]. The review of the July 2007 floods undertaken by Sir Michael Pitt highlighted that at the time no organisation had responsibility for groundwater flooding. The Flood and Water Management Act identified new statutory responsibilities for managing groundwater flood risk, in addition to other sources of flooding, and has a significant component which addresses groundwater flooding.

The following section outlines the methodology used to assess the potential risk from groundwater flooding.

4.4.2 Methodology

In order provide an intermediate assessment of the potential for groundwater flooding a number of data sources have been used within the analysis. These include the review of bedrock and superficial geology, available information from borehole monitoring and borehole drilling logs, historical records of groundwater flooding, groundwater modelling (where available) and existing reports on groundwater resources.

[9] See for further information: http://archive.defra.gov.uk/environment/flooding/policy/strategy/index.htm

These sources of information have been used to build a conceptual understanding of the hydrogeology for each settlement and have allowed an intermediate assessment to be undertaken to provide the following:

- Potential groundwater flooding mechanisms;
- Evidence for groundwater flooding;
- Areas susceptible to groundwater flooding; and
- Recommendations for further investigation.

These findings are used in conjunction with results from the pluvial modelling, and the linkages with flooding from sewer and ordinary watercourses, to provide a wider understanding of surface water flooding issues.

4.5 Ordinary Watercourse Flooding

4.5.1 Overview

Ordinary watercourses include rivers, streams, brooks, ditches and dykes that are not designated as 'Main River'. Local authorities have permissive powers to undertake flood defence work at their discretion with maintenance typically being the responsibility of the riparian owner.

Surface water runoff and surface water sewer discharges can contribute to flow within ordinary watercourses which typically convey that flow to joining watercourses designated as 'Main River'. Ordinary watercourses usually have small catchment areas and are not covered by Environment Agency Flood Zone Mapping.

4.5.2 Methodology

Similar to the methodology for sewer flooding, a qualitative assessment has been undertaken for ordinary watercourses. The Environment Agency has provided 'Main River' designations in GIS format, these have been combined with OS mapping and the results of the pluvial modelling to identify flow paths associated with ordinary watercourses.

This approach allows the identification of areas where surface water flow may exceed the capacity of the ordinary watercourses and where potential flow routes are impeded either by culverts or other manmade features.

5 Chippenham

5.1 Overview

Chippenham is located within the north west of Wiltshire and has a population of over 40,000[10] including surrounding areas. The 'Wiltshire Core Strategy Consultation Document'[11] released in June 2011 identifies that Chippenham Community Area should provide 4500 new homes over the period 2006 to 2026, of which 4000 should be within Chippenham. Approximately 895 new homes have been delivered since 2006 and a further 325 are committed and considered developable. In addition, 30.5 to 33 ha of new employment land should be provided over this period in Chippenham. This supersedes the information previously contained within the 'Wiltshire 2026 – Planning for Wiltshire's Future'.

Two proposed site options have been identified within the Wiltshire Core Strategy Consultation Document, these are shown in Figure 5-1. However, it is understood that other options have been considered and therefore the extent of the SWMP has been defined to encompass potential options (in particular, the 'Wiltshire 2026 – Planning for Wiltshire's Future' report indentified a preferred option to the east that has now been superseded). This allows a holistic appreciation of existing and future potential flooding from surface water, groundwater, sewer, ordinary watercourse or a combination of these, and helps to inform the strategic planning process.

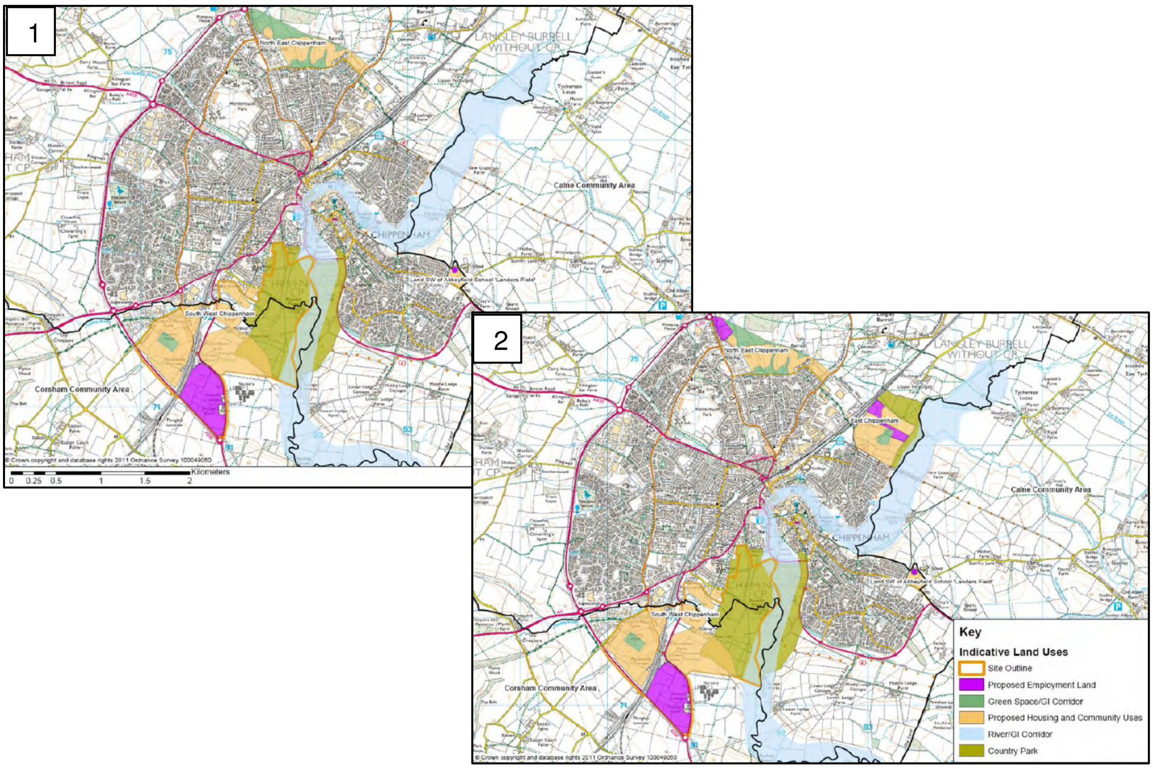


Figure 5-1: Strategic site options for Chippenham

Historically, the majority of reported flooding issues within Chippenham have been linked with fluvial flooding from the River Avon. Surface water flooding combined with sewer exceedance has occurred within the High Street causing localised flooding of surrounding commercial

10 http://www.chippenham.gov.uk/
11 http://www.wiltshire.gov.uk/planninganddevelopment/planningpolicy/wiltshirecorestrategy/wcsconsult2011.htm

properties. Remedial works have been undertaken by Wessex Water within this area to help alleviate the potential for future flooding. However, it should be remembered that whilst the risk and consequences of flooding can be reduced to acceptable levels, flooding can still occur in extreme conditions.

5.2 Data / Information Review

In order to inform the Phase II element of the SWMP for Chippenham, two principal activities have been completed. The first activity was direct rainfall and pluvial flood modelling (as described in Section 4.2). The second activity was to verify and augment the pluvial modelling with historical flooding information and records.

During the preparation of this SWMP, meetings between URS/Scott Wilson and Wiltshire Council Drainage Engineers have been held to ensure that local drainage knowledge held by the Council is used to gain a thorough understanding of drainage issues within each settlement.

The meetings with Wiltshire Council drainage engineers identified that whilst surface water can be an issue, it is typically localised and does not cause significant issues in general. Where previous drainage issues have occurred within Chippenham they are normally associated with maintenance issues, such as obstructions to screens or culverts restricting the flow of water.

5.2.1 Information Required for Pluvial Modelling

The pluvial modelling was undertaken using TuFLOW software, Double Precision version 2010_iDP_w32. As described in Section 4.2 and Appendix B, the model simulates what happens to rainfall once it falls on the ground in Chippenham. The movement of water on the ground is influenced by the local topography and land use. For example, water will flow much more quickly on a steep road than a flat grassed area. Therefore, the model requires data that represents the local topography and predominant land use. In addition, the model requires relevant data to represent the various rainfall events. Table 5-1 summarises the data used, the source of the data and the limitations.

Table 5-1 Data required for the pluvial flood modelling at Chippenham and its source

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
LiDAR (Light Detection and Ranging), Digital Terrain Model (DTM) and Digital Surface Model (DSM)	Environment Agency (Geomatics group) and Third party (Bluesky)	• Topographical information • Used to generate a grid providing ground heights for application within the model	• Not as accurate as surveyed levels but suitable for a strategic scale study • The DSM caused model instabilities that required alteration of the LiDAR data
Ordnance Survey 1:10,000 scale mapping	Wiltshire Council	• Background mapping for analysis and display purposes (see the Chippenham Figures)	• Not provided in colour • Due to their release date, they do not include more recent developments
Ordnance Survey Mastermap data	Wiltshire Council	• Used to inform land uses throughout the Chippenham area • Different land uses are assigned different friction values that affect the	• Due to their release date, they do not include more recent developments

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
		movement of surface water runoff	
Flood Estimation Handbook (FEH)	Centre for Ecology and Hydrology - FEH CD-ROM v3	• Used to obtain Catchment Descriptors that provide a hydrological profile of the area	• Not necessarily calibrated in detail for the required area, but suitable for this strategic level study
Visual inspections of culverts, bridges and other structures	On-site visual inspections	• Informed the sizing of various structures throughout the area	• Outline measurements only, not surveyed and therefore likely to be inaccurate but suitable for the strategic nature of the study
Surface water sewer network	Wessex Water	• Provided location of major public surface water sewers and associated infrastructure	• Due to sensitivities of the data, not all information can be disseminated via this report; • Only sewers of greater than 225mm in diameter shown • Details or locations of private sewers not available from Wessex Water

As shown in Table 5-1, the various data sources had some limitations to their use. However all data was considered suitable for the pluvial modelling given the strategic nature of the study. The following should be taken into consideration when using the findings of this SWMP:

- Pluvial modelling results should be used to identify areas potentially at risk of surface water flooding, but they should not be used to identify individual properties at risk.
- Pluvial modelling has taken a conservative approach where it is assumed that no sewer network is in place (i.e. sewer capacity is exceeded in all events).
- Pluvial modelling has taken a conservative approach where it is assumed that no infiltration occurs into the underlying ground (i.e. soil is saturated).
- Pluvial modelling results for depth have been mapped for flooding greater than 0.1 m. Flooding below this threshold does occur, however, this is not considered significant and is within the limits of model uncertainties.
- Pluvial modelling results for hazard mapping illustrate the low, medium and high hazard associated with pluvial flooding and are a function of depth, velocity and a debris factor. These extents, in some areas, appear greater than those in the depth mapping due to high velocities experienced at depths less than 0.1 m in some locations.
- The combined influence of flood sources should be considered when informing strategic planning.

5.3 Pluvial Flooding

Liaison with the relevant stakeholders, notably the Environment Agency, indicates that some records of surface water flooding exist for Chippenham. These events occurred in the following areas:

- High Street in 2006 and 2007;
- Park Fields in 1999;
- Agricultural land near Harden's Farm in 1960 and 1978; and
- Langley Burrow in 1978.

Direct rainfall pluvial modelling has been undertaken for Chippenham to identify potential flooding issues arising from surface water and their potential interaction with sewer and ordinary watercourse sources. Modelling has been undertaken for a range of scenarios for both present day and future climate change rainfall events as described in Section 4.2. The modelling outputs include potential maximum depth of flooding and the potential hazard associated with the flooding.

The modelling results indicated various locations within and around Chippenham that are potentially susceptible to surface water flooding, and these are discussed below. In general, pluvial flooding throughout Chippenham is not significant, with the main areas of ponding associated with the various watercourses (e.g. River Avon, Ladyfield Brook, Hardenhuish Brook, and Pudding Brook), closely linked with fluvial flooding.

These low lying areas are located within the Environment Agency Flood Zone 2 and Flood Zone 3, and identified as having a medium and high risk of fluvial flooding respectively. Fluvial flood risk in these low lying areas is considered to be the dominant risk of flooding. This assessment focuses on areas located outside the fluvial Flood Zone 2 and Flood Zone 3 extents.

Extracts from both the maximum flood depth and flood hazard mapping are provided in the following sections to identify potential areas for further investigation. In order to inform planning at the strategic level, mapping extracts from the 1% AEP rainfall event, inclusive of climate change, are displayed within the report to be commensurate with the requirements of PPS25.

It is anticipated that these maps should be used for facilitating the engagement of stakeholders on surface water flooding issues - to further inform spatial planning processes, to inform future capital investment decisions, to inform emergency planning functions carried out by Local Resilience Forums and to identify whether critical infrastructure is at risk from surface water flooding. It is important that the limitations of the modelling are considered when using the output maps and data, as described in Section 5.2.

5.3.1 Langley Park Area

Analysis of the results indicates that a potential flow path is impeded by the main railway line in the Langley Park area to the north east of Chippenham railway station. The flow path is associated with a watercourse that rises in the north of Chippenham and is culverted from Birds Marsh Close. Overland flow is likely to occur during times of heavy rainfall where the capacity of the culverted watercourse is exceeded. The flow path is obstructed by a raised section of the railway at Langley Park that may cause potential ponding of surface water in this location (see Figure 5-3). Due to the security measures, visual inspection of this potential flow path within Langley Business Park was unable to be undertaken.

Potential maximum depths of flooding within this area are relatively shallow and are typically less than 0.5 m. The exception is deeper ponding associated with the adjacent railway embankment on the boundary of Langley Park. The flood hazard associated with the potential flooding is medium, meaning that access for ‘more vulnerable’ people (i.e. the elderly or infirm) may be difficult. However, due to the nature of the existing site use (business park), there are a number of access routes that would potentially be unhindered to allow safe egress. Inspection of the Wessex Water surface water sewer map indicates that the flow path is served by an existing surface water sewer network. Therefore, it is likely that any flooding in this location would be in combination with sewer sources and is further explained in Section 5.5.

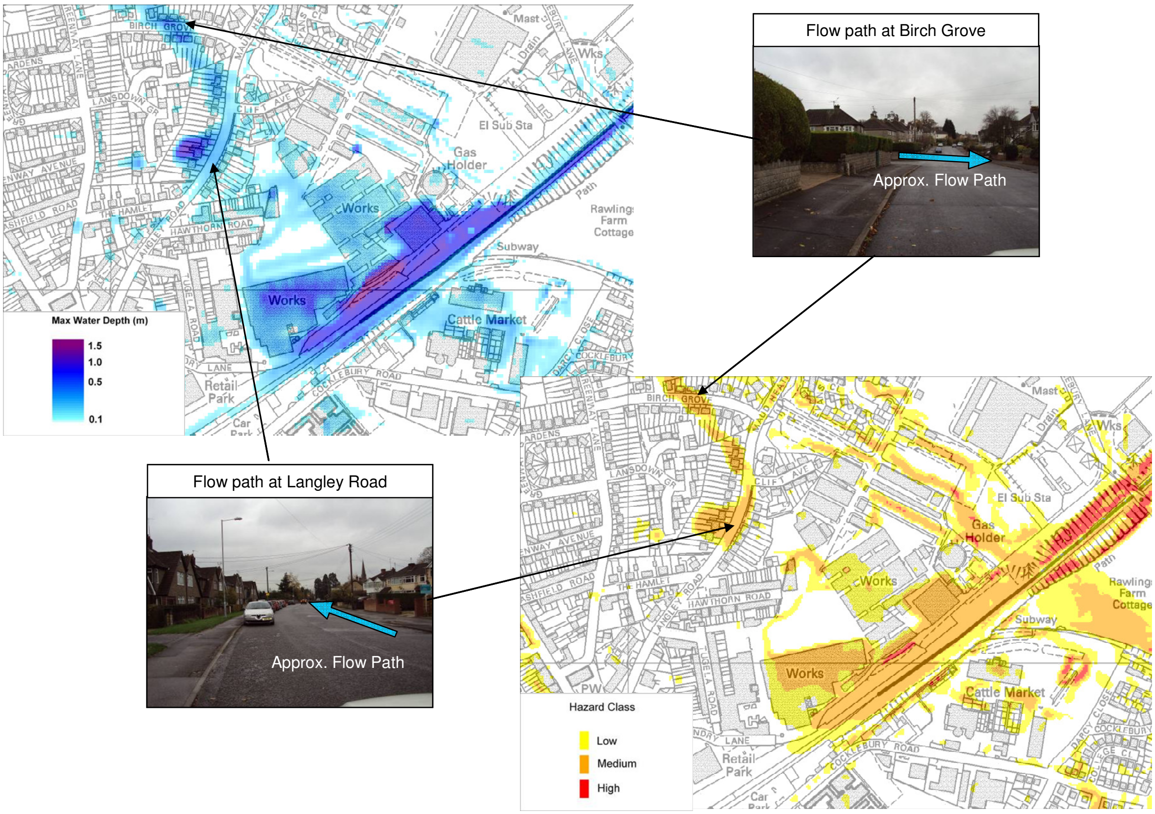


Figure 5-2: Pluvial modelling results (maximum potential depth and hazard) from the 1% AEP rainfall event inclusive of climate change for Langley Park Area, Chippenham.

5.3.2 Eastern Avenue Area

Analysis of the results indicates that a potential flow path exists along Downham Mead and Eastern Avenue in eastern Chippenham. The flow path also exists through the relatively recent housing development area within the vicinity of Gleneagles Close. The flow path is obstructed by a raised bank to the south of Gleneagles Close, which potentially causes additional ponding at this location. It is understood that this embankment was constructed in order to protect the residential development from fluvial flooding associated within the River Avon. Visual inspection of this potential flow path confirms that a low point exists along these routes, as illustrated in Figure 5-3.

Potential maximum depths of flooding within this area are relatively shallow and are typically less than 0.5 m. The exception is the deeper ponding in the vicinity of Gleneagles Close, which is exacerbated by the flood embankment to south of this area. The flood hazard associated with the potential flooding is in general low or medium, meaning that access for 'more vulnerable' people (i.e. the elderly or infirm) may be difficult. However, vehicular and emergency services access would potentially be unhindered. Inspection of the Wessex Water surface water sewer map indicates that the flow path is served by an existing surface water sewer network. Therefore, it is likely that any flooding in this location would be in combination with sewer sources and is further explained in Section 5.5.

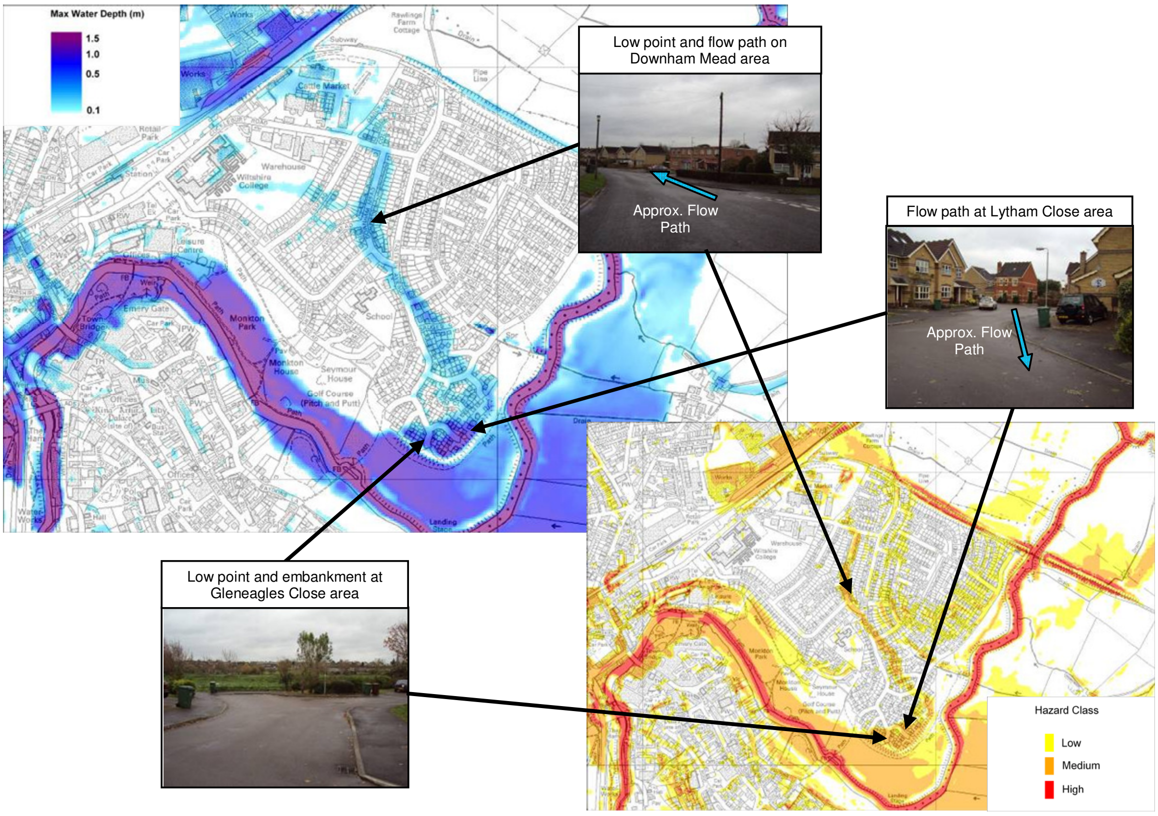


Figure 5-3: Pluvial modelling results (maximum potential depth and hazard) from the 1% AEP rainfall event inclusive of climate change for Eastern Avenue and Downham Mead in eastern Chippenham

5.3.3 High Street

The model results indicate that water could flow down the High Street and pond in the lower (northern) extent of the High Street, adjacent to the River Avon. Visual inspection of this area and discussion with Wiltshire Council drainage engineers verify the model results. Although the High Street is served by a surface water sewer network, the gullies that collect the water from the road and precinct surface were relatively small and widely spaced, potentially reducing the capacity of the drainage network.

As illustrated in Figure 5-4, the thresholds of many of the buildings along the High Street are set at ground level. Therefore, ingress of surface water to these buildings is unlikely to be impeded, causing internal flooding. It is understood that Wessex Water undertook alleviation works in the High Street in 2006 to reduce the potential risk posed from surface water sewer exceedance in this area. It is recommended that any future studies of the High Street area take into consideration these alleviation works.

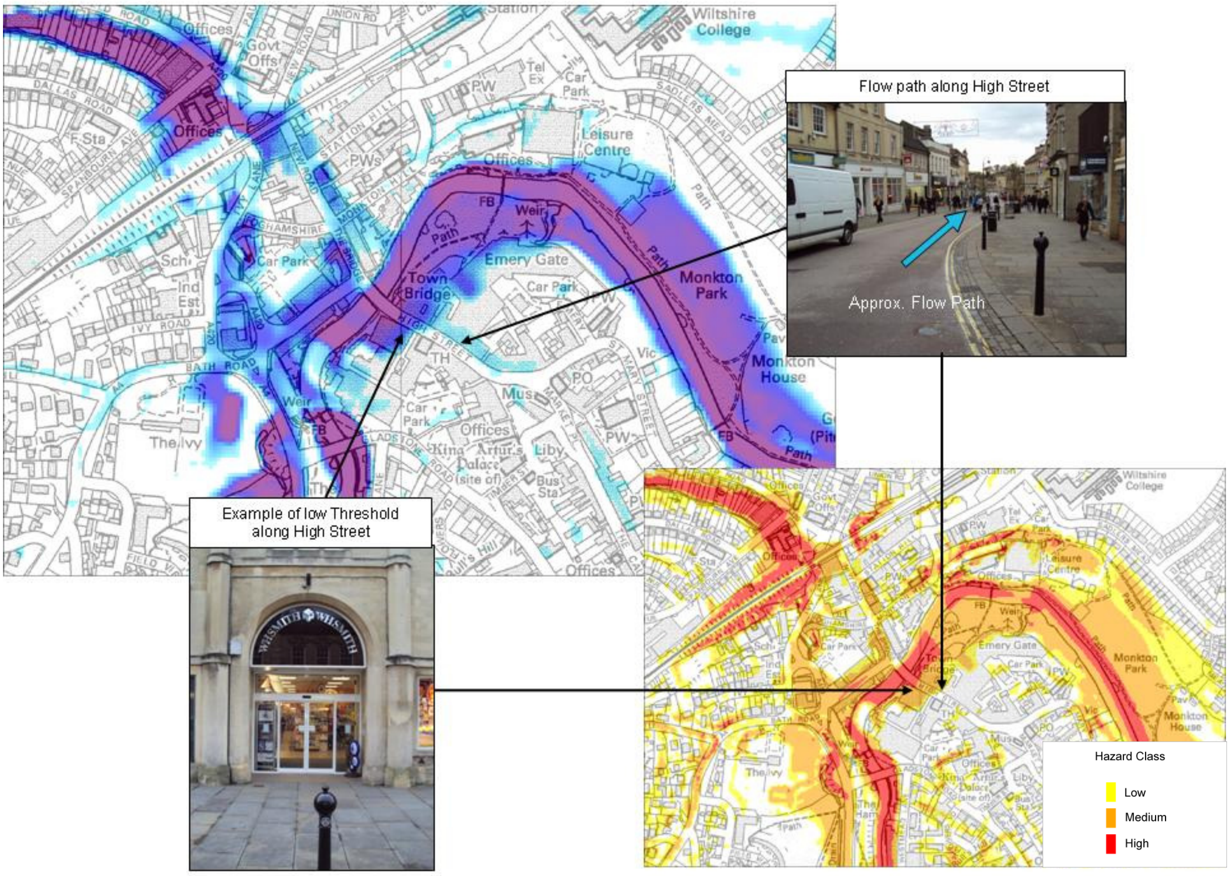


Figure 5-4 Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the High Street in central Chippenham

As shown in Figure 5-4, the potential area that would be inundated during a 1% annual probability storm event, inclusive of climate change is mostly confined to the low lying areas of the town centre, to the north of the High Street. During high flows within the River Avon, areas adjacent to the river are likely to become inundated. In addition, surface water outfalls draining to the River Avon will potentially become ‘locked’. This effect will cause surface water to back up within the drainage system and potentially exceed the capacity, leading to the surface water sewers to surcharge causing overland flow.

5.3.4 Hardenhuish Brook

Analysis of the modelling results indicates that there is a potential flood risk associated with the Hardenhuish Brook, which flows through western Chippenham. Figure 5-5 illustrates that the majority of potential flooding is located adjacent to the Hardenhuish Brook. Depths up to 1.5 m are likely to be experienced but following visual inspection of the watercourse, the channel is incised in relation to the surrounding area, indicating that the Hardenhuish Brook conveys overland flows during heavy rainfall events that collect within the watercourse from the surrounding catchment.

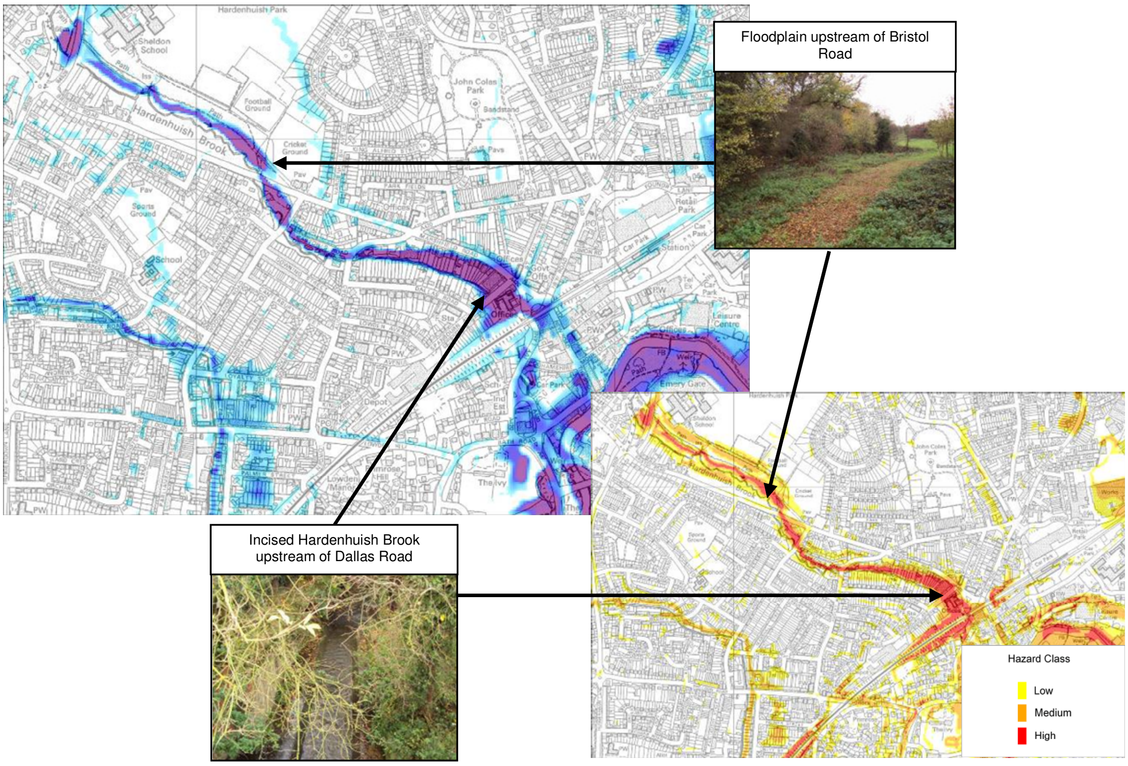


Figure 5-5: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Hardenhuish Brook

An overland flow path exists between the Hardenhuish Brook and the River Avon. This is likely to be associated with the former route of the Brook as an open watercourse, prior to its existing state as a culverted watercourse. Liaison with Wiltshire Council drainage engineers indicates that there are occasionally some minor flooding incidents associated with the culverted section of the Brook. These incidents are typically connected with maintenance or blockage issues that are often associated with urban watercourses.

As with the flood depths, the potential maximum flood hazard extents associated with the Hardenhuish Brook are located adjacent to the watercourse, with the higher hazards associated with the deeper water within the Brook.

5.4 Groundwater Flooding

A conceptual understanding of the hydrogeology for the Chippenham has been developed based on data provided. A wider groundwater assessment describing the bedrock and superficial geology, hydrogeology and wider groundwater elements is appended to this report with accompanying figures. This has been used to identify groundwater flooding mechanisms, evidence of groundwater flooding, areas susceptible to groundwater flooding and potential requirements for long term monitoring. It has also been used to identify constraints with regards to using infiltration SuDS.

5.4.1 Groundwater Flooding Mechanisms

Based on the current hydrogeological conceptual understanding, there is potential for groundwater flooding in the Chippenham study area. The key groundwater flooding mechanisms that could exist are:

- **Cornbrash Formation outcrop area in central and west Chippenham:** The available datasets indicate that a perched groundwater table exists within the Cornbrash Formation. Due to the permeable but thin nature of this Formation, basements / cellars and other underground structures may be at risk from groundwater flooding following periods of prolonged rainfall, increased utilisation of infiltration SuDs and / or artificial recharge from leaking pipes.
- **Kellaways Sand Member outcrop area in north east Chippenham:** There is potential for a perched groundwater table to exist within the Kellaways Sand Member. Due to the permeable but thin nature of this aquifer, basements / cellars and other underground structures may be at risk from prolonged groundwater flooding from periods of prolonged rainfall, increased utilisation of SuDs and / or artificial recharge from leaking pipes.
- **Superficial geology aquifers in hydraulic continuity with the Upper Bristol Avon River:** Groundwater flooding may be associated with the substantial sand and gravel River Terrace Deposits, or to a lesser degree Alluvium, where they are in hydraulic continuity with watercourses. Stream levels may rise following high rainfall events but still remain "in-bank", and this can trigger a rise in groundwater levels in the associated superficial geology. The properties at risk from this type of groundwater flooding are most likely to be limited to those with basements / cellars, which have been constructed within the superficial geology.
- **Superficial aquifers not in hydraulic continuity with the Upper Bristol Avon River:** Groundwater flooding is also associated with substantial River Terrace Deposits (gravel and sand), Alluvial Fan Deposits and Head deposits, but occurs where they are not in immediate hydraulic connection with watercourses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are most likely to be limited to those with basements / cellars.
- **Impermeable (silt and clay) areas downslope of aquifer outcrop (various locations):** Groundwater flooding may occur where groundwater springs / seepages form minor flows and ponding over impermeable strata where there is poor drainage. This mechanism may occur as a result of natural (e.g. rainfall) or artificial (e.g. water main leakage) recharge.
- **Uncapped boreholes drilled into the Combe Down Oolite:** The piezometric levels within the Combe Down Oolite are at, or close to, ground level following sustained wet periods, although overlying clay horizons prevent groundwater flooding from this aquifer. However, uncapped boreholes would provide an artificial pathway for groundwater to flow to surface and cause groundwater flooding.

5.4.2 Evidence of Groundwater Flooding

Figures 1, 3, 4 and 5 (see appended groundwater report and figures) show the location of one historic groundwater flooding incident that was identified by the Environment Agency. They also show the locations of another six flooding incidents that may have been influenced by groundwater conditions, but have been identified as either fluvial or pluvial flooding. These flooding incidents have also been considered by this study, as it is often difficult to identify the cause of a flooding incident. Details of the reported incidents are shown in Table 5-2, including the local geology and the date of the reported incident.

Table 5-2: Selected potential groundwater flooding incidents

Geological Units*	Grid Reference	No**	Reported Incident	Date
Cornbrash Formation / River Terrace Deposits	ST 92428 73140	1	Groundwater flooding – no other comment	30/10/2000
Cornbrash Formation / River Terrace Deposits	ST 92960 72800	2	Fluvial flooding – no other comment	12/04/1960
Cornbrash Formation	ST 90605 73101	3	Fluvial flooding – no other comment	12/01/1979
Kellaways Clay Member / River Terrace Deposits	ST 93430 73120	4	Surface Water flooding – no other comment	12/04/1960
	ST 93400 73200	5	Surface Water flooding – no other comment	03/06/1978
	ST 93520 73570	6	Surface Water flooding – no other comment	12/04/1960
Kellaways Sand Member	ST 93400 75200	7	Surface Water flooding – no other comment	03/06/1978

Note: * Geology of incident based on plotted location on Figures 1 & 4 (see appended report).

** Reference number as shown on Figures 1, 3, 4 & 5 (see appended report).

Based on Figure 1 (see appended report), the hydrogeological situation of incidents 1, 2, 4, 5 and 6 are similar, although only incident 1 is listed as a groundwater flooding incident. These locations are shown to be on a shallow aquifer (Cornbrash Formation / River Terrace Deposits) where groundwater levels are likely to be influenced by the Upper Bristol Avon River but also rainfall runoff from the impermeable Kellaways Clay Member on higher ground.

Figure 1 (see appended report) shows that locations 3 and 7 are both located on shallow aquifers but do not appear to be close to any watercourses. It is plausible that these two flooding incidents were influenced by groundwater conditions.

It is important to note that the listed flooding incidents in Table 5-2 are not contemporary; there are no available data beyond the end of October 2000. In addition, until recent years there have been few drivers in place to ensure the systematic recording of flood incidents and their likely cause.

5.4.3 Areas Susceptible to Groundwater Flooding

The Environment Agency has produced a dataset referred to as 'Areas Susceptible to Groundwater Flooding (AStGWF)', on a 1 km grid (Figure 5 in appended report). This utilises the BGS 1:50,000 Groundwater Flood Susceptibility dataset for consolidated aquifers (bedrock) and superficial geology.

The Environment Agency dataset shows the percentage of each 1 km square that falls within the 'high' to 'very high' BGS groundwater flooding susceptibility categories. It does not show the probability / risk of groundwater flooding occurring; this can only be determined following site specific investigation works and desk studies. It also does not take into account groundwater level rebound following cessation of abstraction.

An absence of values for any grid square means that no part of that square is identified as being susceptible to groundwater emergence.[12]).

The areas that are identified as being most susceptible to groundwater flooding are located close to the Upper Bristol Avon and River Marden. By comparing the dataset with the underlying geology it is apparent that those grid squares identified as having an area greater

[12] Environment Agency, 2010. Areas Susceptible to Groundwater Flooding - Guidance Document.

than 50% with high to very high susceptibility to groundwater flooding are those where significant River Terrace Deposits are present.

Flooding incidents 4, 5 and 6 (see Table 5-2) are located in grid squares within the >=25% <50% category, owing to the proximity of Alluvium and River Terrace Deposits adjacent to the Upper Bristol Avon River.

Incident numbers 3 and 7 (see Table 5-2) located on the Cornbrash Formation and Kellaways Sand Member are shown to be in grid squares with no shading, which suggests no susceptibility to groundwater flooding. However, this could indicate that no water level data were available to the BGS when creating the original AStGWF Map. This notwithstanding, it is thought that the approximate areas identified by the Environment Agency as being susceptible to groundwater flooding are sensible.

5.4.4 Long Term Groundwater Level Monitoring

Groundwater flow direction, depth to groundwater, topography and the degree of artificial influence in the subsurface (e.g. leaking water mains or groundwater abstractions) play an important role when considering the susceptibility of an area to groundwater flooding. Groundwater level data for the superficial aquifers, Cornbrash Formation and Kellaways Sand Member are limited to recorded water strikes or rest water levels on BGS borehole logs, which only provide groundwater levels for one point in time. Without long term groundwater monitoring, it is not possible to derive groundwater level contours, or understand maximum seasonal fluctuations. Therefore it is not possible to provide a detailed assessment of groundwater flood risk or provide detailed advice on suitability for infiltration SUDS.

Groundwater levels are often only measured once or for a short period during site investigations. Where considered necessary, long term monitoring of the Cornbrash Formation, Kellaways Sand Member and superficial aquifer groundwater levels would provide a better understanding of the local hydrogeological conditions.

It is also important to understand how changing policies relating to infiltration SUDS can impact upon groundwater levels. For example the introduction of infiltration SUDS (e.g. soakaways) may cause a localised rise in groundwater levels. This could prevent soakaways from operating and the reduction in unsaturated zone thickness.

Where considered necessary, long term groundwater level monitoring may be implemented to support decision making with respect to future land development and future co-ordinated investments to reduce the risk and informing the assessment of suitability for infiltration SUDS.

5.4.5 Infiltration SuDS Suitability

Improper use of infiltration SuDS could lead to contamination of the superficial or bedrock geology aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SuDS is likely to help improve aquifer quality status and reduce overall flood risk.

Environment Agency guidance on infiltration SuDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/36998.aspx. This guidance should be considered by developers and their contractors and by Wiltshire Council during the planning application process.

The areas that may be suitable for infiltration SUDS (e.g. soakaways, permeable paving) exist where there is a combination of higher ground (interfluves) and permeable geology (see Figure 3 in appended report). However, consideration should be given to the impact of increased infiltration SUDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at the down gradient location. This type of analysis is beyond the scope of the current report.

Restrictions on the use of infiltration SuDS apply to those areas within Source Protection Zones (SPZ), (see Figure 3 in appended report). Developers should seek advice from the Environment Agency on proposed drainage designs where they are located within an SPZ.

It is understood that the SPZs in the Chippenham area are associated with groundwater abstractions from the Forest Marble Formation and Combe Down Oolite, which are expected to be hydraulically isolated from the aquifers that outcrop in the Chippenham area.

5.5 Sewer Flooding

The historic and potential flooding database collated for the North Wiltshire SFRA published in 2007 and updated in 2009 as part of the Wiltshire Council SFRA High Level Executive Summary indicates that only one property was considered at risk from sewer flooding within Chippenham. The DG5 register provided specifically for this study by Wessex Water indicates that there are currently no sewer capacity issues within the town, however, some sewers maybe at or near their hydraulic capacities. Wessex Water has also confirmed that there are also no further entries being added to the DG5 register in the near future but where property flooding does occur the register will be updated.

Where incidents of sewer flooding occur this is typically associated with either exceedance of sewer capacity or a blockage/collapse within the sewer system. Design standards for surface water sewers currently require the sewer design to be for a 3.33% AEP (1 in 30 year) rainfall event. However, existing sewers are likely to have lower capacity due to their age. Therefore, sewer exceedance, blockage or collapse could lead to localised flooding within and from the sewer network.

As identified in Section 5.3, it is likely that areas identified by the pluvial modelling are inherently linked with the sewer network. The likely effects of the inter-relationship between the sewer network and overland flow are described in the following sections.

5.5.1 Langley Park Area

Figure 5-7 illustrates that the potential flow path within the vicinity of Langley Road and Langley Business Park is served by existing surface water sewers. In particular, Langley Road is underlain by a 675 mm diameter sewer. In addition, the area within the vicinity of Langley Business Park is served by a 675 mm diameter sewer passes beneath the main railway line. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced provided that the sewer network is functioning as designed. In addition, the sewer serving Langley Road is to convey large water away from the Langley Business Park, therefore reducing the potential effects of surface water flooding in this area.

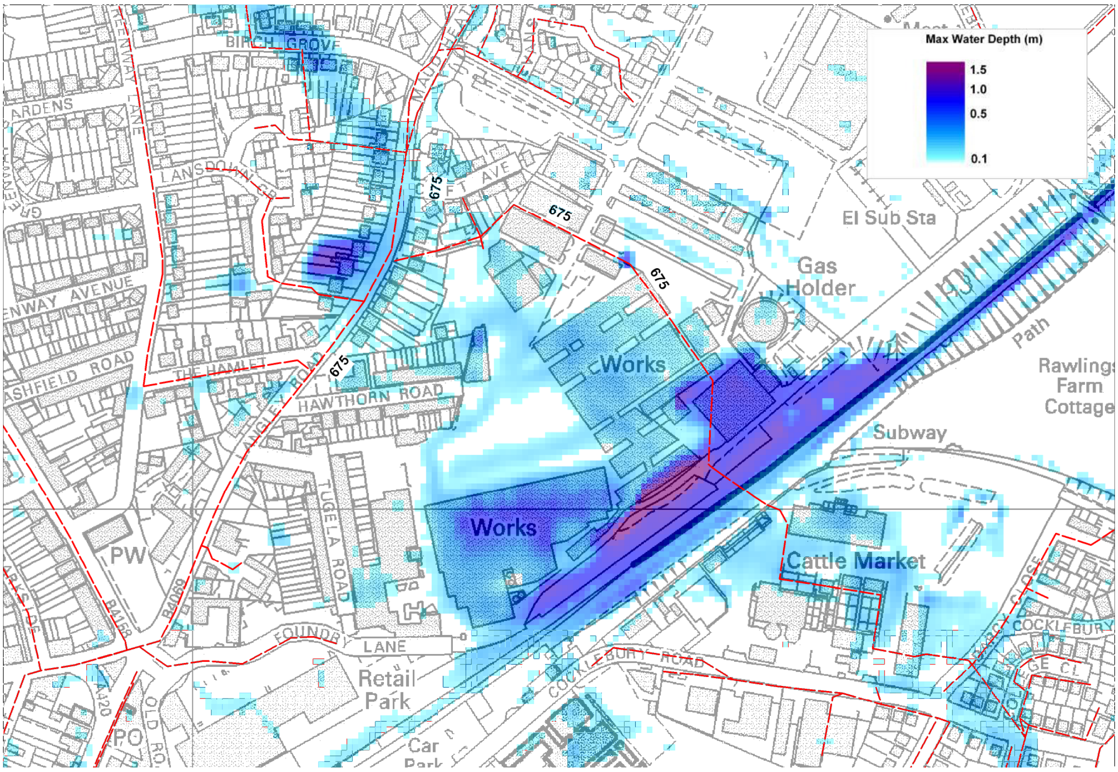


Figure 5-6: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of Langley Business Park. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

The above information provides outline verification of the observations provided in Section 5.3.1 in that any flooding within the vicinity of Langley Park and Langley Road would be caused by a blockage or exceedance of the local surface water sewer network. In addition, Figure 5-7 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network.

5.5.2 Eastern Avenue Area

Figure 5-7 illustrates that the potential flow path within the vicinity of Eastern Avenue and Downham Mead is generally served by existing surface water sewers. In particular, Downham Mead road is underlain by a 900mm diameter sewer. In addition, the area within the vicinity of Gleneagles Close is served by a 450mm diameter sewer that discharges into the River Avon to the east of this area. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced provided that the sewer network is functioning as designed.

The above information provides outline verification of the observations provided in Section 5.3.1 in that any flooding within the vicinity of Eastern Avenue would be caused by a blockage or exceedance of the local surface water sewer network. In addition, Figure 5-7 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network.

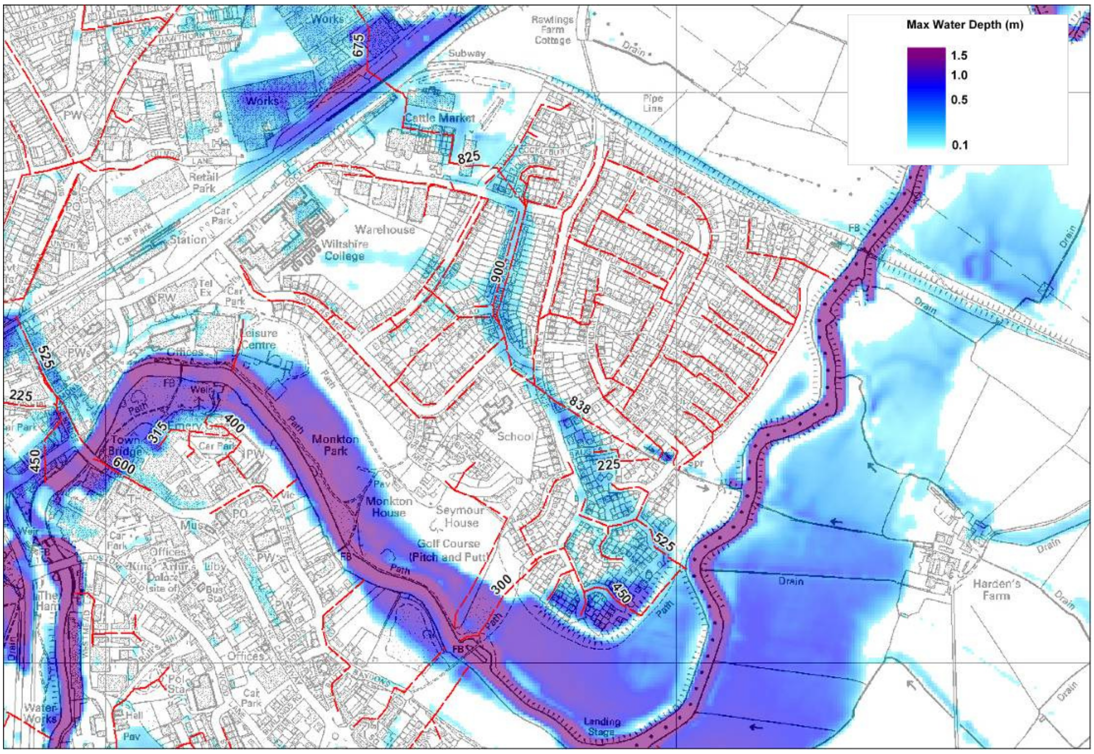


Figure 5-7: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of Eastern Avenue. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

5.5.3 High Street Area

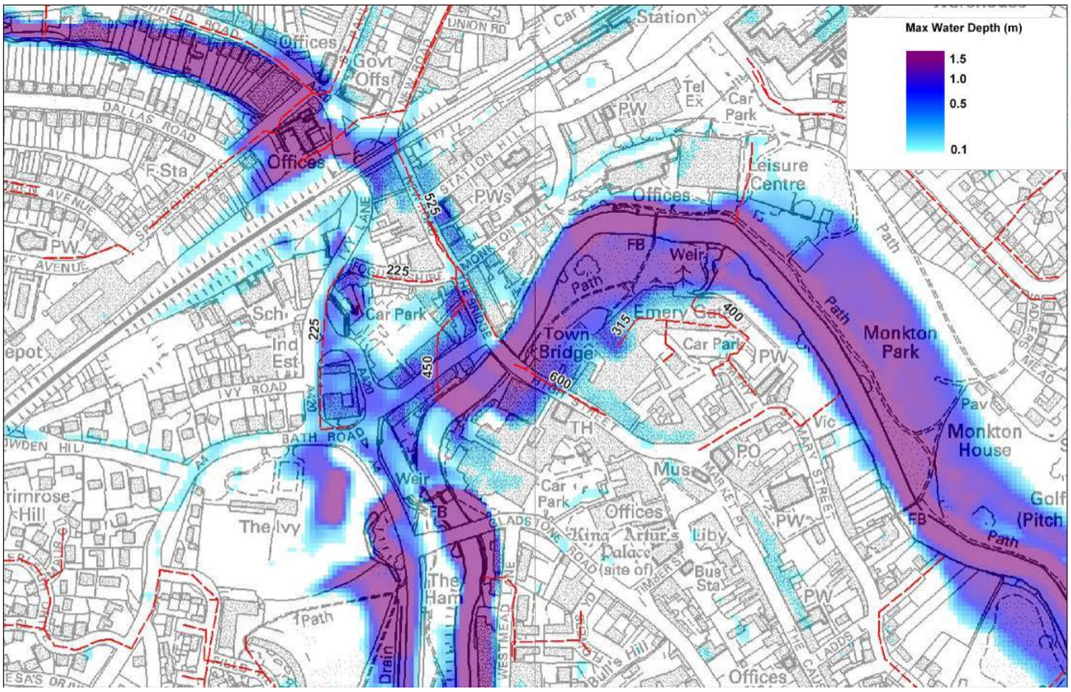


Figure 5-8: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of the High Street. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

Figure 5-8 illustrates the results of the pluvial modelling for the 1% AEP rainfall event including climate change with the surface water network imposed for the High Street area. It is noted that the High Street is served by a 600 mm diameter surface water sewer that will reduce potential flood depths from overland flow providing the network is functioning as designed. In addition, as mentioned in Section 5.3, it is understood that this area has been subject to alleviation works undertaken by Wessex Water, which include an increase in sewer capacity and underground storage tank.

It is also understood that alleviation works in the New Road area were undertaken in January 2007 (to the north of the River Avon), these are likely to help reduce the potential for flooding associated with the former course of the Hardenhuish Brook.

5.6 Ordinary Watercourses

The pluvial modelling results indicate that surface water runoff is closely linked to the network of watercourses within the Chippenham area. 'Ordinary Watercourses' are, in part, the responsibility of the Local Authority alongside riparian owners. However, this responsibility is transferred to the Environment Agency where the watercourse becomes 'Main River'.

Overland flows predominantly drain into the ordinary watercourse network within the headwaters and tributaries of the Hardenhuish Brook, Ladyfield Brook and Pudding Brook. In addition, the pluvial modelling identifies the potential risk from surface water associated with unnamed ordinary watercourses within the Chippenham area that are the responsibility of Wiltshire Council.

This section describes the pluvial modelling results that relate to the various Ordinary Watercourses within and around Chippenham.

5.6.1 Patterdown Area

The Patterdown area is located to the south west of Chippenham and is truncated by the A350 and A4 roads, as well as the main railway line. The pluvial modelling results shown in Figure 5-9) indicate that the flooding from pluvial sources across this area would not be significant on a strategic scale. However, local obstructions and low points such as the railway embankment and Saltersford Lane could potentially cause some localised ponding.

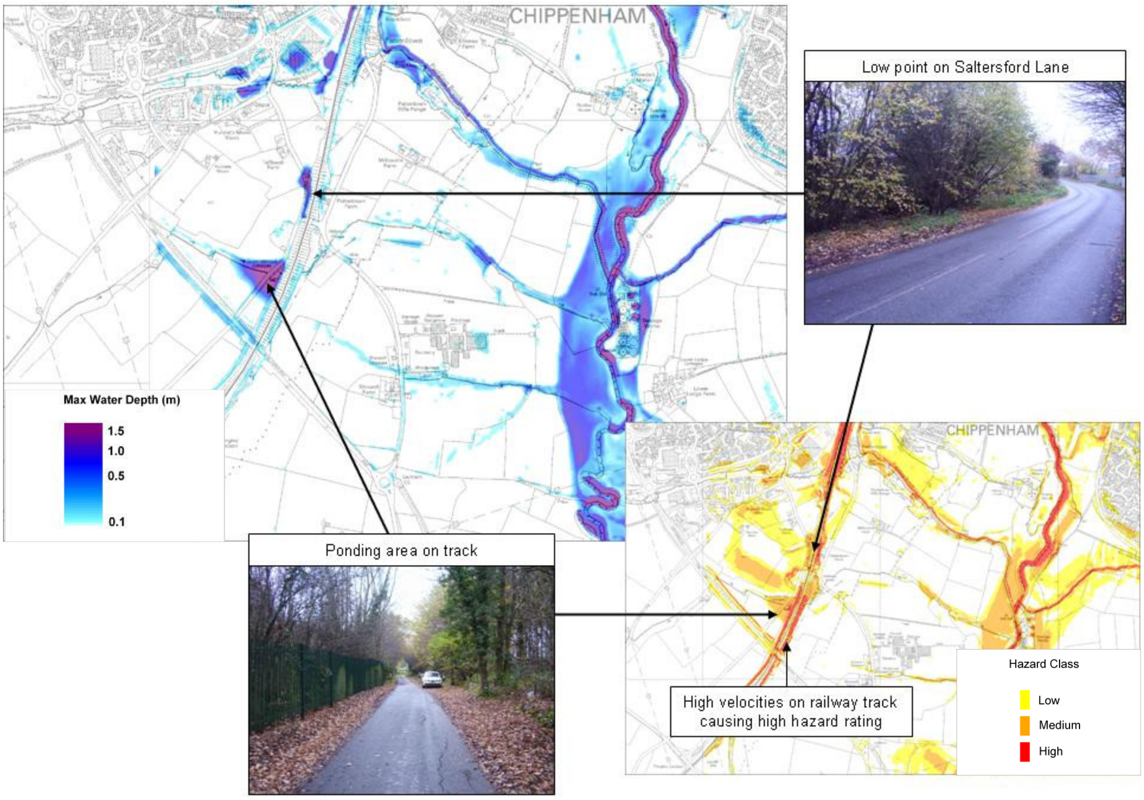


Figure 5-9: Pluvial modelling results during the 1% AEP rainfall event, inclusive of climate change (maximum depth and hazard) for the Patterdown Area

As shown in Figure 5-9, the potential flooding associated with the small watercourses within the Patterdown area is not considered significant. Where required, further investigation could be undertaken but is not considered necessary for the purposes of this SWMP.

In general, the hazard rating associated with any flooding in the Patterdown area is moderate or low. There are some areas of high hazard, mostly located on the railway embankments associated with fast flowing rather than deep water.

5.6.2 Pewsham Way Area

The pluvial modelling results provide outline flood extents for the Ordinary Watercourses to the south east of Chippenham, within the vicinity of Pewsham, Middle Lodge and Pewsham Way (see Figure 5-10).

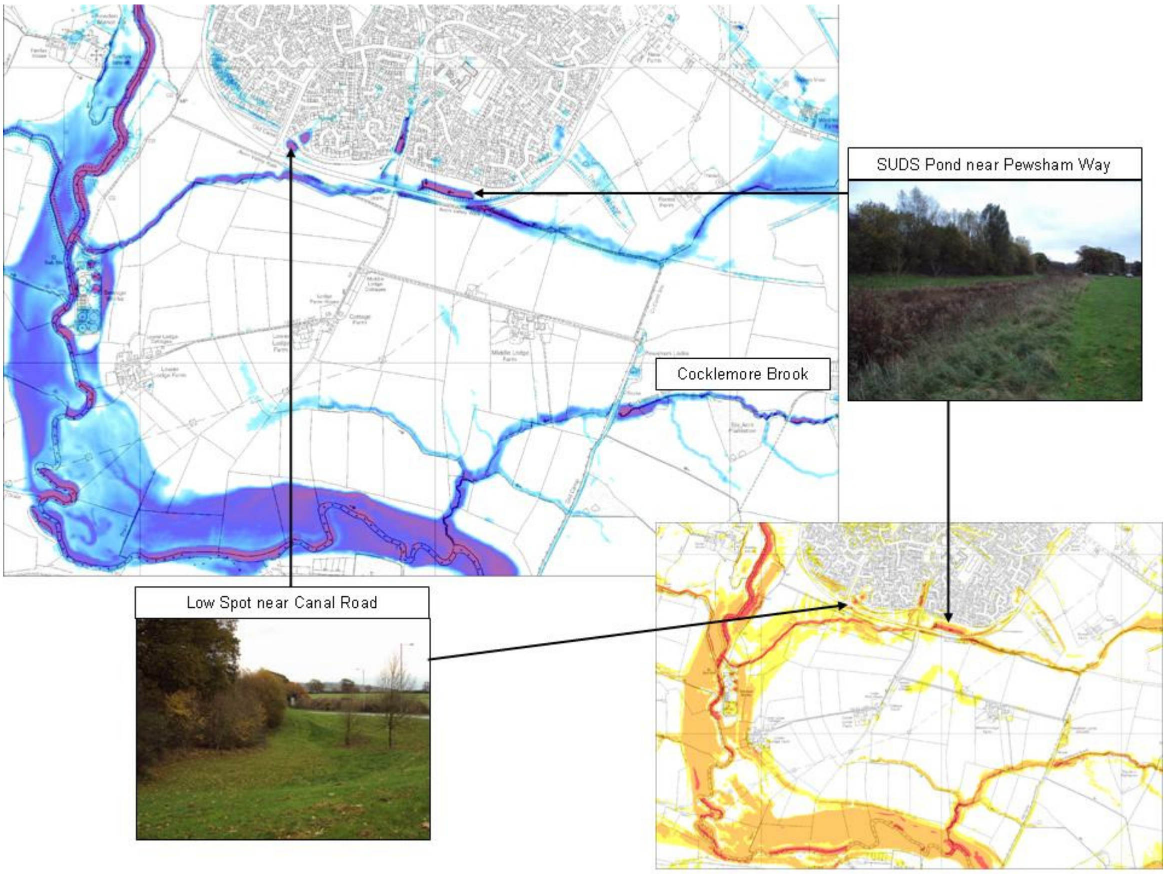


Figure 5-10: Pluvial modelling results during the 1% AEP rainfall event, inclusive of climate change (maximum depth and hazard) for the Pewsham Way Area

The modelling results indicate some minor flooding could occur within the corridor of the Cocklemore Brook and the ordinary watercourse adjacent to the Avon Valley Walk. This flooding would be associated from inputs from the surrounding catchment and provide an indication of the flood risks associated with the watercourses at a strategic scale.

Areas of potential ponding within the vicinity of Pewsham Way and Canal Road are observed and site walkovers identified that the ponding upstream (north) of Pewsham Way is associated with an existing SuDS pond. This pond is 'on-line' with the small watercourse running through with a control structure at the downstream end. In addition, the pond receives surface water runoff from the residential development to the north (Hatherall Road area). The two areas of ponding adjacent to Canal Road are associated with depressions in the ground at this location and were confirmed during the site walkovers (see Figure 5-10). The areas of highest hazard are generally found with the areas of deeper water associated with these features.

5.7 Implications for Future Development

As shown in Figure 5-1, the preferred option for strategic developments proposed at the time of writing are located on the outskirts of the town on predominantly greenfield sites. These are located in the north (Hill Corner Road area) and the south west (Patterdown Area) with a small element within the vicinity of Abbeyfield School. Proposed developments are subject to the requirements of the planning system and therefore it is considered that the findings of the SWMP should be taken into account within design and layout of the developments. It is envisaged that due to the scale of development, an FRA will be required as part of the planning process for each planning application. This should address surface water issues at the development scale.

Figure 5-11 and Figure 5-12 provide an overview of the proposed development areas to the south west and north of Chippenham respectively, along with the pluvial modelling results.

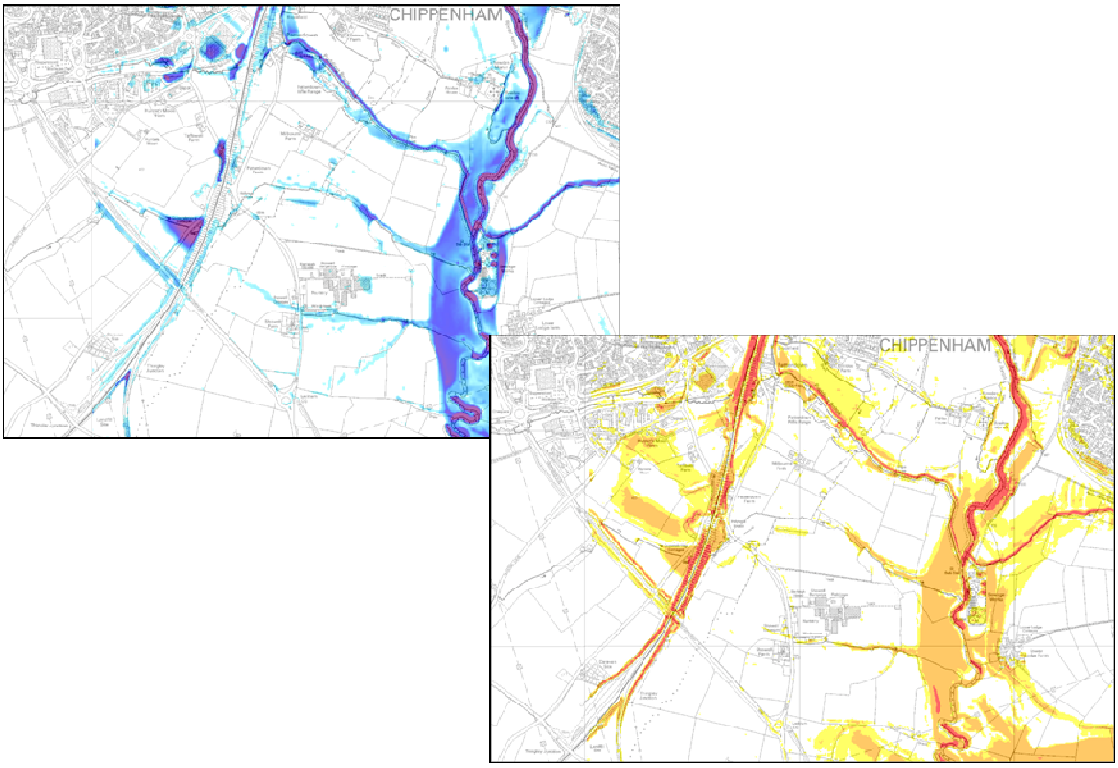


Figure 5-11: Pluvial modelling results during the 1% AEP rainfall event, inclusive of climate change (maximum depth and hazard) for the Patterdown Area

Figure 5-11 indicates that there are no significant flow paths across the Patterdown area. Where flow paths exist, these follow the route of existing drainage ditches and ordinary watercourses across the agricultural land. Proposed development should accommodate such areas within the Masterplanning process and provide open space, for example by setting development back from these features or retaining a corridor within the locality.

Further investigation should be undertaken in conjunction with relevant stakeholders (in particular Network Rail) with regard to the culvert capacity beneath the railway line and the potential for blockage and ponding upstream of this feature. It should be noted that the high hazard associated within the railway line is due to the steep embankments causing high velocities to be generated within the modelling, however, due to required easements associated with such infrastructure these are unlikely to affect potential development.

Figure 5-12: Pluvial modelling results during the 1% AEP rainfall event, inclusive of climate change (maximum depth and hazard) for the Hill Corner Road Farm Area

The Hill Corner Road area does not have significant flow paths and therefore surface water flooding in this area would not be deemed a significant flood risk on a strategic scale. Figure 5-12 illustrates there are some areas of low hazard to the north of Hill Corner Road. However these are likely to be associated with depths of water less than 0.1 m but with a high velocity. At the development scale, this should be investigated further as part of the site design process. In addition, opportunities to alleviate downstream surface water flooding and the exceedance of sewer capacity should be considered due to the culverting of the minor watercourse to the south of this area.

It should be noted that the areas of ponding and high hazard in the north west of the Hill Corner Road area, shown in Figure 5-12, are likely to be exaggerated due to the lower quality of the digital terrain (topographical) data used in this area (see Appendix B for further explanation).

The Wessex Water sewer map indicates that no foul or surface water sewer network exists on the preferred housing option land to the north and south west of Chippenham (they are predominantly greenfield areas at present). Where development is proposed, new infrastructure will be required to manage surface water runoff from the site. The feasibility of suitable SUDS techniques for use onsite will need to be identified. Where management of surface water onsite is not reasonably practicable via infiltration systems, discharge to a nearby watercourse or sewer will need to be sought. Proposed development must also ensure it meets the requirements of PPS25 with regard to surface water management.

5.8 Summary

Based on the findings of the pluvial modelling and the assessment of flooding from other sources including the potential from sewer, groundwater and ordinary watercourses, the following high level observations have been made that can be used to inform the Phase III stage of the SWMP. The observations are as follows:

- A potential overland flow path has been identified within the Eastern Avenue area. This area is served by an existing public surface water sewer network but is likely to have localised flooding where sewer capacity is exceeded. Raised property thresholds (e.g. step up to entrance) were observed during site walkovers and will reduce the potential egress into properties. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Historically, the high street has experience flooding associated with surface water sewer exceedance. Pluvial modelling illustrates that this area will remain susceptible to surface water flooding and is likely to be exacerbated by high water levels within the River Avon. Existing impermeable surfaces, lack of raised curbs and level entry to businesses within this area increase the potential for surface water flooding issues now and in the future. Property level prevention measures could provide simple and easy solutions to help mitigate existing surface water flooding issues.
- Minor incidents associated with maintenance on the Hardenhuish Brook have caused localised flooding. However, flooding associated with surface water is typically confined within the channel and adjacent floodplain and is not considered a significant issue.
- A number of ordinary watercourses were identified that convey surface water flow. Localised flooding would be experienced during times of heavy rainfall. However, these are typically located within undeveloped areas.
- Potential development in the Hill Corner Road area may offer opportunities to reduce the surface water flood risk associated with a culverted watercourse to the south of the area. In addition, whilst not considered to be in an 'Area Susceptible to Groundwater Flooding', site level investigation should be undertaken to identify the suitability for infiltration SuDS associated with the underlying Kellaways Sand Member.
- Potential developments in the Pewsham Way and Hardens Farm area are located in greenfield areas. These are not served by the public sewer system and flow paths associated with ordinary watercourses (ditches, mainly) are likely to convey water to the River Avon. Surface water management should be considered during the masterplanning phases to direct development away from potential flow routes and to provide green open space. Site level investigation should be undertaken to identify the suitability of infiltration SuDS due to the presence in some areas of River Terrace Deposits and Alluvial Deposits.

6 Trowbridge

6.1 Overview

Trowbridge is located within the west of Wiltshire and serves a population of over 30,000[13]. The 'Wiltshire Core Strategy Consultation Document'[14] released in June 2011 identifies that Trowbridge Community Area should provide up to 6,000 new homes over the period 2006 to 2026 of which 5860 should be within Trowbridge. Approximately 1075 new homes have been built and a further 1646 homes are already committed and considered developable. In addition, 30 ha of employment land should be provided over this period. This supersedes the information previously contained within the 'Wiltshire 2026 – Planning for Wiltshire's Future'.

The preferred strategic site option for Trowbridge is identified in Figure 6-1. However, it is understood that other options have been considered and therefore the extent of the SWMP has been defined to encompass potential options. This allows a holistic appreciation of existing and future potential for flooding from surface water, groundwater, sewer, ordinary watercourse or a combination of these, and helps to inform the strategic planning process.

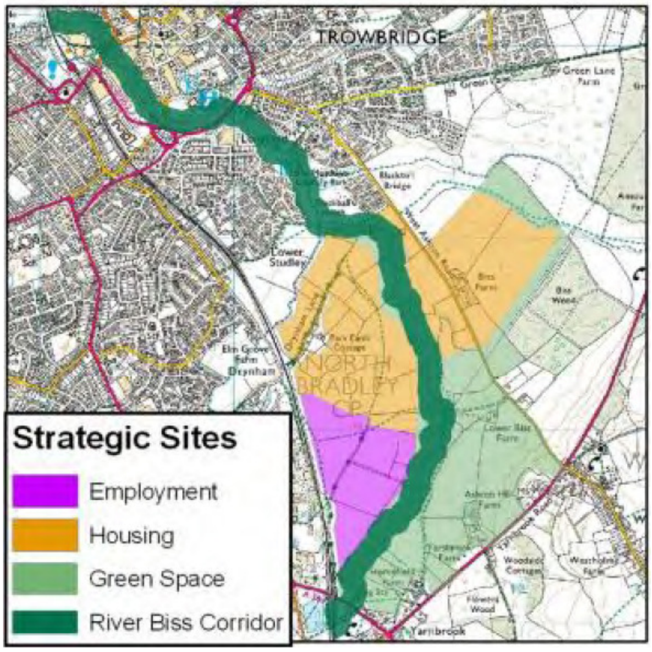


Figure 6-1: Preferred strategic site option for Trowbridge.

Historically, the majority of reported flooding issues within Trowbridge have been linked with fluvial flooding from the River Biss. Surface water flooding incidents have been limited, with no significant issues identified in liaison with Wiltshire Council drainage engineers. It should be remembered that whilst reported incidents indicate that there are no identified issues at present, the risk and consequences of flooding can still occur in extreme conditions and in the future when considering the effects of climate change.

13 http://www.trowbridge.gov.uk/
14 http://www.wiltshire.gov.uk/planninganddevelopment/planningpolicy/wiltshirecorestrategy/wcsconsult2011.htm

6.2 Data / Information Review

In order to inform the Phase II element of the SWMP for Trowbridge, two principal activities have been completed. The first was the direct rainfall and pluvial flood modelling (as described in Section 4.2). The second activity was to verify and augment the pluvial modelling with historical flooding information and records.

During the preparation of this SWMP meetings between URS/Scott Wilson and Wiltshire Council Drainage Engineers have been held to ensure that local drainage knowledge held by the Council is used to gain a thorough understanding of drainage issues within each settlement.

Meetings with Wiltshire Council drainage engineers indicate that drainage issues within Trowbridge are considered less significant than other settlements within Wiltshire Council's administrative area. Where previous drainage issues have occurred within Trowbridge they are normally associated with maintenance issues, such as obstructions to screens or culverts, restricting the flow of water.

6.2.1 Information Required for Pluvial Modelling

The pluvial modelling was undertaken using TuFLOW software, Double Precision version 2010_iDP_w32. As described in Section 4.2 and Appendix B, the model simulates what happens to rainfall once it falls on the ground in Trowbridge. The movement of water on the ground is influenced by the local topography and land use. For example, water will flow more quickly on a steep road than a flat grassed area. Therefore, the model requires data that represents the local topography and predominant land use. In addition, the model requires relevant data to represent the various rainfall events. Table 6-1 provides a summary of the data used and its limitations.

Table 6-1: Trowbridge pluvial flood modelling data, source and limitations

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
LiDAR (Light Detection and Ranging), Digital Terrain Model (DTM)	Environment Agency (Geomatics group) and Third party (Bluesky)	• Topographical information • Used to generate a grid providing ground heights for application within the model	• Not as accurate as surveyed levels but suitable for a strategic scale study
Ordnance Survey 1:10,000 scale mapping	Wiltshire Council	• Background mapping for analysis and display purposes (see Trowbridge Figures)	• Not provided in colour • Due to their release date, they do not include more recent developments
Ordnance Survey Mastermap data	Wiltshire Council	• Used to inform land uses throughout the Trowbridge area • Different land uses are assigned different friction values that affect the movement of surface water runoff	• Due to their release date, they do not include more recent developments
Flood Estimation Handbook (FEH)	Centre for Ecology and Hydrology – FEH CD-ROM v3	• Used to obtain Catchment Descriptors that provide a hydrological profile of the area	• Not necessarily calibrated in detail for the required area, but suitable for this strategic level study

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
Visual inspections of culverts, bridges and other structures	On-site visual inspections	• Informed the sizing of various structures throughout the area	• Outline measurements only, not surveyed and therefore likely to be inaccurate but suitable for the strategic nature of the study
Surface water sewer network	Wessex Water	• Provided location of major public surface water sewers and associated infrastructure	• Due to sensitivities of the data, not all information can be disseminated via this report; • Only sewers of greater than 225mm in diameter shown • Details or locations of private sewers not available from Wessex Water

As shown in Table 6-1, the various data sources had some limitations to their use. However all data was considered suitable for the pluvial modelling given the strategic nature of the study. The following should be taken into consideration when using the finding of this SWMP:

- Pluvial modelling results should be used to identify areas potentially at risk of surface water flooding, they should not be used to identify individual properties at risk.
- Pluvial modelling has taken a conservative approach where it is assumed that no sewer network is in place (i.e. sewer capacity is exceeded in all events).
- Pluvial modelling has taken a conservative approach where it is assumed that no infiltration occurs into the underlying ground (i.e. soil is saturated).
- Pluvial modelling results for depth have been mapped for flooding greater than 0.1 m. Flooding below this threshold does occur, however, this is not considered significant and is within the limits of model uncertainties.
- Pluvial modelling results for hazard mapping illustrate the low, medium and high hazard associated with pluvial flooding and are a function of depth, velocity and a debris factor. These extents, in some areas, appear greater than those in the depth mapping due to high velocities experienced at depths less than 0.1 m in some locations.
- The combined influence of flood sources should be considered when informing strategic planning.

6.3 Pluvial Flooding

Direct rainfall pluvial modelling has been undertaken for Trowbridge to identify potential flooding issues arising from surface water and their potential interaction with sewer and ordinary watercourse sources. Modelling has been undertaken for a range of scenarios for both present day and future climate change rainfall events as described in Section 4.2. The modelling outputs include potential maximum depth of flooding and the potential hazard associated with the flooding.

In general the modelling results show that the low lying areas along the floodplains of the Main Rivers, namely the River Biss, Paxcroft Brook, Lambrok Stream and River Avon to the north of the settlement experience the greatest flood depths and associated flood hazard.

These low lying areas are located within the Environment Agency Flood Zone 2 and Flood Zone 3, areas identified as having a medium and high risk of fluvial flooding respectively. Fluvial flood risk in these low lying areas is considered to be the dominant risk of flooding. This assessment focuses on areas located outside the fluvial Flood Zone 2 and Flood Zone 3 extents.

Extracts from both the maximum flood depth and flood hazard mapping are provided in the following sections to identify potential areas for further investigation. In order to inform planning at the strategic level, mapping extracts from the 1% AEP rainfall event, inclusive of climate change pluvial event are displayed within the report to be commensurate with the requirements of PPS25.

It is anticipated that these maps should be used for facilitating the engagement of stakeholders on surface water flooding issues - to further inform spatial planning processes, to inform future capital investment decisions, to inform emergency planning functions carried out by Local Resilience Forums and to identify whether critical infrastructure is at risk from surface water flooding. It is important that the limitations of the modelling are considered when using the output maps and data as described in Section 6.2.

6.3.1 Timbrell Street Area

Pluvial modelling highlighted in Figure 6-2 indicates a potential flow path exists to the north west of the town centre along Lowmead, Keates Close and through park land and the grounds of St Thomas Church. The flow path is shown to continue across Timbrell Street. This flow path is shown to be obstructed by a raised wall along the alley between Charlotte Street and Timbrell Street. These results indicate significant surface water ponding in the vicinity of the alley. Visual inspection of this potential flow path indicates that a number of other obstructions, including buildings and raised walls would influence the actually surface water flow path during a flood event.

Land immediately south of the Charlotte Street and Timbrell Street alley has been identified as a preferred mixed use regeneration option. The results indicate that the raised wall identified in Figure 1-2 currently offers protection to this potential development site. However, opportunities may exist through a site level assessment to consider potential options to alleviate the potential flooding to the east of the site.

Inspection of the Wessex Water surface water sewer map indicates that the flow path is served by an existing surface water sewer network. It is likely that flooding in this location would be associated with sewer exceedance and is considered in Section 6.5.

Figure 6-2: Pluvial modelling results (maximum potential depth and hazard) for the 1% AEP rainfall event including an allowance for climate change for the Timbrell Street Area

6.3.2 Green Lane Area

Pluvial modelling results illustrated in Figure 6-3 indicate potential areas of surface water ponding in the vicinity of Cornbrash Rise and Stoke Hill. This suggests that during the 1 in 100 year event including climate change, surface water would pond in these lower lying areas with flood depths typically up to 0.5 m being experienced. The hazard associated with these flood depths is predominantly medium and considered 'Danger for Most'.

Inspection of the Wessex Water surface water sewer map indicates that areas identified as being susceptible to surface water flooding identified in Figure 6-3 are served by an existing surface water sewer network. It is likely that any flooding in this location would be from exceedance of the sewer network and is discussed in Section 6.5.

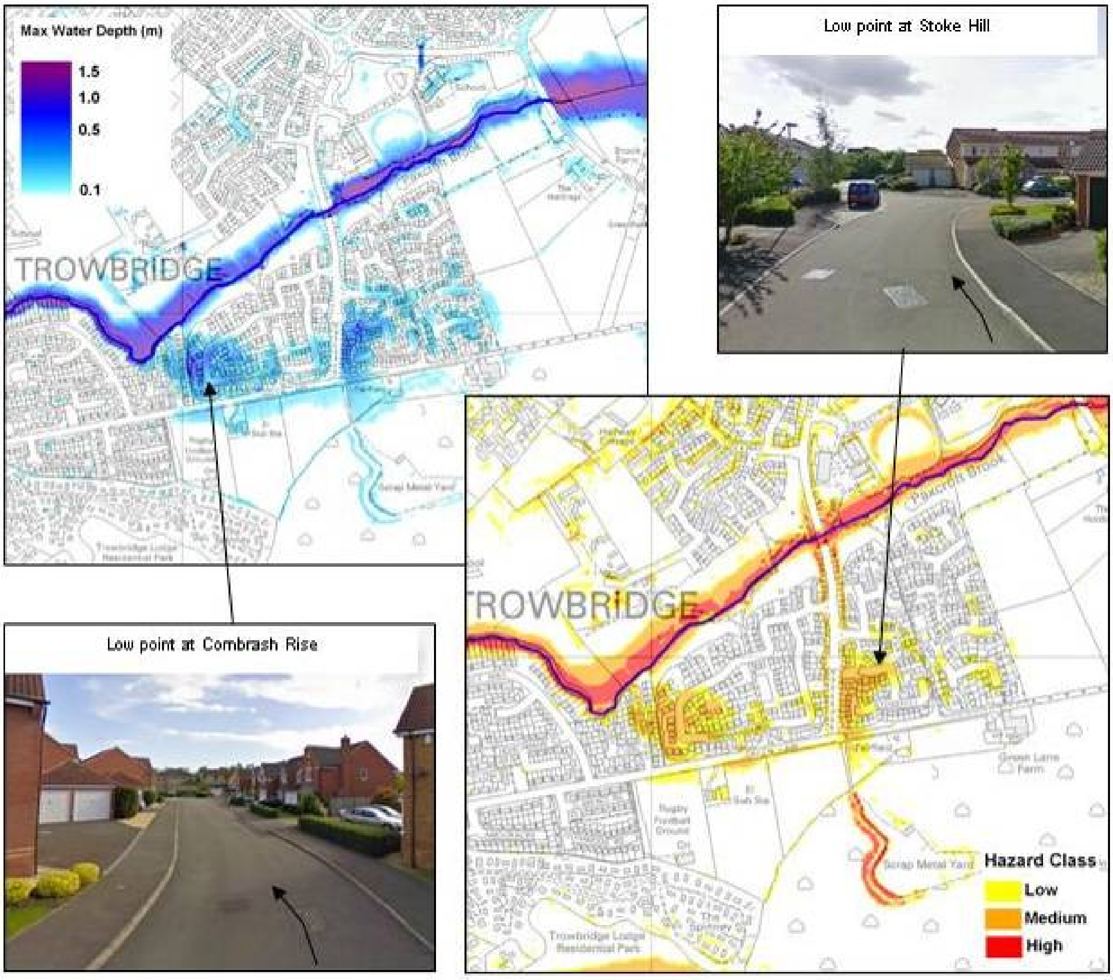


Figure 6-3: Pluvial modelling results (maximum potential depth and hazard) for the 1% AEP rainfall event including an allowance for climate change for the Green Lane Area.

6.3.3 Bramley Lane Area

Figure 6-4 illustrates the pluvial modelling results for the Bramley Lane area and highlights a potential area of surface water ponding at the western end of Bramley Lane. The ponding is associated with a low lying area adjacent to the railway embankment with depths potentially greater than 1 m. The corresponding hazard within this area is medium and considered 'Danger for Most'. In addition, surface water ponding is also shown to occur in this low lying area to the west of the railway embankment on Dursley Road. The results indicate that depths up to 0.5 m with an associated hazard of medium would be experienced in this location.

Figure 6-4: Pluvial modelling results (maximum potential depth and hazard) for the 1% AEP rainfall event including an allowance for climate change for the Bramley Lane Area.

Inspection of the Wessex Water surface water sewer map indicates that there is surface water sewer infrastructure and culverted watercourses located within this area. It is likely that flooding in this location would be associated, in part, with sewer exceedance and is considered in Section 6.5.

6.4 Groundwater Flooding

A conceptual understanding of the hydrogeology for the Trowbridge has been developed based on data provided. A wider groundwater assessment describing the bedrock and superficial geology, hydrogeology and wider groundwater elements is appended to this report with accompanying figures. This has been used to identify groundwater flooding mechanisms, evidence of groundwater flooding, areas susceptible to groundwater flooding and potential requirements for long term monitoring. It has also been used to identify constraints with regards to using infiltration SuDS.

6.4.1 Groundwater Flooding Mechanisms

Based on the current hydrogeological conceptual understanding, there is potential for minor groundwater flooding in the Trowbridge study area. The key groundwater flooding mechanisms that could exist are:

- **Cornbrash Formation outcrop running south west to northeast across the study area, including central Trowbridge:** There is the potential for a perched groundwater table to exist within the Cornbrash Formation. Due to the permeable but thin nature of this Formation, basements / cellars and other underground structures may be at risk from groundwater flooding following periods of prolonged rainfall, increased utilisation of infiltration SuDs and / or artificial recharge from leaking pipes.
- **Hazelbury Bryan Formation (sandstone) and Coral Rag Formation outcrop area in the south east of the study area (West Ashton):** These two Formations are classified as aquifers and whilst there is no supporting water level data it is likely that a perched groundwater table exists within these Formations. Basements / cellars and other underground structures may be at risk from groundwater flooding following periods of prolonged rainfall, increased utilisation of SuDs and / or artificial recharge from leaking pipes.
- **Superficial geology aquifers in hydraulic continuity with the Bristol Avon River and its tributaries:** Groundwater flooding may be associated with the substantial sand and gravel River Terrace Deposits, or to a lesser degree Head and Alluvium deposits, where they are in hydraulic continuity with surface water courses. Stream levels may rise following high rainfall events but still remain “in-bank”, and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits.
- **Superficial aquifers not in hydraulic continuity with surface water courses:** groundwater flooding is also associated with substantial River Terrace Deposits (gravel and sand) and Head deposits, but occurs where they are not hydraulically connected to surface water courses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
- **Impermeable (silt and clay) areas downslope of aquifers in various locations:** Groundwater flooding may occur where groundwater springs / seepages form minor flows and ponding over impermeable strata where there is poor drainage. This mechanism may occur as a result of natural (e.g. rainfall) or artificial (e.g. water main leakage) recharge.
- **Made ground in various locations:** a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this ‘made ground’ is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements, or may equally be considered a drainage issue.

6.4.2 Evidence of Groundwater Flooding

There are no reported groundwater flooding incidents within the study area. However, other sources of flooding have been identified and the locations of historic flood incidents are shown on Figures 1, 3, 4 and 5 (see appended groundwater report and figures) and details are provided in Table 6-2. It is possible that some of these incidents were influenced by groundwater conditions, although there are no available data to confirm this.

Table 6-2: Selected potential groundwater flooding incidents

Bedrock Geological Units*	Superficial Deposits*	Grid Reference	No**	Reported Incident	Date
Cornbrash Fm	None	159084 386421	1	Sewer - 2 in 10 years	09/01/2007
Cornbrash Fm	None	158024 384954	2	Sewer - 2 in 10 years	09/01/2007
Kellaways Fm	None	156104 384675	3	Sewer - 2 in 10 years	09/01/2007
Oxford Clay Fm	None	156616 385466	4	Sewer - 2 in 10 years	09/01/2007
Kellaways Fm	Alluvium	158720385006	5	Sewage Treatment Works, pumping stopped for a while	12/05/1960
Kellaways Fm	Alluvium	158370 384880	6	Fluvial - Ladydown Mill, Trowbridge up to confluence with the Lambrok Stream. No further details.	12/04/1960
Kellaways Fm	Alluvium	159100 385400	7	Unknown	07/10/1968
Kellaways Fm	Alluvium	159100 385400	8	Unknown	01/01/1991
Kellaways Fm	Alluvium	159100 385400	9	Unknown	01/01/1991
Kellaways Fm	Alluvium	159100 385400	10	Unknown	01/01/1991
Oxford Clay Fm	None	157780 386258	11	Sewer - 2 in 10 years	09/01/2007
Oxford Clay Fm	None	157687 386386	12	Sewer - 2 in 10 years	09/01/2007

6.4.3 Areas Susceptible to Groundwater Flooding

The Environment Agency has produced a dataset referred to as 'Areas Susceptible to Groundwater Flooding (AStGWF)', on a 1 km grid (Figure 5 in appended report). This utilises the BGS 1:50,000 Groundwater Flood Susceptibility dataset for consolidated aquifers (bedrock) and superficial geology.

The Environment Agency dataset shows the percentage of each 1 km square that falls within the high to very high BGS groundwater flooding susceptibility categories. It does not show the probability / risk of groundwater flooding occurring; this can only be determined following site specific investigation works and desk studies. It also does not take into account groundwater level rebound following cessation of abstraction.

An absence of values for any grid square means that no part of that square is identified as being susceptible to groundwater emergence (Environment Agency AStGWF Guidance Document).

The areas that are identified as being most susceptible to groundwater flooding are located close to the Upper Bristol Avon River in the north of the study area and close to the River Biss in the south of the study area (Drynham / North Bradley). By comparing the data with the underlying geology it is apparent that the areas susceptible to groundwater flooding are those where significant superficial deposits are present, particularly River Terrace Deposits.

It is interesting to note that many of the grid squares representing outcrops of Cornbrash Formation (e.g. Hilperton), Hazelbury Bryan Formation and Coral Rag Formation (West Ashton) have not been identified as areas susceptible to groundwater flooding. This may reflect the lack of water level data available to the BGS when creating the original Groundwater Flood Susceptibility Map. This notwithstanding, it is thought that the approximate areas identified by the Environment Agency as being susceptible to groundwater flooding are sensible.

6.4.4 Importance of Long Term Groundwater Level Monitoring

Groundwater flow direction, depth to groundwater, topography and the degree of artificial influence in the subsurface (e.g. leaking water mains or groundwater abstractions) play an important role when considering the susceptibly of an area to groundwater flooding. Groundwater level data for the superficial aquifers is limited to recorded water strikes or rest water levels on BGS borehole logs, which only provide groundwater levels at one location and for one point in time. Without long term groundwater monitoring, it is not possible to derive groundwater level contours, or understand maximum seasonal fluctuations. Therefore it is not possible to provide a detailed assessment of groundwater flood risk or provide detailed advice on suitability for infiltration SUDS.

Groundwater levels are often only measured once or for a short period during site investigations. Where considered necessary, long term monitoring of the Cornbrash Formation, and River Terrace Deposit groundwater levels would provide a better understanding of the local hydrogeological conditions.

It is also important to understand how changing policies relating to infiltration SUDS can impact upon groundwater levels. For example the introduction of infiltration SUDS (e.g. soakaways) may cause a localised rise in groundwater levels. This could prevent soakaways from operating and the reduction in unsaturated zone thickness.

Where considered necessary, long term groundwater level monitoring may be implemented to support decision making with respect to future land development and future co-ordinated investments to reduce the risk and informing the assessment of suitability for infiltration SUDS.

6.4.5 Infiltration SUDS Suitability

Improper use of infiltration SUDS could lead to contamination of the superficial or bedrock geology aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SUDS is likely to help improve aquifer quality status and reduce overall flood risk.

Environment Agency guidance on infiltration SUDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/36998.aspx. This guidance should be considered by developers and their contractors and by Wiltshire Council during the planning application process.

The areas that may be suitable for infiltration SUDS (e.g. soakaways, permeable paving) exist where there is a combination of higher ground (interfluves) and permeable geology (see Figure 3 in appended report). For example, although the River Terrace Deposits to the north of the study area are expected to be permeable, they are close to a major watercourse and the depth to groundwater may be unsuitable for infiltration SUDS.

Consideration should also be given to the impact of increased infiltration SUDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at the down gradient location. This type of analysis is beyond the scope of the current report.

Restrictions on the use of infiltration SUDS apply to those areas within Source Protection Zones (SPZ), which are shown on Figure 3. However, Figure 3 shows that currently there are no SPZs in the Trowbridge study area.

6.5 Sewer Flooding

The historic and potential flooding database collated for the West Wiltshire SFRA published in August 2008 and updated in June 2009 as part of the Wiltshire Council SFRA High Level Executive Summary indicates a small number of isolated sewer flooding incidents within Trowbridge. The DG5 register provided specifically for this study by Wessex Water indicates that there are currently there are no sewer capacity issues within the town and indicates that previous capacity issues have been resolved as part of their ongoing programme of works. However, it should be noted that some sewers maybe at or near their hydraulic capacities. Wessex Water has also confirmed that there are also no further entries being added to the DG5 register in the near future but where property flooding does occur the register will be updated.

Where incidents of sewer flooding occur, this is typically associated with either exceedance of sewer capacity or a blockage/collapse within the sewer system. Design standards for surface water sewers currently require the sewer design to be for a 3.33% AEP (1 in 30 year) rainfall event. However, existing sewers are likely to have lower capacity due to their age. Therefore, sewer exceedance, blockage or collapse could lead to localised flooding within and from the sewer network.

As identified in Section 6.3, it is likely that areas identified by the pluvial modelling are inherently linked with the sewer network. The likely effects of the inter-relationship between the sewer network and overland flow are described in the following sections.

6.5.1 Timbrell Street Area

Figure 6-5 illustrates the potential flow path which exists to the north west of the town centre on Lowmead, Keates Close, the grounds of St Thomas Church and continuing across Timbrell Street is served by the existing surface water sewer network.

The upper section of this area is drained by a 450 mm diameter surface water sewer; this connects into a 550 mm diameter pipe on Timbrell Street. In the lower section of the area, surface water drains via a 600 mm diameter sewer to the River Biss, approximately 0.5 km to the south west of Timbrell Street. Flooding is likely to occur where the capacity of the surface water sewer is exceeded or blockage/collapse causes the system to surcharge.

The presence of the surface water drainage network within this area is likely to reduce the potential flood depths provided by the pluvial modelling. However, during rainfall events that exceed the design standard of the surface water sewer network in this location, localised flooding is likely to occur.

6.5.2 Green Lane Area

Figure 6-6 illustrates that the potential areas of surface water ponding in the vicinity of Cornbrash Rise and Stoke Hill are served by existing the surface water sewer network.

This area is typically served by a surface water sewer network with pipe diameters greater than 450 mm. These surface water sewers drain northwards and discharge into the Paxcroft Brook. There is potential for the surface water sewer systems to become surcharged during times of high flow within the Paxcroft Brook if these coincide with heavy rainfall. Flooding is likely to occur where the capacity of the surface water sewer is exceeded or blockage/collapse causes the system to surcharge.

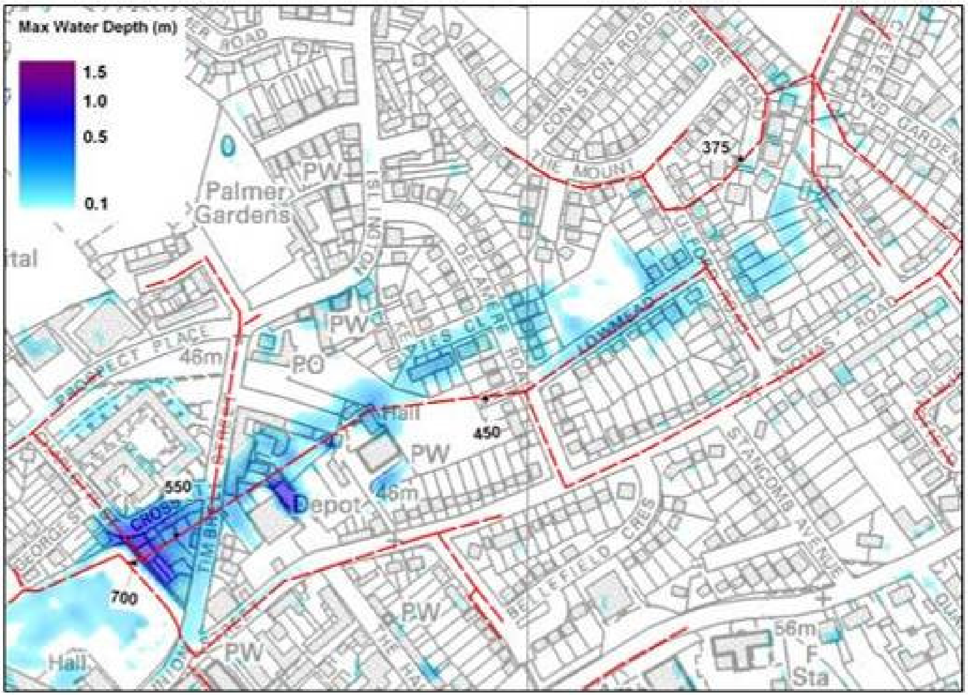


Figure 6-5: Wessex Water surface water drainage network in the vicinity of Timbrell Street. Surface water sewer shown as a red dashed line. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

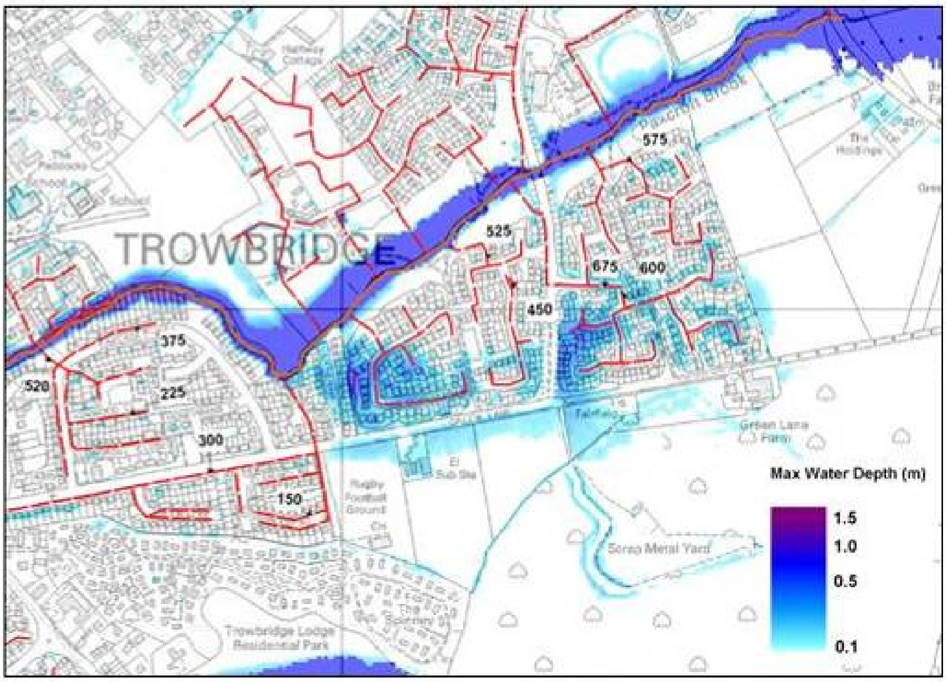


Figure 6-6: Wessex Water surface water drainage network in the vicinity of Green Lane Area. Surface water sewer shown as a red dashed line. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

The presence of the surface water drainage network within this area is likely to reduce the potential flood depths provided by the pluvial modelling. However, during rainfall events that exceed the design standard of the surface water sewer network in this location, localised flooding is likely to occur.

6.5.3 Bramley Lane Area

Figure 6-7 indicates that the potential area of ponding at the western end of Bramley Lane adjacent to the railway line is served by a 600 mm diameter surface water sewer.

This sewer receives surface water draining from the area to the west of the railway line in the vicinity of Dursley Road and includes flows from a culverted watercourse. To the north of Bramley Lane the sewer connects into a culverted watercourse prior to discharge into the River Biss, approximately 0.5 km north.

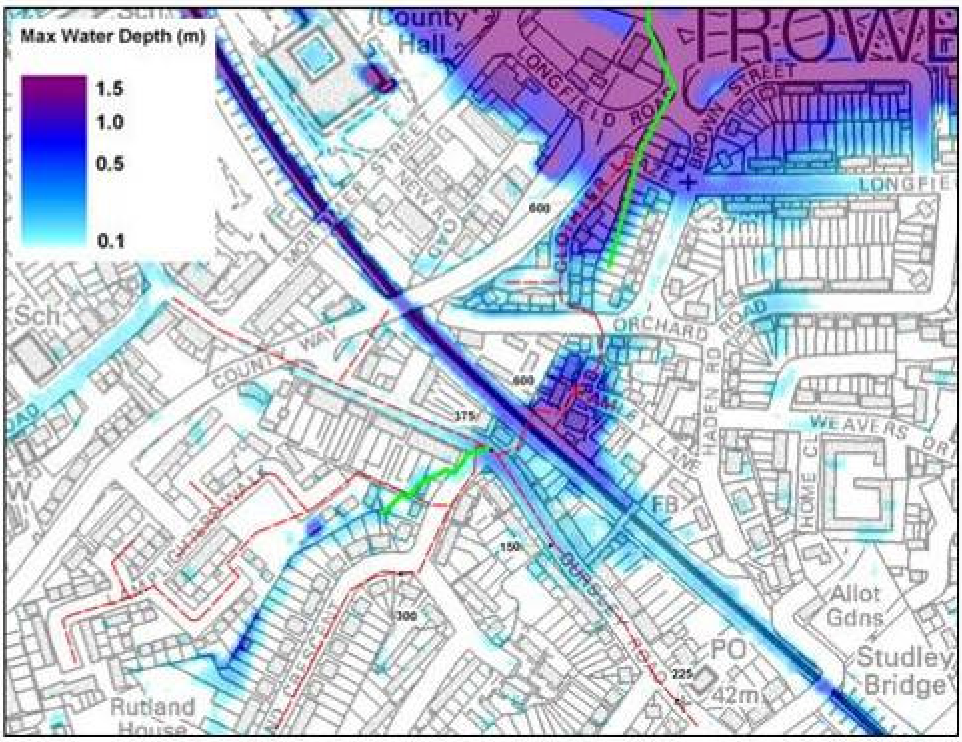


Figure 6-7: Wessex Water surface water drainage network in the vicinity of Bramley Lane Area. Surface water sewer shown as a red dashed line, culverted watercourses shown as a green line. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

The presence of the surface water drainage network within this area is likely to reduce the potential flood depths provided by the pluvial modelling. However, during rainfall events that exceed the design standard of the surface water sewer network in this location, localised flooding is likely to occur. In addition, blockage or collapse of the sewer could also lead to surcharging. Further capacity issues may be associated with locking of the surface water sewer system during times of high flow within the River Biss coinciding with a heavy rainfall event, however, the invert level of the discharge point into the River Biss has not been established as part of this assessment.

6.6 Ordinary watercourses

The majority of the watercourses within the urban extent of Trowbridge are classified as Main River and as such are covered by the Environment Agency Flood Map (i.e. Flood Zones 2 and 3). Minor watercourses within the urban extent of Trowbridge predominantly exist as culverted watercourses often forming part of the wider sewer network. However, the pluvial modelling results do highlight a number of ordinary watercourses at the margins of the urban extent of Trowbridge.

The pluvial modelling results for Trowbridge highlight the link between surface water runoff and flow within ordinary watercourses. For example where flow paths converge to create a dominant flow path, the OS mapping used to inform this study would usually indicate the presence of a minor watercourse.

The flood risk posed by ordinary watercourses is often exacerbated by a poor maintenance regime, which would include managing ‘in channel’ vegetation and removal of foreign objects both of which restrict channel flow.

The pluvial modelling results indicate one area of existing development which may experience flooding from an ordinary watercourse this is described in the following section.

6.6.1 Drynham Road Area

Figure 6-8 illustrates surface water flooding associated with an ordinary watercourse in the Drynham Road area located to the south of the main urban extent of Trowbridge. At this location, two flow paths converge and flow north eastwards as the Drynham Brook.

The results indicate that significant ponding occurs on low lying land to the west of Drynham Road. This ponding is likely to occur where the capacity of the culvert beneath Drynham Road and the railway embankment are exceeded causing flow to back up and inundate the low lying ground within this area. Flow depths may exceed 1.5 m (based on the 1% annual probability event including climate change depths) with areas of existing development experiencing depths of 0.8 m.

It should be noted that during the site inspection carried out to verify the model results, access to the culvert beneath the railway embankment was impeded. The Wessex Water sewer network map indicates that the culvert beneath the Drynham Road is 1.5 m diameter. To ensure a conservative approach was adopted with regard to the railway embankment, a 1 m diameter culvert was assumed in this location. It is suggested, where required, that culvert dimensions are sought from Network Rail to further inform the flood risk from the Drynham Brook in this location. It is also noted that this area is located upstream of the part of the site identified as the preferred option for growth within Trowbridge (see Section 6.7).

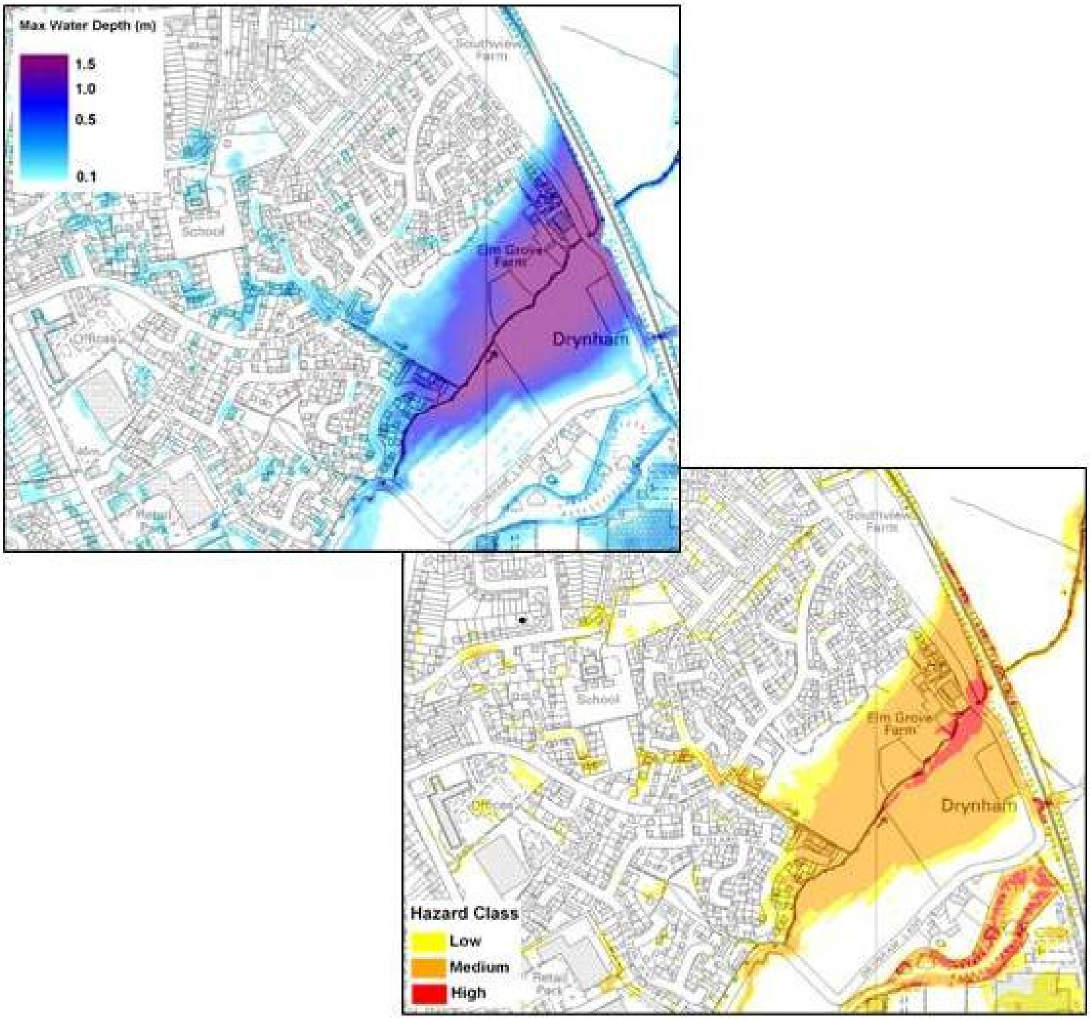


Figure 6-8: Pluvial modelling results (maximum potential depth and hazard) for the 1% AEP rainfall event including an allowance for climate change for the Drynham Road Area.

6.7 Implications for Future Development

As identified in Figure 6-1, the preferred housing option for future development within Trowbridge is predominantly located on greenfield land to the east and south east of the town.

The pluvial modelling results provided in accompanying appendix indicate that no significant flow paths or areas of ponding exist on the preferred housing option land to the north and south of Green Lane (east of Trowbridge), which suggest surface water issues are unlikely to be a significant constraint to development within this area.

Figure 6-9 indicates the pluvial modelling results for the significant area of strategic growth to the south east of Trowbridge. This illustrates that flow paths, including an ordinary watercourse (Drynham Brook) exist within the preferred housing option land to the south east of Trowbridge.

These flow paths are predominantly located along existing field boundaries and future development should be set back from these areas to allow natural flow routes to be maintained.

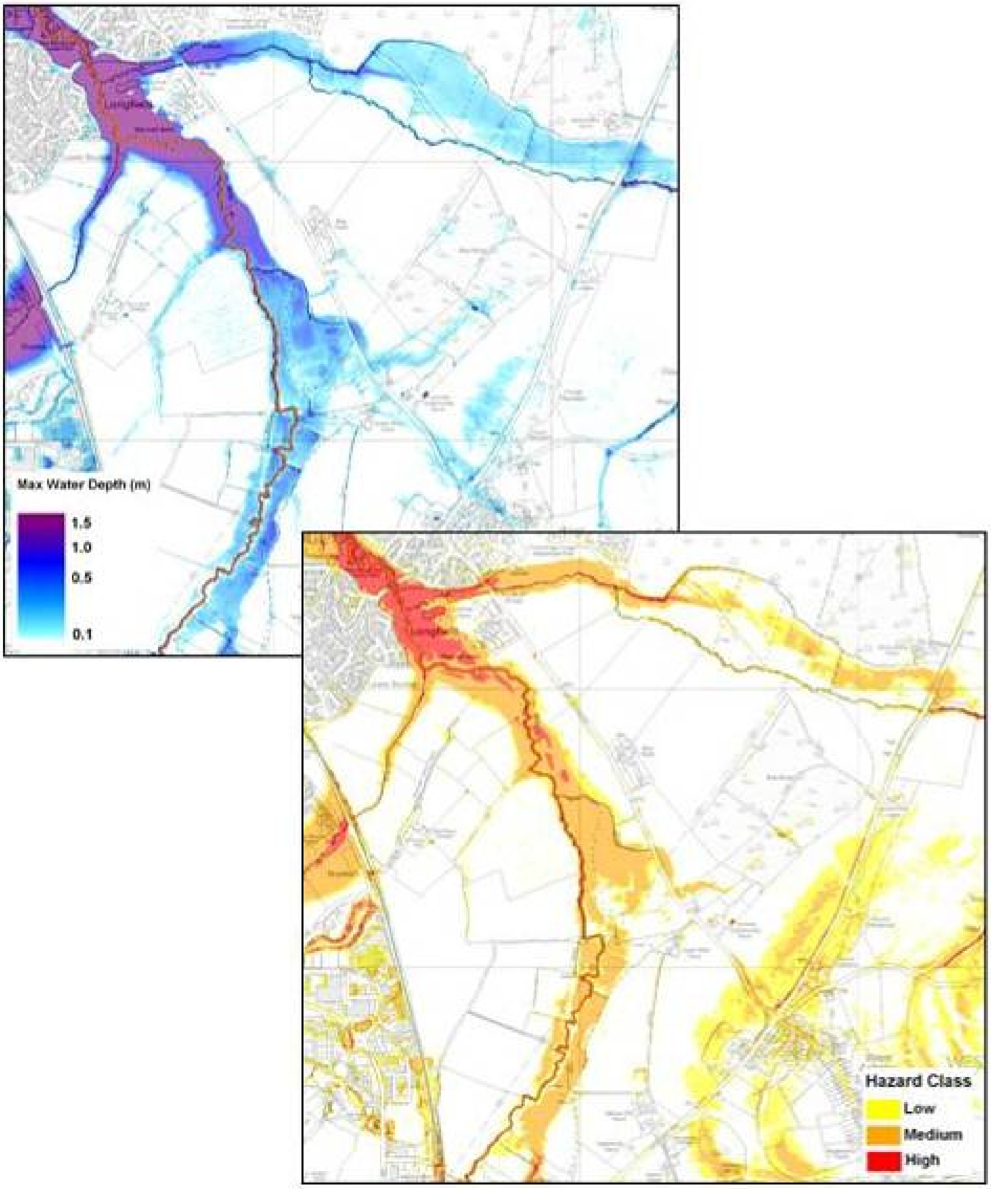


Figure 6-9: Pluvial modelling results (maximum potential depth and hazard) for the 1% annual probability rainfall event including an allowance for climate change for the preferred housing option located south east of Trowbridge.

The River Biss and Stourton Brook are also within the area identified. The floodplains of these watercourses are covered by the Environment Agency Flood Map (Flood Zones 2 and 3) in the vicinity of this potential development land, and therefore appropriate allocation of land in line with planning policy (i.e. PPS25) should be undertaken.

There are no foul or surface water sewer networks within the preferred housing option land to the east and south east of Trowbridge. Where development is proposed new infrastructure will be required to manage surface water runoff from the site. The feasibility of suitable SUDS techniques for use onsite will need to be identified. Where management of surface water onsite is not reasonably practicable via infiltration, discharge to a nearby watercourse or sewer will need to be sought.

6.8 Summary

Based on the findings of the pluvial modelling and assessment of flooding from other sources including the potential from sewer, groundwater and ordinary watercourses, the following high level observations have been made that can be used to inform the Phase III stage of the SWMP. The observations are as follows:

- A potential overland flow path has been identified within the Timbrell Street area. This area is served by an existing public surface water sewer network but is likely to have localised flooding where sewer capacity is exceeded. An existing raised wall obstructs the potential flow path causing localised flooding. It is noted that the site to the west is identified for mixed use regeneration. Opportunities may exist during the masterplanning process to alleviate potential risks from over land flows and sewer exceedance in this location. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Potential surface water and sewer exceedance issues were identified by the pluvial modelling in the Green Lane Area. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Potential surface water and sewer exceedance issues were identified by the pluvial modelling in the Bramley Lane Area. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Potential flood risk issues associated with the Drynham Brook ordinary watercourse were identified by the pluvial modelling. Ponding associated with the railway embankment and culvert sizing in this location are noted and liaison with Network Rail is recommended to identify actual culvert dimensions. In addition, this should be considered with respect to the proposed development located downstream of the culvert.
- Potential development in the east of Trowbridge in the Green Lane area is not considered to be constrained by surface water flooding issues. In addition, whilst not considered to be in an ‘Area Susceptible to Groundwater Flooding’, site level investigation should be undertaken to identify the suitability for infiltration SuDS associated with the underlying geology.
- Potential development in the south east of Trowbridge is in predominantly greenfield areas. These are not served by the public sewer system and flow paths associated with ordinary watercourses (ditches mainly) are likely to convey water to the River Biss. Surface water management should be considered during the masterplanning phases to direct development away from potential flow routes and provide green open space. Site level investigation should be undertaken to identify the suitability of infiltration SuDS due to the presence in some areas of Alluvial Deposits and the potential for infiltration in the underlying Oxford Clays.

7 Salisbury

7.1 Overview

Salisbury is located within the south east of Wiltshire and has a population of over 30,000[15]. In terms of planning for the area, the council have prepared detailed policy proposals for new housing and employment growth. The 'South Wiltshire Core Strategy' has been the subject of an independent examination and the council are waiting for the Inspector's Report.

The process of preparing the South Wiltshire Core Strategy has been complicated by changes to the national planning agenda. The proposal to abolish Regional Strategies; replace top-down forecasts for new development with locally derived and agreed quanta for new housing; and the introduction of a new (draft) National Planning Policy Framework; have influenced the process and led the council to revise its strategy during the independent examination. These revisions essentially seek to reduce the overall development quanta for the areas through a process of deleting strategic sites.

At the time of finalising this report, the council were awaiting the Inspector's Report on the examination process. Therefore, the modelling and assessments presented for Salisbury have been based upon the original submission draft document. Should the position change following receipt of the Inspector's Report, URS Scott Wilson will work with the council in amending the report to reflect any changes that are proposed.

The existing spatial strategy for future development in Salisbury is identified in Figure 7-1. This extends beyond the boundary of Salisbury City and therefore the extent of the SWMP has been defined to encompass strategic sites within the surrounding area (e.g. Wilton and Netherhampton). This allows a holistic appreciation of existing and future potential for flooding from surface water, groundwater, sewer, ordinary watercourse or a combination of these and helps inform the strategic planning process.

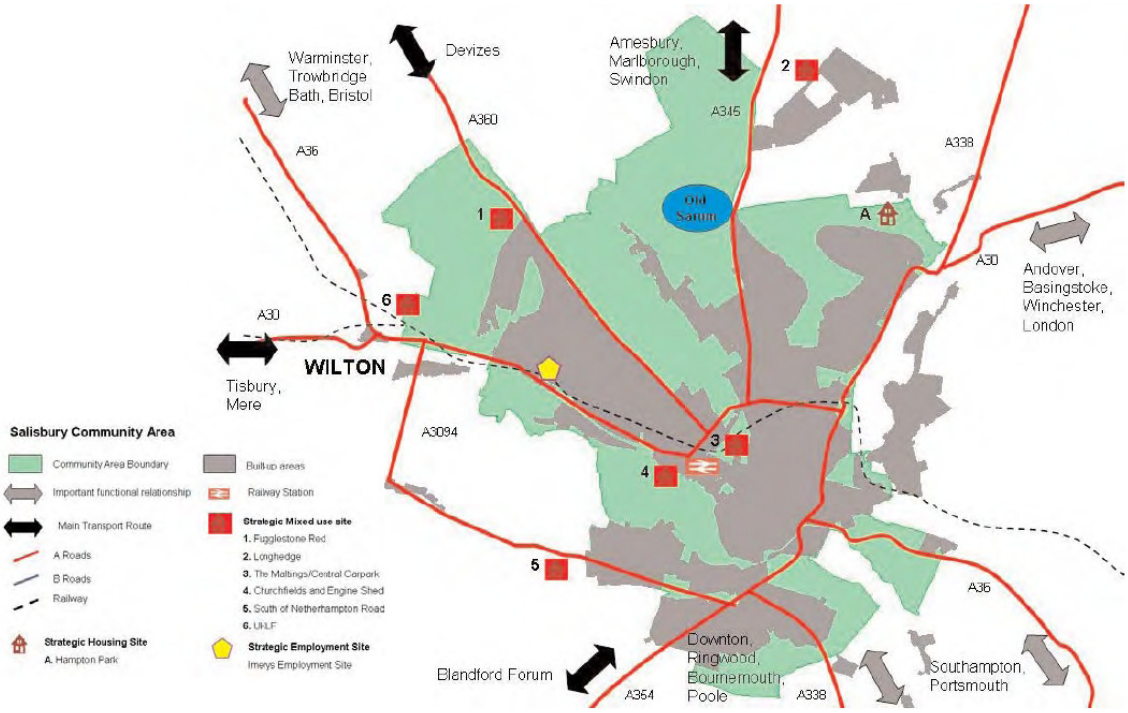


Figure 7-1: Spatial strategy for Salisbury

[15] http://history.wiltshire.gov.uk/community/getcensus.php?item=Salisbury

Historically, the majority of reported flooding issues within Salisbury and the surrounding area have been linked with fluvial flooding from the River Avon (Hampshire), River Nadder and River Bourne. However, due to the nature of the underlying bedrock, base flows within these rivers are inherently linked with groundwater levels. During wet periods, surface water infiltration into the underlying aquifer causes groundwater levels to rise causing increases in base flow within river channels. These cause longer duration flood events that are a combination of groundwater and fluvial flows.

7.2 Data / Information Review

In order to inform the Phase II element of the SWMP for Salisbury, two principle activities have been completed, the first being the direct rainfall and pluvial flood modelling (as described in Section 4.2). The second activity was to verify and augment the pluvial modelling with historical flooding information and records.

During the preparation of this SWMP meetings between URS/Scott Wilson and Wiltshire Council Drainage Engineers have been held to ensure that local drainage knowledge held by the Council is used to gain a thorough understanding of drainage issues within each settlement.

The outcome of the meetings suggests that drainage issues within Salisbury are more significant than other settlements within Wiltshire Council's administrative area. Where previous drainage or surface water issues have occurred within Salisbury they are normally associated with high groundwater levels and river levels reducing infiltration capacity and maintenance issues, such as obstructions to screens or culverts restricting the flow of water.

7.2.1 Information Required for Pluvial Modelling

The pluvial modelling was undertaken using TuFLOW software, Double Precision version 2010_iDP_w32. As described in Section 4.2 and Appendix B, the model simulates what happens to rainfall once it falls on the ground in Trowbridge. The movement of water on the ground is influenced by the local topography and land use. For example, water will flow much quicker on a steep road than a flat grassed area. Therefore, the model requires data that represents the local topography and predominant land use. In addition, the model requires relevant data to represent the various rainfall events. Table 7-1 provides a summary of the data used and its limitations.

Table 7-1: Data required for the pluvial flood modelling at Salisbury and its source

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
LiDAR (Light Detection and Ranging), Digital Terrain Model (DTM)	Environment Agency (Geomatics group) and Third party (Bluesky)	• Topographical information • Used to generate a grid providing ground heights for application within the model	• Not as accurate as surveyed levels but suitable for a strategic scale study
Ordnance Survey 1:10,000 scale mapping	Wiltshire Council	• Background mapping for analysis and display purposes (see the Salisbury Figures)	• Not provided in colour • Due to their release date, they do not include more recent developments
Ordnance Survey Mastermap data	Wiltshire Council	• Used to inform land uses throughout the Salisbury area • Different land uses are assigned different friction values that affect	• Due to their release date, they do not include more recent developments

Data Type	Data Source	Use for Pluvial Modelling and Results interpretation	Limitations
		the movement of surface water runoff	
Flood Estimation Handbook (FEH)	Centre for Ecology and Hydrology (via CD-ROM)	• Used to obtain Catchment Descriptors that provide a hydrological profile of the area	• Not necessarily calibrated in detail for the required area, but suitable for this strategic level study
Visual inspections of culverts, bridges and other structures	On-site visual inspections	• Informed the sizing of various structures throughout the area	• Outline measurements only, not surveyed and therefore likely to be inaccurate but suitable for the strategic nature of the study
Surface water sewer network	Wessex Water	• Provided location of major public surface water sewers and associated infrastructure	• Due to sensitivities of the data, not all information can be disseminated via this report; • Only sewers of greater than 225mm in diameter shown • Details or locations of private sewers not available from Wessex Water

As shown in Table 7-1, the various data sources had some limitations to their use. However all data was considered suitable for the pluvial modelling given the strategic nature of the study. The following should be taken into consideration when using the finding of this SWMP:

- Pluvial modelling results should be used to identify areas potentially at risk of surface water flooding, they should not be used to identify individual properties at risk.
- Pluvial modelling has taken a conservative approach where it is assumed that no sewer network is in place (i.e. sewer capacity is exceeded in all events).
- Pluvial modelling has taken a conservative approach where it is assumed that no infiltration occurs into the underlying ground (i.e. soil is saturated).
- Pluvial modelling results for depth have been mapped for flooding greater than 0.1 m. Flooding below this threshold does occur, however, this is not considered significant and is within the limits of model uncertainties.
- Pluvial modelling results for hazard mapping illustrate the low, medium and high hazard associated with pluvial flooding and are a function of depth, velocity and a debris factor. These extents, in some areas, appear greater than those in the depth mapping due to high velocities experienced at depths less than 0.1 m in some locations.
- The combined influence of flood sources should be considered when informing strategic planning.

With respect to the infiltration assumption, unlike the other key settlements, this is potentially a more realistically conservative assumption for Salisbury, in particular the lower lying areas, due to the known reduction in infiltration during periods of high groundwater levels.

7.3 Pluvial Flooding

Liaison with the relevant stakeholders, notably the Environment Agency and Wiltshire Council drainage engineers indicates that some records of groundwater, surface water and fluvial flooding exist for Salisbury. These events occurred in the following areas:

Table 7-2: Salisbury historic flooding records

Date	Areas Affected	Causes of Flooding
1990	Tilshead*, Harnham, Downton and Wilton – approximately 60 properties flooded	Fluvial, surface water and sewer (Tilshead and Wilton)
Dec 1992	Harnham, Teffant*, Chilmark*	High groundwater, spring flows. Minor flooding only
Jan 1995	Tilshead*, Downton and others – approximately 20 properties flooded	Fluvial, surface water and springs
Dec 1998 – Jan1999	Harnham, Downton, Wilton, South Newton and Tilshead*	Fluvial and surface water runoff from fields
Oct/ Nov 2000	Wilton, Ludwell*, Antsy*, Mere*, Langdon*	Surface water, minor flooding (approximately 1 or 2 properties in each location)
Dec 2000	Downton (significant flooding, mostly fluvial but exacerbated by surface water runoff), Waterditchhampton	Fluvial, surface water and sewer
Oct 2001	Winterbourne, Boscombe*, Newton Tony*, Cholderton*, Shipton Bellinger*, Tidworth*	Groundwater and fluvial
2003	Britford, Downton, City Centre, Laverstock – approximately 25 properties	Groundwater, fluvial and surface water

* Indicates a settlement outside of the Salisbury Phase II study area boundary

Direct rainfall pluvial modelling has been undertaken for Salisbury to identify potential flooding issues arising from surface water and their potential interaction with sewer and ordinary watercourse sources. Modelling has been undertaken for a range of scenarios for both present day and future climate change rainfall events as described in Section 4.2. The modelling outputs include potential maximum depth of flooding and the potential hazard associated with the flooding.

In general, the modelling results show that the low lying areas along the floodplains of the Main Rivers, namely the River Nadder, River Avon, River Bourne and River Wylye experience the greatest flood depths and associated flood hazard where water ponds. Other areas affected include low lying areas within the city centre, Wilton, Quidhampton and Harnham.

These low lying areas are typically located within the Environment Agency Flood Zone 2 and Flood Zone 3, areas identified as having a medium and high risk of fluvial flooding respectively. Fluvial flood risk in these low lying areas is considered to be the dominant risk of flooding. This assessment focuses on areas located outside the fluvial Flood Zone 2 and Flood Zone 3 extents.

Extracts from both the maximum flood depth and flood hazard mapping are provided in the following sections to identify potential areas for further investigation. In order to inform planning at the strategic level, mapping extracts from the 1% annual probability, inclusive of climate change pluvial event are displayed within the report to be commensurate with the requirements of PPS25.

It is anticipated that these maps should be used for facilitating the engagement of stakeholders on surface water flooding issues, to further inform spatial planning processes, to inform future capital investment decisions, to inform emergency planning functions carried out by Local Resilience Forums and to identify whether critical infrastructure is at risk from surface water flooding. It is important that the limitations of the modelling are considered when using the output maps and data as described in Section 7.2.

7.3.1 Bemerton Area

Analysis of the results indicates that a potential flow exists within the vicinity of The Valley and Gainsborough Close in Bemerton, western Salisbury. The flow path originates in agricultural fields to the north west of the Angler Road area, adjacent to Devizes Road (A360). There is a low point within the vicinity of Angler Road and Whitbread Road that would cause localised ponding, (see **Figure 7-2**).

The flow path continues along The Valley and then Gainsborough Close, the flow path is intercepted by Pembroke Road to the south that would cause surface water to accumulate within this area (see **Figure 7-2**). Flow depths are typically less than 0.5 m with the exception of deeper ponding in the vicinity of Pembroke Road. The flood hazard associated with the potential flooding is in general low or medium. Access for more vulnerable people (i.e. elderly or infirmed) may be difficult in certain circumstances, however, vehicular and emergency services access would potentially be unhindered.

Inspection of the Wessex Water surface water sewer map indicates that the flow path is served by an existing surface water sewer network. It is likely that flooding in this location would be associated with sewer exceedance and is considered in Section 7.5.

A second potential flow path was identified from the modelling results, which flows south from a track adjacent to 'The Avenue'. Water is potentially obstructed by the raised railway track adjacent to the A38. However, an access road passes beneath the railway that will allow water to flow through this feature and downslope toward Quidhampton.

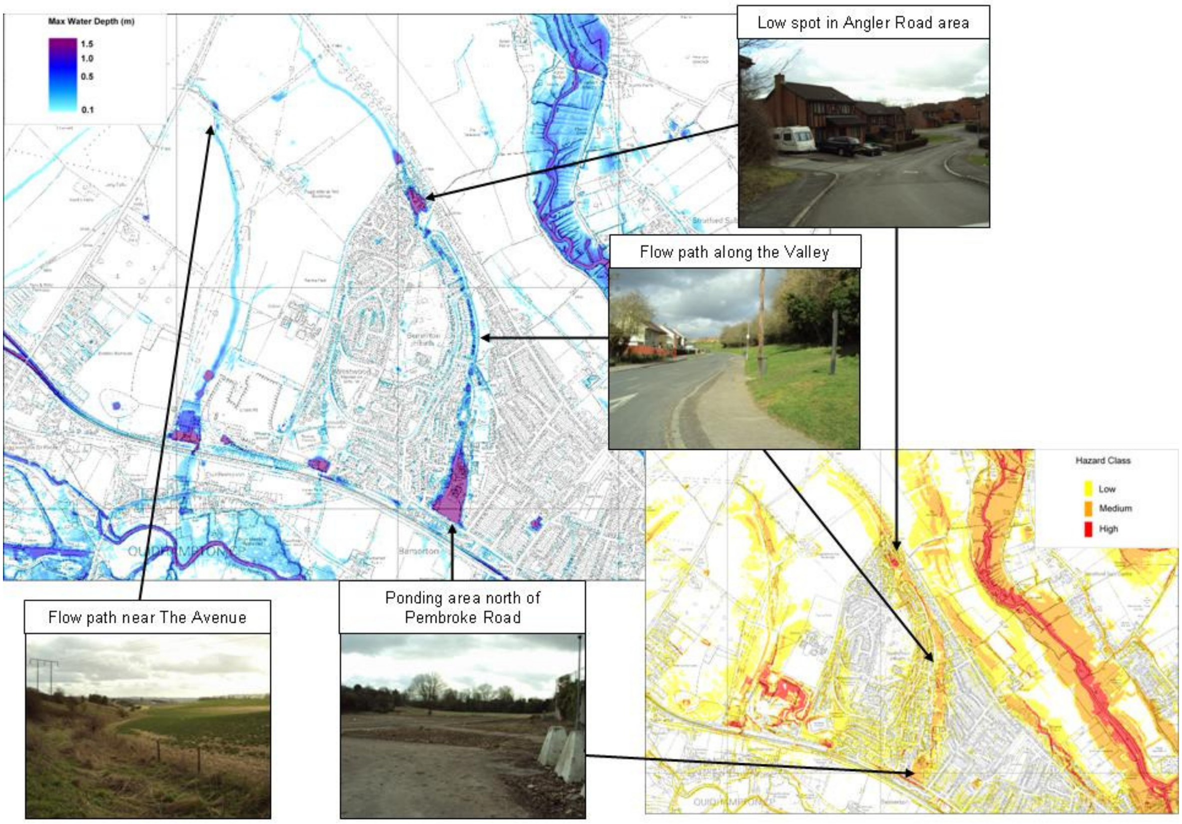


Figure 7-2: Pluvial modelling results (maximum potential depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Bemerton Area, western Salisbury

7.3.2 Britford Area

The modelling results indicate that the Britford area could be affected by shallow but extensive pluvial flooding. However, the low velocities associated with this flooding indicate that the hazard rating is low, (see Figure 7-3). Localised flooding may also be associated with drainage ditches and gullies within the village. However, in these situations it is likely that flooding from fluvial sources would dominate.

Two flow paths exist to the east of Britford. The first exists on the agricultural fields to the north and east of the hospital. The second exists along Lower Road and flows east (downslope) along this road. The velocities of the water flowing along this road are relatively high, resulting in a high hazard rating. In addition, during the site walkovers it was noted that road gullies within Lower Road are susceptible to blockage from leaf debris.

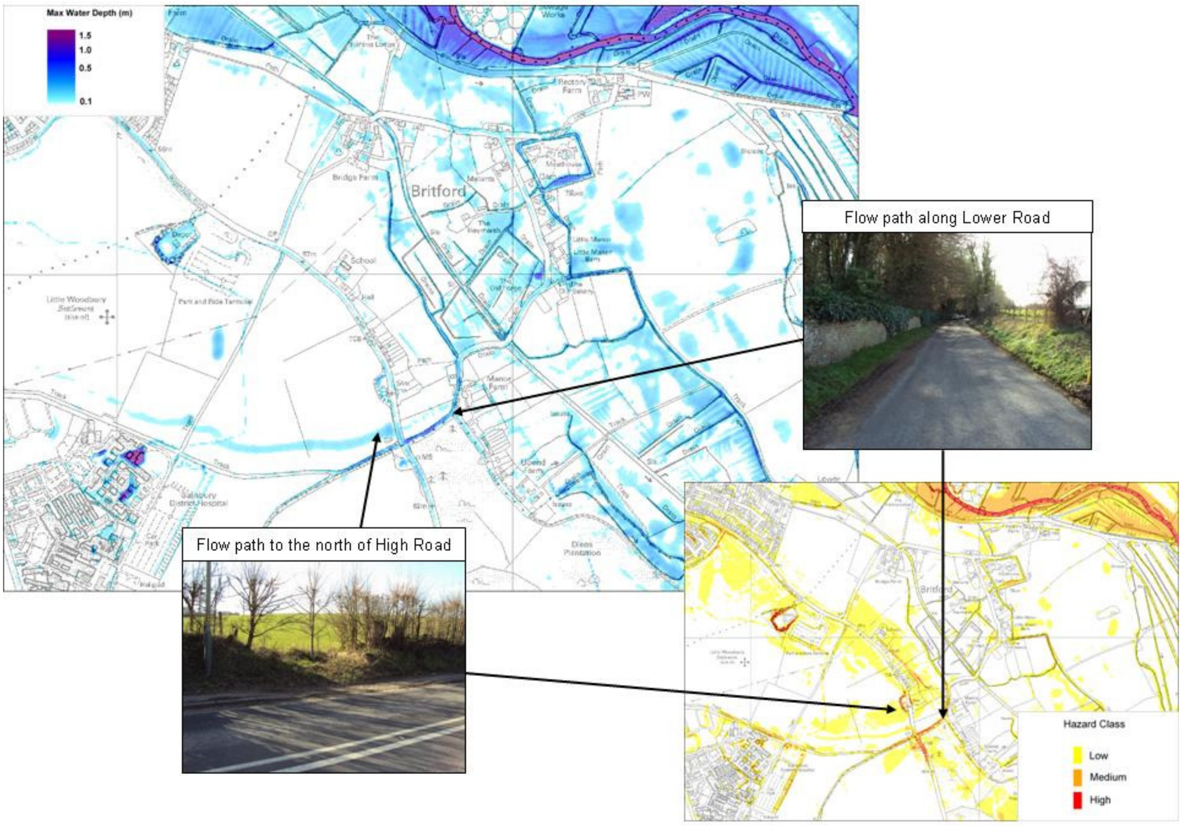


Figure 7-3: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Britford Area, southern Salisbury

7.3.3 City Centre Area

Analysis of the modelling results indicates that there is a potential for surface water flooding within the City Centre, mainly in the vicinity of the Cathedral. Figure 7-4 illustrates that significant depths of flooding may be experienced but are predominantly associated with ponding and low velocities, therefore the associated hazard is low to moderate.

Historical flooding within this area has been noted and is likely to be from a combination of sources including high groundwater levels causing elevated river levels and reduction of the drainage capacity of sewer system.

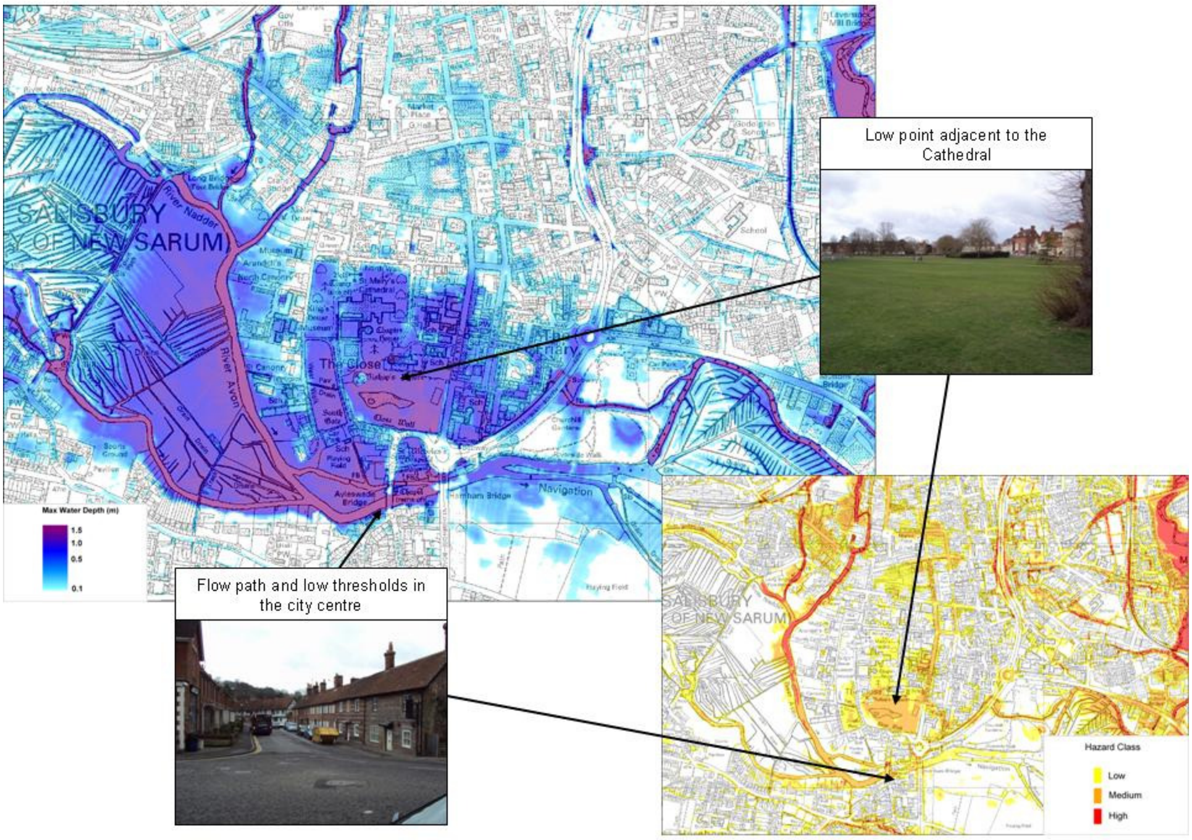


Figure 7-4: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for Salisbury city centre.

7.3.4 Churchill Way Area

The modelling results indicate that there is a potential flood risk associated with Churchill Way Area, however, Figure 7-5 illustrates that the majority of potential flooding is located adjacent to the River Avon. Depths up to approximately 1.2 m are likely to be experienced. These results indicate that the River Avon conveys overland flows during heavy rainfall events that collect within the watercourse from the surrounding catchment.

There are areas of shallow ponding (less than 0.5 m) within the Churchill Way Area, as shown in Figure 7-5 associated with low lying areas. In addition, this area is served by Wessex Water surface water sewers (see Section 7.5). Therefore, given the assumptions of the pluvial modelling mentioned in Section 7.3, these ponding areas are likely to be a conservative estimate of the potential pluvial flooding in this area.

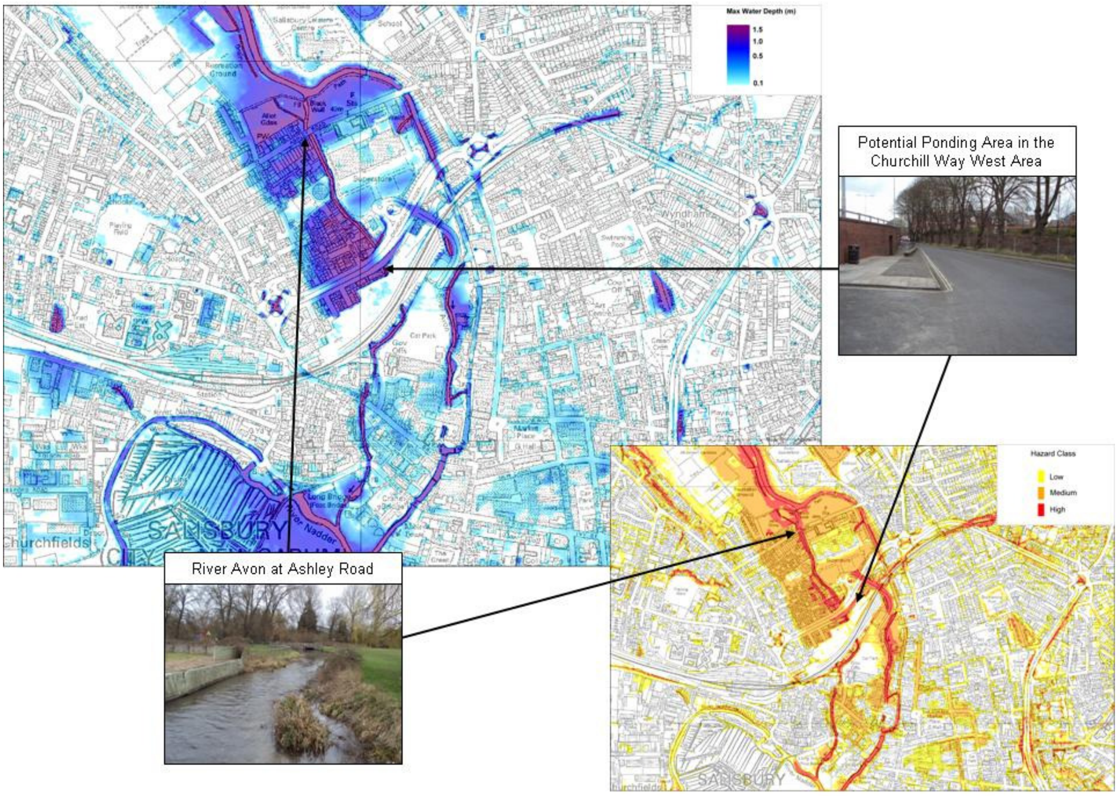


Figure 7-5: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Churchill Way Area

7.3.5 Laverstock Area

The pluvial modelling results indicate that there is a potential pluvial flood risk posed to areas within Laverstock, located to the north east of Salisbury City Centre. Figure 7-6 illustrates that the majority of potential flooding is located adjacent to the River Bourne. Depths up to approximately 1.5 m are likely to be experienced adjacent to the River Bourne and indicates that the River Bourne conveys overland flows during heavy rainfall events from the surrounding catchment.

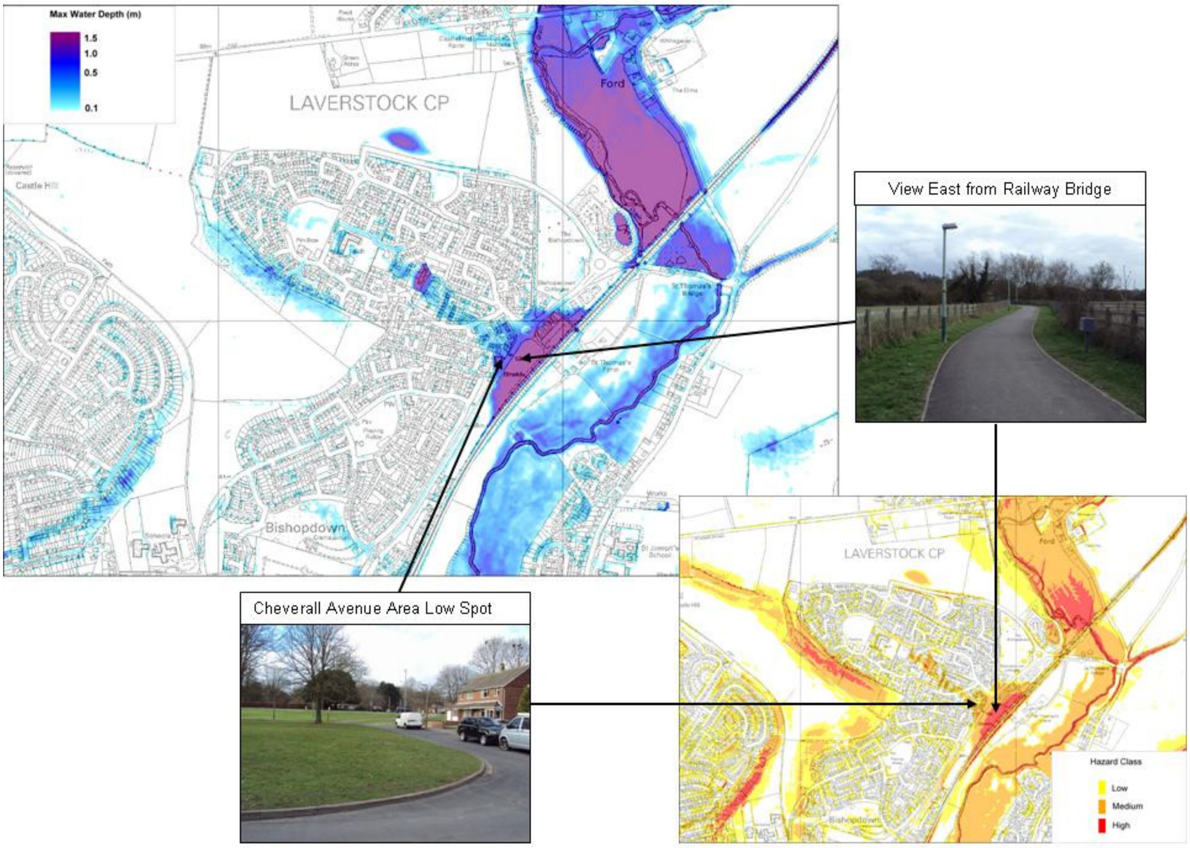


Figure 7-6: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Laverstock Area

Figure 7-6 illustrates an area of ponding exists within the vicinity of Cheverall Avenue. A potential flow path conveys water from the west of Cheverall Avenue and the ponding is associated with the railway embankment, potentially exacerbating the flood risks. The hazard associated with the flood risks in the Cheverall Avenue Area are generally medium or high and are linked to the potential depth of flooding in this location. However, this area is served by Wessex Water surface water sewers (see Section 7.5) and therefore, given the assumptions of the pluvial modelling mentioned in Section 7.3, these ponding areas are likely to be a conservative estimate of the potential pluvial flooding in this area.

7.3.6 Milford Area

The pluvial modelling results indicate that there is a potential flood risk posed to areas within Milford, located to the north east of Salisbury City Centre. Figure 7-7 illustrates that the majority of potential flooding is located adjacent to the River Bourne. Depths up to approximately 1.5 m are likely to be experienced adjacent to the River Bourne and indicates that overland flows are conveyed by this watercourse during heavy rainfall events from the surrounding catchment.

In addition to the flooding associated with the River Bourne, a potential flow path exists to the east of Milford. Visual inspection of this area confirms that this potential flow path is located at the base of a small valley where water is likely to drain during heavy rainfall.

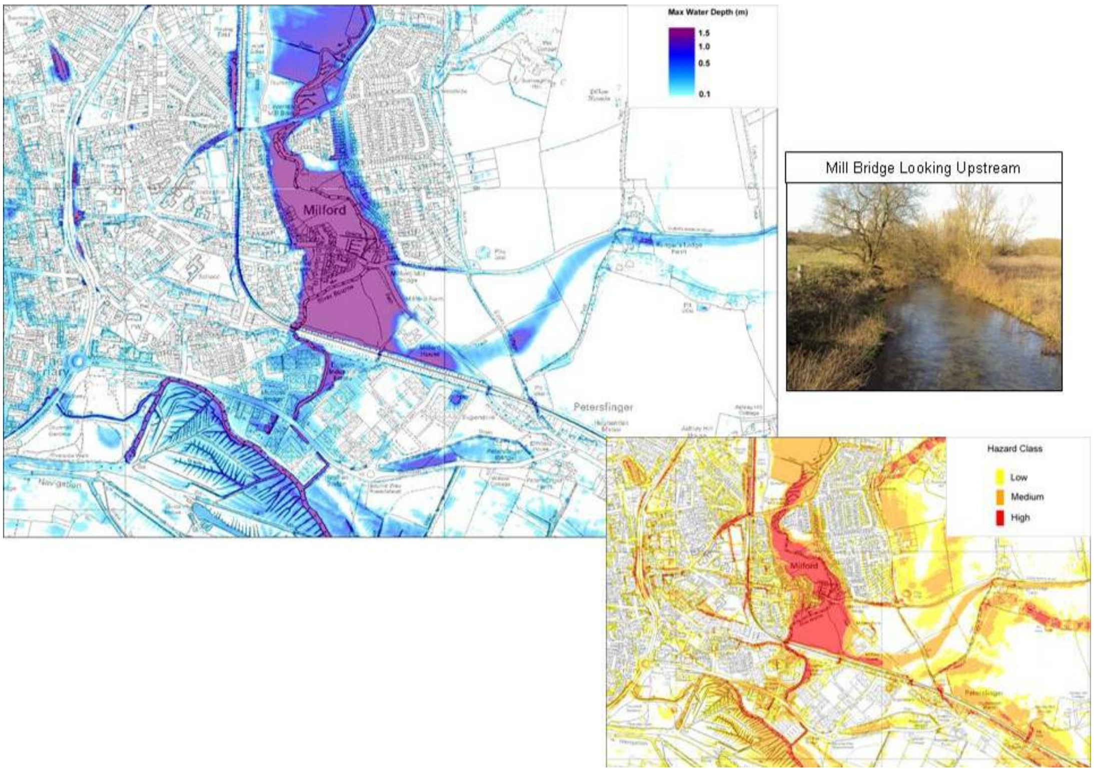


Figure 7-7: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Milford Area, north of east of city centre.

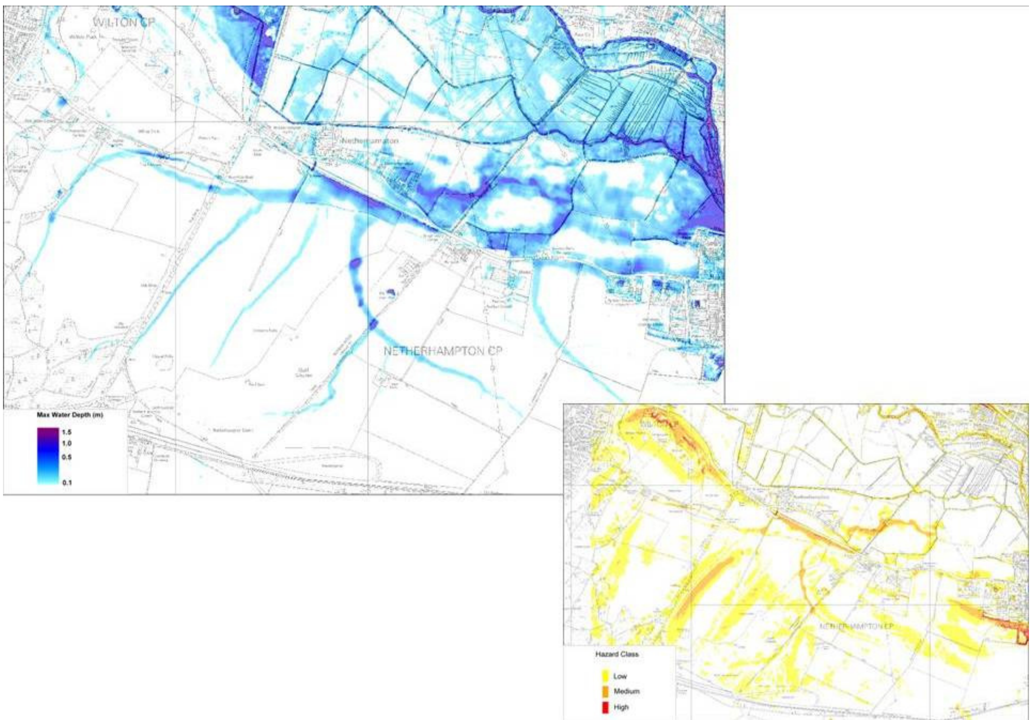


Figure 7-8: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Netherhampton Area.

7.3.7 Netherhampton Area

Analysis of the pluvial modelling results indicates that several overland flow paths exist within the Netherhampton Area. These are primarily located within the existing open space to the south of the settlement. They generally flow northwards and the raised A3094 Netherhampton Road may cause localised ponding. Figure 7-8 illustrates that the potential depths of flooding are relatively shallow and are generally less than 0.5m with the exception of the area adjacent to the A3094 Netherhampton Road. Due to the potential low velocities associated with the flow paths, the flood hazard within this area is generally low.

In the areas to the north of the A3094 Netherhampton Road there is a potential risk of pluvial flooding. However, this area is likely to have a close interaction with the River Nadder system, hence fluvial flooding would potentially be the dominant flooding mechanism in this area.

7.3.8 Old Sarum Area

The pluvial modelling indicates a number of potential flow paths in the greenfield area to the north of Old Sarum. Visual inspection of these potential flow paths indicates that they are located at the base of small valleys or depressions in the land, as shown in Figure 7-9.

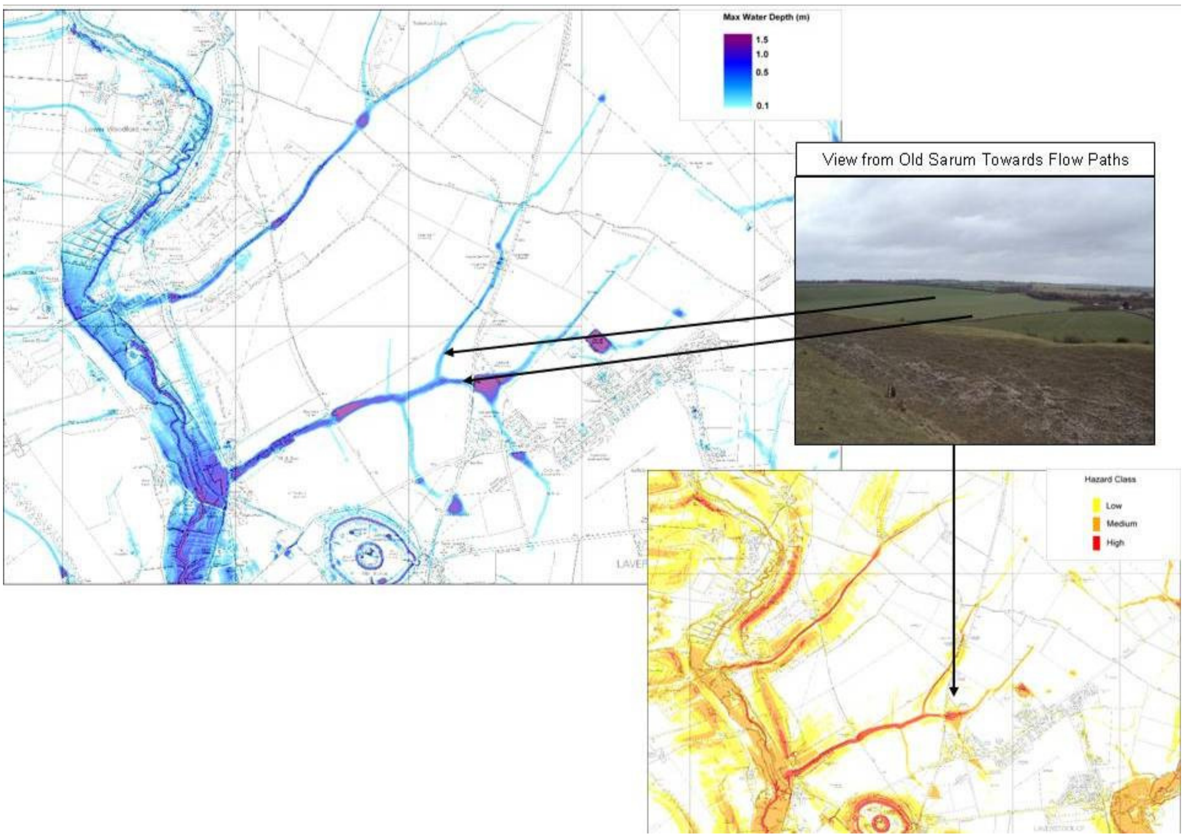


Figure 7-9: Pluvial modelling results (maximum depth and hazard) from the 1% AEP rainfall event inclusive of climate change for the Old Sarum Area

Figure 7-9 illustrates that the potential flow paths have obstructions within their course including raised tracks and roads. During site walkovers, it was noted that the majority of these do not have culverts beneath to drain water to the downstream side, therefore ponding is likely to be experienced upstream of these linear features.

In general, the hazard rating for the potential flow paths are high in the deeper areas of ponding and where flow is concentrated within the valley base. In areas where shallow flooding is experienced, low hazard is predominantly experienced.

7.4 Groundwater Flooding

Using data provided, a conceptual understanding of the hydrogeology for the Salisbury has been developed. A wider groundwater assessment describing the bedrock and superficial geology, hydrogeology and wider groundwater elements are appended to this report with accompanying figures. This has been used to identify groundwater flooding mechanisms, evidence of groundwater flooding, areas susceptible to groundwater flooding and potential requirements for long term monitoring. It has also been used to identify constraints with regards to using infiltration SuDS.

7.4.1 Groundwater Flooding Mechanisms

Based on the current hydrogeological conceptual understanding, there is potential for minor groundwater flooding in the Salisbury study area. The key groundwater flooding mechanisms that may exist are:

- **Water table elevation in the Chalk aquifer rising to above the ground surface:** groundwater flooding during periods of elevated groundwater levels results in water table rising above the ground surface, via springs and seepages; such that the flooded area is a representation of the groundwater table. Areas vulnerable to this type of flood are identified in Figure 5 (see appended report). Substantial areas were affected by this direct groundwater flooding during the flood events of the autumn/winter 2000/2001, and the floods of winter 1959 and 1915 can be attributed to this mechanism.
- **Water table in the Chalk aquifer induced groundwater floods**: water table rises in the Chalk aquifer in the catchments of the River Avon and its tributaries upstream from Salisbury can result in the flowing of ephemeral springs and streams, some of which rarely flow, resulting in greater river flows through the city, causing floods. These high groundwater levels also lead to reduced rainfall infiltration and increased rapid runoff to watercourses. It is believed that this is a key mechanism behind the 1990 fluvial flood event, and will also have contributed to flood events in other years including 2000/2001.
- **Superficial aquifers along the River Avon and its tributaries**: flooding may be associated with Alluvium deposits and the sand and gravel River Terrace Gravels deposits where they are in hydraulic continuity with surface water courses. Stream levels may rise following high rainfall events but still remain “in-bank”, and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits. Within the UK, houses with cellars / basements were largely built within the Victorian era and into the early 1900s. Therefore, the developed areas with properties of this period are more likely to comprise properties with cellars / basements.
- **Superficial aquifers in various locations not in hydraulic connectivity:** a second mechanism for groundwater flooding is also associated with River Terrace Deposits (gravel and sand) and sand lenses within the Valley Deposits and Clay-with-Flints and Head deposits along the River Avon and associated tributaries. Perched groundwater tables can exist within these deposits that are not hydraulically connected to watercourses and developed through a combination of natural rainfall

recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.

- **Made ground in various locations:** a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this 'made ground' is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in or enhance groundwater flooding of properties with basements, or may equally be considered a drainage issue. Areas mapped by the BGS as containing made ground deposits are found both on superficial deposits and directly on the bedrock and may either form a continuous aquifer with respective aquifer horizons, or provide a low permeability cap constraining recharge to and seepage from such horizons, depending on the composition of made ground.

7.4.2 Evidence of Groundwater Flooding

The reported historic flood incidents, including those reported as groundwater flooding, are shown on Figure 5. The groundwater flooding incidents are scattered along the River Bourne, in Wilton to the west, and near Salisbury Cathedral and Britford in the south east. There were 19 incidents during December 2000; 3 incidents in December 1995; 3 incidents in January 2003; others occurred in 1990, 1994, 2002 and 2001.

The Environment Agency has a groundwater flood warning system in the Salisbury area and further details are provided in Table 7-3. The Clarendon monitoring point is closest to Salisbury. The others are west or north of the study area. However, they are still relevant to the current study; high groundwater levels at these upstream locations can lead to increased spring flows and reduced rainfall infiltration, resulting in increased river flows and fluvial flood risk within the City.

Table 7-3: Environment Agency Groundwater Level Warning System

Location	Site ID	Potential Flood Watch Level (mAOD)	Potential Flood Warning Level (mAOD)
Clarendon	9115	67.00	70.00
Everleigh	9114	125.00	127.50
Idmiston	9109	69.00	71.00
Fonthill	9106	Unconfirmed	115.00

7.4.3 Areas Susceptible to Groundwater Flooding

Outputs from the Environment Agency's regional groundwater model have been used to identify those areas where there is potential for elevated groundwater levels (Figure 5 in appended report). The data indicate that, as expected, the elevated (<4 m below ground surface) groundwater levels are likely to occur where Alluvium, Head and River Terrace Deposits are present at surface; notably along the River Avon and its tributaries that flow through Salisbury. All of the recorded groundwater flooding incidents occur within the area defined by the regional groundwater model.

In addition to the above, the Environment Agency / Council has defined a 1 in 20 year groundwater flooding zone (Figure 5 in appended report). There are no historic flood incidents recorded as groundwater flooding in this zone, although this does not necessarily mean that groundwater flooding has not occurred.

Guidance on protecting properties from groundwater flooding has been produced by the Environment Agency, these are available at:

http://www.thebswa.plus.com/Library/Groundwater_Flooding.pdf

7.4.4 Infiltration SUDS Suitability

Improper use of infiltration SUDS could lead to contamination of the superficial or bedrock geology aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SUDS is likely to help improve aquifer quality status and reduce overall flood risk.

Environment Agency guidance on infiltration SUDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/36998.aspx. This guidance should be considered by developers and their contractors and by Wiltshire Council during the planning application process.

The areas that may be suitable for infiltration SUDS (e.g. soakaways, permeable paving) exist where there is a combination of higher ground (interfluves) and permeable geology (see Figure 3 in appended report). For example, although the River Terrace are expected to be permeable, they are close to a major watercourse and the depth to groundwater may be unsuitable for infiltration SUDS.

Consideration should also be given to the impact of increased infiltration SUDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at the down gradient location. This type of analysis is beyond the scope of the current report.

Restrictions on the use of infiltration SUDS apply to those areas within Source Protection Zones (SPZ), these are illustrated in Figure 5 (see appended report). These restrictions should be considered during the masterplanning of strategic development.

7.5 Sewer Flooding

The data provided in Table 7-2 indicates that several areas in Salisbury have suffered from surcharging of the sewer system. The DG5 register provided specifically for this study by Wessex Water indicates that there are currently there are no sewer capacity issues within the town. However, it should be noted that some sewers maybe at or near their hydraulic capacities. Wessex Water has also confirmed that there are also no further entries being added to the DG5 register in the near future but where property flooding does occur the register will be updated.

Where incidents of sewer flooding occur, this is typically associated with either exceedance of sewer capacity or a blockage/collapse within the sewer system. Design standards for surface water sewers currently require the sewer design to be for a 3.33% annual probability (1 in 30 year) storm event. However, existing sewers are likely to have lower capacity due to some being constructed over 100 years ago. Therefore, sewer exceedance, blockage or collapse could lead to localised flooding within and from the sewer network.

As identified in Section 7.3, it is likely that areas identified by the pluvial modelling are inherently linked with the sewer network. The likely effects of the inter-relationship between the sewer network and overland flow are described in the following sections.

7.5.1 Bemerton Area

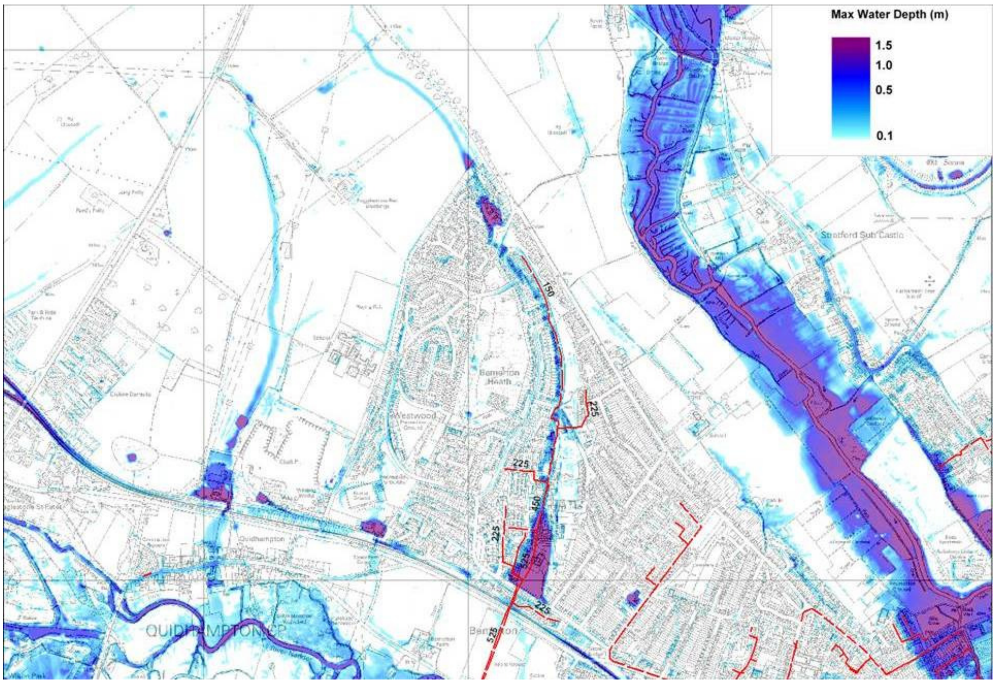


Figure 7-10: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of Bemerton. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

Figure 7-10 illustrates that the potential flow path within The Valley, Gainsborough Close and surrounding development is served by the existing surface water sewers. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced in this location provided that the sewer network is functioning as designed.

The above information provides outline verification of the observations provided in Section 7.3.1 that flooding within the vicinity of Bemerton is likely to be caused by exceedance of the local surface water sewer network or blockage. In addition, Figure 7-10 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network.

At a site specific level, further investigation is likely to be required during masterplanning and associated work (e.g. FRA or drainage strategy) to utilise more accurate sewer information and investigate surface water flooding issues.

7.5.2 City Centre Area

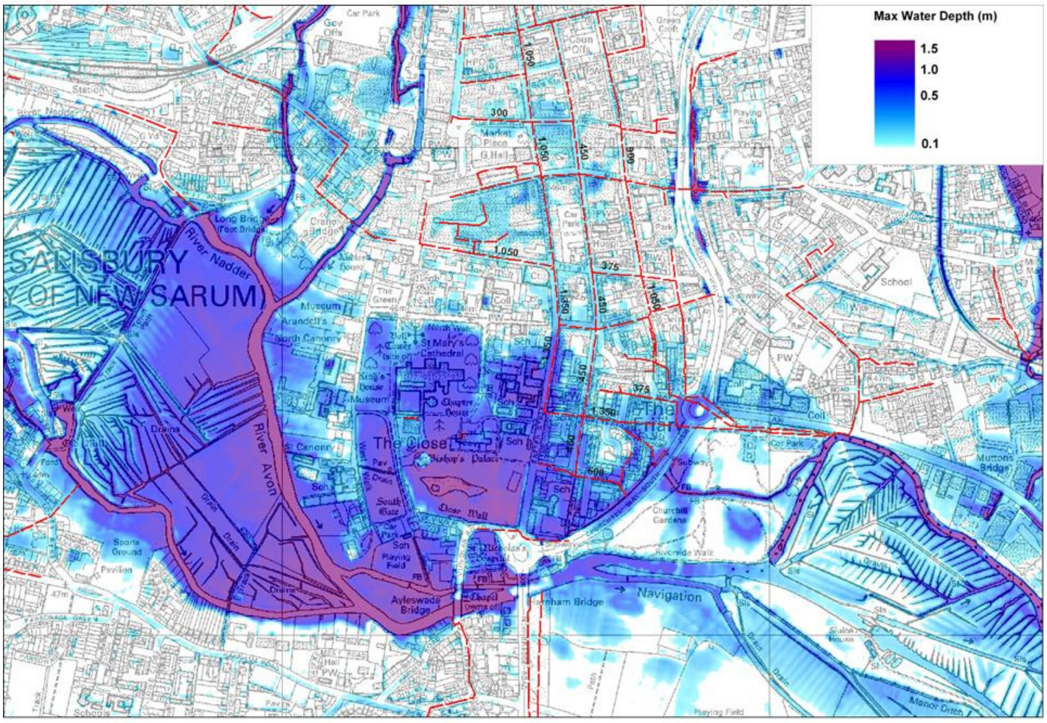


Figure 7-11: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of the City Centre. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

Figure 7-11 illustrates that Salisbury City Centre is served by the public sewer network. In particular, a large (1,050 increasing to 1,350mm diameter) sewer is situated beneath Queen Street and Exeter Street, which is understood to discharge into the River Avon adjacent to Harnham Bridge. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced provided that the sewer network is functioning as designed and is not impeded by high river flows or groundwater levels.

The above information provides outline verification of the observations provided in Section 7.3.3 that flooding within the vicinity of the City Centre is likely to be in combination with the river levels and exceedance of the local surface water sewer network (or localised flooding due to blockage). In addition, Figure 7-11 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network.

7.5.3 Churchill Way Area

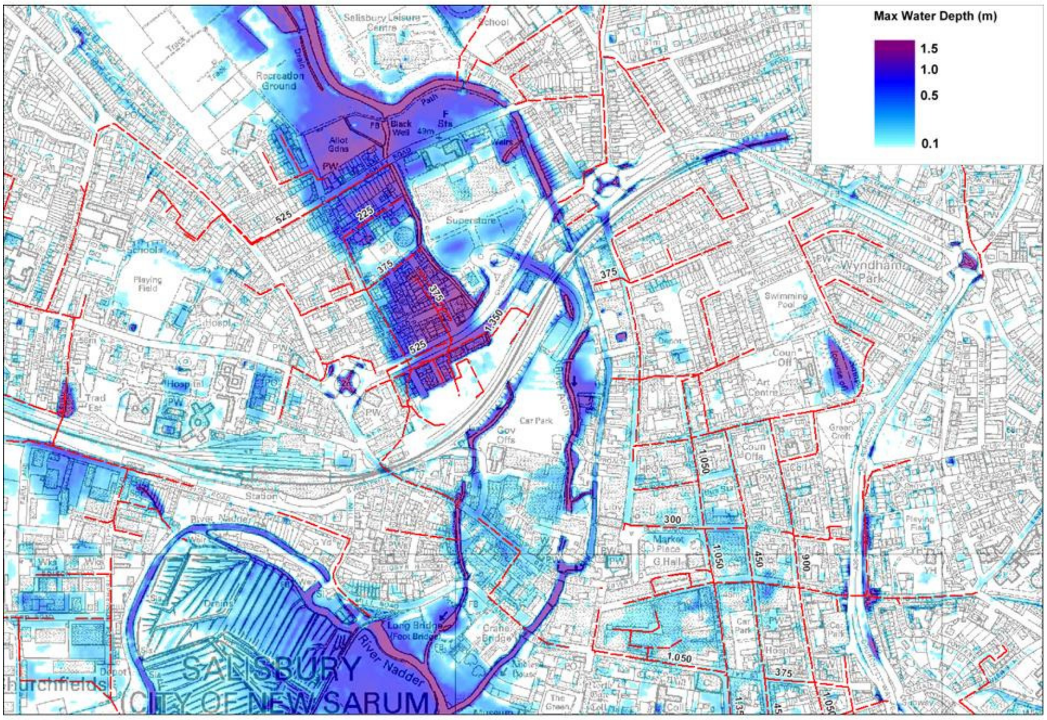


Figure 7-12: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of the Churchill Way. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

Figure 7-12 illustrates that the potential flow path within the vicinity of Churchill Way is generally served by existing surface water sewers. In particular, a large 1,350mm diameter, sewer is situated beneath St Pauls Way and is understood to discharge into the River Avon system adjacent to Churchill Way. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced provided that the sewer network is functioning as designed and is not impeded by high river flows or groundwater levels.

The above information provides outline verification of the observations provided in Section 7.3.4 that flooding within the vicinity of Churchill Way is likely to be caused and likely to be associated with levels within the River Avon. Figure 7-12 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network.

7.5.4 Laverstock Area

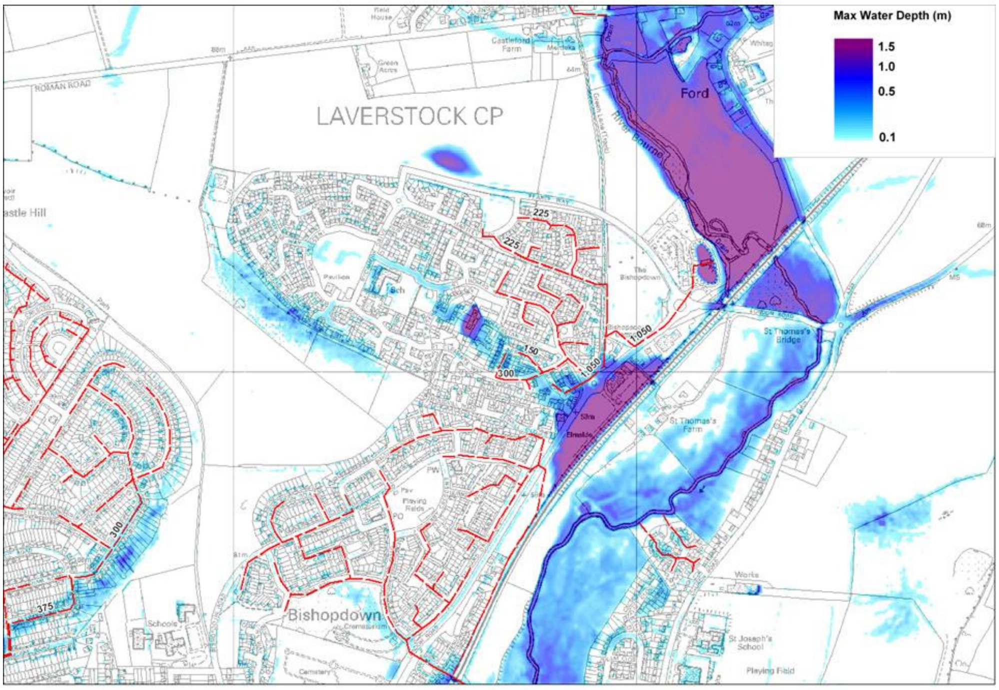


Figure 7-13: Wessex Water surface water sewer location and approximate diameters (in mm) within the vicinity of the Laverstock. Pluvial modelling results for the 1% AEP rainfall event inclusive of climate change.

Figure 7-13 illustrates that the potential flow path within the vicinity of Laverstock is served by existing surface water sewers that convey flows away from the area of ponding. In particular, a 1,050mm diameter sewer is situated beneath London Road. Whilst the actual capacity of the surface water sewer network is unknown, depths of overland flow and surface water flooding are likely to be reduced provided that the sewer network is functioning as designed.

The above information provides outline verification of the observations provided in Section 7.3.4 in that any flooding within the vicinity of Laverstock is likely to be caused by exceedance of the local surface water sewer network. In addition, Figure 7-13 indicates that the potential flooding depths estimated by the pluvial modelling are likely to be a conservative estimate due to the modelling not taking into account the local surface water sewer network. However, the main area of ponding to the east of London Road mostly consists of existing open space and is therefore unlikely to be served by a surface water system. Localised flooding in this location is likely to occur during times of heavy rainfall.

At a site specific level, further investigation is likely to be required during masterplanning and associated work (e.g. FRA or drainage strategy) to utilise more accurate sewer information and investigate surface water flooding issues.

7.6 Ordinary Watercourses

The majority of the watercourses within the urban extent of Salisbury are classified as Main River and as such are covered by the Environment Agency Flood Map (i.e. Flood Zones 2 and 3). Minor watercourses within the urban extent of Salisbury predominantly exist as culverted watercourses often forming part of the wider sewer network. However, the pluvial modelling results do highlight a number of ordinary watercourses at the margins of the urban extent of Salisbury.

The pluvial modelling results for Salisbury highlight the link between surface water runoff and flow within ordinary watercourses. For example where flow paths converge to create a dominant flow path, the OS mapping used to inform this study usually indicates the presence of a minor watercourse. The flood risk posed by ordinary watercourses is often exacerbated by a poor maintenance regime, which would include managing ‘in channel’ vegetation and removal of foreign objects both of which restrict channel flow.

The pluvial modelling results indicate a number of areas that may experience flooding from ordinary watercourses within the Salisbury study area, these are described in the following sections.

7.6.1 Britford Area

In addition to the flow paths and areas at potential risk of flooding described in Section 7.3.2, the pluvial modelling identifies potential interaction between surface water runoff and fluvial flooding from the various small ditches and watercourses within Britford.

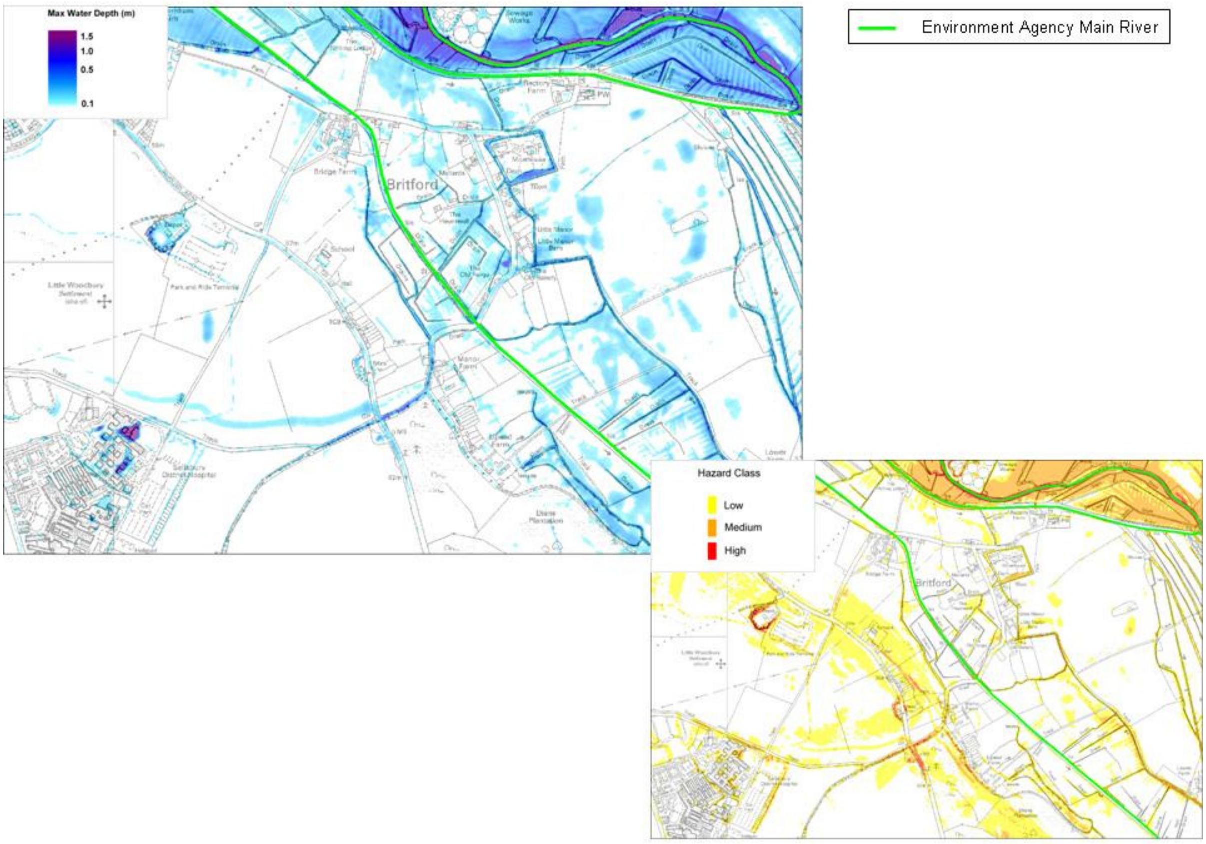


Figure 7-14: Pluvial modelling results during the 1% AEP event, inclusive of climate change (maximum depth and hazard) for the ordinary watercourses in Britford

Figure 7-14 illustrates that potential flooding hazards associated with the ordinary watercourses in Britford are not significant, due to the relatively low depths and velocities. The interaction of these ordinary watercourses with Main Rivers in the vicinity may cause localised flooding during times of high flows within the River Avon or elevated groundwater levels.

7.6.2 Netherhampton Area

In addition to the flow paths and areas at potential risk of surface water flooding described in Section 7.3.2, the pluvial modelling identifies potential interaction between surface water runoff and fluvial flooding from small ditches and watercourses within the Netherhampton area.

Figure 7-15 illustrates that the potential flood depths in this location are shallow and the hazard associated with these ordinary watercourses are not considered. The interaction of these ordinary watercourses with Main Rivers in the vicinity may cause localised flooding during times of high flows within the River Nadder or elevated groundwater levels.

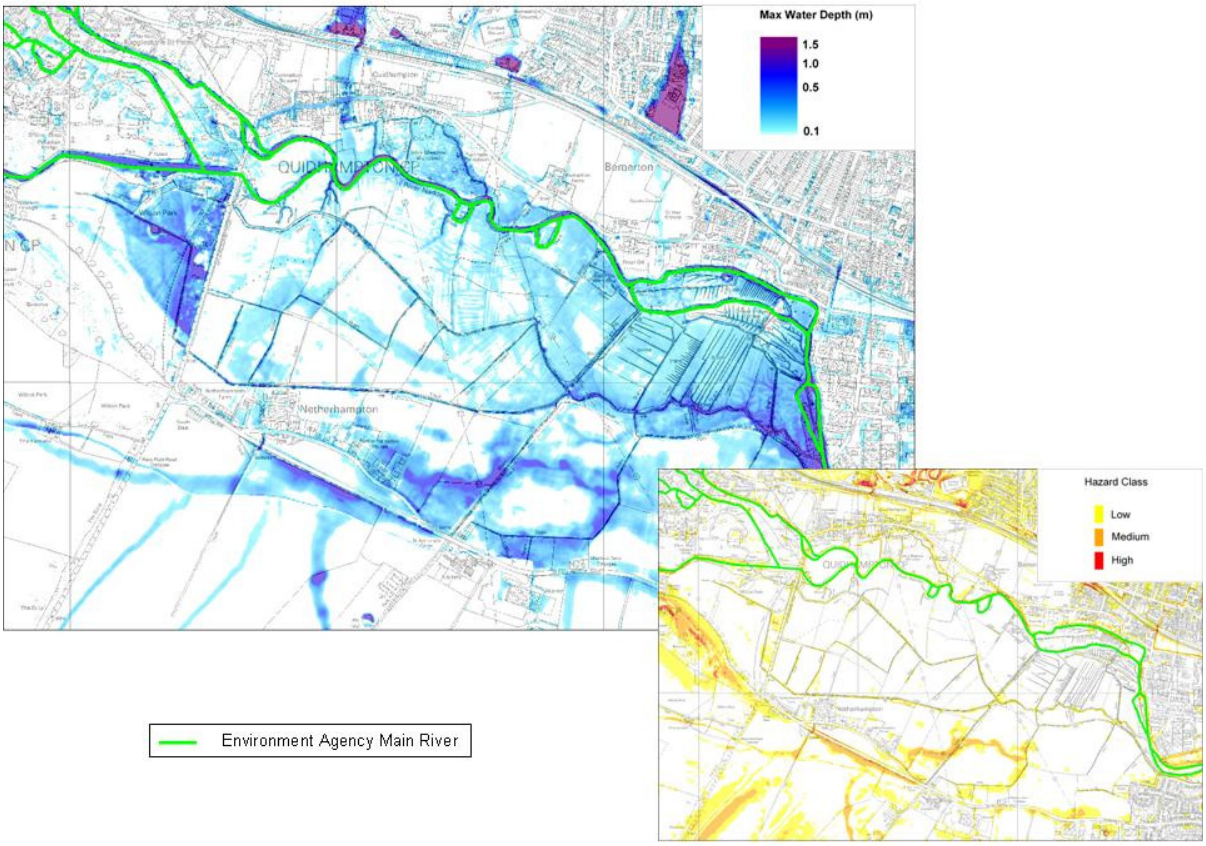


Figure 7-15: Pluvial modelling results during the 1% AEP event, inclusive of climate change (maximum depth and hazard) for the ordinary watercourses in the Netherhampton Area

7.7 Implications for Future Development

As shown in Figure 7-1, there are six potential mixed use development areas proposed within and around Salisbury, as follows:

- Fugglestone Red, near A360 Devizes Road;
- Longhedge (Old Sarum);
- The Maltings/ Central Car Park;
- Churchfields and Engine Shed;
- South of Netherhampton Road;

- United Kingdom Land Forces site, Wilton

In addition, a potential housing site is located at Hampton Park in Bishopdown, to the northeast of the City and a potential employment site is proposed for the Imerys Site adjacent to the A36 Wilton Road near Bemerton. As illustrated in Figure 7-1, these are at a strategic level and therefore the extent and layout of each site is unknown.

Proposed developments are subject to the requirements of the planning system and therefore it is considered that the findings of the SWMP should be taken into account within design and layout of the development. It is envisaged that due to the scale of development, an FRA will be required as part of the planning process and will therefore address surface water issues at the development scale.

7.7.1 Fugglestone Red

Fugglestone Red is located adjacent to the A360 Devizes Road, to the north east of Bemerton. The potential surface water issues for the Fugglestone Red area are outlined in Section 7.3.1. In summary, potential mitigation measures for this area principally involve setting development back from the ordinary watercourses/flow paths and ensuring the potential ponding areas are considered when undertaking the site designs.

7.7.2 Longhedge (Old Sarum)

Longhedge is located to the west of the village of Old Sarum, on the A345 Fourmile Hill road. The potential flooding issues for this area are outlined in Section 7.3.8. In summary, potential mitigation measures for this area principally involves setting development back from the ordinary watercourses/flow paths and ensuring the potential ponding areas are considered when undertaking the site designs.

7.7.3 The Maltings/ Central Car Park

The Maltings/ Central Car Park site is located in the City Centre. The potential issues for this area are highlighted in Section 7.3.3. Due to the combination with fluvial flooding, development should be located sequentially in accordance with PPS25 and should also take account of potential surface water sewer exceedance associated with flow levels within the River Avon.

7.7.4 Churchfields and Engine Shed

The proposed Churchfields and Engine Shed redevelopment site is located in the southern extent of the Bemerton area of Salisbury. The potential surface water flooding issues for this area are shown in Figure 7-16.

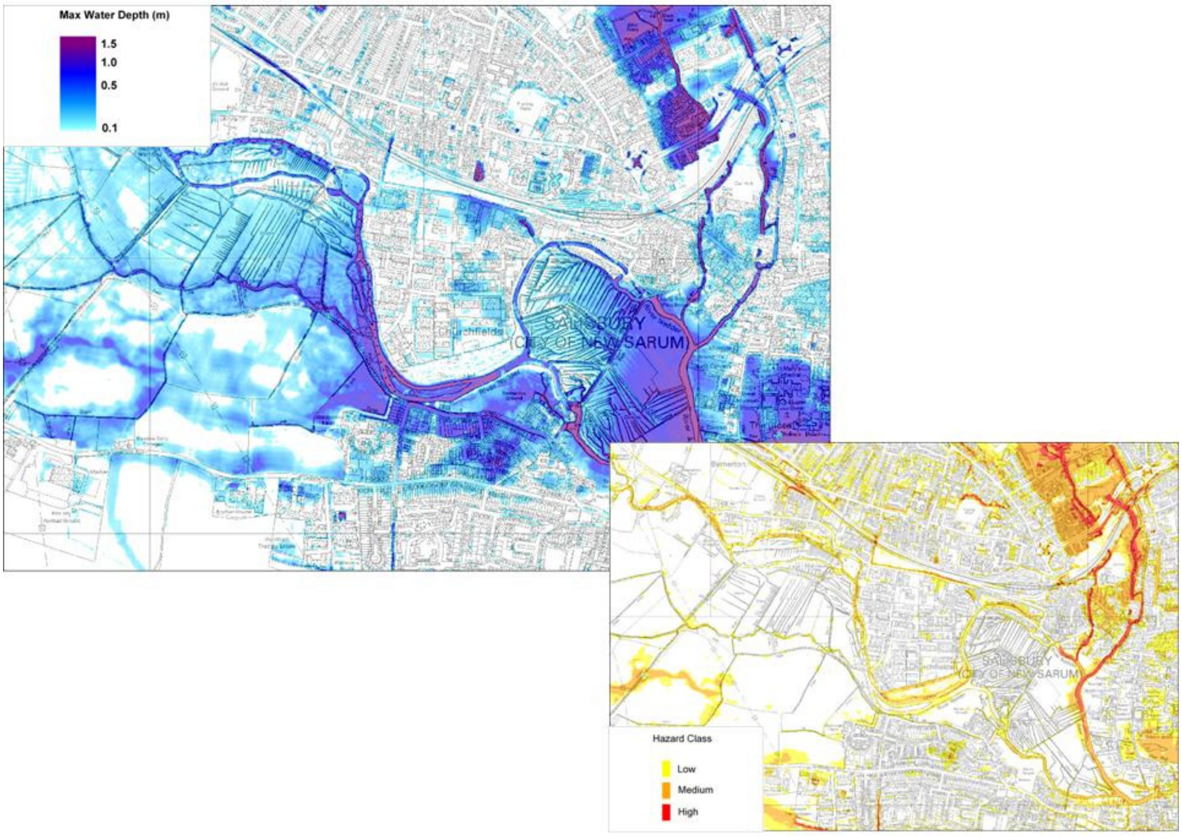


Figure 7-16 Pluvial modelling results during the 1% AEP event, inclusive of climate change (maximum depth and hazard) for the Churchfields and Engine Shed Area

Figure 7-16 indicates that there are areas at potential risk from pluvial flooding. However, the hazard associated with this flooding is considered low or insignificant due to shallow depths and low velocities. The Churchfields and Engine Shed area is served by an existing surface water sewer network and pluvial modelling results are likely to be conservative in this location. Proposed redevelopment of this area should take account of information provided within this report and the Level 2 SFRA to ensure that flood risks from all sources are taken into account during the masterplanning process. Opportunities may exist to improve the surface water network during redevelopment.

7.7.5 South of Netherhampton Road

The potential surface water flooding issues posed to the proposed development area south of Netherhampton Road are described in Sections 7.3.7 and 7.6.2. In summary, potential mitigation measures for this area principally involve setting development back from the ordinary watercourses/flow paths and ensuring the potential ponding areas are considered when undertaking the site designs.

7.7.6 United Kingdom Land Forces Site, Wilton

The United Kingdom Land Forces (UKLF) site is located to the north of Wilton. The potential pluvial flooding issues for this area are shown in Figure 7-17.

Figure 7-17: Pluvial modelling results during the 1% AEP event, inclusive of climate change (maximum depth and hazard) for the UKLF Area

Figure 7-17 indicates that there are no significant flow paths across the proposed development site. There are minor areas of ponding within the site that should be investigated and mitigated (where required) at the masterplanning stage.

7.7.7 Hampton Park, Laverstock

The Hampton Park site is located within the Laverstock / Bishopdown area to the north east of Salisbury. The potential surface water flooding issues for the Hampton Park area are outlined in Section 7.3.5. In summary, potential mitigation measures for this area principally involve setting development back from the ordinary watercourses/flow paths and ensuring the potential ponding areas are considered when undertaking the site designs.

7.7.8 Employment Site, Imerys

The Imerys site is located adjacent to the A36 Wilton Road near Bemerton. The potential issues for the Employment area at the Imerys Site area are outlined in Section 7.3.1. In summary, potential mitigation measures for this area principally involve setting development back from the ordinary watercourses/flow paths and ensuring the potential ponding areas are considered when undertaking the site designs.

7.8 Summary

Based on the findings of the pluvial modelling and assessment of flooding from other sources including the potential from sewer, groundwater and ordinary watercourses, the following high level observations have been made that can be used to inform the Phase III stage of the SWMP. The observations are as follows:

- A potential overland flow path has been identified within the Bermaton area. This area is served by an existing public surface water sewer network but is likely to have localised flooding where sewer capacity is exceeded and depressions within the flow path exist. It is noted that planning permission has been granted for the site at Gainsborough Close and the site specific Flood Risk Assessment has considered surface water management as part of the application. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Potential surface water and exceedance of ordinary watercourses were identified by the pluvial modelling in the Britford Area. Evidence of gully sweeping was noted during the walkover, however, this could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Flooding issues are identified in the city centre area, historical flood incidents have been noted in this location (in particular the cathedral area) and are likely to be from a combination of sources including fluvial, surface water sewer exceedance, surface water ponding and groundwater levels. Existing gully sweeping targeted in those locations most susceptible to potential surface water/sewer exceedance will help to reduce the effects of flooding, however, where fluvial flooding dominates, this is unlikely to provide significant differences. Local awareness raising could be undertaken to alert residents and visitors to the potential surface water issues.
- A potential overland flow path has been identified within the Laverstock area. This area is served by an existing public surface water sewer network but is likely to have localised flooding where sewer capacity is exceeded and depressions within the flow path exist. Gully sweeping could be targeted in those locations most susceptible to potential surface water/sewer exceedance to reduce the effects of flooding. Local awareness raising could be undertaken to alert residents to the potential surface water issues.
- Potential flood risk issues associated with overland flows, ordinary watercourses and the interaction with the underlying groundwater levels and River Nadder in the Netherhampton area. Potential development to the south of Netherhampton Road is predominantly on greenfield land and is not served by the public sewer system at present. Surface water management should be considered during the masterplanning phases to direct development away from potential flow routes and provide green open space. Site level investigation should be undertaken to identify the suitability of infiltration SuDS.
- Potential flood risk issues associated with overland flows/ordinary watercourses in the Old Sarum area. Potential development on greenfield land and is not served by the public sewer system at present. Surface water management should be considered during the masterplanning phases to direct development away from potential flow

routes and provide green open space. Site level investigation should be undertaken to identify the suitability of infiltration SuDS.

8 Summary and Next Steps

This section provides a summary of the findings of the Phase 1 and Phase 2 elements of the Wiltshire SWMP that has focussed on the settlements of Chippenham, Trowbridge and Salisbury due to their strategic significance for future development and growth.

8.1 Phase 1

Phase 1 has identified the need of the SWMP with significant numbers of properties identified that have the potential to be affected by surface water flooding. Historical records of surface water, groundwater and sewer flooding have been identified but are limited in detailed information for validation of the pluvial modelling when considering interactions between these sources of flooding coupled with fluvial flooding.

A partnership between functions within Wiltshire Council, the Environment Agency and Wessex Water has been established with input from URS Scott Wilson. A project governance framework has been written to establish working practices between the partners and identified other potential stakeholders within the process.

Due to the size of the administrative area of Wiltshire Council, focus has been placed initially on strategically significant towns where the majority of future development is planned. These settlements are Chippenham, Trowbridge and Salisbury. Clarification of the scope has been undertaken to identify the aims and objectives of the SWMP study, linkages with other plans, stakeholder engagement, review of existing data and the required level of assessment. An intermediate level of assessment was agreed for the three settlements and progressed within Phase 2.

It is recognised that further work is likely to be required for other smaller settlements where existing surface water issues and future development will require investigation, however, these are beyond the scope of the Phase 2 work at present.

8.2 Phase 2

The Phase 2 work has undertaken settlement level pluvial modelling using a direct rainfall approach to identify surface water flow paths, areas of significant ponding and generalised problem areas. In addition, potential in-combination effects of sewer flooding with the results of the pluvial modelling has been undertaken and an assessment of the potential for groundwater flooding has also been undertaken to identify potential problem areas due to the limited detail in terms of recorded historical incidents (i.e. no information of depth, duration, extent etc).

For each settlement, a review of the results from the pluvial modelling has identified a number of potential problem areas. Based on a qualitative assessment of the mapping results, the potential problem areas for surface water flooding can be subjectively prioritised for each settlement in terms of flood depth and hazard, presence of sewers and known/resolved issues. They are as follows:

Chippenham

- Langley Park/Eastern Avenue – culverted watercourse associated with sewer, potential overland flow paths and significant ponding associated with railway and flood defence embankments.
- High Street – overland flow from impermeable area and sewer capacity exceedance issues associated with fluvial flow levels. Remedial works have been undertaken in the recent past by Wessex Water.

- Hardenhuish Brook – potential flooding issues associated with an ordinary watercourse that in the lower reaches becomes a main watercourse. Collaborative working with Environment Agency required due to split responsibilities.
- Patterdown Area/Pewsham Way – ponding identified associated with existing features (SuDS ponds, depressions) and confirmed through site walkovers.
- Pewsham/Hardens Farm/Hill Corner – areas for proposed future development, opportunities to influence SuDS at masterplanning stage if allocated.

Trowbridge

- Green Lane Area – potential surface water flooding associated with sewer capacity issues and discharge to Paxcroft Brook.
- Bramley Lane Area – potential ponding issues and culverted watercourse capacity issues.
- Timbrell Street Area – potential overland flow path and sewer capacity issues, with associated ponding.
- Drynham Road Area – potential flooding from an ordinary watercourse, associated with the railway embankment and possibly related with culvert capacity beneath the railway.
- South East Trowbridge – area for proposed future development, opportunities to influence SuDS at masterplanning stage if allocated. Potential to look at in combination with Drynham Road area.

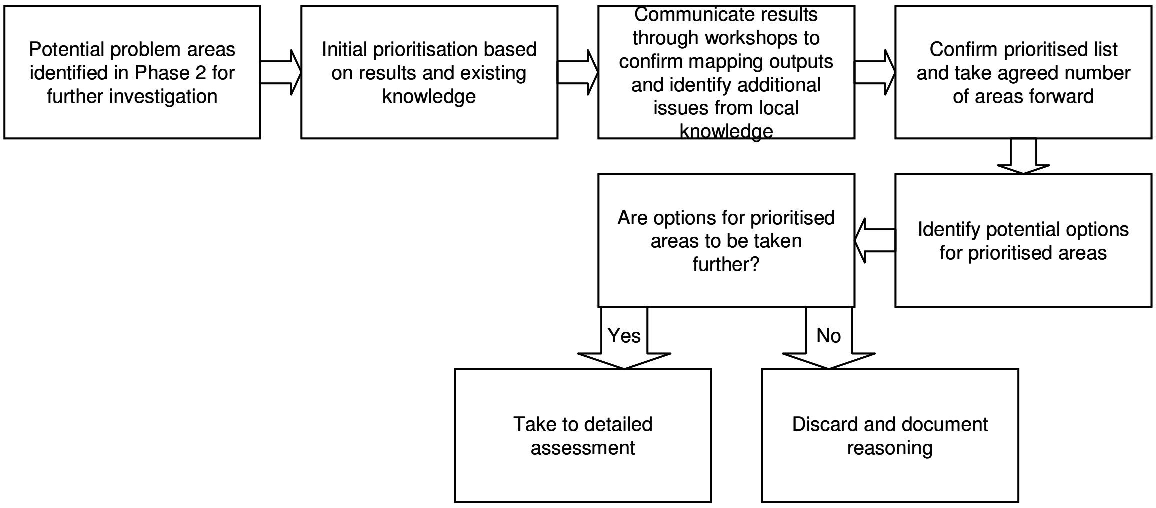
Salisbury

- Central and Churchill Way Area – complex interaction of in-combination flooding likely from surface water, sewer, groundwater and fluvial flooding across significant areas. Future development is planned within the area, therefore holistic approach is required.
- Milford Area – potential in-combination flooding likely from surface water, groundwater and fluvial flooding.
- Bemerton Area – potential overland flow paths with significant ponding associated with the road and rail embankment and potential sewer exceedance. Planning application granted and associated FRA addresses SuDS for Pembroke School site.
- Laverstock Area – potential overland flow path and sewer exceedance causing deep ponding but limited number of properties likely to be affected.
- Britford/Netherhampton/Old Sarum Areas – potential overland flow issues but low number of properties likely to be affected.
- Fugglestone Red, Longhedge, The Maltings/Central Cark Park, Churchfields & engine Shed, South of Netherhampton Road and UK Land Forces Site – areas for proposed future development, opportunities to influence SuDS at masterplanning stage if allocated.

Review of the above summary provides an opportunity to engage with stakeholders by presentation of results in a range of formats and canvassing opinion with regard to the outputs of Phase 2. The suggested approach is provided in the next section.

8.3 Next Steps and Phase 3 Assessment

The next steps within the SWMP are summarised in the flow chart below. It is important to communicate the results of the Phase 2 and it is suggested that a number of local workshops are undertaken within each settlement to present these findings. This process will allow local knowledge to be used to confirm the results of the modelling undertaken as part of Phase 2, alert members of the community to the potential of surface water flooding within the area, collate additional information based on local knowledge and gather constructive feedback to inform the progression of the Phase 3 assessment. This approach has been successful in other Local Authority areas and can provide useful information that has not previously been collected such as unreported flooding incidents and localised issues.



The information gathered from local workshops will aid the prioritisation of potential problem areas. This will bring forward areas that should be addressed in the short term but also acknowledge areas that should be considered and monitored for inclusion in the medium to long term for the Phase 3 assessment.

The Phase 3 assessment will be focussed on the areas prioritised for short term measures with potential options being identified. This process will allow potential options for each area to be considered and assessed against a range of criteria to be confirmed. Where it is considered feasible for options to be progressed, these will be taken to the detailed assessment stage. If the options for the areas are not considered to be taken further, then reasons should be documented to provide a consistent decision making process.

The outcomes of the Phase 3 assessment will form the next step within the SWMP and further contribute to the management of surface water for existing and future development in Wiltshire.

Appendix A – Project Governance Framework

Appendix B – Pluvial Modelling Methodology

Appendix C – Chippenham

Pluvial Modelling Figures:

Figure 1 – Maximum Water Depth 1 in 30 year Pluvial Event

Figure 2 – Maximum Hazard 1 in 30 year Pluvial Event

Figure 3 – Maximum Water Depth 1 in 30 year (Inclusive of Climate Change) Pluvial Event

Figure 4 – Maximum Hazard 1 in 30 year (Inclusive of Climate Change) Pluvial Event

Figure 5 – Maximum Water Depth 1 in 100 year Pluvial Event

Figure 6 – Maximum Hazard 1 in 100 year Pluvial Event

Figure 7 – Maximum Water Depth 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 8 – Maximum Hazard 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 9 – Maximum Water Depth 1 in 200 year Pluvial Event

Figure 10 – Maximum Hazard 1 in 200 year Pluvial Event

Intermediate Assessment of Groundwater Flooding Susceptibility Report + Figures:

Figure 1 – Geological Map

Figure 2 – Geological Cross Section

Figure 3 – Expected permeability map and Source Protection Zones

Figure 4 – Discharge consents and groundwater abstractions

Figure 5 – Areas Susceptible to Groundwater Flooding

Appendix D – Trowbridge

Pluvial Modelling Figures:

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Figure 2 – Maximum Hazard 1 in 30 year Pluvial Event

Figure 3 – Maximum Water Depth 1 in 30 year (Inclusive of Climate Change) Pluvial Event

Figure 4 – Maximum Hazard 1 in 30 year (Inclusive of Climate Change) Pluvial Event

Figure 5 – Maximum Water Depth 1 in 100 year Pluvial Event

Figure 6 – Maximum Hazard 1 in 100 year Pluvial Event

Figure 7 – Maximum Water Depth 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 8 – Maximum Hazard 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 9 – Maximum Water Depth 1 in 200 year Pluvial Event

Figure 10 – Maximum Hazard 1 in 200 year Pluvial Event

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Appendix E – Salisbury

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Figure 5 – Maximum Water Depth 1 in 100 year Pluvial Event

Figure 6 – Maximum Hazard 1 in 100 year Pluvial Event

Figure 7 – Maximum Water Depth 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 8 – Maximum Hazard 1 in 100 year (Inclusive of Climate Change) Pluvial Event

Figure 9 – Maximum Water Depth 1 in 200 year Pluvial Event

Figure 10 – Maximum Hazard 1 in 200 year Pluvial Event

Intermediate Assessment of Groundwater Flooding Susceptibility Report + Figures:

Figure 1 – Geological Map – Bedrock, Superficial and Made Ground

Figure 2 – Geological – Bedrock Geology

Figure 3 – Geological Cross Section

Figure 4 – Expected permeability Map and Source Protection Zones

Figure 5 – Potential for Elevated Groundwater Levels and Historic Flood Events