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Slough Surface Water Management Plan

Slough Borough Council

Final Draft Revision 2 February 2012

www.slough.gov.uk Slough Borough Council

Thames Water

Environment Agency

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Contents

Table 0-1

Executive Summary

This Surface Water Management Plan (SWMP) report, covering all phases of a SWMP, has been prepared on behalf of Slough Borough Council. It forms part of the evidence base that will inform the next round of the Preliminary Flood Risk Assessment investigating the mechanisms of surface water flooding in Slough.

A partnership was formed with the Environment Agency and Thames Water as part of the SWMP. Data was collected from the established partners and other stakeholders and assessed for its quality. A strategic risk assessment was undertaken for the Slough Borough area. The strategic risk assessment found the majority of historical flooding incidents and the estimated future flooding to be within the combined Chalvey Ditches catchment (Salt Hill Stream and Haymill Stream catchments). Therefore the Chalvey Ditches catchment was identified as the priority area requiring a more detailed assessment to understand the flood mechanisms.

The detailed risk assessment was undertaken using enhanced drainage modelling taking into consideration surface water sewers, sink holes within the Burnham Beeches area and the interaction between fluvial and surface water. The detailed risk assessment identified some key overland flow routes between buildings and established that there is generally low surface water flood hazard within Slough for the lower order events (1 in 2 to 1 in 10 annual probability of occurring). However, there are a few areas in the Chalvey Ditches catchment which are shown to have a significant hazard rating during the 10 year event and above.

The detailed assessment found that climate change (with a 30% increase in rainfall intensity to allow for climate change) would result in an 18% increase in estimated damages due to surface water flooding during a 100 year event.

Several measures to reduce surface water flooding ranging from technical, maintenance, awareness, resilience and resistance and change of agricultural land practice were analysed by the SWMP partners using a multi-criteria analysis type of approach and a few measures were shortlisted for detailed assessment.

Two technical options were assessed through modelling and one of those was taken forward to a detailed assessment including cost benefit analysis. The preferred option was found to reduce surface water flooding during the lower order events significantly whilst increasing the number of properties at flood risk for higher order events. However, due to the benefits during the lower order events the cost benefit ratio is higher than the minimum recommended for funding by the FCERM guidance making the scheme eligible for funding via the Grant in Aid funding stream.

The preferred option was also found to have moderate carbon costs, does not have significant environmental impact and can potentially provide environmental benefits. The SEA screening report established that a full SEA would not be required as part of the SWMP but would be undertaken as part of the local Flood Risk Management Strategy which will be undertaken in the next 6 – 12 months.

Although the benefit/cost ratio of preferred scheme is favourable, the increase in number of properties at flood risk for the higher order rainfall events is not considered acceptable. Therefore a revision of the scheme was undertaken resulting in a new Option 2a. The improved scheme includes two storage areas immediately north of Park Road (B416) within Farnham Park and north of Slough Cemetery (as proposed in Option 2). However, the improved scheme aims to increase the flood storage provided north of

Park Road by introducing a new bund upstream of the proposed bund adjacent to Park Road.

The revised option was assessed on a smaller scale, higher resolution model and showed that the revised option would result in a decrease in flood risk south of Park Road for rainfall events up to the 1 in 100 (1%) event. Although an assessment covering the town was not undertaken to allow for quantification of the decrease in flood risk it is expected that the scheme would result in a decrease in the number of properties at risk of flooding for all events. As such, a favourable cost benefit ratio is assured.

It is therefore recommended that the revised Option 2a be adopted to alleviate surface water flood risk to the Salt Hill Stream catchment within Slough. It is also recommended that full assessment covering the town be undertaken to quantify the benefits offered by the revised scheme. The additional assessment should be undertaken before any detailed design of the scheme commences.

The SWMP Action Plan identifies the need for the established partnership to continue working together. The various departments in Slough BC such as Highways, Planning and Development Control also need to work together more closely in order to minimise the surface water flood risk impacts of new developments or extensions. Close collaboration between Council departments will ensure that surface water flood risk is given the same consideration as fluvial flood risk during planning. Slough planning policies should be updated to take into account findings of the SWMP ensuring that surface water flood risk is given greater weighting.

The Thames River Basin Management Plan (RBMP) found the Salt Hill Stream and the Chalvey Ditches to be in a ‘poor’ and ‘moderate’ ecological status respectively. The Thames RBMP objective for most of the watercourses is to achieve good ecological status by 2027 in order to meet the Water Framework Directive requirements. Therefore proposed re-development within Slough would need to take into account water quality and potential ecological improvements when developing the surface water management strategy for each development site. Improvements in water quality from the surface water drainage systems would contribute to achieving the Thames RBMP objectives for the watercourses within Slough.

The SWMP will inform the preparation of future maintenance programmes for surface water management assets within the borough and any necessary co-ordination of maintenance programmes of different partners to ensure their effective operation. As the surface water management plan identifies the locations at greatest risk of surface water flooding, this information can be used to target maintenance improvements in these areas. This can also be used to identify areas to apply for funding, support any funding applications that are made and to feed into planning policies.

Glossary

Annual Average Damages (ADD)	The average flood damages that are predicted to occur annually, and could include damages to people, property and the environment
Areas Susceptible to Surface Water Flooding (AStSWF) Map	Areas Susceptible to Surface Water Flooding (AStSWF) is a strategic scale map showing surface water flood areas specifically by the Environment Agency for use by Lead Local Flood Authorities (LLFAs) for use in Preliminary Flood Risk Assessment (PFRA) as required under the Flood Risk Regulations.
Areas Susceptible to Groundwater Flooding (AStGWF) Map	Areas Susceptible to Groundwater Flooding (AStGWF) is a strategic scale map showing groundwater flood areas on a 1km square grid. It was developed specifically by the Environment Agency for use by Lead Local Flood Authorities (LLFAs) for use in Preliminary Flood Risk Assessment (PFRA) as required under the Flood Risk Regulations.
Aquifer	An aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be usefully extracted using a water well
British Waterways	British Waterways is the organisation responsible for 2200 miles of Britain's canals and rivers.
Chance of flooding	The chance of flooding is used to describe the frequency of a flood event occurring in any given year, e.g. there is a 1 in 100 chance of flooding in this location in any given year. This can also be described as an annual probability, e.g. a 1% annual probability of flooding in any given year.
Core Strategy	A Development Plan Document setting out the spatial vision and strategic objectives of the planning framework for an area, having regard to the Community Strategy.
Cost Benefit Analysis (CBA)	Analysis which quantifies in monetary terms the costs and benefits of a proposed scheme, including items which the market does not provide a readily available monetary value for..
Department for Environment, Food and Rural Affairs (Defra)	Department that brings together the interests of farmers and the countryside; the environment and the rural economy.

DG5 Register	A water company held register of properties which have experienced sewer flooding (either internal or external flooding) due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 10 years.
Digital Terrain Model (DTM)	A model of the terrain of the earth's surface ('bare earth').
Direct Rainfall Method	Applying rainfall events directly to hydrology and hydraulic models using DEM/DTM data directly.
Environment Agency	The Environment Agency is the leading public body for protecting and improving the environment in England and Wales. The organisation is responsible for wide-ranging matters, including the management of flood risk, water resources, water quality, waste regulation, pollution control, inland fisheries, recreation, conservation and navigation of inland waterways.
Flood and coastal erosion risk management appraisal guidance (FCERM)	The FCERM gives guidance on how to appraise flood management projects.
Flood Hazard map	A combined map of the flood depth and velocity. It indicated the likely hazard.
Flood Risk Assessment (FRA)	An assessment of the likelihood and consequences of flooding in a development area so that development needs and mitigation measures can be carefully considered.
Flood Risk Management Strategy	A local document that sets out a statutory framework that will help communities, the public sector and other organisations to work together to manage flood risk. It will support local decision-making and engagement in FRM, making sure that risks are managed in a co-ordinated way across catchments and along each stretch of watercourse.
Flood Risk Regulations (2009)	These Regulations transpose Directive 2007/60/EC (EU Floods Directive) of the European Parliament and of the Council on the assessment and management of flood risks for England and Wales.
The Flood & Water Management Act	In April 2010, the Flood & Water Management Act became law. The Act, which applies to England & Wales, aims to create a simpler and more effective means of managing the risk of flood and coastal erosion. The Act also aims to help improve the sustainability of our water resources and protect against potential droughts.
Flood Zones 1,2 and 3	Flood Zone 1 – less than 1 in 1000 annual probability of river or sea flooding in any year. Flood Zone 2 – between a 1 in 100 and 1 in 1000 annual probability of river flooding or between a 1 in 200 and 1 in 1000 annual probability of sea flooding. Flood Zone 3 – 1 in 100 or greater annual probability of river flooding or a 1 in 200 or greater annual probability of flooding from the sea.

Geographic information system (GIS)	A geographic information system is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographically referenced data.
Grant in Aid Funding	Grant in Aid funding is provided by Defra through the Environment Agency to invest in flood risk management schemes.
Groundwater flooding	Caused by raised groundwater levels, typically following prolonged rain. High groundwater levels may result in increased overland flow flooding
Land Drainage Act 1991	An Act relating to internal drainage boards, and to the functions of such boards and of local authorities in relation to land drainage.
Lead Local Flood Authorities	Sir Michael Pitt's review of the flooding in 2007 stated that "the role of local authorities should be enhanced so that they take on responsibility for leading the co-ordination of flood risk management in their areas". The Act provides for this through the new role of the lead local flood authority. As set out in the Government's response to Sir Michael's Review, the Act defines the lead local flood authority for an area as the unitary authority or the county council.
LiDAR	Light Detection and Ranging – high accuracy, high resolution elevation data derived from airborne sources.
Multi Agency Flood Plans (MAFPs)	Local Authorities and other organisations are responsible, under the Civil Contingencies Act (CCA 2004), for developing emergency plans, contingency plans and business continuity plans to help reduce, control or ease the effects of an emergency.
Multi-Coloured Manual (MCM)	A common name for "The Benefits of Flood and Coastal Risk Management: A manual of Assessment Techniques".
Multi-Coloured Handbook (MCH)	The Multi-coloured Manual is used in flood risk management (FRM) to estimate the benefits of FRM interventions
Multi-Criteria Analysis (MCA)	MCA is a tool to assist decision-making where there are a number of different factors to consider. Each factor is scored and weighted to weigh up the benefits of different intervention options.
National Receptor Database (NRD)	The National Receptor Dataset (NRD) is a collection of risk receptors primarily intended for use in flood and coastal erosion risk management. It is available for use by Local Planning Authorities, the Environment Agency and our contractors
Non Aquifers	These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.
Optimism Bias	This an explicit adjustment made to the estimates of a project's costs, benefits and duration to account for project appraisers' tendency to be over optimistic. This adjustment is based on data from past or similar projects, and adjusted for the unique characteristics of

	the project in hand.
Option	An option is made up of a single, or a combination of previously defined measures.
Ordinary Watercourse	An ordinary watercourse is any other river, stream, ditch, cut, sluice, dyke or non-public sewer which is not a Main River. The local authority or Internal Drainage Board has powers over such watercourses.
Overland Flow/Surface Water Runoff	Water flowing over the ground surface that has not reached a natural or artificial drainage channel
Partner	Defined as someone with responsibility for decisions or actions. They share joint responsibility for these decisions/actions.
Preliminary Flood Risk Assessment (PFRA)	A strategic assessment of the flood risk within a Lead Local Flood Authority area.
Principal Aquifer	These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
Risk	In flood risk management risk is defined as the probability of a flood occurring multiplied by the consequence of the flood.
Secondary Aquifers	These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types: Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers; Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers
Special Protection Areas (SPA)	Strictly protected sites classified in accordance with Article 4 of the EC Birds Directive.
Stakeholder	Defined as anyone affected by the problem or solution.
Strategic Environmental Assessment (SEA)	SEA is a process to ensure that significant environmental effects arising from policies, plans and programmes are identified, assessed, mitigated, communicated to decision-makers, monitored and that opportunities for public involvement are provided.
Strategic Flood Risk Assessment (SFRA)	A SFRA provides information on areas at risk from all sources of flooding. The SFRA should form the basis for flood risk management decisions, and provides the

	basis from which to apply the Sequential Test and Exception Test (as defined in PPS25) in development allocation and development control process.
Surface Water Flooding	In the context of this report, surface water flooding describes flooding from sewers and ordinary water courses that occurs as a result of heavy rainfall.
Surface Water Management Plan (SWMP)	A Surface Water Management Plan (SWMP) is a plan which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.
Sustainable Drainage Systems (SUDS)	Sustainable drainage systems a sequence of management practices and control measures designed to mimic natural drainage processes by allowing rainfall to infiltrate and by attenuating and conveying surface water runoff slowly compared to conventional drainage. SUDS can operate at different levels; ideally in a hierarchy of source control, local control and regional control.

1 Introduction

1.1 BACKGROUND TO PROJECT

1.1.1 Slough is a borough and unitary authority within Berkshire. The town straddles the A4 Bath Road (it becomes the Great West Road closer to London) and the Great Western Main Line, 22 miles (35 km) west of central London. At the 2001 census, the population of Slough was 119,070 and the borough area was the most ethnically diverse local authority area outside London in the United Kingdom. Historically, the larger part of the present-day Slough area was formerly in Buckinghamshire with a small part of the borough originally in Middlesex.

1.1.2 In early 2009 Defra commissioned work to develop a national surface water flooding risk assessment methodology to identify those areas at highest risk of surface water flooding. As a result of this on 18 August 2009, the then Environment Secretary Hilary Benn announced that 77 local authorities across England would share £9.7million in funding to help them tackle surface water flooding.

1.1.3 Slough BC is one of the local authorities that has been prioritised and received funding to undertake a surface water management plan.

1.2 SURFACE WATER MANAGEMENT PLAN

1.2.1 The Flood and Water Management Act[1] gives Lead Local Flood Authorities (unitary or county local authorities) powers to carry out works to manage flood risk from local sources such as surface water, groundwater and ordinary watercourses. The local authorities will need to develop their local flood risk management strategy for its area in partnership with other stakeholders.

1.2.2 One element of the local authorities' leadership role is local flood risk management and the co-ordination of Surface Water Management Plans (SWMPs). The SWMP provides an understanding of the mechanism of surface water flooding and provides an evidence base to inform the planning process. In addition the SWMP can be used to ratify and improve the findings of the Preliminary Flood Risk Assessment (PFRA), which is a requirement of the Flood Risk Regulations (2009)[2].

1.2.3 A SWMP is undertaken in consultation with key local partners and stakeholders who are responsible for surface water management and drainage in their area. Partners work together to understand the causes and effects of surface water flooding and agree the most cost effective process of managing surface water flood risk for the long term. The process of working together as a partnership is designed to encourage the development of innovative solutions and practices as well as identifying funding streams to assist in the delivery of the outcomes of the SWMP.

1.3 THE SWMP APPROACH

1.3.1 The principal phases of undertaking a SWMP are illustrated through the wheel diagram shown in Figure 1-1 below.

[1] Flood and Water Management Act, April 2010
[2] The Flood Risk Regulations, December 2009

Figure 1-1: The SWMP Process Wheel[3]

1.3.2 The four phases of the SWMP are:

- **Preparation** – focussing on preparing and scoping the requirements of the study;
- **Risk Assessment** - broken down into strategic, intermediate and detailed assessment. This includes a review of historical data regarding flooding within the study area, the identification of flood hotspots and detailed baseline modelling with the aim of identifying potential measures to reduce the risk of flooding. The final section of the risk assessment phase is to map and communicate the current risk identified as part of the assessment;
- **Options** – this stage includes a review of the potential measures that can be used to reduce the risk of flooding within the study area. These measures are then shortlisted to identify the preferred options to be taken forward into detailed analysis

[3] Defra Surface Water Management Plan Technical Guidance, March 2010

and testing using a consideration of their relative effectiveness, benefits and costs; and

- **Implementation and Review** – the final phase of the SWMP is about preparing an action plan to deliver the agreed actions and monitoring and implementation of these actions.

1.3.3 This report outlines the SWMP for Slough, which was undertaken following the process illustrated by the SWMP wheel.

1.4 STUDY AREA

1.4.1 The Slough SWMP covers the administrative boundary of Slough Borough Council (Slough BC) and includes the natural catchment areas, which are in part located within South Buckinghamshire.

1.4.2 The Slough administrative boundary covers an area of approximately 33 km^2 with a total population just over 119,000[4] and comprises of seven villages which are Britwell, Chalvey, Cippenham, Colnbrook, Langley, Upton and Wexham (refer to Figure 1, Appendix E. Figure 1-2 below shows the location of Slough.

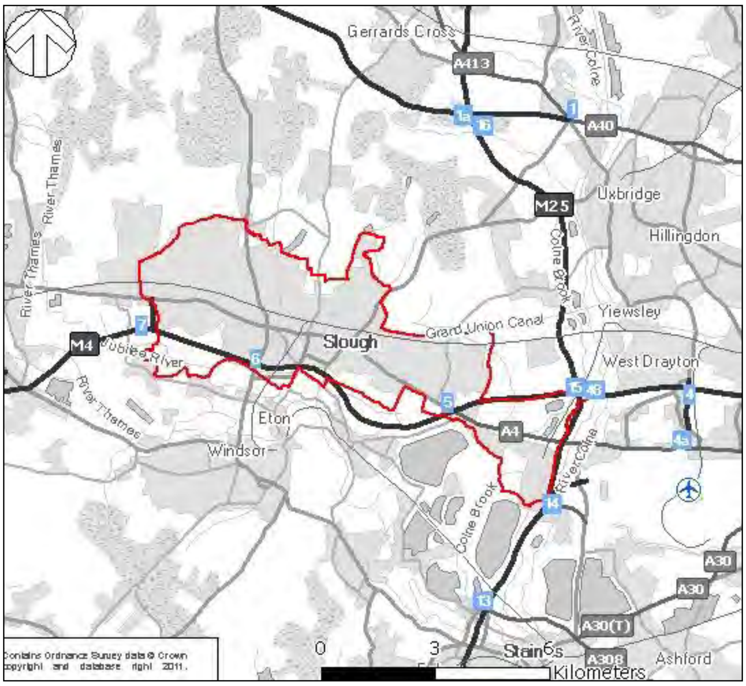

Figure 1-2: Slough Location

1.4.3 The Slough administrative area is bounded by the Jubilee River to the south and the River Colne to the east. The Slough arm of the Grand Union Canal is adjacent to part of the northern boundary of the borough.

1.4.4 Six main watercourses are located within and / or pass through the Slough administrative area. These are the culverted Huntercombe Lane Stream, partly culverted Haymill Stream / Chalvey Ditches, partly culverted Salt Hill Stream, partly culverted Datchet Common Brook, Horton Brook and Colne Brook. The culverted

4 Based on 2001 Census

Huntercombe Lane Stream is a tributary of the Roundmoor Ditch, which originates in South Bucks. The Salt Hill Stream and Haymill Stream / Chalvey Ditches combine to form the Chalvey Ditches immediately south of the Jubilee River. Refer to Figure 1 in Appendix E.

1.4.5 The main watercourses within Slough all discharge into the River Thames to the south of Slough within the Royal Borough of Windsor and Maidenhead.

1.4.6 Five main catchments were identified to contribute surface water flows to Slough. Table 1-1 below and Figure 1 in Appendix E give details of the catchments. All the catchments originate from areas to the north of Slough within South Bucks.

Table 1-1: Catchments within Slough

Catchment	Watercourses within Catchment	Area (km^2)
1	Roundmoor Ditch, Huntercombe Lane Stream	15.37
2	Chalvey Ditches, Haymill Stream, Salt Hill Stream and Common Ditch	42.82
3	Datchet Common Ditch	19.69
4	Horton Brook	22.23
5	Colne Brook and Alder Bourne	46.08

1.4.7 The total catchment area draining to the River Thames equates to $146.19km^2$.

2 Preparation

2.1 THE NEED FOR A SWMP STUDY

2.1.1 The sources of flooding experienced in Slough are numerous (fluvial, pluvial, sewer, overland flow, ordinary watercourses, and groundwater) and often occur in combination with each other. Often it has not been possible to identify the source of flooding; the sources of flooding for the majority of the recorded flooding incidents are unknown (86%) as illustrated in Figure 2-1 below. Anecdotal information indicates that there are very few known incidents of fluvial flooding, indicating the recorded flooding events could be from a combination of sources.

2.1.2 Some watercourses classified as 'main rivers' in Slough have culverted sections, which are not classified as main rivers. In addition the majority of the upstream sections of the watercourses are also not classified as main rivers. This creates a complex interaction between surface water and main river flooding as some of the culverted sections are shown to collect surface water from developed areas. The culverted and non-main river sections are in the ownership of different authorities. In order to get an understanding of the surface water flood risk in Slough, a separate surface water flood risk study is required.

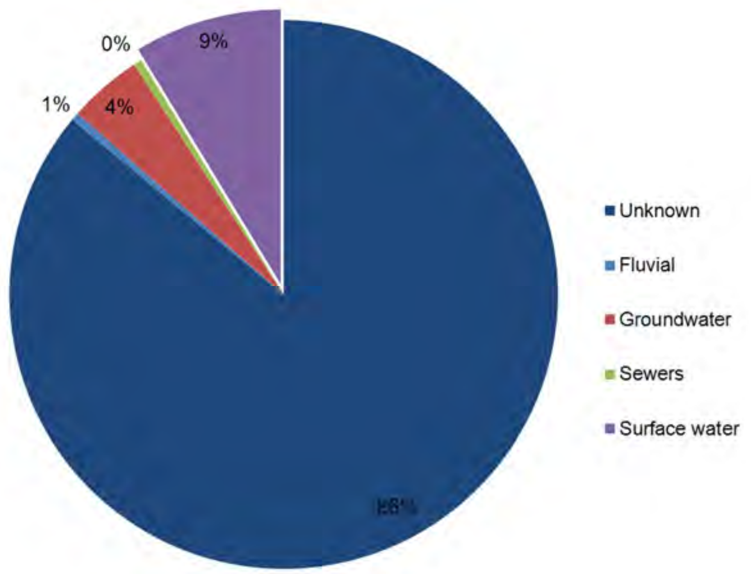

Figure 2-1: Sources of historical flooding (including Fire Services records)

2.1.3 The Slough SWMP is needed to provide a clearer picture of areas at risk of surface water flooding and other types of flooding that occur in combination with surface water flooding. Anecdotal evidence indicates that the green areas to the north of Slough are the source of some overland flow routes in Slough, with some portions containing sink holes that have the effect of reducing overland flows to Slough. Therefore emphasis has been given to the effects of flows originating from areas to the north of the borough boundary.

2.1.4 The areas to the north of Slough are known to be highly permeable with a number of sink holes within the Burnham Beeches area, refer to Figure 1 in Appendix E. Therefore the SWMP should take into account permeability of catchment, obstructions to flow and drainage provision. The SWMP needs to suggest options to mitigate the flooding in the highest risk areas.

2.1.5 The Slough Core Strategy identifies a number of major development sites for different uses including housing and commercial. A main concern regarding the major development sites such as Cippenham is that the large infill that will result in the loss of natural drainage paths and will increase the probability of flooding in the surrounding developed areas. The Slough SWMP needs to provide an understanding of the risk of surface water flooding within the major development sites.

2.2 ESTABLISH PARTNERSHIP

2.2.1 A SWMP is a framework through which key local partners with responsibility for surface water and drainage in their area work together to understand the causes of surface water flooding and agree the most cost effective way of managing surface water flood risk.

2.2.2 The Flood and Water Management Act requires Lead Local Flood Authorities to take the lead role for local flood risk management, leading the development of the SWMPs in partnership with other stakeholders.

2.2.3 The Slough SWMP includes the following Partners[5]:

- Slough Borough Council (Lead Local Authority);
- Environment Agency;
- Thames Water; and
- WSP Group (Flood Risk consultant for SBC)

2.2.4 The following Stakeholders[6] were also involved in the SWMP:

- Other departments of Slough Borough Council;
- Buckinghamshire County Council;
- South Bucks District Council;
- SEGRO (Managers of Slough Trading Estate);
- British Waterways; and
- Britwell Parish Council.

2.2.5 Slough Borough Council's Highways department has taken the lead role for the SWMP. The following departments within the council have also been involved: Drainage, Planning, Emergency, Housing, Communication, Education and Carbon Reduction. WSP is acting as the engineering consultant for Slough BC.

2.3 ROLES AND RESPONSIBILITIES

2.3.1 An inception meeting with all the partners was held on 21 September 2010. The roles and responsibilities for each partner, which were agreed at the inception meeting and are in line with their general responsibilities, are presented in Appendix A.

2.3.2 It was recognised at an early stage that the allocated budget and the timescale for the SWMP would not allow for a comprehensive engagement with all the

[5] A partner is defined as someone with responsibility for the decision or actions. They share joint responsibility of these decisions/actions
[6] A stakeholder is defined as anyone affected by the problem or solution

Stakeholders. Therefore it was agreed that Slough BC would, where possible, involve the residents through the council's website and newsletter, the Citizen, and a series of public meetings where possible.

2.3.3 Communication between the representatives of the Partners was mainly through face-to-face meetings, telephone and email conversations. An engagement plan was prepared and agreed to by all partners. This can be found in Appendix B.

2.4 OBJECTIVES AND SCOPE OF THE STUDY

2.4.1 An inception meeting was held at the council offices where the following objectives were agreed for the SWMP:

- To establish a successful working relationship between all partners during, and most importantly, after the plan is finalised;
- To identify clear roles of responsibility and lines of communication between the members of the project team and other stakeholders;
- To identify links between the SWMP and other plans;
- To create an understanding of flood risk in the Borough by reviewing historical flood records and using modelling techniques;
- To identify areas at risk of flooding and to what level;
- To understand the mechanism of surface water flooding and the connectivity with other types of flooding (e.g. fluvial, groundwater and sewer flooding);
- To identify various mitigation options (taking into account both the current and future situations, including the impacts of climate change) and development plans, and prioritise the options through a selection process and cost benefit analysis;
- To develop an action plan to reduce flood risk in Slough (all project team partners need to agree with this action plan); and
- To improve public awareness of the risks of flooding.

2.4.2 The agreed SWMP objectives are in line with the steering group's requirements and Defra's SWMP Technical Guidance.

2.4.3 The project aimed to create a successful working platform from which all responsible bodies for drainage and emergency response could integrate their requirements and ensure that this process can continue after the SWMP is completed. Quarterly meetings (to be formally agreed by all partners) with the project partners will ensure agreed actions are executed and new issues are discussed and reviewed.

2.4.4 The roles and responsibilities of each partner were agreed at the inception meeting together with the Engagement Plan. Refer to Appendices A and B.

2.5 ESTABLISH LINKS WITH OTHER PLANS AND POLICY

2.5.1 Figure 2-2 below provides an overview of other plans that have an impact on the Slough SWMP.

2.5.2 The following plans were reviewed to establish their impact on the SWMP:

- The Pitt Review;

- Flood Risk Regulations 2009;
- Flood and Water Management Act 2010;
- Draft National Planning Policy Framework (draft NPPF);
- Planning Policy Statement 25 (PPS25);
- Adopted Local Plan for Slough BC;
- Adopted Local Plan for South Bucks;
- The Adopted Core Strategy for Slough BC
- Strategic Flood Risk Assessment for Slough BC;
- South Bucks Core Strategy;
- Strategic Flood Risk Assessment (SFRA) for South Bucks;
- Thames Catchment Flood Management Plan; and
- River Basin Management Plan - Thames River Basin District

2.5.3 An overview of how the above plans and policies link with the SWMP is provided below with more details on the specific plans and policies included in Appendix C.

THE PITT REVIEW

2.5.4 The Pitt Review emphasises the need for local authorities to undertake SWMPs to provide the basis for managing local flood risk as well as the need to map the main flood risk management and drainage assets.

FLOOD RISK REGULATIONS 2009

2.5.5 These regulations transpose Directive 2007/60/EC (EU Floods Directive) of the European Parliament and of the Council on the assessment and management of flood risks for England and Wales.

FLOOD & WATER MANAGEMENT ACT 2010

2.5.6 In April 2010, the Flood & Water Management Act became law. The Act, which applies to England and Wales, aims to create a simpler and more effective means of managing the risk of flood and coastal erosion. The Act also aims to help improve the sustainability of our water resources and protect against potential droughts.

DRAFT NATIONAL PLANNING POLICY FRAMEWORK

2.5.7 The draft National Planning Policy Framework (draft NPFF) sets out important issues to think about when local councils and communities make plans for, and decide, what new development should take place to ensure a better quality of life, both now and in the future. It sets out issues that need to be managed on a national level and leaves other matters for local councils and communities to manage.

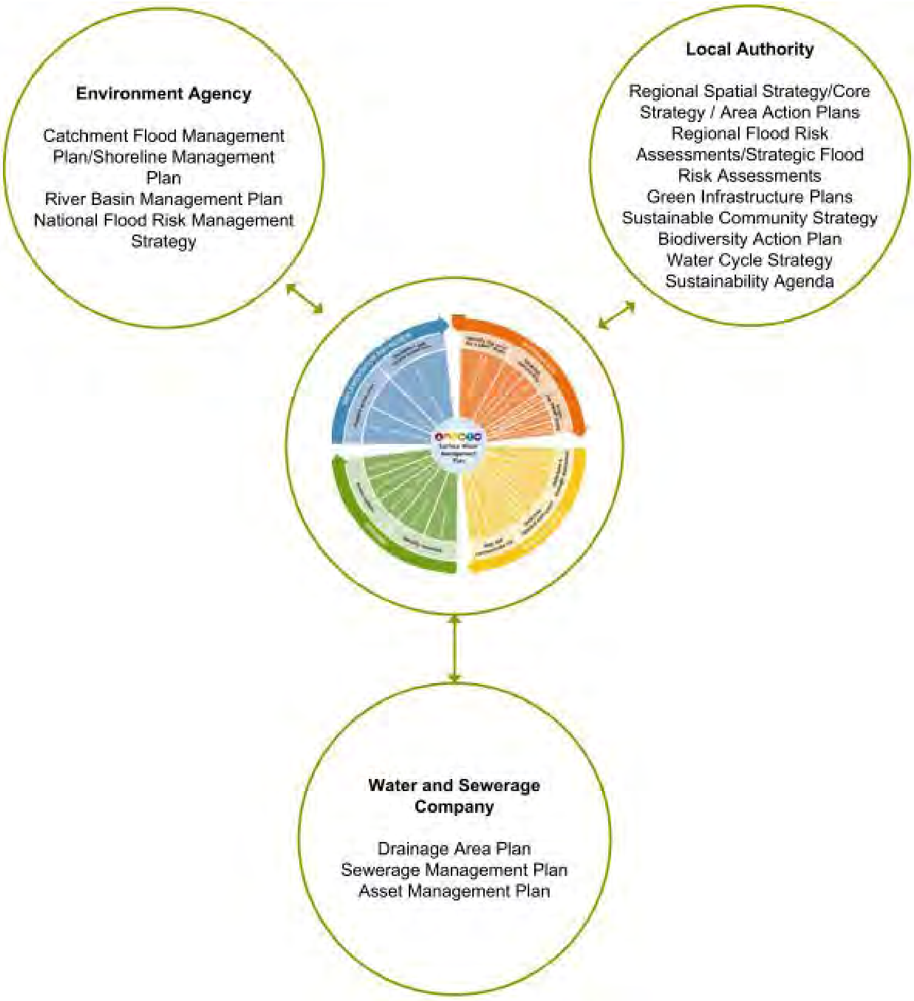

Figure 2-2: An overview of the links between SWMP and other plans[7]

PLANNING POLICY STATEMENT 25

2.5.8 Planning Policy Statement 25 (PPS25) was first published in December 2006. The aim of PPS25 with respect to development and flood risk is to ensure that flood risk from all sources is taken into account at all stages in the planning process so as to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk.

2.5.9 PPS25 also aims to ensure that new developments do not increase flood risk from all sources and that new developments are not at an unacceptable risk of flooding.

LOCAL PLAN FOR SLOUGH

2.5.10 The Local Plan for Slough, which was adopted in March 2004, sets out policies for development control and land use up to 2006. In March 2007, the council submitted a number of policies that would be saved in order to extend the life of the selected Local Plan policies beyond September 2007.

[7] Defra Surface Water Management Plan Technical Guidance, March 2010

SLOUGH CORE STRATEGY

2.5.11 The Slough Core Strategy (2006 – 2026) was adopted by Full Council in December 2008. The Core Strategy is part of the Slough Local Development Framework process and is a Development Plan Document.

2.5.12 The Core Strategy together with the saved Local Plan policies and other documents are the planning tools for development control and spatial planning in Slough.

SLOUGH STRATEGIC FLOOD RISK ASSESSMENT

2.5.13 The Slough SFRA, which is part of the LDF documents, was first drafted in November 2007 and was revised in September 2009. However, the document is yet to be approved by the Environment Agency. It sets out a list of recommendations for proposed developments with the view of reducing the surface water runoff within Slough.

2.5.14 The South Bucks SFRA and adopted Local Plan were considered for this study as the head of the surface water catchments within Slough are all within South Bucks. Therefore any works and plans proposed by South Bucks could have an effect on surface water flooding within Slough

SOUTH BUCKS CORE STRATEGY

2.5.15 The South Bucks Core Strategy was adopted by the Council on 22 February 2011 and presents the broad strategy for accommodating future development in South Bucks until 2026.

SOUTH BUCKS STRATEGIC FLOOD RISK ASSESSMENT

2.5.16 South Bucks undertook Level 1 and 2 SFRAs in February 2008 and August 2008 respectively, both the Level 1 and Level 2 SFRAs set out a list of recommendations, some for specific sites within the borough to reduce the risk of surface water flooding.

THAMES CATCHMENT FLOOD MANAGEMENT PLAN

2.5.17 The Thames Catchment Flood Management Plan (CFMP) was published in July 2008 and sets out the preferred plan for sustainable flood risk management over the next 50 to 100 years.

RIVER BASIN MANAGEMENT PLAN - THAMES RIVER BASIN DISTRICT

2.5.18 The River Basin Management Plan (RBMP) for the Thames River Basin District was published in December 2009. In accordance with the Water Framework Directive, the RBMP contributes to the requirement of all countries throughout the European Union to manage the water environment to consistent standards. This plan focuses on the protection, improvement and sustainable use of the water environment.

2.5.19 The RBMP describes the river basin district, and the pressures that the water environment faces. It shows what this means for the current state of the water environment, and what actions will be taken to address the pressures as well as setting out what improvements are possible by 2015 and how the actions will make a difference to the local environment including the catchments, the estuaries and coasts, and groundwater.

DRAINAGE AREA PLAN

2.5.20 Thames Water currently does not have a Drainage Area Plan for Slough.

2.6 COLLATE DATA

2.6.1 Discussions regarding the data each partner was able to provide were held at the project inception meeting of 21 September 2010. A list of the data that was required from each partner was circulated after the inception meeting.

2.6.2 The SWMP partners have, in general, made every effort to provide the necessary data in a timely manner. However, sensitivity issues and limited data resulted in a delay in starting the project.

2.6.3 In addition to the data provided by the partners data was also collected from other relevant stakeholders.

2.6.4 Most of the data provided was in GIS format. Where GIS format data was not provided, data was converted into GIS format to enable analysis and modelling wherever possible.

2.7 DATA SOURCES

2.7.1 Information and data relevant to the SWMP was provided by the following partners, stakeholders and other data providers:

- Slough Borough Council;
- Environment Agency;
- Thames Water;
- Royal Berkshire Fire & Rescue Services;
- British Waterways;
- South Bucks District Council;
- SEGRO;
- The Corporation of London;
- Infoterra Ltd;
- IverWeather.co.uk;
- Summerleaze Ltd;
- The Met Office; and
- Groundwater Monitoring and Drilling Ltd.

2.7.2 The details regarding the data obtained from each source are presented in Appendix D.

2.7.3 In addition to the data provided by the above, a review was also undertaken of the hydraulic models from the Strategic Flood Risk Assessment (SFRA).

2.7.4 Where the provided data was not sufficient, such as for sewers and controls, information was checked on site. In addition, a topographical survey was undertaken for the areas covered by the 5m DTM (SAR data) provided by Infoterra Ltd to check and correct the ground model wherever the DTM showed large differences with the topographical survey.

2.8 DATA LIMITATIONS

2.8.1 There is no consistent recording system of flood events within the Slough Borough Council. In most cases additional information regarding recorded flood events was obtained from staff based on their memory of what happened. This has resulted in a lack of confidence in some of the data obtained.

Figure 2-3: Historical Flooding of Granville Avenue, 2009 from SBC officer records (Refer to Figure 12 for photo location)

2.8.2 Historic sewer flooding records from Thames Water were only available for the last ten years and were based on the first four postcode digits. This reduces the usefulness of the data as it will give only the general locations instead of specific flooding occurrence.

2.8.3 Discussions were held with Thames Water on the availability of relevant hydraulic modelling data, however the extent of modelling directly applicable to Slough is limited. The discussions also included identifying known capacity constrictions within the Thames network. However, Thames Water was unable to supply such data including information on investment plans affecting Slough.

2.8.4 The majority of the historic flooding records did not include the consequences of the flood.

2.9 DATA RESTRICTIONS

2.9.1 The data collected from the partners was licenced to Slough Borough Council and its consultant to use for the preparation of the SWMP. Table 2-1 provides an overview of the major restrictions on the use of this data.

2.9.2 Other data providers such as Summerleaze Ltd have requested a draft copy of the SWMP before it is published.

Table 2-1 Summary of data restrictions and licensing details

Organisation	Licence details
Environment Agency	The use of some data is restricted to Slough Borough Council and their consultants for the preparation of its SWMP.
Thames Water	The data is licensed for any purpose reasonably required by Slough Borough Council in connection with its functions under the Regulations or its flood functions under the Flood and Water Management Act 2010. Slough Borough Council shall keep confidential all information obtained from Thames Water and will not disclose any such information to any third party unless required by law to do so.
British Waterways	The use of provided data is restricted to Slough Borough Council and their consultants for the preparation of its SWMP
City of London and Summerleaze Ltd	The use of the data is restricted to Slough Borough Council and their consultant for the preparation of its SWMP

2.10 LEVEL OF ASSESSMENT REQUIRED

2.10.1 The level of assessment required was determined based on the data collected in the early stages of the SWMP. This decision making process included a review of the quality of the data collated as well as the suitability to meet the objectives of the SWMP.

3 Risk Assessment

3.1 STRATEGIC RISK ASSESSMENT

3.1.1 The first part of the risk assessment for Slough SWMP is the Strategic Assessment. The principle purpose of this Strategic Assessment is to identify broad locations, which are considered to be at risk of surface water flooding.

3.1.2 The strategic assessment was undertaken in parallel with the Preliminary Flood Risk Assessment (PFRA) for Slough. A PFRA is a high level screening exercise required under the Flood Risk Regulations (2009), which implements the requirements of the European Flood Directive, and the Flood and Water Management Act (2010). Slough Borough Council as the Lead Local Flood Authority (LLFA) is responsible for managing local flood risk and undertaking a PFRA for its administrative area.

3.1.3 The Flood Risk Regulations establishes the four stages of activity within a six year flood risk management. A PFRA covers Stage 1 and 2 of the Flood Risk Regulations, which involves collecting information on past (historic) and future (potential) floods and assembling it into a preliminary assessment report. The PFRA also identifies Flood Risk Areas which are areas where flooding will have significant harmful consequences on human health, economic activity and the environment.

3.1.4 There are a number of flooding records for Slough which have been attributed to different sources of flooding. However, assessing the historical flooding records excluding the records provided by the Royal Berkshire Fire and Rescue Service shows that surface water contributes to 62% of the recorded flooding incidents as shown in Figure 3-1 below.

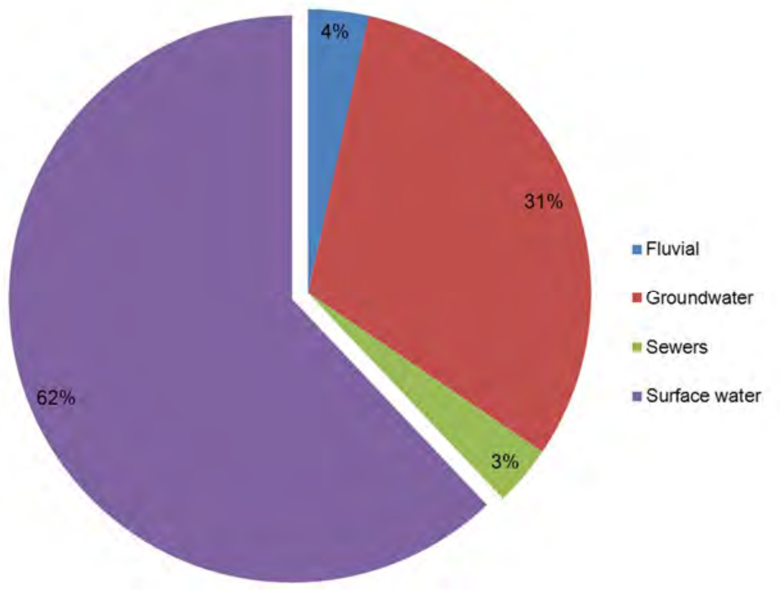

Figure 3-1: Sources of flooding (excluding Fire Services records)

3.1.5 Consideration of the Royal Berkshire Fire and Rescue Services shows that 86% (see Figure 2-1in section 2.1) of the recorded records are from unknown sources, which could be a combination of many sources including surface water. Therefore to understand the risk of surface water flooding, it is important to understand the risk associated with all sources of flooding.

3.1.6 The following information has been used for the strategic assessment:

- Historic flood incident data;
- Environment Agency's Areas Susceptible to Surface Water Flooding (AStSWF);
- Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF); and
- Environment Agency's Flood Maps and hydraulic modelling results – these provided an understanding of the fluvial flood risk within Slough.

3.1.7 At the time of the strategic assessment, understanding the natural overland flow routes within Slough and the interactions between the catchments was considered as important as identifying the flooding hotspots. The AStSWF showed the general flow routes and areas that are at risk of surface water flooding, however it did not differentiate local low spots or specific flow directions. Therefore WSP undertook a quick coarse surface water modelling exercise using Micro Drainage's FloodFlow software to identify the specific overland flow directions (Direct Rainfall Method).

3.1.8 The ground model used in the coarse surface water model was based on 2m LiDAR data supplied by the Environment Agency's Geomatics Group and a 5m Digital Terrain Model (DTM) supplied by Infoterra Ltd. The coarse modelling was undertaken by applying a 100 year plus 30% 120 minutes rainfall event on the terrain with no buildings or surface water sewers to identify the flow routes within Slough.

3.1.9 The strategic assessment was based on the identified natural catchments within Slough.

3.2 FLOOD MECHANISMS (SOURCES, PATHWAYS AND RECEPTORS)

3.2.1 The strategic assessment of the potential flood mechanisms in Slough was undertaken based on the Source, Pathway, Receptor model (SPR) shown in Figure 3-2 below. The SPR model was used to understand the link between hazard and flood risk.

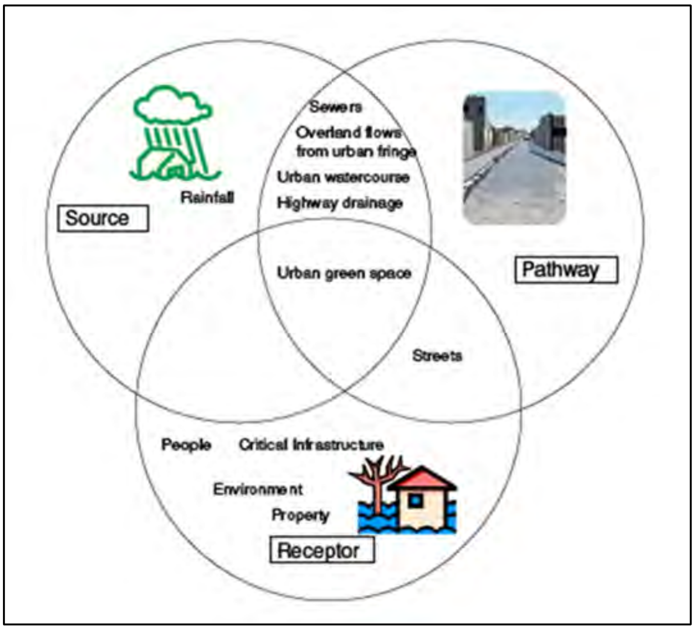

Figure 3-2: Source, Pathway, Receptor Model (SPR)

3.3 HISTORICAL FLOODING

3.3.1 Slough has experienced flooding from various sources in the past. The records of historical flooding were obtained from Slough BC, Environment Agency, Thames Water, Royal Berkshire Fire & Rescue Service, British Waterways, South Bucks SFRA, Slough Library and local newspapers. Figure 3-3 and Figure 3-4 below give an example of the historical flooding records received.

Figure 3-3: Flooding in Hawthorne Crescent, July 2007
(Refer to Figure 12 for photo location)

3.3.2 The sources of flooding experienced in Slough are numerous (fluvial, pluvial, sewer, overland flow, ordinary watercourses, and groundwater) and often occur in combination with each other. Several of the watercourses within Slough are culverted in sections while some of the ordinary watercourses to the north of Slough go into sink holes and emerge further downstream within Slough. Therefore, surface water flooding in Slough is a complex interaction of groundwater, overland and river flows.

3.3.3 This section is only a register of historical flooding incidents that have been recorded within Slough and does not represent a comprehensive assessment of all likelihoods and consequences. Historical data cannot identify all locations at risk of flooding, and it is possible that areas at low probability and high consequence may not have historical records of flooding due to the rarity of such events. Similarly, the available historical information may not provide a complete overview of properties or locations that have previously been flooded. Therefore, there is a risk that this information could previously have been misinterpreted. However, the report represents the best available data currently available.

3.3.4 Figure 2 in Appendix E gives an overview of all the currently recorded historical flooding records within Slough.

3.3.5 Records highlight fluvial flooding in 1947, 1969, 1989, 2000, 2001, 2003 and 2007. The flooding in 1969 and 1989 are known as the worst fluvial flood events in Slough. The areas around Chalvey, Myrke, Langley, Colnbrook, Manor Park and Poyle (refer to Figure 2, Appendix E for locations) are shown to have experienced historic fluvial flooding. The records indicate that the fluvial flooding incidents are concentrated mainly around the Lower Thames and its tributaries. Refer to Appendix E, Figure 2, for a record of all the known historical fluvial flooding incidents.

Figure 3-4: Flooding in Huntercombe Lane South, July 2007
(Refer to Figure 12 for photo location)

3.3.6 The surface water flooding incidents are mainly around the culverted watercourses within Slough. Britwell, Haymill, Farnham, Baylis and Stoke, Wexham Lea, Langley, Colnbrook and Poyle. There areas are shown to have experienced historic surface water flooding. Refer to Figure 2 in Appendix E.

3.3.7 Slough has experienced surface water flooding since the 1930’s. The records indicate surface water flooding appears to be mainly from overloaded sewers and overland flows from areas further to the north of Slough. Records also indicate that the Colnbrook and Poyle areas experience surcharged sewers, although details of the extent and effects of the surcharged sewers were not available.

3.3.8 The fluvial and surface water flooding records highlight that in some years (1989, 2001 and 2003) flooding occurred from both fluvial and surface water sources. This highlights the connectivity and interaction between these two sources of flooding.

3.3.9 Some areas that are shown to have experienced surface water flooding are also shown to have experienced groundwater flooding. Cocksherd Wood and Beechwood School are examples of areas that are shown to have experienced both surface water and groundwater flooding. This suggests an interaction between surface water and groundwater flooding.

3.3.10 The Thames Water DG5 register indicates that the areas around Poyle and Colnbrook and areas around the western and north-western boundary with South Bucks have experienced flooding due to overloaded sewers in the last 10 years.

3.3.11 The Figure 3-5 below shows the distribution of all historical flooding records across the catchments.

3.3.12 Analysis of the distribution of the recorded flood events indicate that the Chalvey Ditches catchment (combines Salt Hill Stream and Haymill Stream catchments) has the most flooding incidents followed by the Datchet Common Ditch catchment.

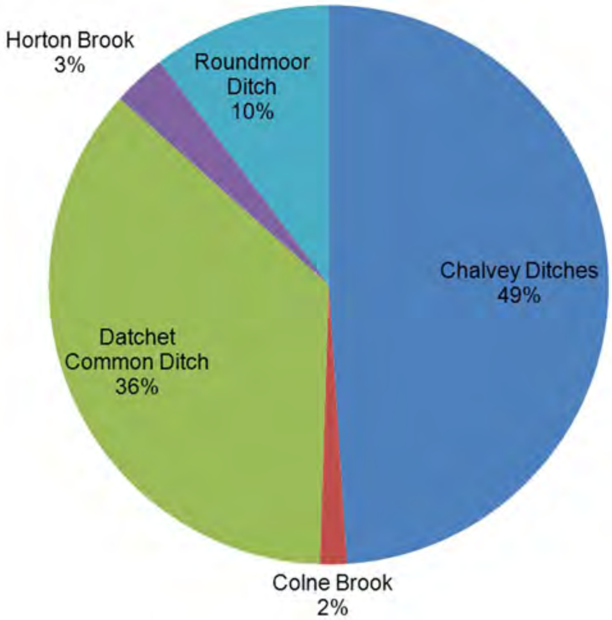

Figure 3-5: Distribution of all historic flooding incidents across the catchments

3.4 FLUVIAL FLOODING

3.4.1 The understanding of fluvial flood risk in Slough was based on the Environment Agency's latest Flood Zone Map, which includes the most recent fluvial modelling results. Refer to Figure 3, Appendix E, for the Flood Zone Map.

3.4.2 The flood map shows a major portion of the Cippenham area and the Chalvey area immediately north of the M4 to be within Flood Zone 2 and 3 associated with the Haymill Stream, Salt Hill Stream and Chalvey Ditches.

3.4.3 A few properties adjacent to the Cocksherd Wood are also shown to be within Flood Zone 2 and 3. However, there is no open or culverted watercourse in the vicinity of the Cocksherd Wood. The Haymill Stream goes into sink holes within the Burnham Beeches area to the north of Slough and emerges as an open watercourse immediately south of Whitaker Road. The area between Whitaker Road and Cocksherd Wood is known to be a dry valley (Lynch Hill valley). Refer to Figure 1 in Appendix A.

3.4.4 The flood map also shows a number of properties within the Manor Park area to the north of the railway to be within Flood Zone 2 and 3 associated with the Salt Hill Stream.

3.4.5 A portion of the Wexham Court and Upton Lea areas to the north of the Slough Arm of the Grand Union Canal are shown to be within Flood Zones 2 and 3 associated with the Datchet Common Brook.

3.4.6 The majority of the Colnbrook and Poyle areas are shown to be within Flood Zone 2 and 3 associated with the Horton Brook and the Colne Brook.

3.5 SURFACE WATER FLOODING

3.5.1 Surface water flooding in Slough was based on the AStSWF maps issued in April 2009 (Figure 4 in Appendix E). The Environment Agency also provided the 'Flood Map for Surface Water (FMfSW)'[8]. However, following a review of the modelling methodology for the AStSWF and FMfSW and the predicted flood extents, it was agreed with Slough Borough Council that the AStSWF is more representative of the flood risk in Slough. The decision was based on the following:

- The AStSWF map provides a better representation of the flood risk estimated by Slough Borough Council based on knowledge of the Borough;
- The majority of surface water within Slough drains to soakaways whose capacity is often reached after 1 hour of rainfall. The FMfSW modelling was based on a 1.1 hour storm duration assuming 12mm/hr will drain to sewers and reduces rainfall to 70% in urban areas to account for infiltration. The AStSWF modelling was based on a 6.5 hour storm and did not make any allowance for the performance of the drainage network;
- Slough has relatively steep surface water catchments and surface water flooding is more influenced by topography than drainage and buildings. The guidance provided together with the maps state that the AStSWF map is more accurate for such areas; and
- AStSWF showed similar results to WSP's coarse (Direct Rainfall) model which was built to identify overland flow routes.

3.5.2 The AStSWF dataset shows three bands of susceptibility to surface water flooding, which are 'less', 'intermediate' and 'more'[9]. The Environment Agency guidance indicates that the susceptibility bands are based on the following flood depths:

- 0.1 to 0.3m (less);
- 0.3 to 1m (intermediate); and
- >1m (more)

3.5.3 The areas within Slough shown to be 'more' susceptible to surface water flooding are around the Lynch Hill valley to the north of Whitaker Road and areas to the east of open Haymill Stream south of Whitaker Road, the Cippenham area to the north of the Chalvey Ditches and the Manor Park area including areas around the A355. Small portions of Upton Lea are also shown to be 'more' susceptible to surface water flooding. Refer to Figure 4 in Appendix E.

3.5.4 Areas that are 'less' susceptible to surface water flooding are concentrated around the area between Huntercombe Lane North road and Burnham Rail Station, the Cippenham area, Lynch Hill, portions of the Slough Trading Estate, the Manor Park

[8] Issued November 2010

[9] The Environment Agency's guidance on the use of the map states that *'the 'more' band will be useful to help identify areas which have a natural vulnerability to:*

- *flood first;*
- *flood deepest;*
- *and/or flood for relatively frequent, less extreme events (when compared to the other bands)'*

area, the Chalvey area, Upton Lea and the Wexham Court area. There are also a number of places 'less' susceptible to surface water flooding dotted around Slough.

Figure 3-6: Flooding in Station Road, October 2006
(Refer to Figure 12 for photo location)

3.5.5 The National Receptor Database was used to estimate the properties at risk of surface water flooding based on the 'less' susceptible band and the catchments. The 'less' band was chosen for this analysis because it identifies all properties at risk (low or high) of surface water flooding. Figure 3-7 below shows the distribution of surface water flood risk across the catchments.

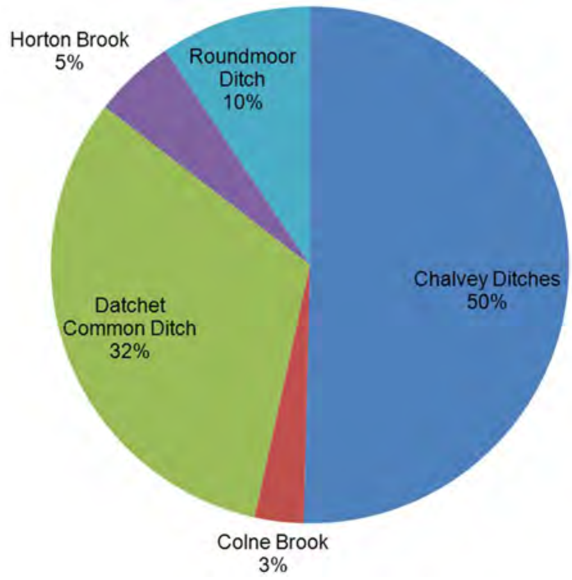

Figure 3-7: Distribution of surface water flood risk across the catchments

3.5.6 The coarse modelling undertaken by WSP as part of the SWMP (using the 100 year 6 hour event) identified two overland flow routes from the A4 / Whittle Parkway junction to properties around St George's Crescent adjacent to the M4 (Huntercombe Spur) as shown in Figure 3-8 below.

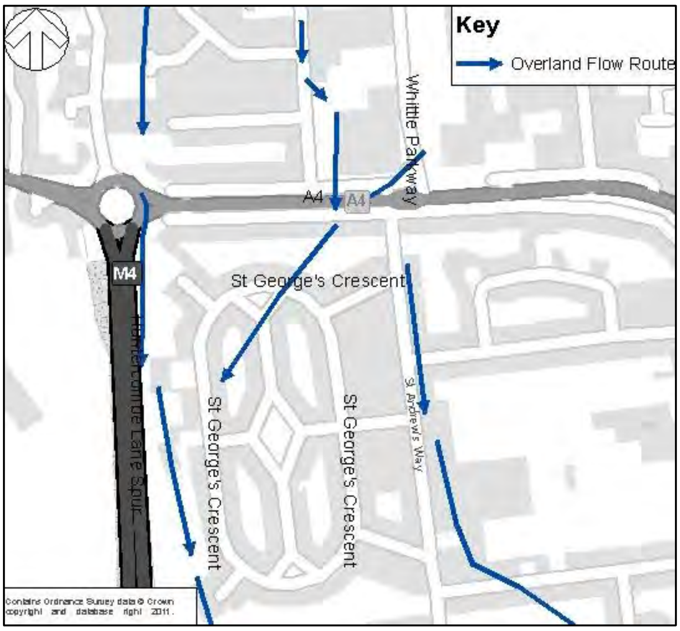

Figure 3-8: Overland Flow Routes adjacent Huntercombe Lane Spur

(Refer to Figure 12 for image location)

3.5.7 Slough BC advised that the identified overland flow routes were due to traffic calming tables which resulted in water flowing from the road into people's drives and flooding the properties. Slough BC has already installed additional gullies to reduce flood risk along this flow route, however the gullies will not remove the risk of flooding during extreme events.

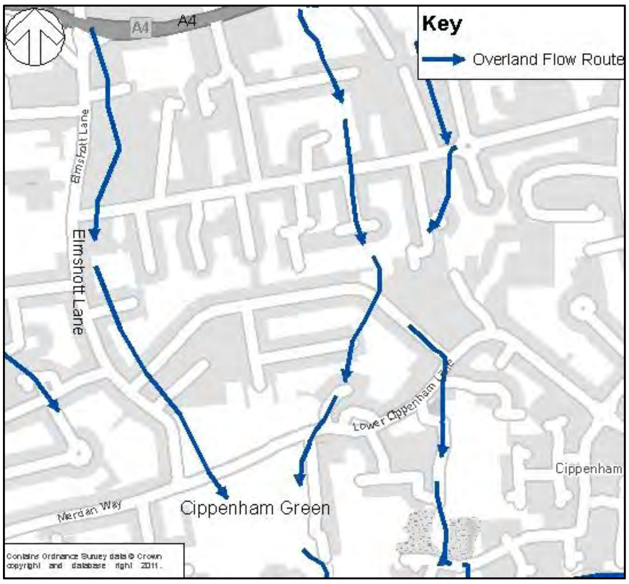

Figure 3-9: Overland Flow Routes to Cippenham Green

(Refer to Figure 12 for image location)

3.5.8 Flows to the Cippenham Green area were found to emanate from two overland flow routes, one flow route from the A4 / Elmshott Lane junction and another flow route from the Lynch Hill valley, which combines two flow routes from East Burnham and Burnham Beeches. Figure 3-9 above shows the identified flow routes.

3.5.9 The other identified flow routes generally follow the routes of watercourses. Refer to Figure 7, Appendix E, for the main overland flow routes identified.

3.5.10 The AStSWF maps show the majority of the major development sites located in the combined Chalvey Ditches catchment to be at risk of surface water flooding. A number of the development sites are shown to have between ‘intermediate’ and ‘more’ susceptibility to surface water flooding as shown in Figure 3-10 below for some of the sites.

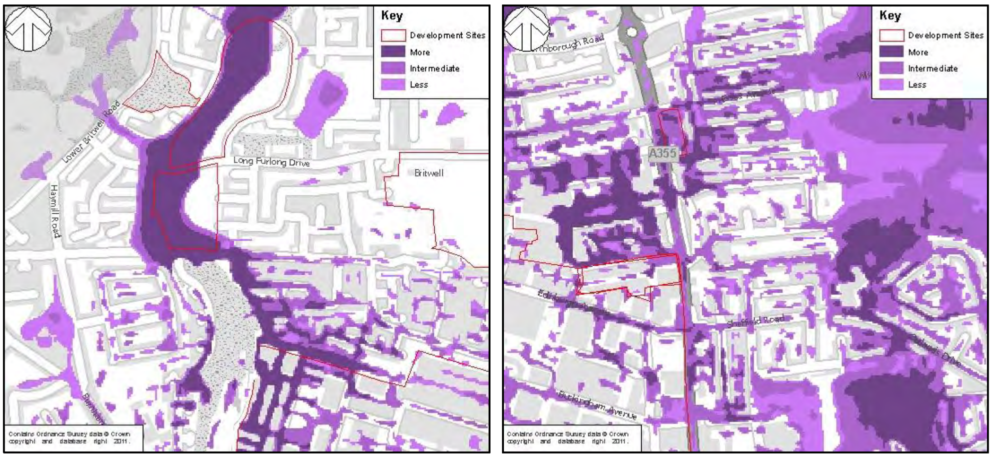

Figure 3-10: Surface water flooding (AStSWF) at some of the major development sites

3.6 GROUNDWATER FLOODING

3.6.1 Groundwater flooding can occur after prolonged periods of rainfall, which causes the water table to rise to the ground surface, and is most common where aquifers occur close to the ground surface under normal conditions. The risk of groundwater flooding is subject to uncertainty as it is dependent upon the water table conditions at any location at any given time. However, areas prone to groundwater flooding are generally also prone to surface water flooding. Therefore understanding surface water flooding could help in understanding groundwater flooding.

3.6.2 The assessed risk of groundwater flooding in Slough has been based on the Environment Agency’s AStGWF maps and the aquifer classifications. The AStGWF maps, Figure 5 in Appendix E, shows the proportion of each 1 km square that is susceptible to groundwater flood emergence based on the following risk bands:

- Less than 25%;
- 25% <50%;
- 50% <75% and
- Greater than 75%.

3.6.3 The majority of the squares shown with ≥75% risk are located to the south of the Borough with only one square located to the north of the Borough.

3.6.4 The aquifer information provided by the Environment Agency, Figure 6 in Appendix E, shows that the areas around Britwell, Corksherd Woods and Wexham Park are underlain by a 'principal' aquifer. The Cippenham and Chalvey areas are also shown to be underlain by a 'principal' aquifer.

3.6.5 The Colnbrook and Poyle areas are underlain by a combination of 'principal' and 'secondary A' aquifers. The rest of the borough is underlain by unproductive 'non' aquifers.

3.6.6 The areas shown to be underlain by 'principal' aquifers are all considered to be at high risk of groundwater flooding. Due to the interaction between surface water and groundwater flooding, areas at high risk of groundwater flooding are generally at high risk of surface water flooding.

3.7 FLOODING HOTSPOTS

3.7.1 Based on available information the Chalvey Ditches catchment (which includes Salt Hill Stream, Haymill Stream and Chalvey Ditches) was identified as the main flooding hotspot that would require more detailed analysis.

3.7.2 The Chalvey Ditches catchment takes up a large part of the Slough SWMP area and is a major contributor of the surface water runoff within Slough. The streams drain large rural / natural areas to the north of Slough. Surface water flooding appears to occur mainly within the developed areas in this catchment.

3.7.3 The majority of the surface water sewers within Slough discharge into the main watercourses (mostly Haymill Stream and Salt Hill Stream) resulting in an interaction between fluvial and surface water elements in that if the water levels within the watercourse are high, the sewer outfalls will be surcharged causing surface water flooding upstream. A detailed risk assessment was therefore required to assess the effects of the fluvial / surface water sewer interaction within Slough.

3.7.4 A part of Cippenham has been identified for major development and this area is also within the Chalvey Ditches catchment. Any findings of the SWMP should be used to inform planning when making decisions about the development.

3.8 CRITICAL INFRASTRUCTURE

3.8.1 By overlaying the Environment Agency's Areas Susceptible to Surface Water Flooding over a map of Slough it is possible to assess the relative proportion of critical infrastructure at risk of flooding in the Chalvey catchment. Table 3-1 below summarises the percentage of critical infrastructure at risk in the Chalvey catchment.

Table 3-1: Proportion of Critical Infrastructure in the Combined Chalvey Ditches Catchment

Critical Infrastructure	Number of Units					
	AStSWF Less		AStSWF Intermediate		AStSWF More	
	Slough	Chalvey	Slough	Chalvey	Slough	Chalvey
Care Homes	2	0	1	0	0	0
Fire Station	1	0	0	0	0	0
Health Care	8	3(38%)	3	2(67%)	1	1(100%)
Industrial Site	3	1(33%)	3	1(33%)	1	1(100%)
Police Station	1	0	0	0	0	0
Electrical Substation	50	24(48%)	32	20(63%)	10	9(90%)
Railway Station	2	0	1	0	0	0
Schools	35	17(49%)	26	16(62%)	8	6(75%)
Sewage Treatment Works	1	0	1	0	1	0

3.8.2 Table 3-1 shows that a high proportion of Slough's critical infrastructure exists within the Chalvey Ditches catchment and is at risk of surface water flooding. Therefore, there is justification for focussing on the Chalvey Ditches catchment in the SWMP study.

3.9 STRATEGIC RISK ASSESSMENT CONCLUSION

3.9.1 The Chalvey Ditches catchment has been identified as a priority area for the SWMP based on historical and future flood risk and proposed major development.

3.9.2 Therefore a more detailed risk assessment will be undertaken for the Chalvey Ditches catchment.

3.10 DETAILED RISK ASSESSMENT

SELECT MODELLING APPROACH

3.10.1 The strategic risk assessment identified the Chalvey Ditches catchment as a flooding hotspot that required a more detailed assessment of surface water flooding.

3.10.2 Historical flooding incidents within the catchment were mostly as a result of the complex interaction between surface water, rivers and groundwater.

3.10.3 The coarse direct rainfall modelling undertaken for the whole of Slough as part of the strategic risk assessment identified overland flow routes within the town. The detailed risk assessment would assess the effects of sewers and buildings on the overland flow routes identified. The assessment would also look at the impact of surcharged sewers.

3.10.4 The detailed risk assessment for the Chalvey Ditches catchment was required to assess the effects of overland flows, surface water sewers and the interaction with the watercourses. In addition, the detailed assessment needed to identify the most strategic locations for any technical mitigation option and to identify the probability of the rainfall event at which surface water sewers would be overwhelmed.

3.10.5 Enhanced drainage modelling was therefore considered the best approach for a detailed assessment of the Chalvey Ditches as it allows for rainfall to be applied directly onto the 2D surface and enter the sewer network (1D) at manholes or continue to be routed on the 2D surface if the sewer network does not have enough capacity. The enhanced drainage modelling was undertaken using Micro Drainage's FloodFlow module.

3.10.6 The modelling methodology is outlined in the Surface Water Modelling report in Appendix F.

IDENTIFIED SURFACE WATER FLOODING

3.10.7 The modelling identified the 6 hour summer storm as the most critical storm for the Chalvey Ditches catchment. The model was simulated for the 2 year, 5 year, 10 year, 30 year, 75 year, 100 year and 100 year plus 30% (for climate change) rainfall events.

3.10.8 The base model was calibrated against the July 2007 rainfall event and validated against the February 2009 rainfall event. The model correlated relatively well against observed flood depths from these two events.

3.10.9 The results of the surface water modelling exercise are plotted on maps in Appendix G, Drawings 3061/FLD/01 to 09.

3.10.10 The model results indicated that there is less widespread property flooding during the lower order (1 in 2 to 1 in 10 annual probability of occurring) rainfall events in the Chalvey Ditches and Salt Hill Stream catchments. The results also indicate that surface water flooding is largely concentrated on the highways and that there is less flooding of properties for return periods up to the 10 year event.

3.10.11 Localised ponding on some low spots within urban areas was identified; however, localised flooding could be drained away by the highway drainage and the smaller public sewers that were not included in the model.

3.10.12 The surface water sewer network was found to be overwhelmed in some areas during the 10 year rainfall event. However, there are also sections where the sewer network was found to have enough capacity to contain the lower order events up to the 10 year scenario.

3.10.13 The flooding observed around Manor Park, the area where the worst historical flooding event was been recorded, appears to be mainly from overland flows coming from the area around Farnham Park. Although there are some overland flows from Stoke Park, these appear to be slowed down by the upper and lower lakes in Stoke Park. Figure 3.9 below shows the impact buildings have on overland flow routes in Manor Park (N.B. shallow flooding: 100mm – 350mm; deep flooding: 350mm – 1000mm).

Figure 3-11: Effects of buildings on flow paths - buildings not included in ground model (left) and buildings included in ground model (right)

3.10.14 The model also identifies some overland flow routes between existing buildings. Figure 3-12 below shows some of the overland flow routes between buildings. Terraced properties that leave no flow paths between them were shown to be blocking flows and causing water build up to the rear of the properties as illustrated in Figure 3-11 above.

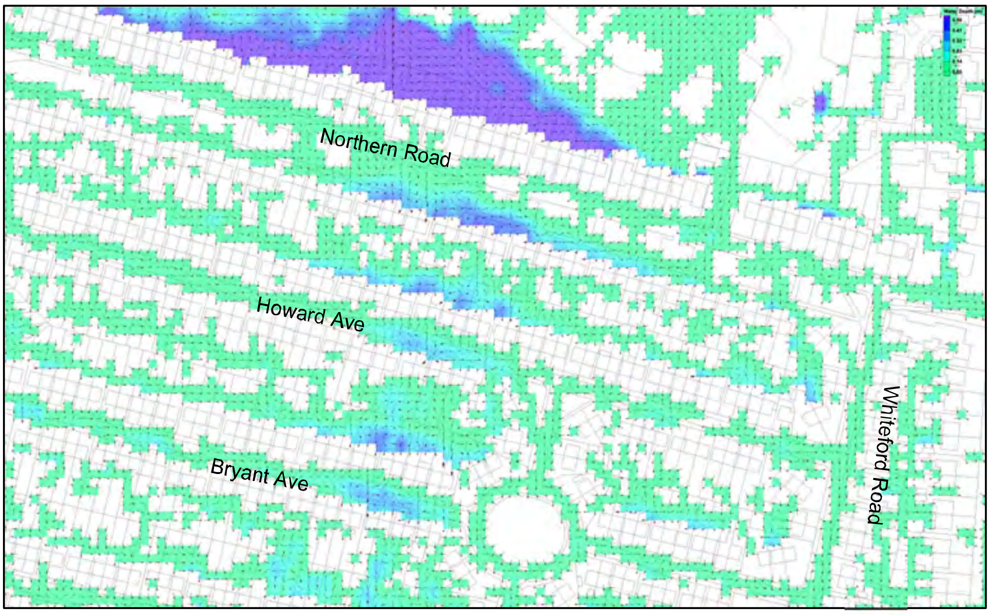

Figure 3-12: Flow paths identified around Manor Park

SURFACE WATER FLOODING HAZARD

3.10.15 *Flood Hazard describes the flood conditions in which people are likely to be swept over in a flood with the possibility of drowning, and is a combination of flood depth, velocity and the presence of debris*[10]. Defra guidance (Flood Risk Assessment Guidance for New Development Phase 2 FD2320: Flood Risks to People Phase 1 FD2321 and Supplementary Note on Flood Hazard Rating and Thresholds – May 2008) give the methodology to be used in assessing the hazard associated with flood events.

3.10.16 The modelling results were used to determine the flood risk hazard based on Defra guidance. The flood hazard was determined for the 10 year, 30 year and 100 year rainfall events. The hazard maps are in Appendix G, Drawing Nos. 3061/FLD/200, 201 and 202.

3.10.17 The hazard maps indicate that there is generally low surface water flood hazard within Slough for the lower order events with a few areas in the combined Chalvey Ditches catchment shown to have a significant hazard rating during the 10 year event. Areas such as Northern Road in Manor Park have a hazard rating of 'danger for some' and 'danger for most' during the 10 year event. Refer to Drawing No. 3061/FLD/200 in Appendix G.

3.10.18 The 100 year results indicate that there are more areas with a significant hazard rating in the Salt Hill catchment than the Chalvey Ditches / Haymill Stream catchment. However, the majority of the hazard is confined to roads instead of properties. The roads shown to have significant hazard rating are as follows (refer to Drawing No. 3061/FLD/202 in Appendix G for locations):

- Northern Road around Manor Park;
- Oatlands Drive, south of Granville Park;
- Warwick Avenue and Surrey Avenue east of the A355;
- Melbourne Avenue;
- Lower Cippenham Lane in Cippenham; and
- Richards Way in Cippenham

3.10.19 The above mentioned roads would not be able to provide safe access and egress routes during flood events.

3.11 WATER QUALITY AND WATER FRAMEWORK DIRECTIVE

3.11.1 The impacts of surface water flooding spread beyond flooding. Surface water runoff from a site washes off pollutants off the surface, usually at the beginning of the flow for small catchments, however on large catchments pollutants would not be in the initial flow. Therefore increased runoff can result in more pollution, leading to pollution downstream in the system as well as in receiving watercourses.

3.11.2 There is significant manufacturing and industrial activity within Slough around the Slough Trading Estate. Increased runoff and surface water flooding within such areas could result in increased pollutant in the watercourse.

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[10] Defra Flood and Coastal Defence Appraisal Guidance Social Appraisal Supplementary Note to Operating Authorities Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures, May 2008

3.11.3 The detailed assessment results indicate some areas with shallow to deep flooding within Slough Trading Estate. These overland flow routes would need to be considered during the re-development of the trading estate and be managed in such a way that the risk of water quality pollution is reduced.

3.11.4 The Water Framework Directive (WFD), a European Union directive which commits European Union member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to one nautical mile offshore) by 2015, is implemented in England through the River Basin Management Plans. The watercourses in Slough are within the River Thames Catchment. The Thames River Basin Management Plan (Thames RBMP) was published in December 2009.

3.11.5 The Thames RBMP found the status of water bodies within Slough ranging from 'moderate' to 'poor' in terms of ecological and chemical status. The Salt Hill Stream was found to be a 'poor' ecological status and the Chalvey Ditches were 'moderate'. The objective for most of the watercourses within Slough is to achieve good ecological status by 2027. The Thames RBMP found that achieving good ecological status by 2015 was technically infeasible for the majority of the watercourses within Slough or contributing flows to Slough. Refer to Appendix C.

3.11.6 Proposed re-development within Slough would need to take into account water quality and habitat improvement when developing the surface water management strategy for each development site. Improvements in water quality and habitat from the surface water drainage systems would contribute to achieving the Thames RBMP objectives.

3.12 CURRENT AND FUTURE FLOOD RISK

3.12.1 Properties flooding during the various return periods were counted using GIS based on an adaptation of the counting method used by the EA for PFRAs. The property counting method included a 1m buffer around the polygons representing the properties to ensure flooding around the properties is picked up since buildings had been blocked out in the model.

3.12.2 To best understand the effects of climate change on surface water flood risk a comparison was made between the flood risk presented by the 100 year and the 100 year plus climate change events. The comparison was based on a flood depth range of 100 - 350mm being considered shallow and 350 – 1000mm considered deep.

3.12.3 Consideration of the 100mm minimum flood depth allowed the minimum depth considered to be in line with the minimum depth mapped on the EA's surface water maps (AStSWF and FMfSW). The maximum depth for shallow flooding is based on a 200mm internal flooding of properties utilised in the calculation of flood damages based on the 2010 depth-damage curves in the Multi-Coloured Manual for residential properties (assuming finished floor levels are 150mm above existing ground).

3.12.4 The comparison of the 100 year events indicates that climate change would result in deeper flooding within Slough as shown in Figure 3-13 below. The graphs also indicate that the total estimated properties at risk of surface water flooding and a flood depth above existing ground in excess of 150mm would increase by approximately 10%.

3.12.5 The increased rainfall intensity due to climate change effects results in slight increase in the flood extent and areas that previously experienced shallow flooding experiencing deeper surface water flooding. This in turn transfers properties previously experiencing shallow flooding to deeper flooding.

Figure 3-13: Comparison of current and future (climate change) flood risk

3.12.6 The damages to residential properties caused by surface water flooding were monetised based on the number of properties counted as being affected by flooding. The damages were calculated using the 2010 depth-damage curves in the Multi-Coloured Manual for residential properties. The damages were based on the average damage to residential properties at each flood depth, without going into a detailed classification of the properties.

3.12.7 The estimated damages for the baseline scenario would feed into the cost-benefit analysis for a proposed mitigation option.

3.12.8 To further understand the effects of climate change in monetary value, a comparison of the damages resulting from the current 100 year event and the100 year event with climate change is shown in Figure 3-14 below. The results indicate that climate change would result in an 18% increase in estimated damages due to surface water flooding.

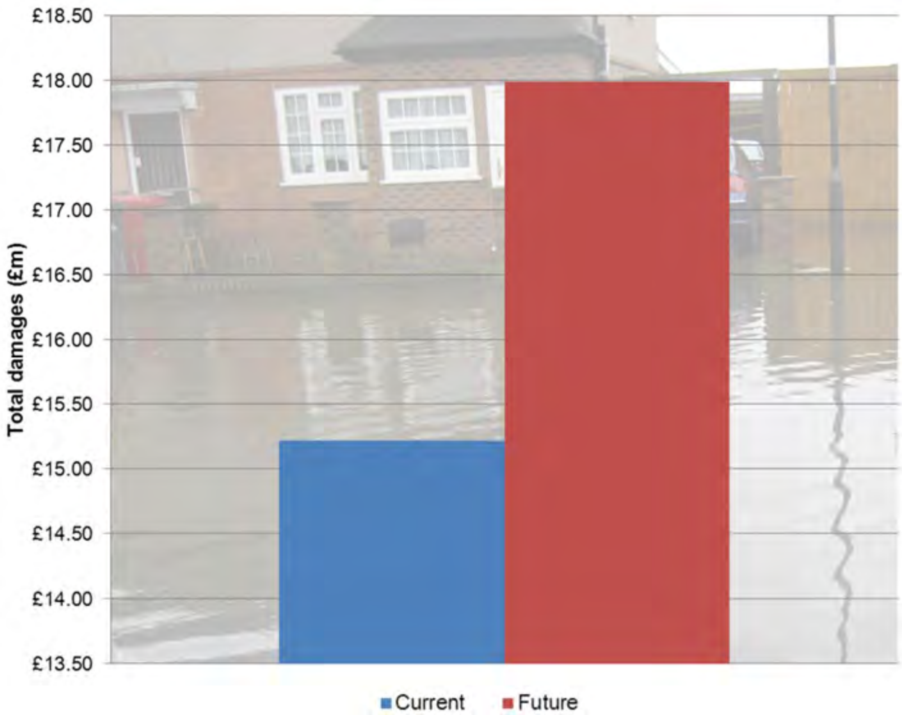

Figure 3-14: Effects of climate change on total damages (100 Year Baseline)

3.13 URBAN CREEP AND SHEDS

3.13.1 Slough BC has been comparing past ordinance survey maps with the most recent aerial photographs in order to identify any unknown increases in impermeable areas in Slough.

3.13.2 Slough Borough Council has identified a large proportion of private uncontrolled development with impermeable areas increasing by high proportions in some areas of the Borough.

3.13.3 According to an article written by the BBC, approximately 500 households have converted their sheds to accommodate people in Slough[11]. This has mostly occurred in the Upton, Baylis, Central and Chalvey wards.

3.13.4 Anecdotal evidence suggests that there are approximately six individuals at each household where a shed has been converted to house people. Defra guidance indicates that the average number of people per residential property for determining people at risk of flooding is 2.34[12]. Therefore the conversion of sheds to residential properties puts more people at risk of surface water flooding.

3.14 FUTURE MAJOR DEVELOPMENT

3.14.1 The Core Strategy for Slough indicates that undeveloped areas of the borough will be protected from inappropriate development. The Core Strategy identifies the following major regeneration sites:

- Slough town centre (Heart of Slough Regeneration Scheme, 12.7ha);
- Britwell and Cippenham;
- Slough Trading Estate;
- Parts of Chalvey; and
- Two major development sites within Green Belt, which are Wexham Park Hospital and Slough Sewage Works.

3.14.2 Refer to Figure 8 in Appendix E for location of Core Strategy areas.

3.14.3 The predicted flooding for two of the allocated sites (Britwell and Cippenham) is shown in Figure 3-15 below during the 100 year rainfall event.

3.14.4 The detailed risk assessment indicates some existing overland flow paths and surface water flood risk on some of the allocated sites. The surface water flood risk is high in some portions of the allocated sites.

3.14.5 Opportunities to reduce existing surface water flooding could be considered during the design of all major development sites. This could involve maintaining existing overland flow routes or diverting them to areas where the consequence of flooding is significantly less.

[11] http://www.bbc.co.uk/news/uk-england-berkshire-13863343 and http://news.bbc.co.uk/1/hi/england/berkshire/8405312.stm

[12] Selecting and reviewing Flood Risk Areas for local sources of flooding, Guidance to Lead Local Flood Authorities, Flood Risk Regulations 2009, Defra, Published 15 December 2010

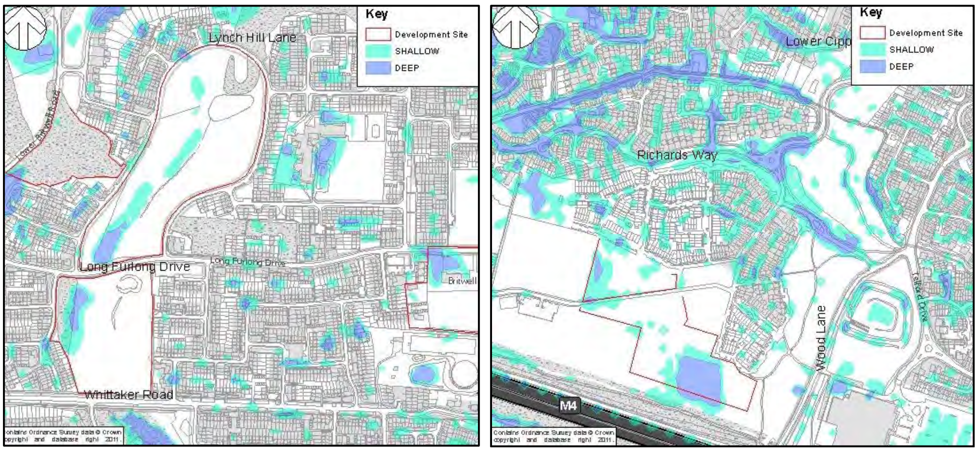

Figure 3-15: Predicted 100 year flooding in the vicinity of two major development sites, Britwell (left) and Cippenham (right)

4 Options

4.1 IDENTIFYING OPTIONS

4.1.1 A workshop was convened with the SWMP partners to identify and assess the feasibility of measures to alleviate surface water flooding in Slough. The measures covered technical, maintenance, awareness, resilience and resistance and change of agricultural land practice issues. The measures included the 'Do Nothing' and 'Do Minimum' option.

4.1.2 The measures were scored by the partners based on technical, economic, environmental and meeting the objectives. The scoring was based on the SWMP Guidance example scoring criteria presented in Table 4-1 below.

Table 4-1: Scoring method used for the options[13]

Criteria	Description	Score
Technical	Is it technically possible and buildable? Will it be robust and reliable?	U (Unacceptable) - measure eliminated from further consideration -2 severe negative outcome -1 moderate negative outcome +1 moderate positive outcome +2 high positive outcome
Economic	Is it affordable and will benefits exceed costs?	
Social	Will the community benefit or suffer from the implementation of the measure?	
Environmental	Will the environment benefit or suffer from the implementation of the measure?	
Objectives	Will it help to achieve the objectives set at the beginning of the SWMP?	

4.1.3 The long list of all the possible measures considered and scored is presented in Appendix H, including justification for taking forward or rejecting each option. The options that scored highly and were recommended for taking forward are:

- Do nothing;
- Construction of detention basins/flood storage areas; and
- Water network asset database with responsible parties and maintenance schedules;

4.1.4 The 'Do Nothing' scenario is a required in every options assessment as it allows proposed options to be compared against the baseline during Cost Benefit Analysis. Construction of detention basins is likely to modify the probabilities of flooding and reduce the properties flooding at a given annual probability of flooding.

4.1.5 An 'Asset Register' with responsible parties and maintenance schedule was put forward. However, under the Flood and Water Management Act (FWMA) this is now a requirement for LLFA to own and maintain an asset register which will need to be kept up to date. Slough BC as an LLFA is currently undertaking an asset register inline with the FWMA

[13] Defra Surface Water Management Plan Technical Guidance, March 2010

4.1.6 The following measures were highlighted as potentials if used in conjunction with other measures:

- Upsizing surface water sewers at identified 'pinch points';
- Proactive versus reactive maintenance;
- Continue to enforce existing policies and education on updated policies;
- SUDS advice leaflet;
- New policies to reduce surface water run-off and
- Development of information pack for self-help.

4.1.7 In addition to the above resistant and resistance measures, together with retrofitted SuDS, may be considered in the future.

4.2 TECHNICAL OPTIONS

4.2.1 Among the feasible technical options identified for detailed analysis was the construction of detention basins or flood storage areas. The worst historical flooding incident had been experienced in the Manor Park area because of overland flows from areas to the north within the Salt Hill Stream catchment (refer to Figure 2 in Appendix E). Therefore it was agreed to identify technical options that would alleviate flooding within the Manor Park area.

4.2.2 The ideal locations for the basins were identified by Slough BC following a review of the baseline modelling results and land ownership boundaries in order to locate the basins in locations where Slough BC would be able to acquire the land.

4.2.3 Less significant flooding is also experienced within the Chalvey Ditches / Haymill Stream Catchment however due to lack of available land within this catchment only technical options for the Salt Hill Stream catchment have been considered.

4.2.4 Three technical options were tested using the surface water model and these are:

- **Option 1** – Do nothing (Baseline scenario);
- **Option 2** – construction of two flood storage areas immediately north of Park Road (B416) within Farnham Park and north of Slough Cemetery (refer to Drawing No. 3061/SK/100 in Appendix H).
- **Option 3** – construction of three flood storage areas immediately north of Park Road (B416) within Farnham Park, north of Slough Cemetery and east of the Salt Hill Stream in Granville Park (refer to Drawing No. 3061/SK/101 in Appendix H).

4.2.5 The two 'do something' options were assessed for the 10 year event however Option 3 did not offer any significant additional benefit when compared to Option 2. Therefore Option 3 was not assessed in detail for more return periods or economic viability. The 10 year rainfall event was used for the initial assessment because it was identified by Slough BC as their main concern at project inception.

4.2.6 Option 2 was assessed for the 6 hour storm during the 2 year, 10 year, 30 year, 75 year, 100 year and 100 year plus climate change.

4.3 BENEFITS OF THE SCHEME

4.3.1 The Option 2 proposed bunds were designed to provide a 1 in 10 year (10%) standard of protection. However, the model results showed that the bund immediately north of Park Road would be slightly overtopped during the 10 year event. The predicted flood extents are plotted on Drawing Nos. 3061/FLD/10 to 16 in Appendix H.

4.3.2 The Option 2 model results showed that the mitigation scheme would result in a reduction in flood risk for the lower order events ((1 in 2 to 1 in 10 annual probability of occurring), which is illustrated in Figure 4-1 below for the 10 year event. The graph is based on the assumption that the threshold levels for the properties is 150mm above existing ground and properties with flood depths of 0.150m or greater around the perimeter of the property would flood internally. Flood depths above existing ground levels ranging from 150 - 350mm were considered shallow and 350 – 1000mm considered deep.

4.3.3 In addition to reducing the number of properties flooding for the lower order events, Option 2 also reduces the number of properties experiencing deeper flooding. However, during the higher return periods the proposed flood mitigation reduces the number of properties experiencing deeper flooding but increases shallow flooding slightly suggesting that the option introduces flood risk to new properties. Refer to Figure 4-2.

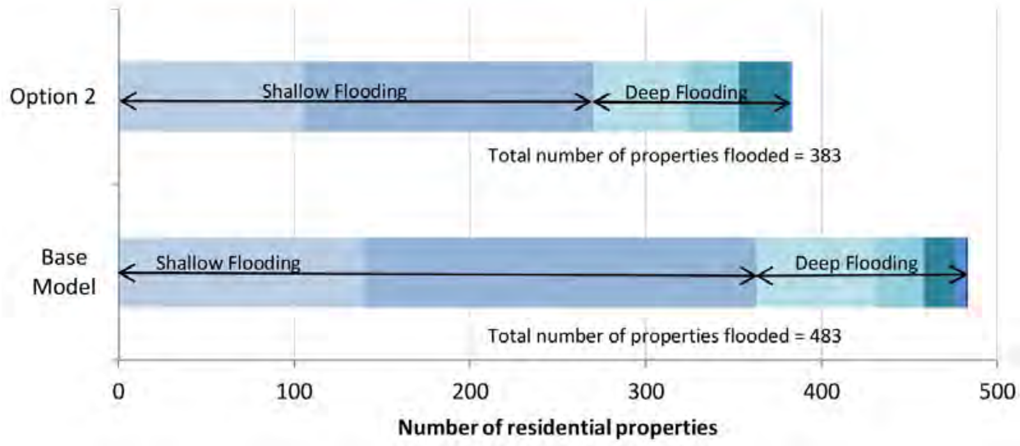

Figure 4-1: Number of residential properties per risk band (1 in 10yr event, 10%)

4.3.4 The effects of the mitigation scheme were also assessed based on the number of properties at medium and high risk. Medium and high risks were defined in the Environment Agency's document (Flooding in England: A National Assessment of Flood Risk). High risk has been considered as annual flood risk greater than 1.3% (1 in 75) and medium risk has been considered to be annual flood risk between 1.3% (1 in 75) and 0.5% (1 in 200).

4.3.5 The mitigation scheme reduces the number of properties at high flood risk while increasing those at medium flood risk slightly as illustrated in Figure 4-2 below.

4.3.6 The increase in risk during the higher order events appears to be due to the changes in the peaking time for the flow route crossing Park road and increased channelled peak flow resulting in an increase in flow to the culverted Salt Hill Stream. However, further analysis of the scheme is required, on the individual catchment with more data, to determine causes of the increased risk and any possible actions to reduce the increase.

4.3.7 While Option 2 is unlikely to be taken forward due to the increase in flood risk during the higher order events, a cost benefit analysis was undertaken to assess its viability and decide whether further work should be undertaken to refine the scheme and prevent the increased risk.

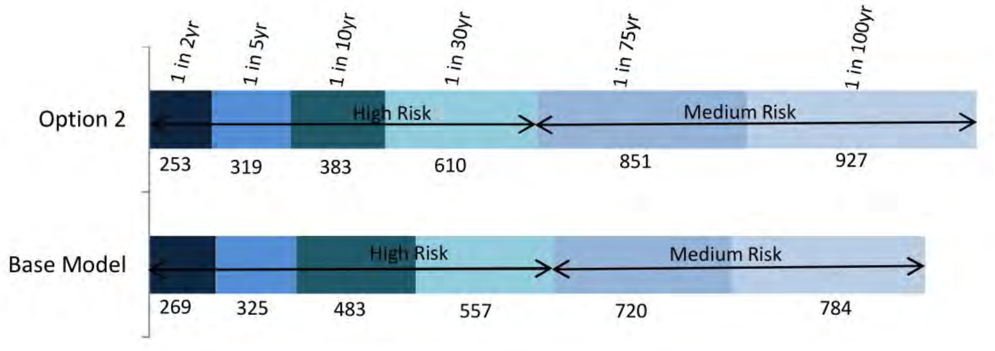

Figure 4-2: Number of residential properties at risk per return period

4.4 COST BENEFIT ANALYSIS

4.4.1 A cost-benefit analysis was undertaken comparing the two technical options:

- Option 1 – Do Nothing; and
- Option 2 – construction of two bunds.

4.4.2 The only benefits to be monetised were the reduction of flood risk to residential and commercial properties. The emergency costs were included in the assessment as 5.6% of the damages to residential properties based on the estimated emergency services costs incurred during the July 2007 flood event across England.

4.4.3 The following benefits of the scheme were not monetised:

- Reduced social and health impacts of flooding;
- Reduced risk to life;
- Contribution to creating or enhancing biodiversity.

4.4.4 The Multi Coloured Manual (MCM) has been used to determine the benefits associated with the scheme. The residential sector average depth damage curves have been used in line with the Multi Coloured Handbook (MCH), Chapter 4. The estimated damages per residential property were lower than the average market value of the residential properties in Slough based on the Land Registry data. Therefore no capping was applied to the residential annual average damages (AAD).

4.4.5 The benefits provided to non-residential properties (retail, offices and warehouses) were assessed based on the depth/damage data (Bulk classes) in Appendix 5.5 of the MCM CD for non-residential properties with no basements. No capping was applied to the non-residential properties damages as the estimated damages did not exceed the market value of the properties.

4.4.6 The assessment was undertaken for a 100 year period in line with the EA's FCERM guidance. Table 4-2 provides a summary of the present value costs and benefits for Option 2 based on an optimism bias of 60% (suitable for strategic / feasibility stage). Table 4-2 also gives the cost benefit ratio of Option 2. Information about the cost benefit analysis is included in Appendix H.

Table 4-2: Benefit-Cost Assessment

	Damage (PVd) (£k)	Damage Avoided (£k)	Total PV Costs (£k)	PV Benefits (£k)	Benefit/Cost Ratio
Do Nothing	506,774	-	-	-	-
Option 2	464,547	42,226	1,029	42,226	41.0

4.4.7 Although Option 2 does not result in reduced total damages during the higher order events, it provides significant reduction in damages for the more frequent events resulting in an overall reduction in damages over a 100 year period.

4.4.8 The FCERM guidance recommends a cost benefit ratio >5 for schemes that seeks funding through the Grant in Aid (GiA) funding stream. Therefore the scheme would be eligible for funding via the Grant in Aid funding stream.

4.4.9 The benefits of Option 2 are such that it is worth taking forward. Therefore it is recommended that the scheme be taken forward to the next stage where the scheme can be modified to prevent the increase in flood risk during the higher order events. This further work should result in a reduction in flood risk for all events up to and including the 100 year event.

4.5 NEED TO UNDERTAKE A STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

4.5.1 The need to undertake a Strategic Environmental Assessment (SEA) was assessed as part of the SWMP. A SEA screening report was undertaken by Slough BC as part of the SWMP. The screening report did not identify any significant environmental effects. Refer to Appendix I for the screening report.

4.5.2 Slough Borough Council as a Lead Local Flood Authority has obligations under the Flood and Water Management Act (2010) to produce a local Flood Risk Management Strategy, which will take into account findings of this SWMP. Since the Council has a statutory requirement to meet the requirements of the Flood and Water Management Act (2010), any Strategies produced are subject to a SEA.

4.5.3 The formal Strategic Environmental Assessment (SEA) process will be carried out as part of the future local Flood Risk Management Strategy. Slough BC is producing the Flood Risk Management Strategy in the next 6-12 months that would be sufficient in terms of addressing the SEA requirements.

4.6 CARBON IMPACT

4.6.1 The SWMP guidance recommends a carbon costing assessment in order to understand the wider sustainability of the options to mitigate surface water flood risk.

4.6.2 The majority of carbon calculators use a bill of quantities approach to the estimation of the carbon dioxide associated with the construction activities of each scheme. However, this level of detail is normally not available at strategy level and would require excessive resources.

4.6.3 Therefore it was decided to estimate the carbon costing of the scheme based on the table provided as an example in the SWMP guidance and as presented in Table 4-3 below.

Table 4-3: Carbon Impact Scoring[14]

Score	Carbon Impact	Adaptability to Climate Change
1	Nominal carbon cost – Non-structural measures e.g. flood warning.	Nominal climate change impact – e.g. flood warning
2	Low carbon cost	Low climate change impact
3	Moderate carbon cost – earthworks with minor inputs of other materials	Medium climate change impact – e.g. above ground storage / SUDS which can relatively simply be upsized to accommodate climate change
4	High carbon cost	High climate change impact
5	Very high carbon cost – significant below-ground civils e.g. new pipes, tanks	Very high climate change impact – e.g. below-ground assets which are very expensive to upsize to accommodate climate change

4.6.4 Option 2 consists of earthworks for the bunds and storage area with a few additional materials for the headwalls and the pipes conveying flows through the bund. Therefore based on the carbon impact scoring in Table 4-3 the scheme has moderate carbon cost and medium climate change impact.

4.7 REVISED SCHEME – OPTION 2A

4.7.1 The recommended Option 2 increased the number of properties at flood risk for events ranging from 1 in 30 (3%) to 1 in 100 (1%) while reducing the number of properties for high frequency events. Although the benefit/cost ratio of the scheme was favourable, the increase in the number of properties at flood risk for the higher order rainfall events was not considered acceptable. Therefore a revision of the scheme was undertaken resulting in a new Option 2a.

4.7.2 The improved scheme maintains the two storage areas immediately north of Park Road (B416) within Farnham Park and north of Slough Cemetery proposed in Option 2. However, the improved scheme aims to increase the flood storage provided north of Park Road by introducing a new bund 240m upstream of the proposed bund adjacent to Park Road. Refer to Option 2a Summary Note in Appendix K.

4.7.3 The revised option was assessed for rainfall with 1 in 30 (3%) and 1 in 100 (1%) annual probability of occurring based on a 4m grid. However, the assessment was undertaken on an area covering the catchment contributing flows to the bunds north of Park Road extending to Manor Park and truncating immediately north of Northern Road.

[14] Defra Surface Water Management Plan Technical Guidance, March 2010

No assessment was undertaken on a catchment-wide model including the areas within the town therefore no property counting was undertaken.

4.7.4 The assessment undertaken on the smaller catchment shows that the revised option would result in a decrease in flood risk south of Park Road for rainfall events up to the 1 in 100 (1%) event. Although an assessment covering the town was not undertaken to allow for quantification of the decrease in flood risk it is expected that the scheme would result in a decrease in the number of properties at risk of flooding for all events.

4.7.5 It is recommended that the revised Option 2a be adopted to alleviate surface water flood risk to the Salt Hill Stream catchment within Slough. However, it is also recommended that full assessment covering the town be undertaken to quantify the benefits offered by the revised scheme. The additional assessment should be undertaken before any detailed design of the scheme.

4.7.6 Refer to Appendix K for a summary note and details of the revised scheme.

5 Conclusions and Recommendations

5.1 CONCLUSIONS

5.1.1 There is a complex interaction of overland surface water, watercourses, sewers and groundwater in Slough. The recorded historical flooding is, in most cases, attributed to a combination of sources.

5.1.2 There are six main watercourses within the Slough administrative area, which collects flows from areas to the north of Slough before discharging them into the River Thames.

5.1.3 The strategic risk assessment identified the Salt Hill Stream and Haymill Stream / Chalvey Ditches catchments as the most critical drainage areas that require detailed assessment. There are some overflows between the sewer networks draining the two catchments which necessitated the need to model the two catchments as one combined Chalvey Ditches catchment.

5.1.4 The detailed risk assessment for the combined Chalvey Ditches catchment identified some overland flow routes between the existing buildings, which are critical for surface water flood risk within the catchment. Also terraced properties that leave no flow paths between them were shown to be blocking flows, causing water build up to the rear of the properties.

5.1.5 The detailed risk assessment established that there is generally low surface water flood hazard within Slough for the lower order events. However, for a few areas in the combined Chalvey Ditches catchment the study has shown a significant hazard rating to exist during the 10 year event.

5.1.6 Some of the sites identified for future development in the Core Strategy were found to have some existing overland flow routes and existing surface water flood risk in portions of the allocated sites.

5.1.7 Assessment of the climate change impacts showed that effects of climate change would result in increased extents and depths of flooding within Slough. This would result in a significant increase in the estimated damages to properties.

5.1.8 Several options were assessed for mitigating flood risk within Slough and two technical options were assessed through hydraulic modelling. Based on the results of the initial assessment, only one of the options was assessed in more detail. The technical options were identified for the Salt Hill Stream catchment but none were identified for the Chalvey Catchment / Haymill Stream catchment due to lack of space.

5.1.9 Option 2 was found provide significant benefits during the lower order events. However, it resulted in increased risk during the higher order events, which need to be assessed in more detail. The benefits provided for the lower order events result in a high cost benefit ratio for the scheme.

5.1.10 Although the benefit/cost ratio of the scheme was favourable, the increase in the number of properties at flood risk for the higher order rainfall events was not considered acceptable. Therefore a revision of the scheme was undertaken resulting in a new Option 2a.

5.1.11 The revised Option 2a was assessed for the 1 in 30 (3%) and 1 in 100 (1%) rainfall events to determine the scheme benefits during the higher order events. The assessment was undertaken by constructing a more detailed model on a smaller part of the catchment it benefits. This refined model showed that the revised Option 2a would result in a decrease in flood risk south of Park Road for rainfall events up to the 1 in 100 (1%) event (reduction in flood risk for all events up to the 100 year event). Although an assessment covering the town was not undertaken to allow for quantification of the decrease in flood risk it is expected that the scheme would result in a decrease in the number of properties at risk of flooding for all events. As such, a favourable cost benefit analysis is assured.

5.1.12 Due to the nature of the scheme it was found to have moderate carbon cost and medium climate change impact.

5.1.13 A SEA screening report undertaken by Slough BC as part of the SWMP did not identify any significant environmental effects associated with the scheme. The formal Strategic Environmental Assessment (SEA) process will be carried out as part of the local Flood Risk Management Strategy which Slough BC will be producing in the next 6-12 months.

5.2 RECOMMENDATIONS

5.2.1 It is recommended that the revised Option 2a be adopted to alleviate surface water flood risk to the Salt Hill Stream catchment within Slough. However, it is also recommended that a full and detailed assessment be undertaken - covering the town and using a topographical survey for the land identified for the bunds, and the watercourses downstream of the bunds - to quantify the benefits offered by the revised scheme. The additional assessment of the scheme should be undertaken before any detailed design commences for the scheme.

5.2.2 It is recommended that TWUL, Slough BC, Environment Agency and riparian assets be identified and surveyed to assess their condition and for the results to be recorded in an Asset Register. Minimum requirements for annual maintenance and checking of surface water drainage structures by social housing providers and for publicly owned properties should be established.

5.2.3 The findings of this SWMP report should be used to inform local policies and Local Development Framework documents such as the core strategy and Area Action Plans. The allocated development sites need to take into account surface water flood risk and maintain existing flow routes within the development site.

5.2.4 The SWMP Action Plan identified the need for the established partnership to continue working together. The various departments in Slough BC such as Highways, Planning and Development Control also need to work together more closely in order to minimise the surface water flood risk impacts of new developments or extensions. Close collaboration between Council departments will ensure that surface water flood risk is given the same consideration as fluvial flood risk during planning.

5.2.5 No mitigation option has been assessed for the Chalvey Ditches / Haymill Stream catchment as part of this SWMP. It is therefore recommended that flood resilient and resistance measures be considered for the properties at high risk of surface water flooding.

5.2.6 Efforts should be made to maintain the key and critical flow paths between existing buildings as blocking them off through new development or extensions would result in increased surface water flood risk to the properties.

5.2.7 Opportunities to reduce surface water flooding in new developments should be considered during the planning stage including maintaining existing overland flow routes or ensuring diversion of the overland flow route if development is going to cross the flow path. However, it should be noted that the risk identified by this SWMP is strategic and additional local surface water analysis should be recommended for major developments to quantify the risk specific to the site.

5.2.8 The consideration of SUDS measures for surface water drainage of new and re-developments should be encouraged within Slough to ensure new developments do not exacerbate surface water flood risk to offsite areas. Retro-fitting of SUDS for existing developments should also be considered as an action to undertake in the future.

5.2.9 It is also recommended that the various departments in Slough BC such as Highways, Planning and Development Control work together more closely in order to minimise the surface water flood risk impacts of new developments or extensions. Closer collaboration of Council departments would ensure that surface water flood risk is given the same consideration as fluvial flood risk during planning.

6 Implementation and Review

6.1 INTRODUCTION

6.1.1 The Surface Water Management Action Plan will be a living document that needs to be reviewed approximately every 3 to 5 years. This is to ensure that the implications of the agreed actions are correct and appropriate and that any new issues arising after the SWMP production are addressed. However, a review may be required following any new flood events, new flood data becoming available or new modelling techniques and change of policy in the catchment.

6.1.2 The SWMP will inform the Flood Risk Management Strategy for Slough, which is required under the Floods and Water Management Act (2010), and inform the next round of Preliminary Flood Risk Assessment.

6.2 ACTION PLAN

6.2.1 A stand-alone Action Plan has been set out to identify the SWMP actions, target commencement & completion dates, maintenance regime(s), how the preferred option is going to be funded, what needs to be done to make this happen and who is responsible for an action. Refer to Appendix J for the Action Plan.

6.2.2 The Action Plan identifies the items that need to be taken forward which are as follows:

- Continue existing partnership;
- SUDS to be incorporated in new and infill development (retrofitting of SUDS in existing development should also be considered as a future measure);
- Continue to apply, and review, existing policy and look to influence national policy;
- Set up an asset register and maintenance schedule for critical drainage infrastructure (this is now a requirement under the Flood and Water Management Act);
- Slough Borough Council, Thames Water and Environment Agency maintenance regimes / strategies of drainage features to be coordinated;
- Give surface water flood risk the same consideration as fluvial flood risk during planning;
- Undertake a SEA;
- Complete a Multi-Agency Flood Plan;
- Secure funding and implement Option 2a; and,
- Continue with public awareness campaigns through the Slough BC website and by publishing articles in Slough Borough Council's newsletter the 'Citizen'.

6.3 EMERGENCY PLANNING

6.3.1 The findings from the SWMP will be used to inform the Major Incident Plan, the Thames Local Resilience Forum, the Environment Agency's Berkshire Plan and the Multi Agency Flood Plan.

6.3.2 The findings of the SWMP such as the flood hazard maps should be used to inform the emergency plan for Slough in terms of drainage and flooding issues.

6.3.3 Slough Borough Council is in the process of undertaking their Multi Agency Flood Plan which will assess flood risk in terms of Health, Social, Economic and Environmental issues

6.4 NEXT STEPS

6.4.1 Slough BC as the lead partner of the SWMP will undertake a scrutiny of the Action Plan with input from the SWMP partners.

6.4.2 To ensure a successful implementation and review of the Surface Water Management Plan, all parties must contribute to the process. Clear lines of communication and defined responsibilities are critical.

6.4.3 The recommended option for surface water flood mitigation would require a more detailed assessment including carbon costing based on additional data.

6.4.4 A full SEA will be undertaken as part of Slough Borough Council's Flood Risk Management Strategy which will be undertaken in the next 6 – 12 months

6.4.5 The SWMP should be used to inform and advise Local Authority Plans and Polices for the area and emergency planning as well as informing local planning decisions.

6.4.6 A programme of further works or follow up actions should be prepared and a provisional timetable for completing follow up actions should be agreed by all partners. As a SWMP study is considered to be a long-term plan, partners should continue to work together after the SWMP study has been completed.

6.4.7 The SWMP will inform the preparation of future maintenance programmes for surface water management assets within the borough and any necessary co-ordination of maintenance programmes of different partners to ensure their effective operation. As the surface water management plan identifies the locations at greatest risk of surface water flooding this information can be used to target maintenance improvements in areas at greatest risk. This can also be used to identify areas to apply for funding and support any funding applications that are made.

7 References

- British Waterways (2010 & 2011) email correspondence regarding canal network and overtopping events
- Defra (March 2010) Surface Water Management Plan Technical Guidance. Available from http://www.defra.gov.uk/environment/flooding/manage/surfacewater/plans.htm
- Environment Agency (2010 & 2011) email correspondence regarding data sharing
- Flood and Water Management Act 2010 Available from http://www.legislation.gov.uk/ukpga/2010/29/contents
- Office for National Statistics (2001) Census 2001 information. http://www.statistics.gov.uk/census2001/census2001.asp
- Comments on the A.J Dixon report (March 2004) and the Haycock report (July 2004), Centre for Ecology & Hydrology, December 2004
- Royal Berkshire Fire and Rescue Service (2010) email correspondence regarding data sharing
- Assessment of the hydrological impact of Waste Management Licence WML80015 on Burnham Beeches SAC, A. J. Dixon, December 2003
- Secretary of State (2009) Flood Risk Regulations 2009 No 3042. Available from http://www.legislation.gov.uk/uksi/2009/3042/introduction/made
- Slough Borough Council (Dec 2008) Slough Local Development Framework Core Strategy Development Plan Document 2006-2026. Available from http://www.slough.gov.uk/services/8698.aspx
- Slough Borough Council (2010) Draft Strategic Flood Risk Assessment
- Slough Borough Council (2010 & 2011) email correspondence regarding data sharing
- Slough Library (2010) Newspaper cuttings
- Thames Water (2010 & 2011) email correspondence regarding data sharing
- http://web.ead.anl.gov/resrad/datacoll/porosity.htm
- Flood Hazard Research Centre, The Befits of Flood and Coastal Risk Management (Multi-Coloured Manual)
- Environment Agency, Flood and Coastal Erosion Risk Management appraisal guidance (March 2010)
- Environment Agency, Flooding in England: A National Assessment of Flood Risk (2009)
- Defra and Environment Agency, River Basin Management Plan Thames River Basin District (December 2009). Available from http://www.environment-agency.gov.uk/research/planning/125035.aspx
- BBC website, http://www.bbc.co.uk/news/uk-england-berkshire-13863343
- Defra, Flood and Coastal Defence Appraisal Guidance Social Appraisal Supplementary Note to Operating Authorities Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures, May 2008

Appendices, Figures & Tables

Appendix A Partners' Roles and Responsibilities

Roles and Responsibilities for the SWMP Partners

Appendix B Engagement Plan

Engagement Plan

Appendix C Links between SWMP and other plans

Appendix D Data Sources

SWMP Data Sources

Appendix E Slough Characteristics

Appendix F Surface Water Modelling Report

Surface Water Modelling Report and Appendices

Appendix G Baseline Surface Water Flood Maps

Baseline Surface Water Flood Maps

Drawing Nos: 3061/FLD/01 - 2 year

3061/FLD/02 -5 year

3061/FLD/03 – 10 year

3061/FLD/04 – 30 year

3061/FLD/05 – 75 year

3061/FLD/06 – 100 year

3061/FLD/07 – 100 year +CC

3061/FLD/08 – July 2007

3061/FLD/09 – February 2009

Flood Hazard Maps

Drawing Nos: 3061/FLD/200 – 10 year

3061/FLD/201 – 30 year

3061/FLD/202 – 100 year

Appendix H Options Assessment

Full List of Measures

Technical Options Assessed

Drawing Nos: 3061/SK/100 – Option 2

3061/SK/101 – Option 3

Option 2 Surface Water Flood Maps

Drawing Nos:	3061/FLD/10 – 2 year
	3061/FLD/11 – 5 year
	3061/FLD/12 – 10 year
	3061/FLD/13 – 30 year
	3061/FLD/14 – 75 year
	3061/FLD/15 – 100 year

Option 2 Flood Hazard Maps

Drawing Nos:	3061/FLD/203 – 10 year
	3061/FLD/204 – 30 year
	3061/FLD/205 – 100 year

Estimated Costs for Option 2

Cost Benefit Analysis

Appendix I SEA Screening Report

[Click here and type Appendix text.]

Appendix J Action Plan

Action Plan

Appendix K Revised Option (Option 2a) Summary Statement 2a)

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