DACORUM BOROUGH SURFACE WATER MANAGEMENT PLAN

FINAL REPORT

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Hertfordshire County Council

Final

Project no: 70006808
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KEY DEFINITIONS

Surface water flooding (Pluvial Flooding)	**In the context of a Surface Water Management Plan, Defra's SWMP Technical Guidance[1] defines surface water flooding as flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.**
Groundwater flooding	**Surface water flooding due to groundwater occurs when the water held underground rises to a level where it breaks the surface in areas away from usual above ground channels and drainage pathways, though it can occur when subterranean (underground) rivers rise to above the surface. It is generally a result of exceptional extended periods of heavy rain, but can also occur as a result of reduced abstraction, underground leaks or the displacement of underground flows.**
Overland Flow / Surface Water Runoff	**Water flowing over the ground surface that has not reached a natural or artificial drainage channel.**
Fluvial flooding	**Fluvial flooding occurs when rivers overflow and burst their banks, due to high or intense rainfall which flows into them. In the SWMP only fluvial flooding from Ordinary watercourses is assessed.**
Main River	**Main Rivers are usually larger streams and rivers which have been designated as such by Defra and the Environment Agency. The Environment Agency has powers to undertake works on any stretch of Main River and is responsible for flood risk management activities.**
Ordinary watercourse	**Ordinary watercourses are deemed to be all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers vested with utilities) and passages, through which water flows that are not classified as Main River by the Environment Agency.[2]**

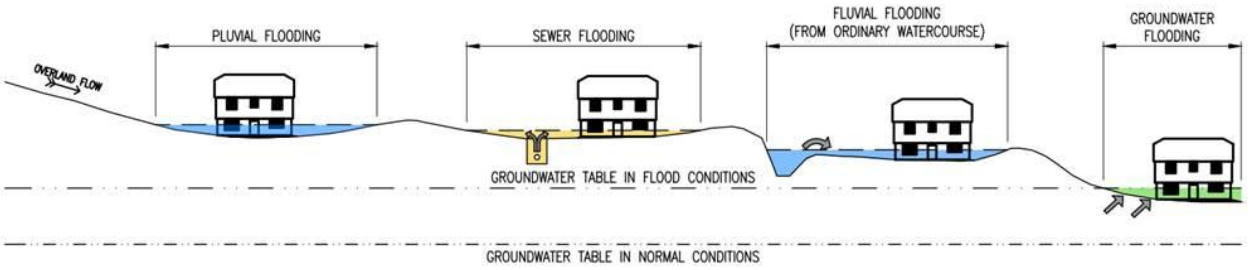


Figure 1: A diagrammatic summary of the key definitions

[1] Surface Water Management Plan Technical Guidance, Defra (March 2010) (Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf)

[2] Hertfordshire County Council's definition of Ordinary watercourses, as stated on Herts Direct (Source: http://www.hertsdirect.org/services/envplan/water/floods/ordwatercourse/)

EXECUTIVE SUMMARY

1.1 BACKGROUND

WSP | Parsons Brinckerhoff has completed a Surface Water Management Plan (SWMP) for the Borough of Dacorum on behalf of Hertfordshire County Council, as Lead Local Flood Authority. The study has been undertaken in consultation with key stakeholders. The stakeholders worked together to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. The process of working together 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.

The Defra SWMP Technical Guidance (2010) suggests that a SWMP study will not be required in all locations but rather where areas are "considered to be at greatest risk of surface water flooding or where partnership working is considered essential to both understand and address surface water flooding concerns". The need for a SWMP for the Borough of Dacorum was identified within the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire.

The Surface Water Management Plan is to be a living document that should be reviewed approximately every five years, to ensure the implementation of the agreed actions is correct and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, or new modelling techniques are developed, and when there is a change of policy in the catchment.

1.2 IDENTIFICATION OF HOTSPOTS

The first part of the risk assessment phase of the Dacorum Borough SWMP was the strategic and intermediate assessments. The principle purpose of these assessments was to identify broad locations which were considered to be vulnerable to surface water flooding. This was undertaken using the best information available, including some GIS analytical techniques, and historical information.

The Risk of Flooding from Surface Water Map (sometimes referred to as the updated Flood Map for Surface Water, uFMfSW) is considered to be the best available Hertfordshire-wide representation of potential surface water flood risk. Historical flooding incidents were then used as supporting evidence when looking at the Risk of Flooding from Surface Water Maps, in order to determine areas to focus on in this SWMP. This included the Section 19 Flood Investigation Reports produced under the Flood and Water Management Act 2010.

Local knowledge was used to pinpoint instances of surface water flooding. However, only broad areas were identified (by the Local Planning Authorities and the Environment Agency) as having experienced known incidents of surface water flooding. These included areas identified as being potential development sites. Hertfordshire County Council, as LLFA, identified areas which have had Section 19 Investigations already undertaken. Following the February 2014 flooding, a Section 19 Flood Investigation Report was completed for Long Marston, near Tring in the Borough of Dacorum.

A Desk-Based analysis was conducted to assess the flood risk to receptors within the Borough of Dacorum. From this, 19 hotspots (areas perceived and identified locally as being at greatest risk of surface water flooding) were analysed using GIS Multi-Criteria Analysis (MCA) to prioritise the hotspots most at risk of flooding within the Borough of Dacorum. A stakeholder meeting was then held in February 2015, followed by site visits to confirm the findings.

As a result, hotspots were then assessed for suitability of modelling, which resulted in the final four SWMP Modelled Hotspots:

- Hotspot 0 Tring
- Hotspot 20 Berkhamsted
- Hotspot 24 Highfield, Hemel Hempstead
- Hotspot 53 Kings Langley

1.3 DETAILED PHASE OF SWMP

The detailed phase of the SWMP focussed on the four SWMP Modelled Hotspots identified above. The detailed modelling involved the construction of individual hotspot models to assess the baseline flood mechanisms, pathways and extents. This included:

- Collection and review of available digital terrain models (DTM) (e.g. LiDAR) for the area;
- Topographic surveys to supplement the DTM where necessary;
- Collation and review of below ground infrastructure;
- Consideration of land use; and
- Specific items where further consideration was required. This included for example an additional site investigation of sewer capacity for a specific area within a hotspot.

The models were 1D-2D linked ESTRY-TUFLOW models to represent the below ground infrastructure (1D) and above ground flow paths (2D), with direct rainfall applied across the model domain. This produced flood extents, depths, velocities and hazard ratings for events ranging from the 1 in 5 year (20% annual exceedance probability) event up to the 1 in 1,000 year (0.1% annual exceedance probability) event.

Following the hydraulic modelling a review of the modelled flood extents was undertaken. From this review the types of mitigation measures which could be implemented for each hotspot were identified with the aim to reduce the impacts and damage associated with flooding.

The table below summarises the findings for each hotspot, including details on the mitigation and proposed recommendations to be taken forward.

LOCATION	SUMMARY OF FLOOD RISK	PROPOSED MITIGATION MEASURES	RECOMMENDATIONS
Hotspot 0 - Tring	Flooding predicted to the southwest of the hotspot at Duckmore Lane junction, with highly localised flooding elsewhere. The hazard rating for Mill Gardens and Duckmore Lane is shown to be danger for all.	→ Ground truthing the flooding on Duckmore Lane; → Measures such as automated flood warning signs or drainage/profile improvements/ modifications; and → Raise awareness regarding the requirement to maintain a flow route around their homes (i.e. through the gardens).	→ Further assessment/secure financing of mitigation measures; → Wider coverage of LiDAR is required; → Undertake CCTV analysis of the culvert under the Old Silk Mill Industrial Estate to confirm the size and condition; → Review highway gully maintenance programme; → Ensure that the pre-storm action plan includes the inlet of the culvert under the Old Silk Mill; and → Consideration of a CCTV camera on the inlet of the culvert under the Old Silk Mill to provide a permanent monitoring solution.
Hotspot 20 - Highfield, Hemel Hempstead	The three main flowpaths in this hotspot (from east to west - Woodhall Lane, the Nickey Line and Cattsdell) are all in operation. Flooding is predicted at the convergence location on Queensway (B487) where it is crossed by the Nickey Line and immediately downstream in Keen Fields. The hazard is generally danger for most for the 1 in 30 year event, rising to danger for all in the 1 in 100 year event.	→ Ensure that the highway and disused railway (the Nickey Line) can be utilised as preferential flow paths; → Incorporate blue corridor features to control and attenuate the flows and improve the wider environment; → Separate flows east of the underpass on Queensway (B487); → Re-profile land between Keen Fields and the Nickey Line to increase the available storage and control the discharge from this area; → Ensure preferential flow paths exist between properties and into the gardens where needed; and → Work with the Fire and Ambulance Service to ensure operability of the Fire and Ambulance Station during flood events.	→ Further assessment/secure financing of mitigation measures to enable their implementation; → Installation of automatic flood warning signs on the Queensway (B487) at the Nickey Line crossing; and → Ensure the highway gully maintenance programme is representative of the flood risks and preferential flow paths.

LOCATION	SUMMARY OF FLOOD RISK	PROPOSED MITIGATION MEASURES	RECOMMENDATIONS
Hotspot 24 - Kings Langley	Flooding is predicted in two key locations, both of which are adjacent to the Grand Union Canal/ River Gade. One area is in the north of the village at Rectory Farm and the other in the southeast of the village around the fishing lake. Other areas of flooding, which are more limited in extent are predicted to the west of Station Footpath and to the west of the A4251. Generally the hazard ranges from danger for some to danger for most.	→ Ensure that a preferential flow path exists along the highway network to facilitate flow conveyance along Langley Hill; → Improve drainage connectivity to the river in the east of the hotspot near the industrial estate and ensuring that a flap valve is in place; → Install an interception ditch in the southeast of the hotspot to divert water into the river; → Formalise/increase capacity of the storage area in Wayside Farm; and → Install an interception ditch to the west of Blackwell Road to intercept water before it reaches properties.	→ Further assessment and secure funding to research further the mitigation measures to assess and enable their implementation; → Encourage flood awareness and Property Level Protection (PLP) in areas of risk; and → Ensure the highway gully maintenance programme is representative of the flood risks and preferential flow paths.
Hotspot 53 - Berkhamsted	Flooding is predicted at Berkhamsted School / Butts Meadows. A flowpath of mainly shallow depth is predicted to flow from the southwest of the hotspot, along Kings Road (A416) and through Butts Meadow. Generally the hazard ranges from danger for some to danger for most for the 1 in 30 year event, with the A416 shown as danger for all. For the 1 in 100 year event the hazard is generally shown to be danger for all, with areas of danger for most around the school.	→ Raise kerbs or a wall and speed bumps to keep water on Kings Road rather than flowing into Berkhamsted School; → Insert a spillway from Kings Road to Butts Meadows and create a storage area by raising the footpath just upstream of the Victoria Church of England Infant and Nursery School; → Ensure flowpath connectivity in the area downstream of the High Street (A4251). Some Property Level Protection (PLP) measures may be needed in the properties in this area; and → A bund may help to achieve storage in the northern part of the catchment, in the area around the National Film Archive.	→ Further assessment and secure funding to assess and enable the implementation of the proposed mitigation; → Encourage flood awareness and Property Level Protection (PLP) in areas of risk; → Work with the Environment Agency to extend the LiDAR coverage of the hotspot; → Ensure the highway gully maintenance programme is representative of the flood risks and preferential flow paths.

An economic viability assessment of the potential benefits of each option compared to an indicative cost estimate was then undertaken. This assessment was undertaken to ensure that HCC could prioritise their future work to focus on measures which not only would reduce flood risk but also be the most attractive in securing funding to facilitate their construction. A summary of the economic assessment for each site is provided in the table below.

HOTSPOT	MITIGATION OPTION	PRESENT VALUE DAMAGED (£)	PRESENT VALUE BENEFITS (£)	PRESENT VALUE COSTS (£)	BC-RATIO
0 -Tring	Baseline	4,740,000			
	No option identified	N/a			
20 - Berkhamsted	Baseline	24,780,000			
	75 yr SoP for all benefit areas (construction scheme)	11,592,000	13,188,000	5,904,000	2.2
	75yr SoP for all benefit areas (Property Level Measures)		13,188,000	4,987,000	2.6
24 - Highfield, Hemel Hempstead	Baseline	32,000,000			
	30yr SoP for all benefit areas	14,048,000	17,952,000	1,658,000	10.8
	75yr SoP for all benefit areas	12,561,000	19,439,000	2,294,000	8.5
53 - Kings Langley	Baseline	38,890,000			
	30yr SoP for northern benefit area	36,382,000	2,510,000	150,000	16.8
	30yr SoP for central benefit area	37,888,000	1,002,000	151,000	6.6
	75yr SoP for southern benefit area	35,039,000	3,851,000	2,100,760	1.8

The economic assessment finds that five schemes across three hotspots are considered sufficiently viable to be submitted to the Environment Agency for inclusion on their MTP and further assessments undertaken to refine the schemes to a level suitable for a formal funding

application (Outline Business Cases). For these schemes HCC are likely to need to work with key stakeholders to secure additional third party funds to improve the overall funding scores for the schemes.

In addition to the four Modelled Hotspots, six of the Non-Modelled hotspots were allocated recommendations and actions, as shown in table below.

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
■ Hotspot 3	Adeyfield, Hemel Hempstead	Ensure Thames Water tanks and highway gullies are suitably maintained and cleaned after larger storm events.
■ Hotspot 22	Chaulden, Hemel Hempstead	Hold any further investigations pending the outcome of the mitigation features already in place at the site.
■ Hotspot 23	Warners End, Hemel Hempstead	To be discussed with DBC on any background history of known flooding.
■ Hotspot 26	St Albans Hill, Hemel Hempstead	Ensure highway gullies are suitably maintained and cleaned after larger storm events.
■ Hotspot 27	Hogpits Bottom, Flaunden	HCC to work with local residents to inform them of the benefits of Property Level Protection (PLP) or on property flow diversions.
■ Hotspot 28	Cupid Green, Hemel Hempstead	Work with tenant/property owners to ensure awareness and suitable drainage maintenance regimes are in place across the industrial estate.

1.4 ACTION PLAN

An Action Plan (provided in Appendix G) has been developed to cover the measures identified and recommended as part of the SWMP. The action plan identifies the process that would need to be undertaken for each element that would require capital funds to facilitate its implementation.

2 INTRODUCTION

2.1 BACKGROUND

The Borough of Dacorum has suffered flooding in February 2014 and more recently in June 2016. Historically, flooding has been associated with fluvial sources; however more recent events in urban areas have seen pluvial flooding.

The overall SWMP process is set out in Section 4.

This document specifically deals with surface water flooding. However, where there is potential interaction between fluvial flows and surface water flooding it outlines the potential impacts.

This report has been developed using the 'Surface Water Management Plan Guidance' published by the Department for Environment, Food and Rural Affairs (Defra) in March 2010. Since the publication of this document the Environment Agency has published the Risk of Flooding from Surface Water map. The information contained within this dataset means that the full Strategic and Intermediate Phases as detailed in the guidance are no longer necessary.

2.2 STUDY AREA

The Borough of Dacorum is a local authority in Hertfordshire, England. The borough includes the towns of Hemel Hempstead, Berkhamsted, Tring and the western part of Kings Langley. Figure 2 below illustrates the location of the Borough of Dacorum within Hertfordshire; the area of the borough is 212km^2.

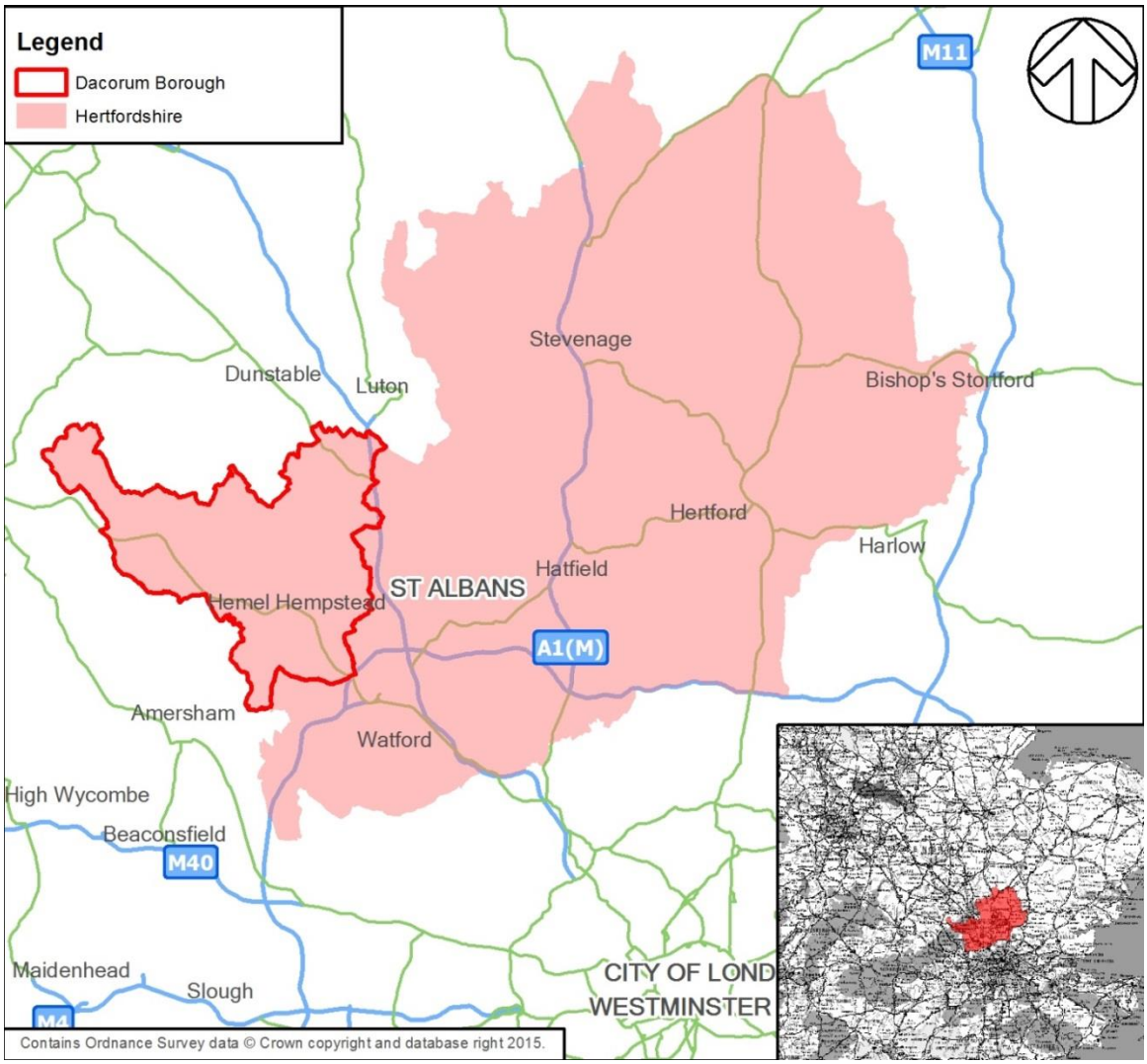


Figure 2: The Borough of Dacorum location plan

There are three river catchments, within the Borough of Dacorum, shown in Figure 3. The “Colne” and “Thame and South Chilterns” are the two principal catchments, both catchments drain to the Thames; one towards the south-east direction, the other in a westerly direction. The third river catchment, “Upper and Bedford Ouse”, shown in yellow in Figure 3 covers a very small area of the Borough of Dacorum, and does not contain any Main Rivers within the Borough of Dacorum. Within the two principal catchments:

- The rivers that fall in south easterly directions are the Ver, Gade and Bulbourne, which have catchments that cover large proportions of the east of the borough. These rivers drain into the River Colne and then eventually the River Thames. This river catchment, the “Colne” is shown in pink in Figure 3.
- To the west of the borough, the River Thame rises out of the Chilterns and falls in a north westerly direction. There are a number of different Main Rivers in this area that converge and diverge. This river catchment, “Thame and South Chilterns” is shown in the green in Figure 3.

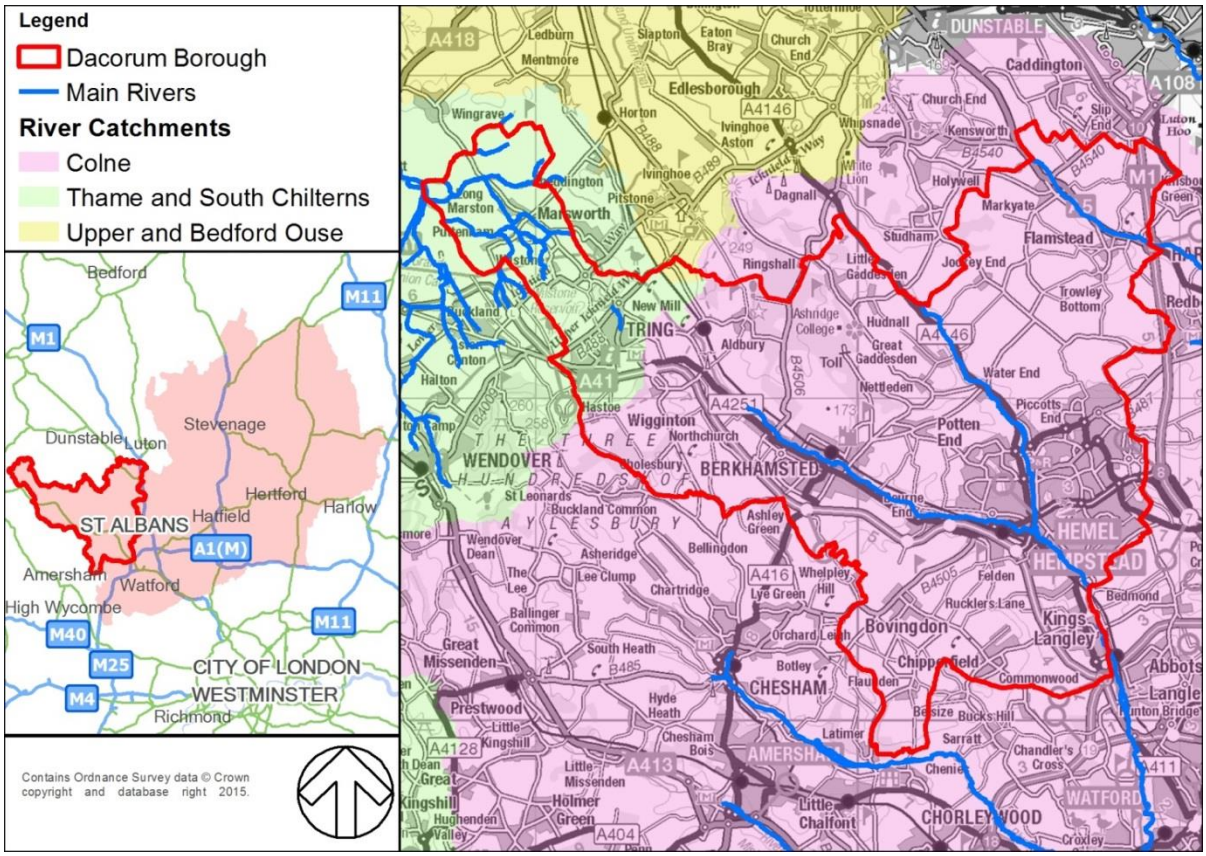


Figure 3: River catchments within the Borough of Dacorum

The British Geological Survey (BGS) mapping indicates that the Borough of Dacorum is underlain by various chalk formations as shown by Figure 4.

Lewes Nodular Chalk Formation and Seaford Chalk Formation underlays large swathes to the east of the Borough with other chalk formations including, Holywell Nodular Chalk Formation, Gault Formation and West Melbury Marly Chalk Formation underlay the western parts of the borough.

In general, chalk catchments are considered to be permeable with large proportions of the rain falling on the ground able to infiltrate providing baseflow to the surface water features, often delaying the flood peak. Certain types of storms, particularly heavy summer storms, can however lead to flooding.

The majority of the bedrock underlying the borough is classified as a “Principal Aquifer.” These are rock layers that have high intergranular and/or fracture permeability. As a result, the aquifers can provide a high level of water storage. They may support water supply and/or river baseflow on a strategic scale.

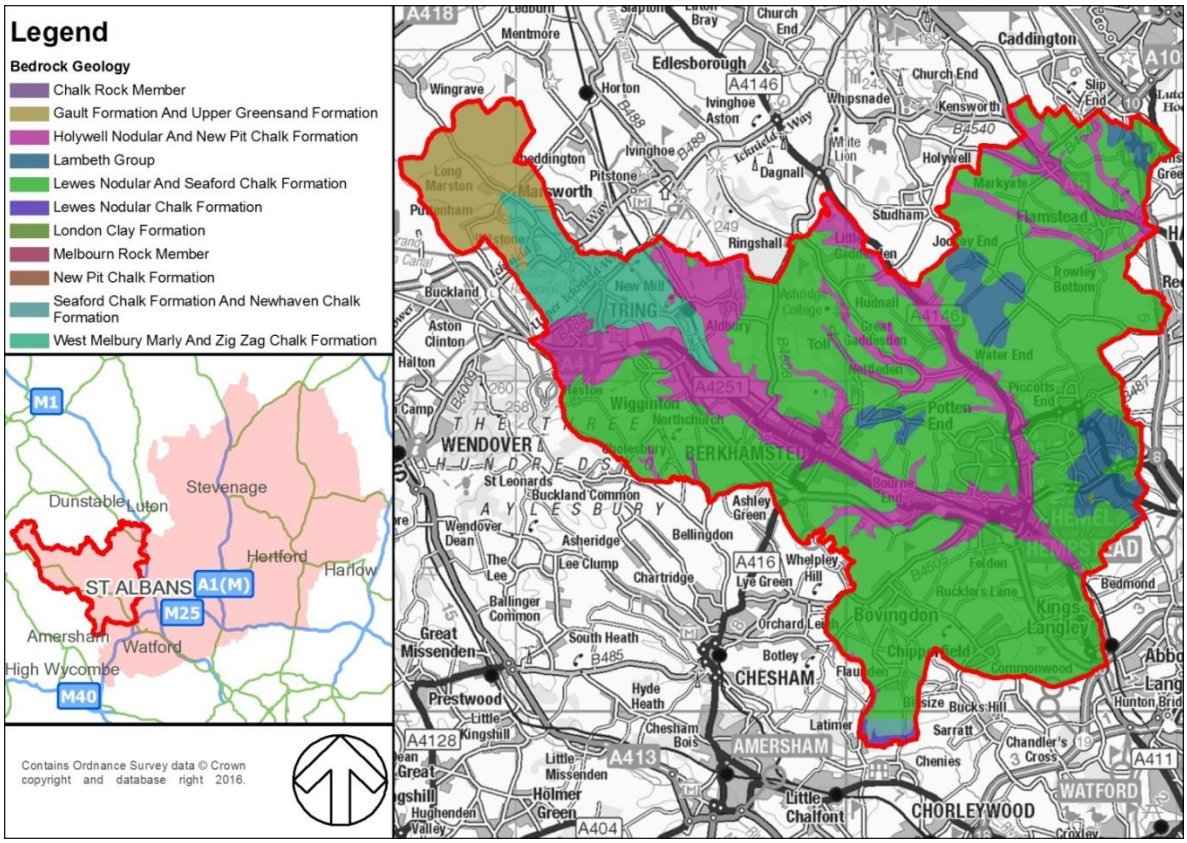


Figure 4: British Geological Survey Map of the Borough of Dacorum – Bedrock deposits

Figure 5 shows the superficial deposits overlaying the chalk bedrock. The Borough of Dacorum is overlain predominantly by Clay with Flints Formation; however, there are also significant areas where there are no recorded superficial deposits.

The majority of the superficial deposits are classified as “Secondary A” aquifers, capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of baseflow to rivers. These are generally aquifers formerly classified as minor aquifers. During times of heavy rainfall, water may saturate the underlying soils and as a result cause groundwater to seep out of the ground.

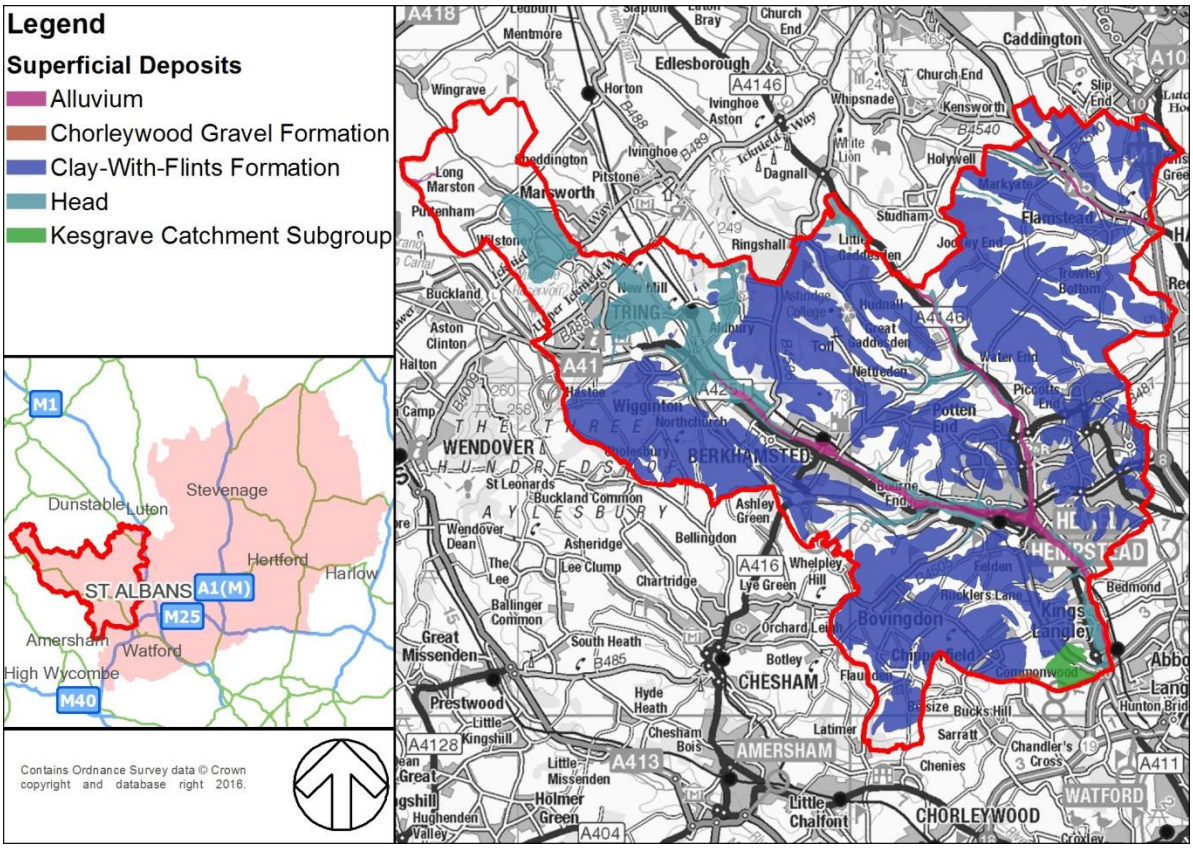


Figure 5: British Geological Survey Map of the Borough of Dacorum – Superficial deposits

2.3 SURFACE WATER MANAGEMENT PLANS (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 watercourses and ditches that occur as a result of heavy rainfall. It does not include river (fluvial) flooding except to the extent that river levels impact on surface water flooding.

The study is undertaken in consultation with key stakeholders who are responsible for surface water management and drainage in their area. All parties should work together to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. The process of working together 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.

2.4 STAGES OF A SWMP

There are four phases to be completed in order to undertake a SWMP study as illustrated in Figure 6.

The Defra Surface Water Management Plan Technical Guidance (March 2010) sets out a description of the four stages as follows[3]:

- **Preparation** – The first phase of a SWMP study focuses on preparing and scoping the requirements of the study. Once the need for a SWMP study has been identified the LLFA and the key stakeholders should identify how they will work together to deliver the SWMP study. The aims and objectives of the study should be established, as well as details of how all parties should be engaged throughout the SWMP study. An assessment should subsequently be undertaken to identify the availability of information. Based on the defined objectives, current knowledge of surface water flooding, and the availability of information, an agreement is made regarding the level of assessment at which the SWMP study should start.
- **Risk assessment** – The outputs from the preparation phase will identify which level of risk assessment will form the first stage of the SWMP study. The first stage is likely to be the strategic assessment where little is known about the local flood risks. The strategic assessment focuses on identifying areas more vulnerable to surface water flooding for further study. The intermediate assessment, where required, will identify flood hotspots in the chosen study area, and identify quick win mitigation measures, and scope out any requirements for a detailed assessment. A detailed assessment of surface water flood risk may be required to enhance the understanding of the probability and consequences of surface water flooding and to test potential mitigation measures in high risk locations. Guidance is provided on undertaking modelling to support a detailed assessment of surface water flood risk and mitigation measures. The outputs from the strategic, intermediate and/or detailed assessment should be mapped and communicated to all stakeholders including spatial planners, local resilience forums, and the public.
- **Options** – In this phase a range of options are identified, through stakeholder engagement, which seeks to alleviate the risk from surface water flooding in the study area. The options identified should go through a short-listing process to eliminate those that are unfeasible. The remaining options should be developed and tested using a consideration of their relative effectiveness, benefits and costs. The purpose of this assessment is to identify the most appropriate mitigation measures which can be agreed and taken forward to the implementation phase.
- **Implementation and Review** – Phase 4 is about preparing an implementation strategy (i.e. an action plan), delivering the agreed actions and monitoring implementation of these actions. The first step is to develop a coordinated delivery programme. Once the options have been implemented they should be monitored to assess the outcomes and benefits, and the SWMP should be periodically reviewed and updated, where required.

[3] Page xvi, Paragraphs i29 to i32.

Figure 6: Different stages of a SWMP study

The Local Flood Risk Management Strategy (LFRMS) for Hertfordshire 2013 – 2016 (published February 2013) identified the need for district scale SWMPs. A strong partnership has already been developed to implement aspects of the Flood and Water Management Act 2010, as well as deliver the St Albans and Watford SWMP update (February 2015), undertaken by WSP | Parsons Brinckerhoff. Given the work undertaken across Hertfordshire to date, it was deemed suitable to combine the Strategic and Intermediate Assessments of the Risk Assessment Phase.

3 WIDER POLICY AND LEGISLATIVE CONTEXT

3.1 POLICY AND LEGISLATIVE HISTORY

There has been a sequence of legislative and policy frameworks which cover flood risk developed by central government over the course of the last 15 years. The following information details a chronology of when this policy was developed, published and the main changes it brought about.

→ Land Drainage Act (1991)

The Land Drainage Act brought together legislation relating to IDB's and local authorities previously in the Land Drainage Act 1976 concerning inland and sea defence matters. This was amended by the Land Drainage Act 1994 and the key elements are duties on the enhancement of the environment, restoration and improvement of ditches, provision of funding and compulsory purchase of land.

→ Planning Policy Guidance Note 25 (PPG25): Development and Flood Risk (2001)

PPG25 set out the government's guidance to local authorities and others on planning policy associated with flood risk. This document was replaced in 2006 by the introduction of PPS25.

→ Planning Policy Statement 25 (PPS25): Development and Flood Risk (2006)

PPS25 set out the government's policy on development and flood risk following a review of the PPG25 document. Its aim was to ensure that flood risk was taken into account at all stages in the planning process to avoid inappropriate development. Key methodologies promoted within the document were as follows:

- Defining four Flood Zones for fluvial or coastal flooding based on the Annual Exceedance Probability (AEP) of an event occurring.
- Requiring the preparation of Regional Flood Risk Appraisals (RFRAs) or Strategic Flood Risk Assessments (SFRAs).
- Development of the Sequential and Exception Tests which guides development away from areas most at risk of flooding; only permitting development in flood risk areas where it is appropriate.

A Practice Guide was issued in 2008 and offers guidance on how to implement the policies within PPS25.

In PPS25 SWMPs were referred to as tools to manage surface water flood risk on a local basis by improving and optimising coordination between relevant stakeholders. The guidance issued alongside PPS25 advised that planners at the strategic and development control levels should use SWMPs to inform their Core Strategy documents, such as the SFRA. The core strategy policies would have the SWMP as evidence to support any policies on flooding and surface water drainage. This document was superseded in 2012 when it was incorporated into the National Planning Policy Framework (NPPF).

→ The Pitt Review: Learning Lessons from the 2007 Floods (2008)

The Pitt Review was undertaken following the summer 2007 flooding and looked at the causes and response to the flood events across the UK. The review found inadequacies in terms of who was responsible for different types of flood risk and how that flood risk was communicated to emergency services and the wider community when required. The review

made 92 recommendations, particularly aimed at driving closer collaboration between government agencies and improved information on where there is risk of flooding.

Recommendation 18 of the Pitt Review states that Surface Water Management Plans (SWMPs) "should provide the basis for managing all local flood risk. SWMPs will build on or inform Strategic Flood Risk Assessments (SFRAs) and provide the vehicle for local organisations to develop a shared understanding of local flood risk, including setting out priorities for action, maintenance needs and links into local development frameworks and emergency plans."

- Flood Risk Regulations (FRR) (2009)

  The Flood Risk Regulations (FRR) transposed the EU Floods Directive into law in England and Wales. Under the FRR the Environment Agency (EA) and Lead Local Flood Authorities (LLFAs) had to prepare preliminary flood risk assessments (PFRAs). Completed by LLFAs, these PFRAs are published by the Environment Agency. There is also a duty on LLFAs with an agreed Flood Risk Area to publish flood hazard and flood risk maps for all sources of flooding and flood risk management plans. These flood risk management plans should set objectives for flood risk management and outline measures for achieving these objectives.

- Flood and Water Management Act (FWMA) (2010)

  The FWMA (2010) was first proposed as the legislative vehicle to implement the European Floods Directive, however due to delays in the bill, it was not implemented within the timeframe set out by the Floods Directive, hence the FRRs implemented the Floods Directive and the FWMA was delayed until 2010.

  The FWMA provided the legislative basis for a number of recommendations in the Pitt Review. In October 2010, Section 9 of the FWMA came into force requiring all LLFAs in England to develop, maintain, review, update as well as apply and monitor the application of a strategy for local flood risk in their area. This is known as a Local Flood Risk Management Strategy (LFRMS).

- National Planning Policy Framework (NPPF) (2012)

  The NPPF was published in 2012 and simplified all the disparate Planning Policy Statements into one coherent framework to underpin the planning system. PPS25 was updated and included in the NPPF in *Section 10: Meeting the challenge of climate change, flooding and coastal change.*

  Planning Practice Guidance was published alongside the NPPF and the section of the Guidance for flood risk provides additional details on the approach for strategic level studies. The NPPF does reiterate the importance of the Strategic Flood Risk Assessment (SFRA) in setting local planning policy.

  NPPF does not explicitly mention SWMPs but highlights the importance of assessing flood risk from all sources including surface water. A SWMP can be undertaken either proactively to inform future SFRAs or reactively as a result of an SFRA study.

  On 24th March 2015, the Government laid a statutory instrument making the Lead Local Flood Authority a statutory consultee in planning for all major development in relation to the management of surface water drainage from 15th April 2015. The NPPF and associated Planning Practice Guidance were updated to reflect these changes.

3.2 LEAD LOCAL FLOOD AUTHORITY (LLFA)

Hertfordshire County Council, as the Lead Local Flood Authority for Hertfordshire, has the role of managing flood risk from surface water and groundwater and is a statutory consultee in planning for all major development in relation to the management of surface water drainage.

As LLFA the county council has a range of duties which includes:

- Preparing reports and plans to meet the requirements of the Flood Risk Regulations 2009 (FRR).
- Carrying out investigations of flooding where appropriate and publishing reports.
- Keeping a public register and associated record of structures and features which have a significant effect on local flood risk.
- Designation of structures and features where appropriate.
- Regulation of Ordinary watercourses outside of areas covered by Internal Drainage Boards (IDBs).

In accordance with the Flood and Water Management Act (2010), LLFAs are required to co-ordinate and lead local flood risk management activities by preparing and implementing a Local Flood Risk Management Strategy (LFRMS). HCC has already prepared a Local Flood Risk Management Strategy, and is currently progressing through 10 district/borough based Surface Water Management Plans (SWMPs) throughout Hertfordshire, to gain a better understanding of local flood risk and the priorities for management.

3.3 OTHER PLANNING POLICIES

This section details the different sources of information available to help inform the production of the SWMP and a summary on the content of each planning policy document is detailed further in this section. An overview of the interaction of the documents is provided in Figure 7 below.

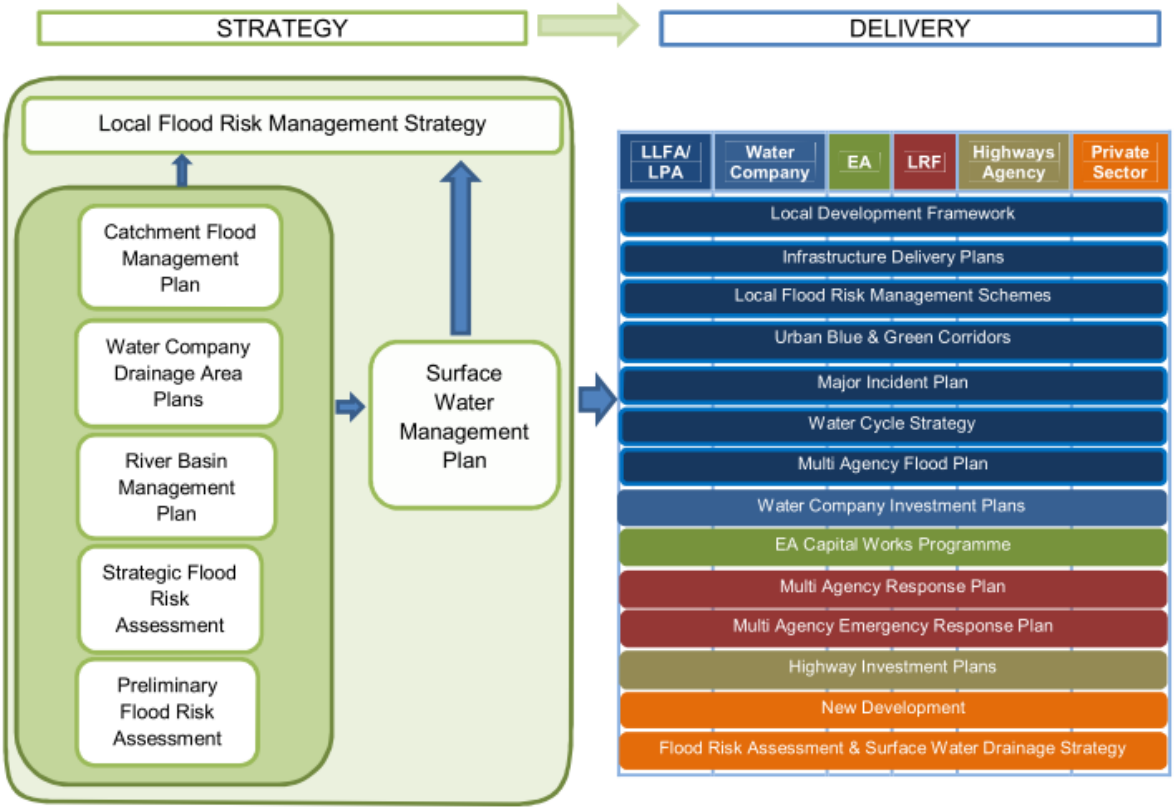


Figure 7: Link between Surface Water Management plans and other strategies, plans and policies

STRATEGIC FLOOD RISK ASSESSMENTS (SFRAS)

The Planning Practice Guidance states the following with regards to Strategic Flood Risk Assessments[4]:

"A Strategic Flood Risk Assessment (SFRA) is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that land use changes and development in the area will have on flood risk.

The Strategic Flood Risk Assessment will be used to refine information on river and sea flooding risk shown on the Environment Agency's Flood Map for Planning (Rivers and Seas). Local planning authorities should use the Assessment to:

- *Determine the variations in risk from all sources of flooding across their areas, and also the risks to and from surrounding areas in the same flood catchment;*
- *Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies, including policies for flood risk management to ensure that flood risk is not increased;*
- *Apply the Sequential Test and, where necessary, the Exception Test when determining land use allocations;*
- *Identify the requirements for site-specific flood risk assessments in particular locations, including those at risk from sources other than river and sea flooding;*
- *Determine the acceptability of flood risk in relation to emergency planning capability;*
- *Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and of storage for flood water."*

Each Local Planning Authority (LPA) area in Hertfordshire is covered by an SFRA which was produced in 2007-2008. A number have been supplemented with further assessment.

CATCHMENT FLOOD MANAGEMENT PLANS (CFMP)

Catchment Flood Management Plans are key strategic documents that outline future flood risk management policies on a catchment by catchment basis. The Borough of Dacorum lies almost entirely within the River Thames CFMP.

CFMPs give an overview of the flood risk across each river catchment. They recommend options for managing those risks at present and over the future 50 – 100 years. CFMPs have been prepared in partnership with regional and local planning authorities, community environmental groups and other stakeholders.

CFMPs consider all types of inland flooding, from rivers, groundwater, surface water and tidal flooding, but not coastal flooding, which is covered in Shoreline Management Plans. They also take into account the likely impacts of climate change, the effects of how we use and manage the land, and how areas could be developed to meet our present day needs without compromising the ability of future generations to meet their own needs.

[4] http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/strategic-flood-risk-assessment/

Figure 8 illustrates the area extents of the River Thames CFMP and River Great Ouse CFMP within the Borough of Dacorum.

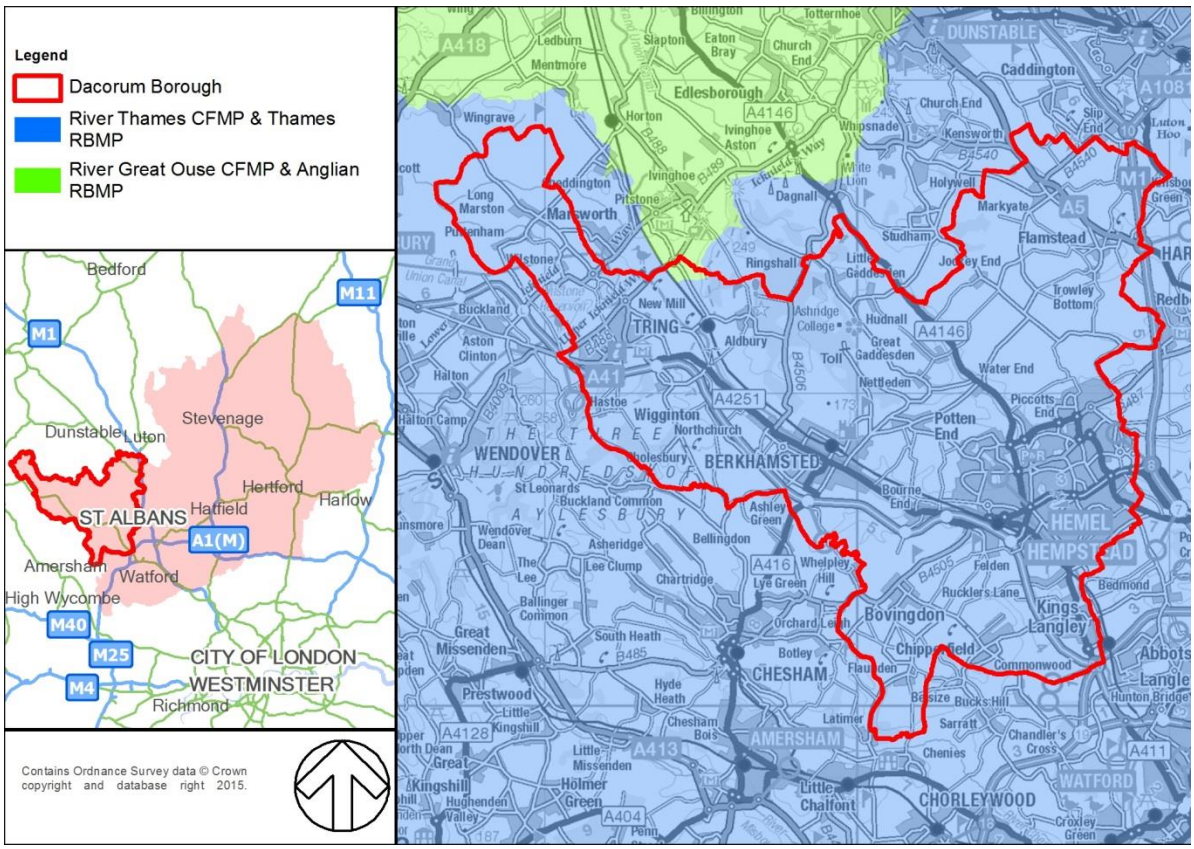


Figure 8: Environment Agency CFMP areas and RBMP areas covered within the Borough of Dacorum

WATER FRAMEWORK DIRECTIVE (WFD)

The Water Framework Directive was introduced in December 2000 and became UK law in December 2003. The directive focuses on improving the ecology of our water ecosystems and aims to protect and enhance the quality of surface water, groundwater, estuaries and coastal waters. The Environment Agency is the lead authority responsible for the delivery of these targets, but must work closely with Lead Local Flood Authorities (LLFAs), in this instance Hertfordshire County Council, to ensure that targets are achieved.

RIVER BASIN MANAGEMENT PLANS (RBMP)

Dacorum Borough lies almost wholly within the Thames River Basin Management Plan area. Figure 8 shows the RBMP and CFMP areas within the Borough of Dacorum. The following is quoted from the plan covering 2009-2015[5]:

"This plan focuses on the protection, improvement and sustainable use of the water environment. Many organisations and individuals help to protect and improve the water environment for the benefit of people and wildlife. River Basin Management is the approach the Environment Agency is using to ensure our combined efforts achieve the improvement needed in the Thames River Basin District.

[5] https://www.gov.uk/government/publications/thames-river-basin-management-plan

This plan has been prepared under the Water Framework Directive, which requires all countries throughout the European Union to manage the water environment to consistent standards. Each country has to:

- *"Prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters;*
- *Aim to achieve at least good status for all water bodies by 2015. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve good status by 2021 or 2027;*
- *Meet the requirements of the WFD protected areas;*
- *Promote sustainable use of water as a natural resource;*
- *Conserve habitats and species that depend directly on water;*
- *Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants;*
- *Contribute to mitigating the effects of floods and droughts."*

WATER CYCLE STUDY / STRATEGY (WCS)

A Water Cycle Study identifies the potential conflict between growth proposals and environmental requirements and identifies feasible solutions to addressing them. Effective planning and close cooperation between all parties involved is essential to the success of a water cycle study.

The WCS provides the evidence base for setting out allocations, phasing of development, potential developer contributions and further guidance. Since all organisations work in partnership to carry out the WCS, each partner is more likely to be committed to delivering the resulting WCS.

The effect of development on the water environment forms a key part of the Sustainability Appraisal (SA) and Strategic Environmental Assessment (SEA), required under the Local Plan process. As part of the Local Plan a WCS will give planning authorities a robust evidence base to assess this. It identifies and assesses risk, investigates all the options and issues and helps decide which option(s) will best support the Local Plan and related policies.

The WCS helps to plan for water more sustainably by:

- Bringing together all partners and stakeholders existing knowledge, understanding and skills;
- Bringing together all water and planning evidence under a single framework;
- Understanding the environmental and physical constraints to development;
- Working alongside green infrastructure planning to identify opportunities for more sustainable planning, and;
- Identifying water cycle planning policies and a water cycle strategy to help all parties plan for a sustainable future water environment.

The Water Cycle Study for the Borough of Dacorum was completed as part of a joint Dacorum Borough Council, St Albans City and District Council, Three Rivers District Council, Watford Borough Council, Welwyn Hatfield Borough Council Water Cycle Study.

The WCS was prepared to inform the Core Strategy and Site Allocation Documents, and provide evidence to support any policies included in the Local Development Framework (LDF) that relate to water resources, supply and sewerage, wastewater treatment, flood risk, water quality and the wider water environment. Figure 9 shows the Water Cycle Study area the Borough of Dacorum was part of.

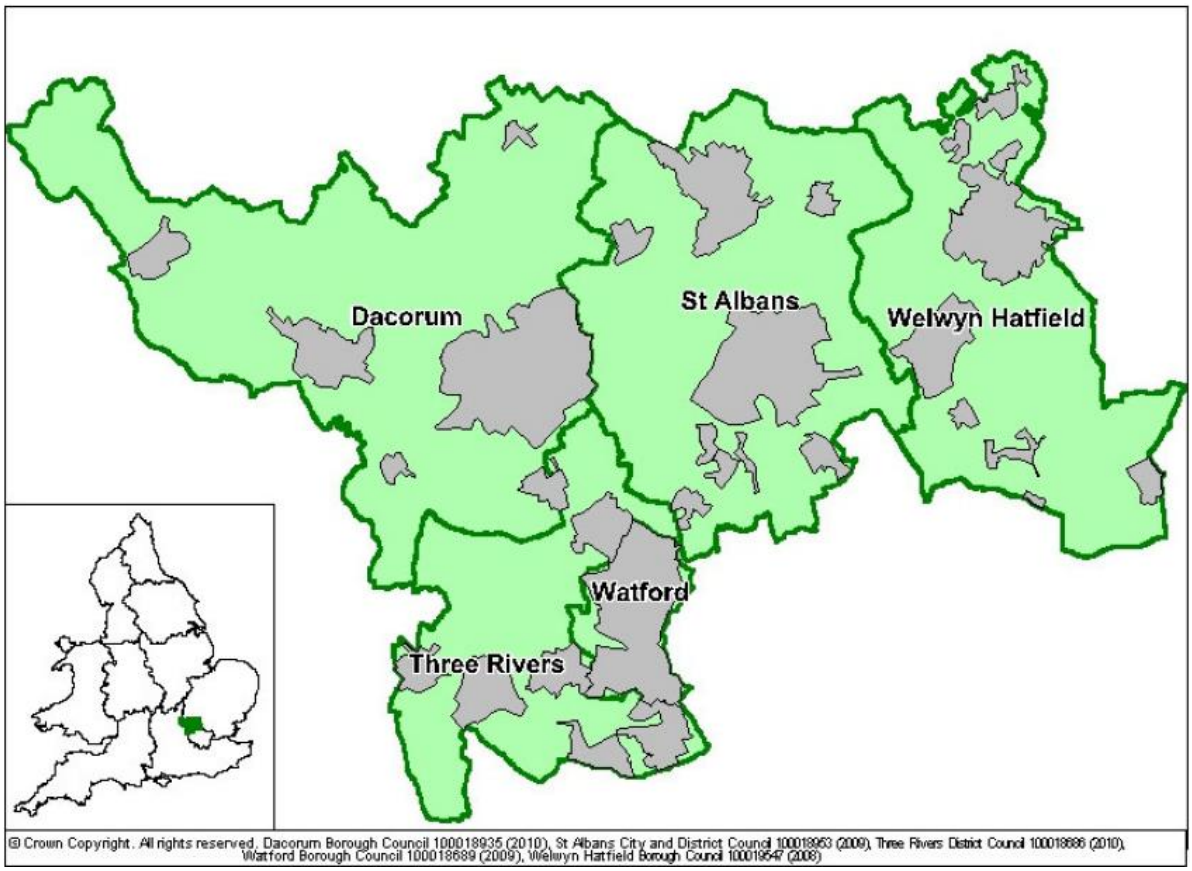


Figure 9: Dacorum Borough Council, St Albans City and District Council, Three Rivers District Council, Watford Borough Council, Welwyn Hatfield Borough Council Water Cycle Study Area.
(Source: Water Cycle Study - Scoping Study, Hyder Consulting (UK), April 2010, page 7)

LOCAL FLOOD RISK MANAGEMENT STRATEGY (LFRMS)

In October 2010 Section 9 of the Flood and Water Management Act (FWMA) 2010 came into force. This element of the FWMA required all Lead Local Flood Authorities (LLFAs) in England to develop, maintain, review, update as well as apply, and monitor the application of a strategy for local flood risk in their area. The overarching aim of the Local Flood Risk Management Strategy is to provide a robust local framework that employs a full range of complementary approaches towards managing and communicating the risks and consequences of flooding arising from surface runoff, groundwater and Ordinary watercourses in Hertfordshire and the surrounding areas.

The objectives by which the county council will achieve this vision are set out below and actions and measures that have been developed to achieve these objectives are set out in Section E7 of the Hertfordshire LFRMS.

- **Studies, assessments and plans** – Developing a greater understanding of local flood risk in Hertfordshire will be critical to deploying the most effective measures for managing the risk and making the best use of limited resources.
- **Information-sharing protocols** – This function will be developed to understand what data is needed for, what information is available, what information is missing and how information will be shared. The data will help define 'locally significant' flood risk and set criteria for when the LLFA will investigate a flooding incident.
- **Development control** – (The policy context for this area of the LFRMS has recently changed. National Planning Practice Guidance has superseded previous guidance. The Lead Local

Flood Authority is identified as a statutory consultee on surface water drainage arrangements for all major development). An improving information base about local sources of flooding will help inform the determination of development proposals and support the Strategic Flood Risk Assessments produced by the local planning authorities.

- **Sustainable Drainage Systems (SuDS) –** The CIRIA SuDS Manual (C753) set out how "Sustainable drainage systems (SuDS) are designed to maximise the opportunities and benefits we obtain from surface water management. SuDS can deliver four main benefits by improving the way we manage water quantity, water quality, amenity and biodiversity"[1] It was anticipated that Hertfordshire County Council would become the SuDS Approving Body (SAB) after enactment of Schedule 3 of the Flood and Water Management Act. Following Defra consultation, Schedule 3 will not be enacted and instead HCC in their role as LLFA will become the statutory consultee on planning applications for major developments with surface water drainage (DMPO 2015)[6].
- **Raising awareness** – Individuals and communities should understand that there will always be a degree of flood risk and the role that they can play in the local management of that risk. Raising awareness will be a critical aspect of the Strategy.
- **Resilience** – The Strategy will explore ways in which flood risk can be reduced through individuals and communities increasing their own resilience.
- **Investment and funding** – The Strategy will look at the development of priorities for investment and at the same time explore opportunities for funding.

Hertfordshire County Council (HCC) has prepared their Local Flood Risk Management Strategy (LFRMS), which is consistent with the national strategy. The Local Flood Risk Management Strategy for Hertfordshire 2013-2016 was published in February 2013), this has identified the following objectives:

- The risk management authorities in the LLFA area and what flood risk management functions they may exercise in relation to the area.
- The objectives for managing local flood risk. These are relevant to the circumstances of the local area.
- The measures proposed to achieve objectives.
- How and when the measures are expected to be implemented. In some instances this could be linked to the Flood Risk Regulations outputs – The Preliminary Flood Risk Assessment.
- The costs and benefits of those measures and how they are to be paid for.
- The assessment of local risk for the purpose of the strategy. HCC as the LLFA have used the information from previous studies to identify the risk and identify gaps in understanding the local flood risk and specify what actions need to be taken to close these gaps (i.e. completion of this SWMP).
- How and when the strategy is to be reviewed.
- How the strategy contributes to the achievement of wider environmental objectives.

[1] The SUDS Manual –C753 (2015) CIRIA
[6] http://www.legislation.gov.uk/uksi/2015/595/made

4 PREPARATION

4.1 IDENTIFY THE NEED FOR A SWMP

Action 8.2.4 of the LFRMS 2013 – 2016 is “Develop Surface Water Management Plans based on the boundaries of the 10 district authorities.” This SWMP for Dacorum Borough is a realisation of Action 8.2.4.

4.2 ESTABLISH PARTNERSHIP

A SWMP is a framework through which key stakeholders 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.

Under the legislative framework, involvement in a SWMP by all stakeholders is voluntary. The Flood and Water Management Act 2010 requires Lead Local Flood Authorities (LLFA) to take the lead role for flood risk management and have a coordination role amongst the other stakeholders, in the development of SWMPs.

The Borough of Dacorum SWMP was produced in consultation with:

- Hertfordshire County Council;
- Dacorum Borough Council;
- Thames Water;
- The Environment Agency.

As part of the Strategic Assessment, consultation has been undertaken with a number of stakeholders to obtain historical flooding information. As the SWMP progresses, other stakeholders will be invited to provide additional information.

In addition, parish councils were contacted to inform key stakeholders on any flooding issues which they wish to be taken into consideration as part of the hotspot selection.

The project aims to build upon the successful working platform between all bodies responsible for drainage and emergency response and ensure that this will continue after the SWMP is complete. Project meetings (at appropriate times) with the key stakeholders will ensure agreed actions are executed and that any new issues are discussed and reviewed. This is subject to an agreement between all stakeholders and availability of resources.

4.3 SCOPING THE SWMP STUDY

The key objectives of the SWMP are:

- → To continue and enhance the successful working relationship between all stakeholders and to provide a future framework for this forum;
- → Enhance the understanding of local flood risk across the Borough of Dacorum;

- Establish the areas at significant risk[7] of flooding and the potential impacts;
- Aid in understanding the mechanism of flooding. It may be that while local knowledge suggests one singular cause, there may be multiple factors with interconnectivity between sources;
- Identify various mitigation options (taking into account both the current and future situations, including the impacts of climate change) and prioritise the options;
- Develop an Action Plan agreed by all stakeholders to reduce the flood risk within the Borough of Dacorum.

4.4 POLICY DOCUMENTS REVIEWED

As part of the review of the available information, an assessment was undertaken of the link between the SWMP and other flood related plans and policy.

During the preparation of this Surface Water Management Plan, the following national and local policy documents were referred to:

- The Pitt Review, 2008;
- Water Framework Directive (WFD), 2003;
- Flood Risk Regulations, 2009;
- Flood and Water Management Act (FWMA), 2010;
- National Planning Policy Framework (NPPF), 2012;
- Level 1 Strategic Flood Risk Assessment prepared for Dacorum Borough Council, St. Albans City & District Council, Three Rivers District Council and Watford Borough Council, 2007 (Referred to as the Four Council's SFRA)
- Dacorum Borough Council Level 2 Strategic Flood Risk Assessment, June 2008;
- Dacorum Borough Council, St Albans City and District Council, Three Rivers District Council, Watford Borough Council, Welwyn Hatfield Borough Council Water Cycle Study, Scoping study, Final report (WCS), April 2010;
- Thames River Basin Management Plan (RBMP), 2009;
- River Thames Catchment Flood Management Plan (CFMP), December 2009;
- Hertfordshire Preliminary Flood Risk Assessment (PFRA), August 2011;
- Local Flood Risk Management Strategy (LFRMS) for Hertfordshire, February 2013;

The Surface Water Management Plan (SWMP) will be a living document that needs to be reviewed as part of the LFRMS update cycle. This will ensure the implications of the agreed actions and new issues are addressed. However, a review may be required following any future surface water flood events, new data becoming available, new modelling data techniques becoming available or any changes in policy within the catchment.

[7] In accordance with the NPPF, all areas at risk of flooding are considered. However, weightings are applied to the analysis based on the mechanism of flooding and the annual probability of occurrence. This is done to guide the SWMP to areas most at risk of surface water flooding. Further information can be found within the Hotspot Selection Technical Note.

4.5 COLLATING AVAILABLE INFORMATION

During the preparation stage of the SWMP, consideration was also given to the availability of information and the appropriate sources of this information. This included an assessment of which data could be provided by each stakeholder and the format in which the information can be provided.

A review of all the data received was undertaken as part of the Strategic Assessment.

In addition to an assessment of the historical flooding experienced within the Dacorum Borough SWMP study area, analysis was also undertaken utilising the following datasets from the Environment Agency (EA):

- Risk of Flooding from Surface Water Maps (the third generation of surface water flood maps);
- Flood Map for Planning
- Locations of Main Rivers and defences
- National Receptor Database (information on properties at risk of flooding)
- Areas Susceptible to Groundwater Flooding (AStGWF) Map

Consideration has also been given to the following data, as well as the reports detailed in earlier sections:

- Level 1 and Level 2 SFRAs covering the Borough of Dacorum dated 2007 and 2008 respectively
- Ordnance Survey Data, MasterMap Topography and Integrated Transport Layers

A Geographic Information System (GIS) was used to collate the available information, including the extents/locations of historical flooding.

4.6 QUALITY, LIMITATIONS AND RESTRICTIONS

Hertfordshire County Council have mechanisms in place to record reported incidents of flooding, this information has been used to inform the study along with the information detailed within other studies, such as the PFRA to provide an assessment of all recorded historical flooding within the study area.

Some of the data collated as part of the SWMP is subject to licensing restrictions. These restrictions include the level of detail that the SWMP is able to make publically available. For instance, the findings of the SWMP are based upon detailed site specific flooding information which cannot always be shown in publically available maps. In some instances assumptions were required and the resulting SWMP should be treated as a ‘living document’ with regular updates in line with improvements in collated data.

The data that has been collated as part of the Strategic Assessment, has come from a number of sources and in some cases is licensed to Hertfordshire County Council for the purposes of preparing this SWMP for the Borough of Dacorum.

The level of assessment for the Strategic and Intermediate Assessments that was agreed with Hertfordshire County Council was an over-arching assessment, based upon the LFRMS and other recent studies, to cover the flood risk across the whole borough. This identifies the hotspot areas for detailed assessment, which may include hydraulic modelling.

5 STRATEGIC AND INTERMEDIATE RISK ASSESSMENT

5.1 INTRODUCTION

The principle purpose of the Strategic Assessment is to identify broad locations, which are considered vulnerable to surface water flooding. This is undertaken on a coarse spatial scale and therefore provides a simplified assessment using the best information available, starting with a review of the historical events.

The purpose of the Intermediate Assessment is to identify the nature and sources of the flooding, and the frequency and severity of flooding. This improved understanding is then used to identify flood hotspots and begin to identify mitigation measures to reduce surface water flooding.

As there have been several completed assessments that cover Hertfordshire (e.g. the Hertfordshire LFRMS and the Hertfordshire PFRA), it was determined that the Strategic and Intermediate Assessments should be combined.

This phase of the assessment considers flooding from surface water runoff, Ordinary watercourses, sewers, canals and groundwater. This assessment also takes into consideration the interaction of these sources with Main Rivers and their associated tributaries in order to identify areas most at risk of surface water flooding.

In the context of this report, surface water flooding includes the following (as defined in the Key Definitions section):

- Surface water runoff; runoff before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity;
- Flooding from groundwater;
- Sewer flooding; flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall;
- Flooding from open-channel and culverted watercourses;
- Overland flows from the urban/rural fringe entering the built-up area; and
- Overland flows resulting from groundwater sources.

The following information has been used for this phase of the assessment:

- Historic flooding records;
- Environment Agency's Risk of Flooding from Surface Water maps (sometimes referred to as the updated Flood Map for Surface Water, uFMfSW);
- Environment Agency's Areas Susceptible to Groundwater Flooding (AStGWF);
- Dacorum Level 1 and Level 2 SFRAs dated 2007 and 2008 respectively;
- Local Flood Risk Management Strategy (LFRMS) for Hertfordshire (2013);
- Environment Agency's Flood Maps for Planning.

5.2 FLOODING HISTORY

HISTORIC FLOOD RECORDS

A review of the reported and recorded historical events experienced within the Borough of Dacorum was undertaken however, it does not constitute a comprehensive assessment of all flood risk. Historical data cannot identify all locations at risk of flooding; it is possible that areas that have experienced flooding are not represented in this assessment as not all occurrences may be reported or recorded.

FLUVIAL FLOODING

Markyate was affected by flooding in June 1993 and October 1993; a total of 34 properties were flooded. This was thought to have been caused by an inadequate culvert. A flood alleviation scheme was constructed in Markyate in 2003 and there were no reported flooding incidents following construction up to publication of the SFRA.

Out of bank flooding from the River Gade is known to have occurred in Gadebridge Park, Hemel Hempstead in March 2007. Major flood events are also described in local papers having occurred in 1879 and 1947 and are estimated at 1 in 100 and 1 in 50 year (1% and 2% AEP) events respectively

In 1879, properties were flooded at the junction of the Grand Union Canal and the Bulbourne as well as in Boxmoor, King's Langley and Great Gaddesden. These events happened before the Hemel Hempstead flood relief scheme was constructed in 1959.

Flood events occurred in 1977 and 1988 at the junction of Station Road in Aldbury. Flooding also occurred in Aldbury again in 1992 and also in Tring and Chaulden.

FLOOD RISK FROM CANALS

The Borough of Dacorum is intersected by the Grand Union Canal. The Canal has a number of exchanges between it and the River Bulbourne and River Gade. The Canal is classed as Environment Agency Main River and was assessed as part of the Four Council's SFRA. As the Grand Union Canal is classed as Main River it has not been assessed within this SWMP beyond its interaction with surface water flooding.

SURFACE WATER FLOODING

Surface water flooding is known to have occurred in many locations across the Borough of Dacorum. The Four Council's SFRA outlines a number of locations in detail with many more locations listed. A number of these locations are the subject of Section 19 Flood Investigation Reports under the Flood and Water Management Act 2010. (Quoted information from the SFRA is shown in *italics*).

- ***Chequers Hill, Friar Wash*** *– Flooding regularly occurs on Chequers Hill where it crosses under the A5 and the River Ver at Junction 9 of the M1. The source of the flooding is not clearly understood and thought to be either from fluvial flooding or surface water flooding, attributed to the topography of the field being lower than that of the road.*
- ***A5 Roundabout, Junction 9, M1*** *– The A5 roundabout is subject to regular flooding, the source of the problem is not clearly understood and is thought to be either from fluvial flooding (River Ver) or surface water flooding attributed to the topography of the surrounding land.*
- ***Bede Cottage, Frithsden*** *– Bede Cottage regularly floods from surface water drainage running off the surrounding fields. This problem is currently under investigation by Hertfordshire Highways.*

- ***Parsons Close, Flamstead*** *– Properties on Parsons Close in Flamstead are frequently flooded due to surface water runoff from the fields to the north. A solution to this problem is currently being considered possibly involving re-profiling of the road.*
- ***Two Ponds Lane, Northchurch*** *– Surface water flooding occurs on Two Ponds Lane, Tring Road, Boswick Lane and Duswell Lane. This is thought to be attributed to the land owner making modifications to the land (i.e. reshaping the fields) at the end of Two Ponds Lane (private road). As a result, water weirs over Two Ponds Lane and cuts over the main 'A' road (Tring Road) and down Boswick Land and into the River Bulbourne. These roads are regularly flooded. Hertfordshire Highways are investigating this further.*
- ***Buncefield Lane, Leverstock Green*** *– Buncefield Lane at the crossing with Green Lane, in Leverstock Green is impacted by surface flooding. It has been suggested that the clearing of ditches and gullies may solve the problem. Entec, who represent the owners of a potential Housing Proposal site here (site H38) have also informed Dacorum Borough Council that the balancing pond is flooding over the site. They have engaged other water experts to investigate solutions to this involving a possible new balancing pond onsite or off site to the south.*
- ***Church Street, Bovingdon*** *– Flooding from surface water drainage occurs at the confluence of Church Street and Green Lane. This is attributed to the convergent topography of the area. Flooding from this mechanism occurred in 1946 and is known as 'The Great Flood of Bovingdon.' There is an important pond feature at this location, known as 'The Dock' which should be retained to reduce the likelihood of future surface water flooding.*
- ***Junction of Cupid Green Lane with Dodds Lane, Cupids Green*** *– At the junction of Cupid Green Lane and Dodds Lane, there is a low point in the topography, resulting in surface water ponding and subsequent disruption to the flow of traffic.*
- ***Long Marston, Tring*** *– Long Marston has been flooded twice, most recently in May 2007. The exact flooding source and mechanism is not fully understood. However, the area had been subject to continuous medium to heavy rainfall for 48 hours prior to the flooding. An open drainage ditch runs through the village next to the main road. It forms part of the network of ditches and channels which combine to form the Upper Thame. The flooded properties were located on the opposite side of the road to the drainage ditch however the ditch itself was not overtopping and was not therefore the direct source of the flood water. It is thought that the flooding may have arisen from overland flow from the surrounding saturated farmland. Approximately 7 residential properties and the local pub were flooded. Flooding of Long Marston also occurred in 2003 via the same mechanism, resulting in internal flooding to 15-20 residential properties.*

Under Section 19 of the Flood and Water Management Act 2010, Lead Local Flood Authorities are responsible for investigating reported flooding issues within their area. Hertfordshire County Council has published a number of flood investigation reports on their website with one located within the Borough of Dacorum.

- **Long Marston, Tring** – Flooding on the 7th February 2014 caused internal damage to one commercial and at least 5 residential properties, flooding also made a number of roads, including access into the village, impassable. This event was concluded to be the result of heavy rainfall over an extended period of time saturating the surrounding catchment prior to the flooding on the 7th February. Inadequately sized culverts and lack of maintenance of culverts and watercourses were also cited as reasons for surface water flooding.

GROUNDWATER FLOODING

Groundwater flooding occurs when the water held underground rises to a level where it breaks the surface in areas away from usual channels and drainage pathways. It is generally a result of exceptional extended periods of heavy rain, but can also occur as a result of reduced abstraction,

underground leaks or the displacement of underground flows. Once groundwater flooding has occurred, the water can be in situ for a lengthy period of time.

The presence of the chalk aquifer in Hertfordshire and other underground water bearing areas such as the river gravel deposits, mean that there is potential for groundwater flooding. There are confirmed cases, both widespread and in settlements known to be at particular risk.

Groundwater flooding was assessed in the Four Council's SFRA on a catchment by catchment basis. The SFRA noted groundwater flooding had been observed in a number of locations including Tring, within the Dacorum Borough.

Within the Ver, Gade and Bulbourne catchments, groundwater flooding in the winter of 2000/2001 was limited to dry valleys and caused by the emergence of new springs above ground level.

A number of groundwater flooding locations have been reported by Dacorum Borough Council and included in the SFRA. With regular groundwater flooding occurring in Delmerend Lane, Flamstead, adjacent to Sawpit Wood; Puddlehats Lane, Gaddesden Row and Nettleden Road, Great Gaddesden.

It should be noted from the data provided and following consultation with the key stakeholders, it is sometimes difficult to ascertain if a source of flooding is from groundwater only. This is because flood risk may be as a result of a combination of sources, or a culverted watercourse may have been mistaken for a spring or underground stream.

WATER COMPANIES FLOOD RISK REGISTER

The water company for the borough (Thames Water) has also been consulted to obtain the sewer flooding records from their flood risk register. This register lists the areas and properties which have previously experienced an internal or external sewer flooding incident caused by overloaded sewers or other causes (temporary problems) (whether foul, combined or surface water sewers).

Temporary problems such as blockages, siltation, sewer collapses and equipment or operational failures have been excluded from the register. An entry upon this register will not be removed until the problem has been solved. It should be recognised that reporting is not necessarily complete as some property owners do not report sewer flooding events. In addition, instances of surface water flooding in remote areas are unlikely to be reported.

The water companies have subsequently supplied postcodes of places that have been subject to sewer flooding. The listing gives the number of properties which suffered internal flooding and the number of places subject to external flooding. External flooding includes highways, public open space, open land, parkland, as well as private gardens.

5.3 AVAILABLE DATA

DATASETS

In recent years, the risk of flooding from non-fluvial sources has become better understood and information about the risk has become more informed. This information is now publicly available with further data held by stakeholders or commercially available; these datasets are:

- Areas Susceptible to Groundwater Flooding (greater than 75%)
- Risk of Surface Water Flooding Maps – 1 in 30, 1 in 100 and 1 in 1,000 year (this is sometimes known as the updated Flood Map for Surface Water, uFMfSW)
- Flood Map for Planning Flood Zones 2 and 3
- Areas Benefitting from Defences

AREAS SUSCEPTIBLE TO GROUNDWATER FLOODING (ASTGWF)

This 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) to inform their Preliminary Flood Risk Assessments (PFRA). Greater than 75% refers to the percentage of the 1km square that has the potential for groundwater flooding.

RISK OF FLOODING FROM SURFACE WATER MAPS (SOMETIMES REFERRED TO AS THE UPDATED FLOOD MAP FOR SURFACE WATER, UFMFSW)

These maps are the third generation of surface water flooding maps produced by the Environment Agency. The earlier generations were "Areas Susceptible to Surface Water Flooding" and "Flood Map for Surface Water Flooding." The Risk of Flooding from Surface Water maps are the most recently produced dataset developed by the Environment Agency. They represent the mechanisms that cause surface water flooding in the following ways[8]:

- Better ground and surface elevation data in many areas – using 'local' data;
- Drainage capacity – using a single 'national' figure of 12mm/hour;
- Infiltration now represented – using 'national' figures;
- Storm duration more representative – using a single 'national' figure;
- Buildings now included – using 'local' data;
- Different roughness figures for urban and rural now included – using 'national' figures.

It is considered that the latest map is the best available Hertfordshire-wide representation of potential surface water flood risk, using the Historic Flooding incidents as supporting evidence.

The Environment Agency has put in place an update cycle in conjunction with the LLFAs to ensure that these maps are based upon the latest available information.

FLOOD MAP FOR PLANNING

The Environment Agency Flood Map for Planning was previously the only available flood map for fluvial and coastal flooding. There are Flood Risk Maps available online; these are largely based upon the National Flood Risk Assessment undertaken by the Environment Agency. However, it was determined that for the purposes of this stage of the study, the Flood Map for Planning would be more suitable given, that it is largely based upon more detailed modelling and focuses on the Main River network. Assessment of flooding from Main Rivers is not within the scope of SWMP studies, yet any detailed modelling previously undertaken could be suitable for using as boundary conditions for any future modelling work undertaken as part of the Dacorum Borough SWMP.

These maps show areas that could be affected by flooding from rivers or the sea. It does not show the effects of climate change, ignores the presence of flood defences and is divided into 3 main flood zones. Flood Zone 3 is land assessed as having a 1% (1 in 100 year) or greater annual probability of fluvial flooding. Flood Zone 2 shows land assessed as having between a 1% (1 in 100 year) and 0.1% (1 in 1,000 year) annual probability of fluvial flooding.

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297432/LIT_8988_0bf634.pdf

AREAS BENEFITTING FROM FLOOD DEFENCES (ABD)

The ABD maps highlights areas of land that may benefit from the presence of major defences during the 1% (1 in 100 year) annual probability of fluvial flood events. These are areas that would flood if the defence were not present, but may not flood because the defence is present.

PUBLISHED STUDIES

STRATEGIC FLOOD RISK ASSESSMENT (SFRA)

Flooding can result not only in costly damage to property, but can also pose a risk to life and livelihood. It is essential that future development is planned carefully, steering it away from areas that are most at risk from flooding, and ensuring that it does not exacerbate existing known flooding problems. The Strategic Flood Risk Assessment is the first step in this process, and it provides the building blocks upon which the council's planning and development control decisions will be made.

PRELIMINARY FLOOD RISK ASSESSMENT (PFRA)

The Preliminary Flood Risk Assessment was published by Hertfordshire County Council (HCC), in June 2011 to meet their duties as Lead Local Flood Authority (LLFA) and the requirements of the Flood Risk Regulations 2009 (FRR 2009). The Flood Risk Regulations came into force in England and Wales in December 2009. The Regulations transposed the EC Floods Directive (2007/60/EC) on the assessment and management of flood risks across EU Member States into domestic law and now implements its provision.

The Preliminary Flood Risk Assessment represents the first stage of the requirements of the Regulations. The PFRA process is aimed at providing a high level overview of historical and future flood risk from local sources, including surface water, groundwater, Ordinary watercourses and canals. Flooding from the sewerage systems will also be included. Flooding associated with the sea, Main Rivers and reservoirs is the responsibility of the Environment Agency and does not need to be considered by the LLFA as part of the PFRA, unless it is considered that it may affect flooding from one of the sources listed above.

The PFRA is a high-level screening exercise and must therefore consider floods which have significant harmful consequences for human health, economic activity, the environment and cultural heritage. The PFRA identifies such areas and if they are considered to be nationally significant, as defined by Defra, they are highlighted as 'Flood Risk Areas'. Flood Risk Areas warrant further examination and management through the production of flood risk and flood hazard maps and flood risk management plans.

The methodology for identifying a Flood Risk Area involves the assessment of the national flood risk information, which was used to identify 1km grid squares where local flood risk is considered to be an issue. Thresholds for these squares are:

- Number of people at risk greater or equal to 200;
- Critical Services (i.e. schools, hospitals, fire and police stations, sewage treatment works) at risk greater or equal to 1;
- Non-residential properties at risk greater or equal to 20.

A Flood Risk Area is identified using the above set of criteria to form a cluster. Where more than 5 highlighted grid squares are touching a cluster is formed. If these clusters contain more than 30,000 people at risk, the cluster is identified as an indicative Flood Risk Area.

No Flood Risk Areas with a total population of greater than 30,000 people were identified within Hertfordshire. The three largest clusters identified were around Watford (11,946 people), Hemel Hempstead (5,655) and Stevenage (5,110). Hemel Hempstead is within Dacorum Borough.

HYDRAULIC MODELS

The SWMP will build upon previous flood investigations and other capacity assessments (e.g. hydraulic models to assess the surface water runoff, surface water sewer capacities and fluvial flooding). This will ensure consistency between all previous work and on-going assessments, while minimising any duplication and data collection requirements. It will also maximise the local knowledge, the number of sites that can be assessed and the potential to secure funds for future mitigation schemes.

5.4 AREAS IDENTIFIED AT SIGNIFICANT RISK OF FLOODING

The methodology used to select the hotspots is contained within the Hotspot Selection Technical Note, included in Appendix B of this report. The Summary section of the Hotspot Selection Technical Note is also presented here.

A Desk-Based analysis was conducted to assess the flood risk to receptors within the Borough of Dacorum. From this, 19 hotspots were analysed using a GIS Multi-Criteria Analysis (MCA) to prioritise the hotspots most at risk of flooding within the Borough of Dacorum.

A stakeholder meeting was held on 3rd February 2015 to discuss the results of the analysis with relevant stakeholders and to allow stakeholders to share information and recommend further sites that should be analysed.

Site visits were conducted with Hertfordshire County Council in attendance in February 2015. The aim of the site visits was to assess hotspots on the ground and determine if the proposed solutions would be appropriate and cost-beneficial.

The initial top five Desk-Based Identified Hotspots, produced as a result of the Multi-Criteria Analysis (MCA) were:

- Hotspot 0 Tring
- Hotspot 24 Highfield, Hemel Hempstead
- Hotspot 3 Adeyfield, Hemel Hempstead
- Hotspot 28 Cupids Green, Hemel Hempstead
- Hotspot 20 Berkhamsted

Following stakeholder engagement and site visits, four of the Desk-Based Identified Hotspots and two Stakeholder Identified Hotspots were chosen to be considered for hydraulic modelling, and for further analysis in the Modelling Methodology Technical Note. Six hotspots were taken forward for further evaluation, these hotspots are detailed below:

- Hotspot 0 Tring
- Hotspot 1 Aldbury
- Hotspot 2 Bovingdon
- Hotspot 20 Berkhamsted
- Hotspot 24 Highfield, Hemel Hempstead
- Hotspot 53 Kings Langley

Four hotspots were then assessed as to the suitability of modelling and determined as the final SWMP Modelled Hotspots, there hotspots are:

- Hotspot 0 Tring
- Hotspot 20 Berkhamsted
- Hotspot 24 Highfield, Hemel Hempstead
- Hotspot 53 Kings Langley

The hotspots detailed in Table 1 are not being considered further; however, the recommendations and actions, detailed in Table 1, are included in the Action Plan as appropriate. .

Table 1: Recommendations and actions for the Borough of Dacorum - SWMP Non-Modelled Hotspots

HOTSPOT NUMBER	LOCATION	RECOMMENDATIONS AND ACTIONS
■ Hotspot 3	Adeyfield, Hemel Hempstead	Ensure Thames Water tanks and highway gullies are suitably maintained and cleaned after larger storm events.
■ Hotspot 22	Chaulden, Hemel Hempstead	Hold any further investigations pending the outcome of the mitigation features already in place at the site.
■ Hotspot 23	Warners End, Hemel Hempstead	To be discussed with Dacorum Borough Council on any background history of known flooding.
■ Hotspot 26	St Albans Hill, Hemel Hempstead	Ensure highway gullies are suitably maintained and cleaned after larger storm events.
■ Hotspot 27	Hogpits Bottom, Flaunden	HCC to work with local residents to inform them of the benefits of Property Level Protection (PLP) or on property flow diversions.
■ Hotspot 28	Cupid Green, Hemel Hempstead	Work with tenant/property owners to ensure awareness and suitable drainage maintenance regimes are in place across the industrial estate

6 DETAILED RISK ASSESSMENT - APPROACH

6.1 INTRODUCTION

The intermediate assessment (Section 0) identified four hotspots for a detailed assessment of surface water flood risk through hydraulic modelling. The Defra guidance suggests that hydraulic modelling must be outcome-focussed and improve the understanding of the surface water flood risk. The key components of the detailed assessment are shown in Table 2.[9]

Table 2: Key components of detailed assessment *(based on Table 6-1 in the Defra guidance)*

COMPONENT	DESCRIPTION
Purpose	To understand the causes, probability and consequences of surface water flooding in a greater level of detail, and to consider mitigation measures to reduce surface water flooding.
Scale	Hotspot level.
Inputs	Information from the intermediate assessment. Additional evidence collated from site visits, surveys or modelling. Local knowledge (Hertfordshire County Council/Dacorum Borough Council/Environment Agency/Thames Water).
Process	Use of modelling approaches to assess surface water flood risk (where the conceptual equation is used: risk = probability x consequence).
Outputs	Understanding of 'annualised' surface water flood risk, both now and in the future. Understanding the benefits and costs of mitigation measures to reduce surface water flooding. Detailed mapping of baseline flood risk and flood hazard.
Benefits	Improved understanding of the probability and consequences of flooding. Detailed understanding of the flood risk will enable informed judgements to be made of the benefits and costs of potential mitigation measures. Assess benefits of mitigation measures (where a benefit is a reduction in damages due to surface water flooding). Justification for mitigation measures based on benefits and costs.

Each of the four hotspots identified for further assessment within the intermediate phase are covered in turn below, with their specific considerations, modelling approach and summarised. Further more specific information on the considerations, constraints and adopted approach can be found in the modelling methodology (Appendix C).

6.2 DATA COLLECTION

The hydraulic models were generally constructed utilising the data outlined below, the exact data/combinations are detailed in the hotspot specific modelling report (Appendix C):

TOPOGRAPHY

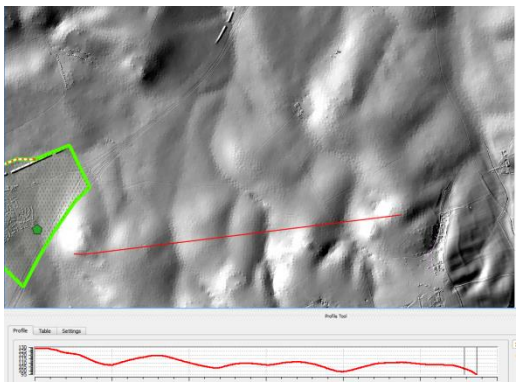
DTM

The Environment Agency provided a Digital Terrain Model (DTM) for all the hotspots, in some instances this was based upon LiDAR (which has a vertical accuracy of 5-15cm +/- RMSE and a

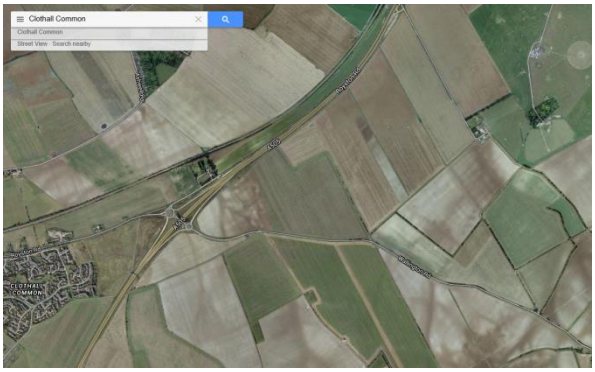
[9] Based on Table 6-1 in the Defra guidance, page 44 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf

horizontal accuracy of 40cm +/- RMSE), in others NEXTMap Height Data (which has a vertical accuracy of around 1m +/- RMSE and a horizontal accuracy of 2.5m +/- RMSE). In some instances a combination of sources were used to constructed the DTM, with preference given to the highest level of accuracy.

Prior to the commencement of the modelling, investigations were undertaken into ground truthing the DTM to ensure that any processing undertaken by others (e.g. the Environment Agency to construct their Risk of Flooding from Surface Water Maps) did not adversely impact the accuracy or level of resolution. These investigations established that the LiDAR part of the DTM was suitable for use across all hotspots where the data was available. However, questions were raised over the presence of small pit like features in some of the areas covered by the NEXTMap part of the DTM. One example of this is to the west of Clothall Common, Baldock, which is within North Hertfordshire District but the assessment was undertaken concurrently. At this location the features are observed to the east of the main hotspot, as shown in Figure 10, but are not visible in the aerial imagery or during site inspections. A representative area of the maximum flood depth of these pit like features was extracted in GIS and the volume within the raster extract calculated. The total area of the model domain with these features present was then estimated in comparison to the whole area. The volume of the extract was ratioed up to cover the affected area and this was compared to the whole model domain volume. These calculations suggested less than 2% of the volume was present in the pit like features, and therefore these features can be considered insignificant with respect to the overall model accuracy, given that no other appropriate DTM was readily available.



a) DTM extract



b) Google Aerial Image

Figure 10: Example of uncertainties in the DTM

SURVEY

A topographical survey was specified for each hotspot to enable the DTM to be refined and key elements within the flow path to be better represented within the model. Topographical survey generally included road levels and kerb heights in specific locations, footpath levels and some property thresholds.

BELOW GROUND INFRASTRUCTURE

The hydraulic models required a representation of the culverted watercourses and public surface water drainage network, as these networks can be complicated to model and limited data is available for some aspects (particularly the connectivity aspects of the highway drainage). The following aspects were included to provide a suitable level of representation within the strategic scale models:

→ Pipes equal to or greater than 225m

- Flow between the pipe network and the flood plain was represented by connectors at every pipe junction
- Pipe information was sourced from the sewage undertaker (i.e. Thames Water).
- Where information was missing or considered to be incorrect, engineering judgement was used to estimate the pipe direction, location or gradient.

LAND USE

The locations of land use features across the study area were identified through the incorporation of Ordnance Survey MasterMap data and the National Receptor Database to combine location with the type of building. This enabled temporary/outbuildings etc. to be removed from the modelling (i.e. buildings which are unlikely to be barriers to flow) in accordance with best practise. The mapping also enable varying roughness coefficients to be applied, along with ensuring that preferential flow paths (i.e. highways) were suitably represented, lowered by 125mm (the height of a standard kerb) and buildings raised by 300mm (a typical freeboard level). This is also in accordance with the updated Flood Map for Surface Water Modelling Guidance.

CONSIDERATIONS

Prior to and during the modelling process some elements were identified that required further consideration to ensure that they were suitably represented in the model. For instance at some hotspots there was a degree of uncertainty that could not be addressed through engineering judgement and modelling assumptions, these required further site specific investigations to establish linkages. These are detailed in each hotspot as applicable, these included a range of features, an example of which is the Cambridge Road Hotspot, where the sewer records were considered ambiguous when compared to the current land uses and the inferred discharge routes and mechanisms could no longer operate. To provide a suitable level of certainty for the modelling a separate investigation into the sewer connectivity was commissioned and undertaken by the surveyor. Model Approach

All the modelled hotspots use a direct rainfall approach. An ESTRY-TUFLOW (hydraulic modelling software) approach was preferentially undertaken as this combines an accurate 1D channel and pipe solver (with the allowance for complicated structures) with a 2D floodplain model based on a finite grid approach. The two solvers are dynamically linked, such that water can flow from the channel/pipe to the floodplain, and vice-versa. In some instances it was necessary to use other software packages such as InfoWorks ICM or Flood Modeller Pro; this was largely dependent on previous studies.

Hydrological analysis was undertaken with reference to the Flood Estimation Handbook (FEH) and the Flood Estimation Guidelines[1] to produce flow estimates following best practice techniques.

More information is provided in the modelling methodology reports (Appendix C) and individual model reports.

The hydraulic modelling provides estimates of flood risk in terms of extent, depth, velocity and hazard. Flood hazard is defined by the Environment Agency's Flood Risks to People Guidance Document[10] as being a function of depth and velocity with a debris factor and breaks the resulting hazards into four categories:

- Very low hazard – Less than 0.75 –Caution

[1] Published by the Environment Agency as Operational Instruction 197_08, Version 3 on 06/11/2009
[10] Defra/Environment Agency R&D Outputs: Flood Risks to People, Phase 2 FD2321/TR2

- Danger for some – 0.75 to 1.25 –includes children, the elderly and the infirm
- Danger for most – 1.25 to 2.0 –includes the general public
- Danger for all – More then 2.0 –includes the emergency services

6.3 MITIGATION OPTIONEERING

For each hotspot, a review of the flood extents and mechanisms was undertaken following completion of hydraulic modelling. From this review it was possible to determine the types of measures which could be implemented in each hotspot to mitigate the impacts and damage associated with flooding. At each hotspot several measures were identified and assessed as a first step in evaluating the various options to manage surface water flood risk in line with the SWMP objectives. The mitigation measures have not been modelled within the hydraulic models, given the strategic nature of this study. If the economic benefits are such that schemes are considered suitable for a funding application, detailed studies which will include further hydraulic modelling will be required,

The following categories of measures have been considered:

- Technical;
- Maintenance;
- Development, building control and policy;
- Awareness;
- Resilience;
- Other.

A measure is defined as a proposed individual action or procedure intended to minimise current and future surface water flood risk. An option (or options) is made up of a single, or a combination of defined measures.

The measures and options were discussed during meetings and site visits. Throughout this process the criteria in Table 3 were considered to ensure the options were viable and beneficial.

Table 3: Option criteria

CRITERIA	DESCRIPTION
Technical	Is it technically possible and buildable? Will it be robust and reliable?
Economic	Is it affordable and will benefits exceed costs?
Social	Is the option socially acceptable and in keeping with the local area.
Environmental	Is the option environmentally acceptable and in keeping with the local area and designations.
Objectives	Will it help to achieve the objectives set at the beginning of the SWMP?

In addition to the criteria in Table 3, it was 5 schemes certain land uses (e.g. cemeteries) are unsuitable for flood storage.

6.4 ECONOMIC ASSESSMENT

INTRODUCTION

Economic analysis has been undertaken to assess the predicted economic damages that may occur from flooding in each hotspot. This economic analysis is based on the current arrangements for management of surface water, and the benefits that may accrue from the proposed mitigation options. This has been undertaken to a level of detail which is suitable to inform inclusion of potential schemes within the Environment Agency's Medium Term Plan (MTP). It will also enable the LLFA to establish the order of priority for further assessment and implementation of the mitigation options across all SWMPs in Hertfordshire. The inclusion of schemes within the Environment Agency's MTP is the first step towards securing funding, once a scheme is included, further studies are undertaken to refine the assumptions and demonstrate its financial viability.

METHODOLOGY

The financial viability of a flood defence scheme is assessed by looking at the *Benefit Cost Ratio* (BCR) between the present value benefits and the present value costs. The *present value benefits*, is the *present value damages* (the damages that are forecast to be incurred over the assessment period, in this instance 100 years) minus the reduced damages that would be realised with the scheme in place through the prevention of flooding at events below the design threshold (standard of protection of the scheme). The *present value costs* are the costs associated with design and build along with maintenance of the scheme.

In all instances the present value is utilised as this provides a standardised approach for comparing the differing levels of investment that will be required to deliver and maintain the scheme, it also assumes that all the funding required for this is allocated at the approval stage of the scheme.

PRESENT VALUE DAMAGES

The calculation of economic damages from flooding has used the standard approaches and data of Flood and Costal Risk Management - A Manual for Economic Assessment (Flood Hazard Research Centre 2013)[11] and the 'Green Book' (HM Treasury, 2003)[12].

The properties shown by the hydraulic modelling to be within the main surface water flow paths have been identified using OS MasterMap and the National Receptor Database. The economic analysis assessment area for each hotspot is shown in the study area plans included in Appendix F.

This assessment has taken into account and monetised the direct damages to properties, the costs of evacuation, the costs to the emergency services, damages to parked vehicles at residential properties and the impact of flooding on human health. Other damages that have not been monetised include disruption of road traffic, disruption to rail traffic, risk to life, damage to utilities/highway etc.

Damages have only been calculated for the flood risk associated with the main surface water flow paths in each hotspot, for the mitigation specific standard of protection, which the SWMP will seek to address. Isolated flooding of properties within the hotspots outside of these areas have not been included as it is unlikely that any options proposed by the SWMP will be able to have any impact on reducing this type of flooding.

[11] https://www.mdx.ac.uk/our-research/centres/flood-hazard/projects/multi-coloured-manual
[12] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

Climate change has been incorporated into the assessment of damages to obtain present value damages that are expected to occur over the next 100 years. This has utilised the allowances for increases in peak rainfall intensity given by Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities (Environment Agency, 2016). This guidance gives a central and upper estimate of the expected change in peak rainfall intensity over the next 100 years. A conservative approach has been taken using the central estimate so that the economic damages from flooding are not overestimated.

PRESENT VALUE COSTS

Mitigation options were identified at a strategic scale for each hotspot and these are illustrated in the plans in Appendix E and discussed in the relevant parts of Section 6.3above. The likely requirements and impacts of the options were identified utilising engineering judgement. This has mainly been to identify the return period for which a standard of protection can be achieved, the associated properties that are likely to be removed from the flood risk area and the possible engineering intervention. The costs for the selected mitigation options have been developed through the use of the Environment Agency's Long Term Costing Tool.

7 DETAILED RISK ASSESSMENT - INVESTIGATION

7.1 DEFINITIONS

The Environment Agency use a variety of terms when describing the flood risk in their Risk of Flooding from Surface Water Maps, for consistency these have been adopted here when describing the risk in the baseline information section for each of the hotspots, these are:

- Very Low – means that each year, this area has a chance of flooding of less than 1 in 1000 (0.1%)
- Low – means that each year, this area has a chance of flooding of between 1 in 1000 (0.1%) and 1 in 100 (1%)
- Medium – means that each year, this area has a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3%)
- High - means that each year, this area has a chance of flooding of greater than 1 in 30 (3.3%)

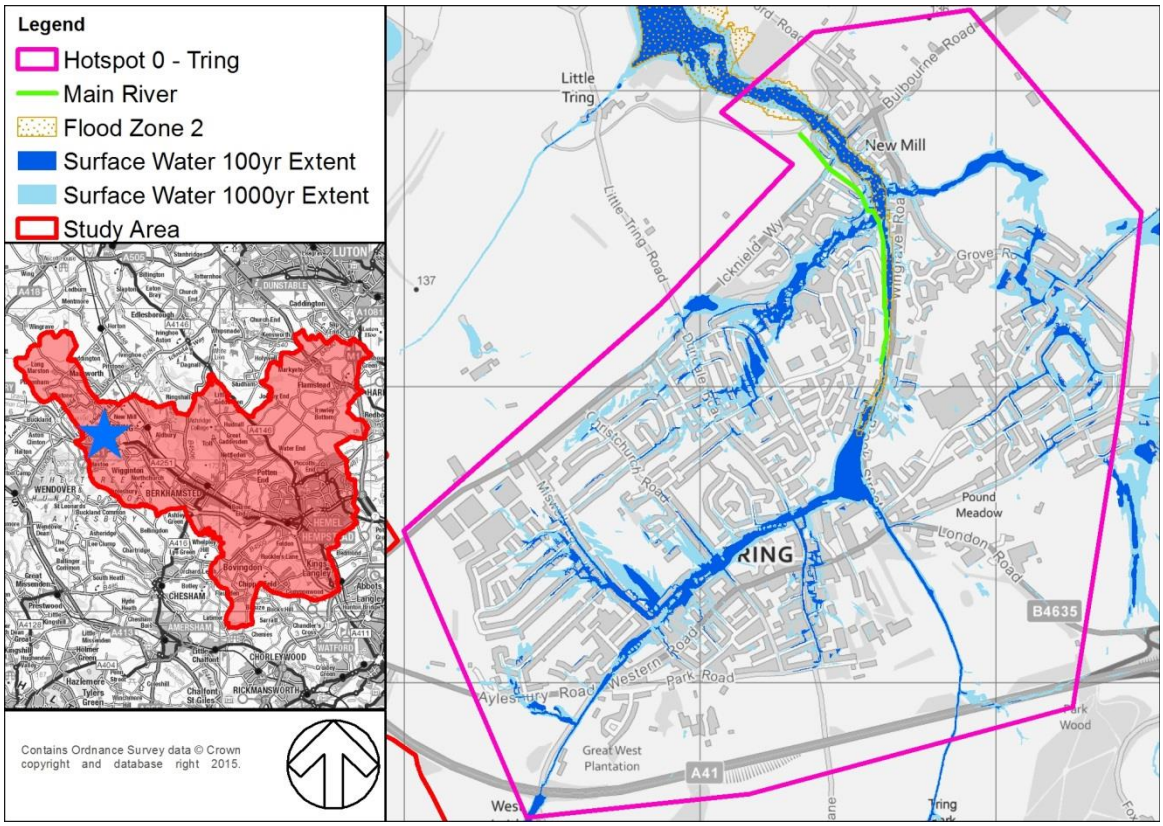
7.2 HOTSPOT 0 - TRING

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements (as shown in Figure 11):

- The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - Flooding along Brook Street, with an extensive area near Mill Gardens (medium to high risk).
  - Two overland flowpaths from the east and west which converge to the south and east of Icknield Way (B488).
  - A further flowpath is shown to enter the hotspot from the south.
- A detailed DTM (LiDAR) is not available for the whole hotspot; this means that lower accuracy predications of likely flooding will not be possible for the southern section.

Figure 11: Hotspot 0 – Tring – extents and baseline information



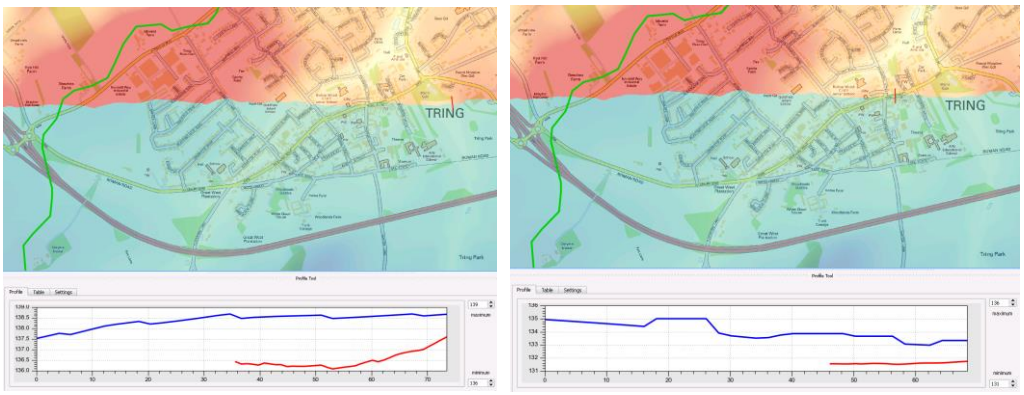
HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach. Given the LiDAR coverage is not sufficient for the whole study area two models were developed, one using the uFMfSW DTM for the whole study area, and the second using LiDAR for the available area.

KEY CONSTRAINTS

The LiDAR based DTM did not cover the whole study area, with coverage limited to areas north of the B4635 (Aylesbury Road/High Street) and Christchurch Road/Langdon Street roundabout. Investigations between the two DTMs were undertaken and established that they could not be combined to enable the development of one model. This is because there was a vertical disparity of over 2m across the study area, see Figure 12.

Figure 12: Difference in elevation between EA 1m LiDAR and uFMfSW DTM.



EA 1m LiDAR is shown in red, the uFMfSW DTM is shown in blue

Two models were therefore developed for this hotspot, with the flows from the southern model (i.e. using the less accurate DTM) extracted and input at the key flow paths to provide a more refined representation of the flood risks within the northern aspects of the study area. The maps are therefore a combination of both models, with an area of uncertainty between the two, due to the complexities of combining the outputs.

KEY LIMITATIONS AND ASSUMPTIONS

Other than the LiDAR coverage, previously discussed, the main limitation is associated with the culvert size and condition under The Old Silk Mill Trading Estate, which links a pond to the open watercourse downstream. The topographical survey identified this pipe at the upstream end as being 100mm, whereas the downstream end is 750mm. No CCTV was undertaken to confirm how the pipe varies or its condition. Therefore, the pipe has been modelled as a 32.8m length pipe at 100mm diameter going into a 228.5m length pipe at 750mm diameter

SENSITIVITY TESTING

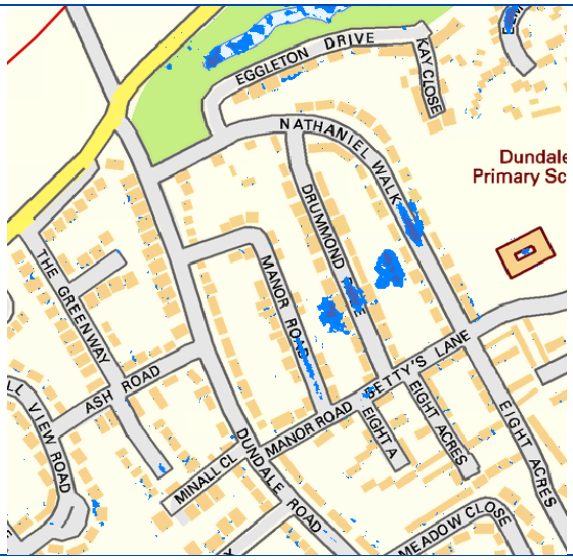
Sensitivity testing on The Old Silk Mill Trading Estate culvert was undertaken and the flood extents were not sensitive to the pipe size in this location.

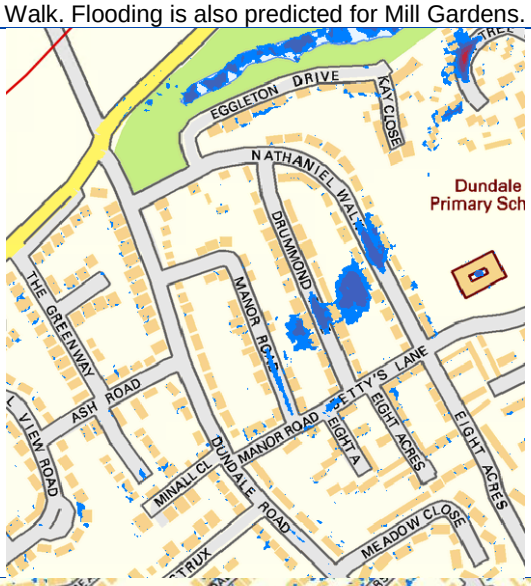
KEY FINDINGS

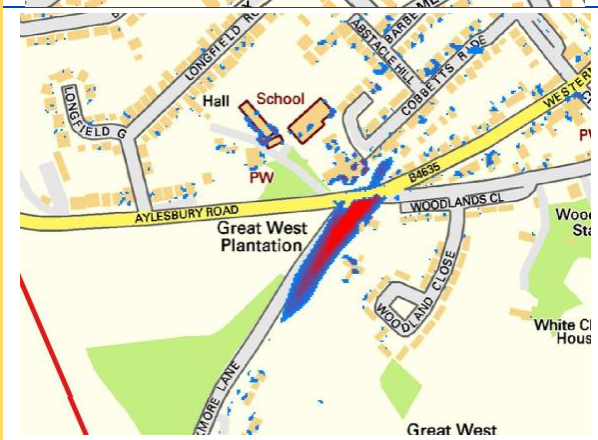
The key findings of the hydraulic modelling for the 1 in 30 and 1 in 100 year events are shown in Table 4; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 4: Key findings – Hotspot 0 - Tring

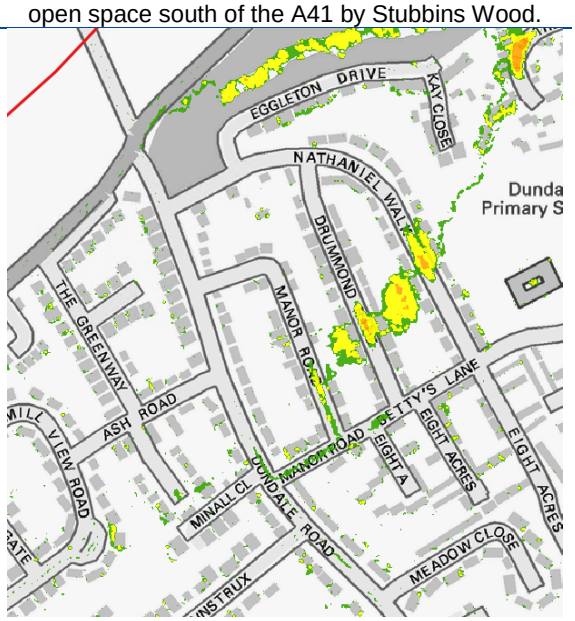
MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	Deep flooding (over 2m) predicted to the southwest of the hotspot at the junction of Aylesbury Road and Duckmore Lane. Some highly localised flooding is predicted on Manor Road, Drummond Ride and Nathaniel Walk.	The flood extents are similar to the 1 in 30 outlines, with a larger extent of flooding in the southern section, however, this is likely to be overstated given the accuracy of the DTM. Deeper flooding (maximum depth of 0.6m) and potential flooding of several properties is predicted on Manor Road, Drummond Ride and Nathaniel Walk. Flooding is also predicted for Mill Gardens.







MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Hazard	There is only one area showing as danger for most; this is Duckmore Lane.	Mill Gardens and Duckmore Lane are shown to range from danger for some to danger for most. There are small areas of danger for most around Manor Road, Drummond Ride and Nathaniel Walk. There are other areas of danger for most in public open space south of the A41 by Stubbins Wood.



POTENTIAL MITIGATION

Given the localised and limited nature of the flooding predicted within the hotspot; flooding only occurs in the downstream extent of the hotspot, in the open channel north of The Old Silk Mill Industrial Estate), an overriding mitigation scheme is not proposed. Mitigation measures which could be considered are:

- Ground truthing the flooding on Duckmore Lane and consideration of measures such as automated flood warning signs or drainage/profile improvements/modifications.
- Ensure that the residents on Manor Road, Drummond Ride and Nathaniel Walk are aware of the flow paths across their wider properties and maintain a flow route around their homes (i.e. through the gardens).

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the action plan:

- Further assessment/secure financing of mitigation measures outlined above to enable their implementation.
- Work with the Environment Agency to extend the LiDAR coverage of the hotspot, when neighbouring areas are being flown.
- Undertake CCTV analysis of the culvert under the Old Silk Mill Industrial Estate to confirm the size and condition.
- Ensure the highway gully maintenance programme is representative of the flood risks and preferential flow paths.
- Ensure that the pre-storm action plan includes the inlet of the culvert under the Old Silk Mill.
- Consideration of a CCTV camera on the inlet of the culvert under the Old Silk Mill to provide a permeant monitoring solution.

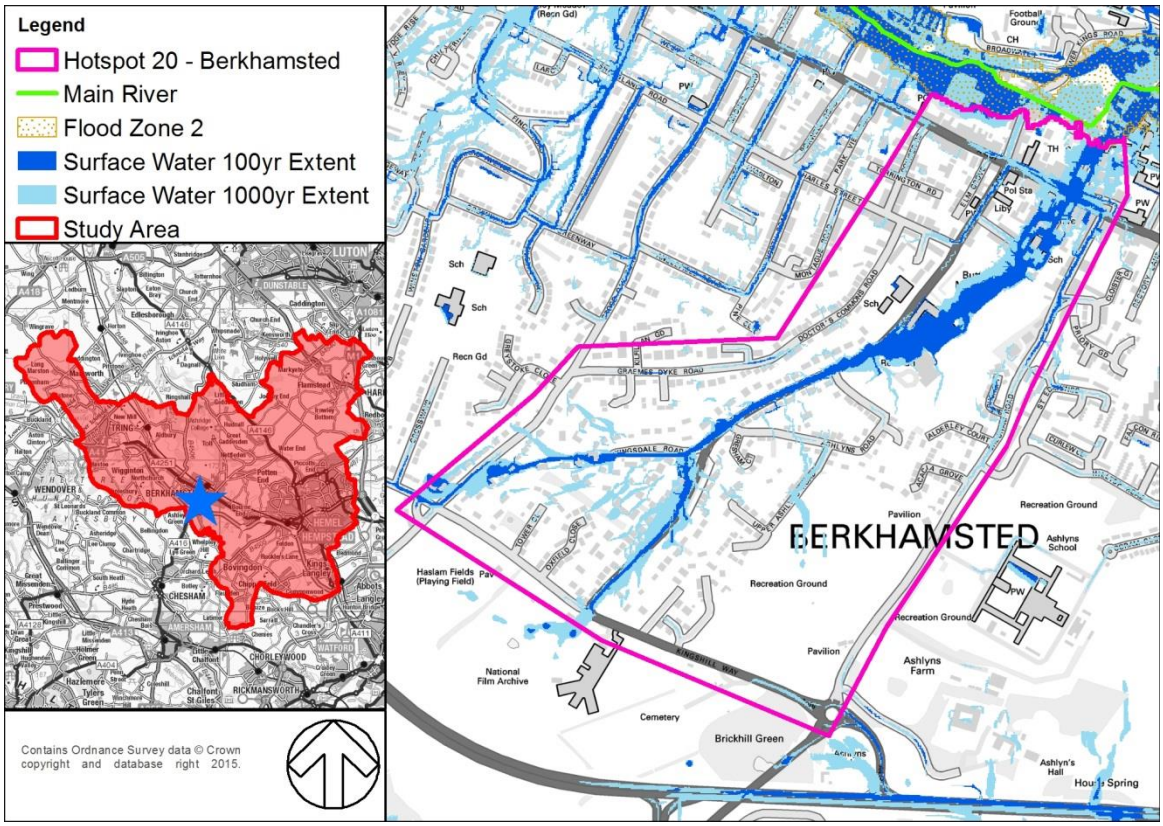
7.3 HOTSPOT 20 - BERKHAMSTED

KEY CONSIDERATIONS

This hotspot was selected for hydraulic modelling to refine the understanding of the following elements, as shown in Figure 13:

- The Environment Agency's Risk of Flooding from Surface Water map shows:
  - The preferential flowpath along Kings Road (A416) diverges from the road towards Berkhamsted School.
- A detailed DTM (LiDAR) is not available for the whole hotspot; this means that lower accuracy predictions of likely flooding will not be possible for the southern section.
- The stakeholders considered that it is important to understand the accuracy of the potential spilling of the flood waters off the highway and towards the school.
- The secondary aim with this hotspot is to refine their understanding of the approach required to interpret similar local instances in the national scale surface water flood mapping and the associated risks.
  - The method for hydraulic modelling has been designed to focus on the representation and associated accuracy of the preferential flow route; i.e. whether the flood waters leave Kings Road (A416) and flow through Berkhamsted School. This involved an assessment to if water remains on the highway or flows into the school and on to Butts Meadow Recreation Ground as suggested by the Risk of Flooding from Surface Water Map.

Figure 13: Hotspot 20 – Berkhamsted – extents and baseline information



HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach. Although the LiDAR coverage is not sufficient for the whole study area a single model has been developed utilising the uFMfSW DTM. The uFMfSW DTM includes a combination of LiDAR for the northern area and NEXTMap for the southern area. This was deemed sufficient, as the area covered by NEXTMap is not critical for the assessment purposes and is limited to upstream locations. The NEXTMap section of the uFMfSW is used to establish the flood flows and convey them into the primary area of interest, which is the area covered by the LiDAR section of the uFMfSW DTM.

KEY CONSTRAINTS

With the exception of the LiDAR, no other significant constraints with the model construction were observed.

KEY LIMITATIONS

The model is strategic in purpose; therefore, further information will need to be obtained regarding the flow paths, connectivity and constraints relating to the area downstream of Butts Green Recreation Ground if further assessment is required.

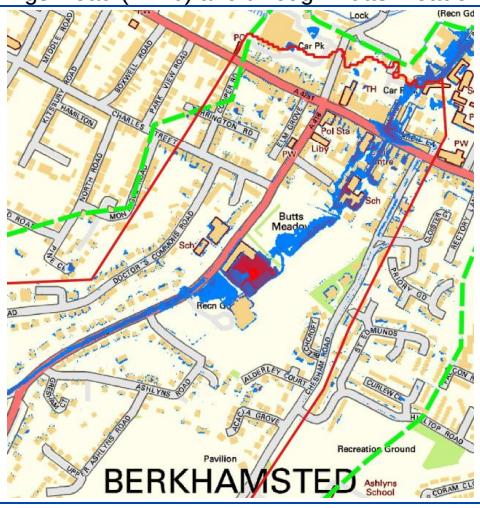
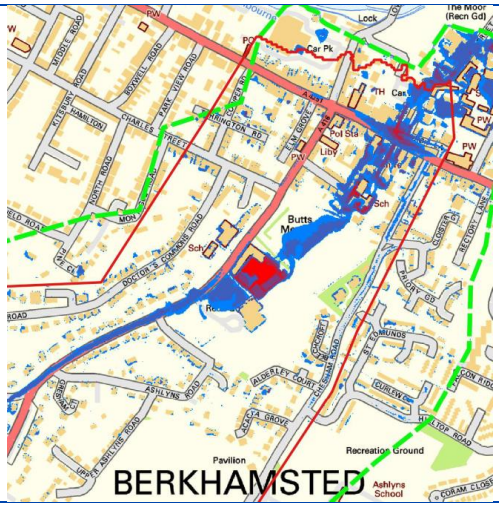
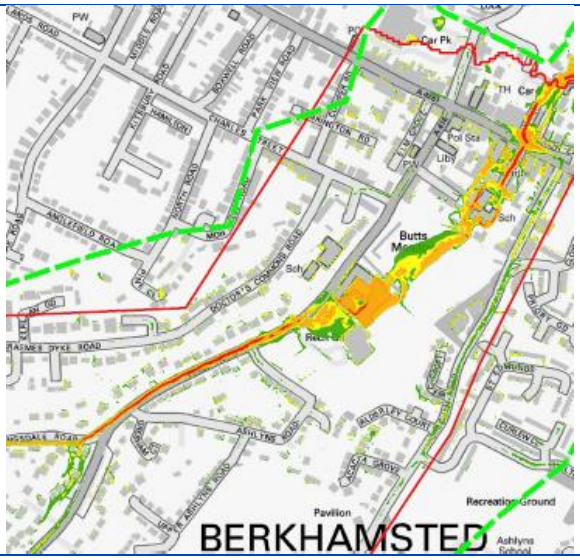
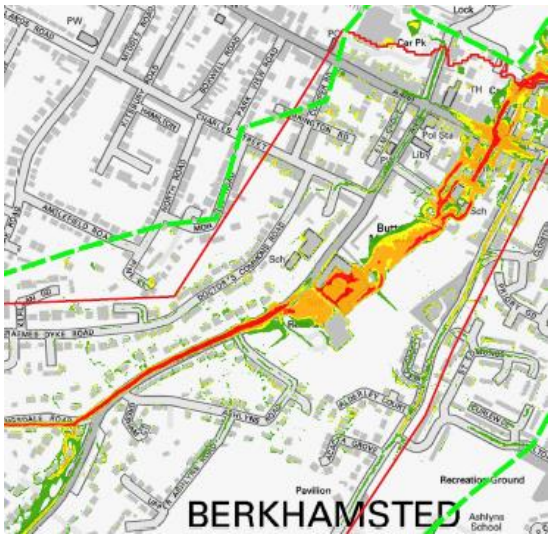
SENSITIVITY TESTING

Sensitivity testing was undertaken on roughness coefficients. The flood extents were not deemed to be overly sensitive to the changes in roughness. Figures of sensitivity analysis can be found in the individual model report in Appendix C.

KEY FINDINGS

The key findings of the hydraulic modelling are detailed in Table 5 for the 1 in 30 and 1 in 100 year events, snapshots of the key flooding extents are provided; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 5: Key findings – Hotspot 20 - Berkhamsted

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	Deep flooding (1.3m deep in the centre of the school) is predicted at Berkhamsted School / Butts Meadows. A flowpath of mainly shallow depth (maximum depth of 0.40m) is predicted to flow from the southwest of the hotspot, along Kings Road (A416) and through Butts Meadow.	The depth and extent of flooding at Berkhamsted School / Butts Meadows is slightly greater in the 1 in 100 year event. The extent of the flowpath along Kings Road (A416) is slightly larger.
		
Hazard	A large area of danger for some and danger for most is shown at Berkhamsted School. Much of the flow path along Kings Road (A416) is shown to be danger for all.	The majority of the flowpath from the southwest of the hotspot is shown to be danger for all. This extends into the school area. Extensive areas of danger for most are shown around Berkhamsted school and Butts Meadows.
		

POTENTIAL MITIGATION

As the surface water flowpath is still shown to flow through the school; as it does in the Risk of Flooding from Surface Water map, the following mitigation measures could be considered:

- Raise kerbs or a wall and speed bumps to keep water on Kings Road and so preventing it from flowing into Berkhamsted School.
- Insert a spill from Kings Road to Butts Meadows; here water can be stored by raising the footpath just upstream of the Victoria Church of England Infant and Nursery School. It will have to be designed as such so that surface water is not stored or does not spill into the school grounds.
- Ensure flowpath connectivity in the area downstream the High Street (A4251). Some Property Level Protection (PLP) measures may be needed in the properties in this area.
- A bund may help to achieve storage in the northern part of the catchment, in the area around the National Film Archive.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the action plan:

- Further assessment and secure funding to research further the mitigation measures outlined above to assess and enable their implementation,
- Encourage flood awareness and Property Level Protection (PLP) in areas of risk.
- Work with the Environment Agency to extend the LiDAR coverage of the hotspot, when neighbouring areas are being flown,
- Ensure the highway gully maintenance programme is representative of the flood risks and preferential flowpaths.

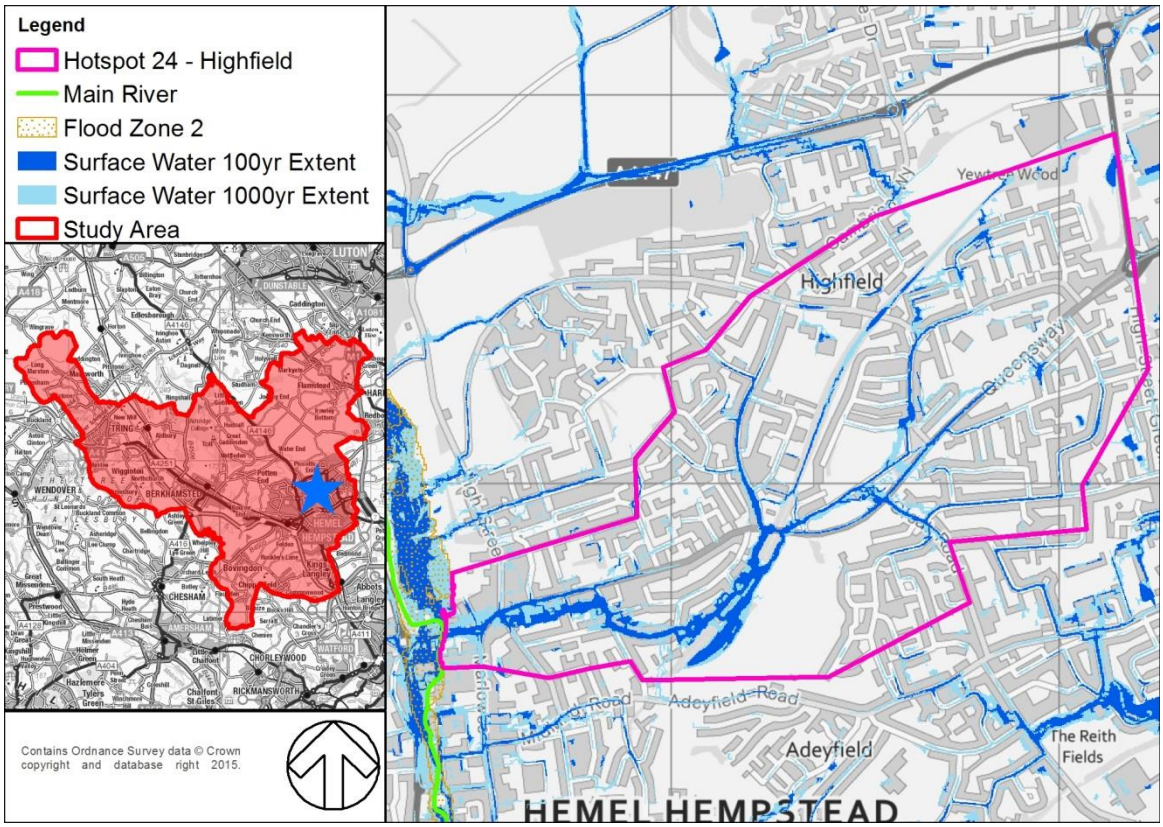
7.4 HOTSPOT 24 - HIGHFIELD, HEMEL HEMPSTEAD

KEY CONSIDERATIONS

It was decided that this area of Hemel Hempstead should be taken forward for hydraulic modelling. The main elements taken into consideration when determining the need for hydraulic modelling to refine the understanding of the flood extents and mechanisms were the following elements (as shown in Figure 14):

- The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - A medium to high risk of surface water flooding from overland flow paths across the hotspot,
  - The highway network acts as preferential flowpaths which spills into residential areas south of Queensway (B487) around the point where it is crossed by the disused railway crossing (the Nickey Line).
- The Environment Agency's Flood Map for Planning which shows:
  - An area of fluvial floodplain (Flood Zone 2) to the west of the hotspot.
- Potential for a risk of locking of the surface water sewer system as the water levels within the River Gade rise during a flood event potentially preventing surface water runoff from discharging at normal rates.

Figure 14: Hotspot 24 - Highfield, Hemel Hempstead – extents and baseline information



HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach utilising a LiDAR based DTM for the whole study area. The downstream end of the 2D model was set at a suitable location on Queensway (B487) around the Environment Agency floodplain and discharge restricted to fluvial levels for the 20% AEP event; extracted from the model provided by the Environment Agency model of the River Gade.

KEY CONSTRAINTS

No significant constraints with the model construction were observed.

KEY LIMITATIONS

The key limitations of this hydraulic model are the interactions with the fluvial flood plain and the area in Keen Fields where three flow pathways converge, both of which will require further investigations if a detailed mitigation model is to be developed.

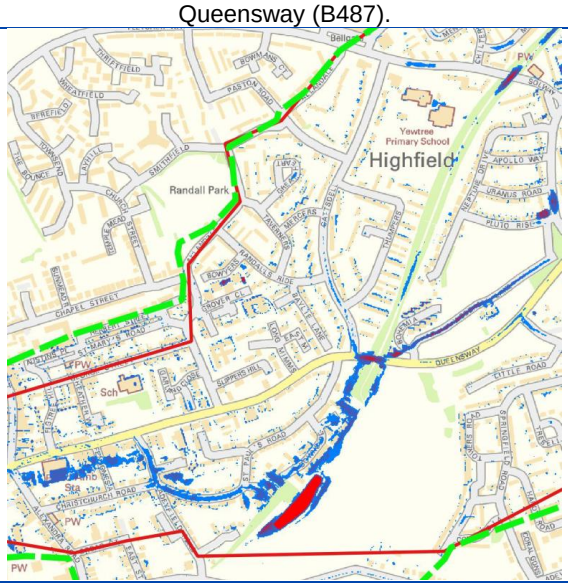
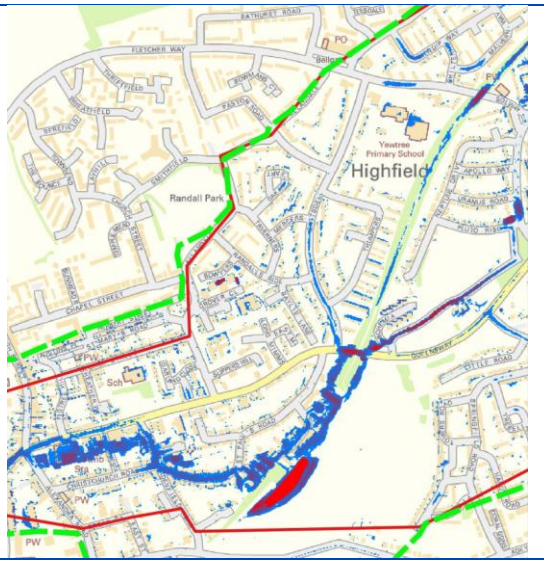
SENSITIVITY TESTING

In line with the modelling methodology, no sensitivity testing was undertaken on this hotspot.

KEY FINDINGS

The key findings of the hydraulic modelling are shown in Table 6 for the 1 in 30 and 1 in 100 year events, snapshots of the key flooding extents are provided in this table; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 6: Key findings – Hotspot 24 - Highfield, Hemel Hempstead

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	The main flowpath operating in this event is along Woodhall Lane to the east. Limited flood depths are observed on the other two flowpaths (Cattsdell (0.22m deep), Nickey Line (0.50m deep)). The model predicts ponding around the convergence area in Keen Fields, which then continues along St Paul's Road and the adjacent residential area to the south of Queensway (B487).	The three main flowpaths in this hotspot (from east to west - Woodhall Lane, the Nickey Line and Cattsdell) are all operating in this event. Flooding is predicted at the convergence location on the Queensway (B487) where it is crossed by the Nickey Line and immediately downstream in Keen Fields.
		
Hazard	The flood hazard is mostly classed as danger for most with a small area of danger for all along Woodhall Lane and the pond in Keen Fields. Downstream of Keen Fields the hazard is largely limited to the highway.	In this event the flood hazard has increased to danger for all along much of Woodhall Lane and St Paul's Road. Danger for most and danger for all is shown across the residential area in the south. The area around Keen Fields is also shown to be an area of danger for all.
		

POTENTIAL MITIGATION

Mitigation measures which could be considered for Highfield, Hemel Hempstead are outlined below and shown in Appendix E:

- Ensure that the highway can be and is utilised as a preferential flowpath on St Paul's Road and the surrounding estate roads to the south of Queensway (B487).
- Ensure that the Nickey Line (disused railway) is used as a preferential flowpath and incorporate blue corridor features to control and attenuate the flows and improve the wider environment.
- Separate flows east of the underpass on Queensway (B487) and re-profile land between Keen Fields and the Nickey Line to increase the available storage and control the discharge from this area. Opportunities could also be explored to divert water from Queensway (B487) into this area.
- In the southwest of the hotspot where flooding is predicted, ensure preferential flowpaths exist between properties and into the gardens.
- Work with the Fire and Ambulance Service to ensure operability of the Fire and Ambulance Station during flood events.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the action plan:

- Further assessment/secure financing of mitigation measures outlined above to enable their implementation.
- Installation of automatic flood warning signs on the Queensway (B487) at the Nickey Line crossing.
- Ensure the highway gully maintenance programme is representative of the flood risks and preferential flow paths.

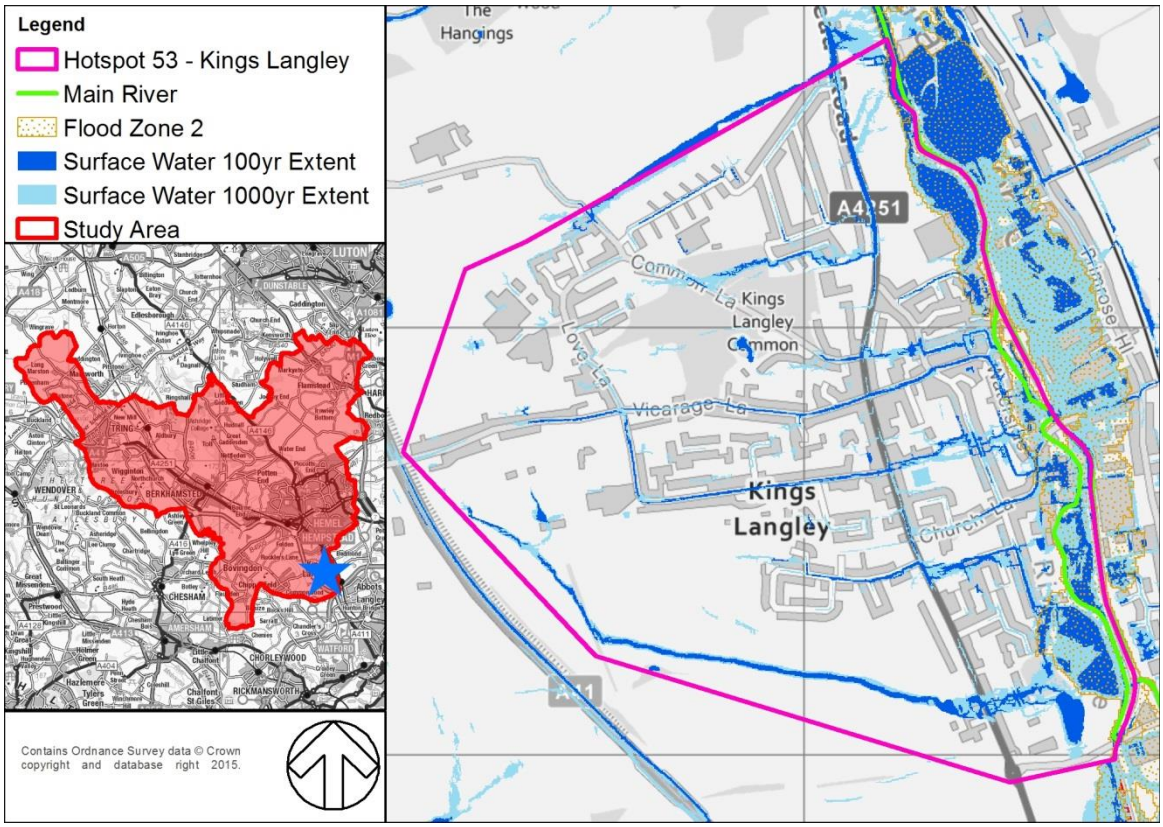
7.5 HOTSPOT 53 - KINGS LANGLEY

KEY CONSIDERATIONS

It was decided that Kings Langley should be taken forward for hydraulic modelling. The main elements taken into consideration when determining the need for hydraulic modelling to refine the understanding of the flood extents and mechanisms were the following elements (as shown in Figure 15):

- Historical flood records
- The Environment Agency's Risk of Flooding from Surface Water map which shows:
  - Medium to high risk of flooding along overland flow paths across the hotspot that utilise the highway network as preferential flow paths.
- The Environment Agency's Flood Map for Planning which shows:
  - Flood Zone 2 to the east of the hotspot which forms the downstream boundary.
- A potential risk of locking of the surface water sewer system as it discharges into the River Gade / Grand Union Canal.

Figure 15: Hotspot 53 - Kings Langley – extents and baseline information



HYDRAULIC MODEL SUMMARY

The model has been developed in ESTRY-TUFLOW with a direct rainfall approach utilising a LiDAR based DTM for the whole study area. The downstream boundary was been defined as the 20% AEP fluvial boundary; extracted from the Environment Agency River Gade draft model (defended scenario).

KEY CONSTRAINTS

No significant constraints with the model construction were observed.

KEY LIMITATIONS

The main limitations are the connectivity and flow paths around the fishing lake in the south, along with the representation required for the flow paths into the River Gade / Grand Union Canal.

SENSITIVITY TESTING

In line with the modelling methodology, no sensitivity testing was undertaken on this hotspot.

KEY FINDINGS

The key findings of the hydraulic modelling are shown in Table 7, for the 1 in 30 and 1 in 100 year events, snapshots of the key flooding extents are provided in this table; mapping of the whole hotspot is in Appendix D, which provides better resolution maps and a legend.

Table 7: Key findings – Hotspot 53 - Kings Langley

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
Flood Depth	In this event flooding is predicted in two key locations, both of which are adjacent to the Grand Union Canal/River Gade. One are is in the north of the village at Rectory Farm and the other in the southeast of the village around the fishing lake. Other areas of flooding, which are more limited in extent are predicted to the west of Station Footpath and to the west of the A4251.	In this event flooding is predicted in the same locations, although the depth has increased. Relatively deep flooding (maximum depth 1.4 m) is predicted to the west of the Grand Union Canal/River Gade.
Hazard	There is an area of mainly danger for some shown for the flooding area to the north of the village, likewise there are areas of danger for most and danger for all to the west of Station Footpath and the A4251, respectively. The flowpaths along Vicarage Lane, The Nap, Mill Lane, Langley Hill, and a small stretch of the A4251 are shown to be areas of danger for some and danger for most.	For this return period, the areas in which flooding is predicted are shown as danger for most. The area of danger for most predicted to the west of Station Footpath, has increased in size. An area of danger for all is located to the west of the A4251, although this is associated with a pond. The other flowpaths in this hotspot remain largely similar to the 1 in 30 year event, and are shown to be danger for most.

MAP	1 IN 30 YEAR EVENT	1 IN 100 YEAR EVENT
		
		

POTENTIAL MITIGATION

Potential mitigation measures which could be considered for Kings Langley are outlined below and shown in Appendix E:

- Ensure that a preferential flowpath exists along the highway network to facilitate flow conveyance along Langley Hill.
- Improve drainage connectivity to the river in the east of the hotspot near the industrial estate and ensuring that a flap valve is in place.
- Install an interception ditch in the southeast of the hotspot to divert water into the river.
- Formalise/increase capacity of the storage area in Wayside Farm.
- Install an interception ditch to the west of Blackwell Road to intercept water before it reaches properties.

RECOMMENDATIONS

The following recommendations are made for further consideration of this site and for inclusion within the action plan:

- Further assessment and secure funding to research further the mitigation measures outlined above to assess and enable their implementation.
- Encourage flood awareness and Property Level Protection (PLP) in areas of risk.
- Ensure the highway gully maintenance programme is representative of the flood risks and preferential flowpaths.

8 VIABILITY SUMMARY

The results of the baseline economic analysis for each hotspot are summarised in Table 8. This illustrates the number of properties currently at risk of internal flooding, in line with the Environment Agency's bands for economic assessment.

Table 8: Number of properties at risk of flooding

HOTSPOT	PROPERTIES AT RISK OF FLOODING		
	VERY SIGNIFICANT (>5% AEP)	SIGNIFICANT (5% – 1.33% AEP)	MODERATE (1.33% – 0.5% AEP)
0 - Tring	2	3	22
20 - Berkhamsted	3	7	110
24 - Highfield, Hemel Hempstead	8	49	209
53 - Kings Langley	9	26	243

The results of the mitigation option economic analysis for each hotspot are summarised in Table 9. This illustrates the expected present value economic damages from flooding over a 100 year period. It also provides the present value benefits and costs associated with the mitigation options that have been considered at each hotspot. For each mitigation option the Benefit Cost Ratio is provided to demonstrate its viability. When considering the findings of the economic assessment it needs to be considered that this has been undertaken at a strategic scale and the associated benefit cost ratio will be refined as the scheme is progressed through later stages of the funding process, where greater information is available on the local flood mechanisms and associated depths, along with the associated mitigation requirements and cost.

Each mitigation option as identified in Section 7 was assigned a standard of protection, below which it is considered, through engineering judgement, that property flooding would be alleviated. The area which would benefit from the mitigation scheme, the 'benefit area' is identified in the Option Maps (Appendix E).

Table 9: Baseline and mitigation options economic damages

HOTSPOT	MITIGATION OPTION	PRESENT VALUE DAMAGED (£)	PRESENT VALUE BENEFITS (£)	PRESENT VALUE COSTS (£)	BC-RATIO
0 -Tring	Baseline	4,740,000			
	No option identified	N/a			
20 - Berkhamsted	Baseline	24,780,000			
	75 yr SoP for all benefit areas (construction scheme)	11,592,000	13,188,000	5,904,000	2.2

HOTSPOT	MITIGATION OPTION	PRESENT VALUE DAMAGED (£)	PRESENT VALUE BENEFITS (£)	PRESENT VALUE COSTS (£)	BC-RATIO
	75yr SoP for all benefit areas (Property Level Measures)		13,188,000	4,987,000	2.6
24 - Highfield, Hemel Hempstead	Baseline	32,000,000			
	30yr SoP for all benefit areas	14,048,000	17,952,000	1,658,000	10.8
	75yr SoP for all benefit areas	12,561,000	19,439,000	2,294,000	8.5
53 - Kings Langley	Baseline	38,890,000			
	30yr SoP for northern benefit area	36,382,000	2,510,000	150,000	16.8
	30yr SoP for central benefit area	37,888,000	1,002,000	151,000	6.6

The viability assessment demonstrates that all the proposed mitigation options are economically viable, as the benefit cost ratio is greater than 1. Further work will be required to consider the costs for the Kings Langley southern benefit area prior to any further assessment works being undertaken as should the land not be freely available or other currently unforeseen elements be encountered then the benefit cost ratio could drop below 1, at which point schemes are not considered economically viable.

To secure FCERM GiA funding then a benefit cost ratio of 10-14 would normally be expected, however, this is dependent upon the competing schemes. This combined with the current funding process which aims to get third party funding (which could be from Local Levy) then the majority of the schemes will not be viable without attracting additional funds. The types and availability of these additional funding streams are discussed in the following section (Section 9).

9 FUNDING

The hydraulic modelling and optioneering phases have identified a range of potential mitigation measures that could be implemented to help reduce flood risk. Where these measures are the promotion of capital local flood risk management schemes, the delivery depends on sufficient funding being available, either from ongoing revenue funding or project based support for capital schemes.

The funding available for any measure will be linked to the outcomes it will provide. Measures that deliver benefits beyond flood risk management, such as enhanced ecosystems, public amenity, economic growth or cultural heritage, are likely to attract funding from alternative sources beyond those typically used to support flood risk management. Funding is therefore based on the economic viability of schemes; not all potential flood alleviation schemes will be viable and not all will achieve funding.

This chapter describes the available sources of funding that could be used to support the measures previously identified. Hertfordshire County Council have already achieved funding for flood risk projects from various sources, including Local Levy and Grant in Aid. HCC as the LLFA also receives separate funding from government to fund delivery of their statutory duties under the Flood and Water Management Act (2010). This is separate from the funding described in the following sections that are focused on delivery of specific flood risk management schemes.

9.1 NATIONAL FUNDING

FLOOD AND COASTAL EROSION RISK MANAGEMENT GRANT IN AID FUNDING

Defra has the national policy responsibility for Flood and Coastal Erosion Risk Management (FCERM) and provides funding through Grant in Aid (GiA) to the Environment Agency, who then administer grants for capital projects; Risk Management Authorities (RMAs), such as Hertfordshire County Council as LLFA, are able to request FCERM GiA.

A contribution to flood risk management schemes from the Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) funding will be provided whenever there is a positive ratio of benefit to cost. However, a positive ratio does not necessitate full funding and the formula determines the amount of Central Government funds based on the calculated ratio.

Funding levels for each scheme are linked to the number of households protected, the damages prevented, environmental benefits, amenity improvements, agricultural productivity and economic benefits. The payment rates for household protection will vary depending on the index of multiple deprivation; with more deprived households receiving higher payment rates. This ensures that schemes identified within poorer areas are more likely to receive full funding from Central Government.

The calculation of funds to be provided by FCERM GiA is as follows[13]:

[13] Taken from the Framework to assist the development of the Local Strategy for Flood Risk Management, 2nd Edition (Local Government Association, 2011)

$$\text{Share of costs funded by Defra} = \frac{\text{Household benefits + other whole-life benefits + environmental outcomes}}{\text{Amount of funding required}} \times \text{Fixed payment rates}$$

The benefit of this approach is that more schemes will be eligible for some national funding including minor schemes and those not solely related to fluvial and/or surface flooding. However, it will be more difficult to obtain 100% funding from national sources and therefore cost saving measures and other sources of funding are likely to be required to ensure that the scheme is fully funded.

9.2 REGIONAL FUNDING

LOCAL LEVY

Local Levy funding is an additional locally-raised source of income, gathered by way of a levy on Local Authorities and collected via the council tax. The levy is used to support (with the approval of the Regional Flood and Coastal Committee) flood risk management projects that are not considered to be national priorities and hence do not attract national funding through FCERM GiA. Alternatively, local levy funding can be applied to FCERM GiA projects, at the discretion of the Regional Flood and Coastal Committee (RFCC), to meet the partnership funding requirements. Each RFCC annually sets the level of local authority funding that local authorities will contribute in the following year.

Hertfordshire is covered by the Thames and Anglian Central RFCC. Each RFCC collects Local Levy funds from the county, which are used to contribute towards locally important flood risk management schemes across their areas of responsibility.

To obtain these funds it is important to engage with the RFCC early in the allocation process once possible schemes have been identified. To facilitate this officers and elected members from the council attend and are part of the RFCC.

9.3 LOCAL FUNDING

Depending on the shortfall from FCERM GiA and the number of schemes competing for the RFCC's allocation, it is possible that the Local Levy will not solely provide all the required funding for a scheme and therefore other measures could be explored in the future if necessary.

Potential sources of local funding could include:

- **Section 106 Agreements**, in accordance with the Local Planning Authority – this is a contribution, linked to specific developments and the related infrastructure required to make them acceptable in planning terms.
- **Community Infrastructure Levy (CIL)** – this is a sum levied upon development in line with a locally set charging schedule to be used by local authorities to provide the necessary infrastructure to support development generally.
  - Currently only four of the ten districts in Hertfordshire (Dacorum, Hertsmere, Three Rivers, and Watford) have adopted CIL charging schedules.
  - Where there is a neighbourhood plan in place the parish or town council are eligible for 25% of the CIL charge relating to a development in the plan area.
- **Local Authority Funding** – for capital schemes funded through Council Tax and Revenue Support Grant. Where there is benefit to business, Business Rates levies and Business Improvement Districts could provide source funding.

→ **Private Funding Sources** – Landowners, Natural England and other relevant agencies in some circumstances may be willing to contribute funds to flood risk management where they can see a direct benefit to reducing their flood risk or improving their land drainage.

9.4 COMBINATION OF FUNDING SOURCES

The preferred approach for funding schemes is to use a variety of funding sources. No flood risk mitigation schemes proposed in this SWMP are likely to have sufficient benefits to be 100% funded through the FCERM GiA system. The use of multiple and combined sources of funding is shown in the Figure 16[14] below as "Payment for Outcomes (anticipated)".

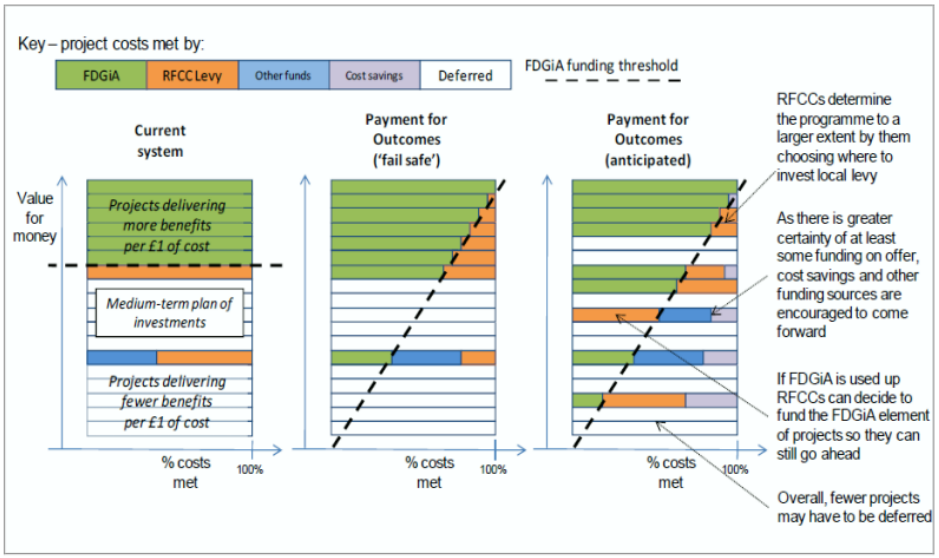


Figure 16: Combination of possible different funding sources to cover costs of flood risk management schemes

9.5 FUNDING CONCLUSIONS

The economic assessment finds that five of the recommended schemes across three hotspots are considered sufficiently viable to be submitted to the Environment Agency for inclusion on their MTP and further assessments undertaken to refine the schemes to a level suitable for a formal funding application (Project Appraisal Report). For these schemes HCC are likely to need to work with key stakeholders in Hertfordshire to secure additional third party funds to ensure the schemes to have sufficient funding for delivery. Alternatively, smaller more localised schemes could be considered as part of current operational and capital work streams.

[14] Taken from the Framework to assist the development of the Local Strategy for Flood Risk Management, 2nd Edition (Local Government Association, 2011)

10 IMPLEMENTATION AND REVIEW

The Surface Water Management Plan (SWMP) is to be a living document that should be reviewed approximately every five years, to ensure the correct implementation of the agreed actions and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, new modelling techniques are developed or when there is a change of policy.

The SWMP will be used as an evidence base for the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire. It will inform the Local Plan and lead the direction of flood risk projects within each district and borough.

10.1 ACTION PLAN

The Action Plan for each hotspot details recommendations for options to be explored further. This is then accompanied by the actions that will be needed as part of the further investigation, after the completion of this SWMP. The Action Plan is targeted towards each of the assessed hotspots and provides a summary of all the mitigation measures that are likely to lead to a reduction in flood risk if they are implemented. As many of these actions are likely to require capital costs to be implemented, funding will need to be secured to fully investigate their feasibility.

The further investigation for any options involving construction works will likely require the development of a detailed study, refining the assumptions and undertaking hydraulic modelling of the option in order to verify the approaches adopted within this strategic study. This detailed study will also enable a better understanding of the baseline risk prior to testing a range of mitigation measures to determine the best option in both economic and environmental terms.

The stages that would be involved in this process are outlined in Table 10, during this process community involvement should be considered at each stage to ensure that they have a greater stake in project design and delivery at an early stage of flood risk management schemes and ownership of the final solution. Other elements which will run throughout are consideration of how the scheme will be funded and how to maximise the environmental benefits and reduce the impacts of flooding.

Table 10: Further assessment phases

TIME	ACTION	REASON/WHAT IS NEEDED FOR THIS?
	County Wide Priority Site Review	HCC LLFA team to review priority sites from this SWMP in conjunction with other SWMPS to determine the list of overall priority sites.
	Determine Workstream	HCC LLFA team to determine the approach for incorporating SWMP findings in overall deliverables.
	Agree Funding Approach	Assess Third Party funding options, FCERM GiA, HCC or contributions from stakeholders.
	Set up project Steering Group	Co-ordinated approach between the EA, HCC, DBC, TW and other stakeholders.
	Appoint Project Team	Consult with stakeholders involved. This should include, if necessary, consultants.
	Undertake further studies	Undertake modelling and further studies to fully understand surface water flooding issues at the site. Any surveys required to facilitate and future mitigation solutions or modelling are to also be undertaken (i.e. soakaway tests / topographical surveys etc.).
	Mitigation Review	Based on the results of the further studies review mitigation options and confirm adopting authority (LLFA, HH, DBC, TW).
	Economic Viability	Undertaken a review of the economic assessment for the updated mitigation studies.
	Funding	Identify and maximise all other funding sources including CIL, local authorities, environmental funding, and other external organisations.
	Supplementary Studies	Undertake any additional studies (ecology / site investigations/ additional topographical surveys).
	Apply for Funding	Apply for funding.
	Detailed Design	Undertake detail design of proposed mitigation and gain approvals from the LPA, regulators and adopting authorities.
	Tender	Issue proposed design for tender.
	Appoint Contractor	A rigorous selection programme.
	Construction	Construction and final approval (including amending the flood map).

10.2 EMERGENCY PLANNING

The findings from the SWMP should be used to inform the Major Incident Plan and improve the Multi Agency Flood Plan.

The findings and outputs of the SWMP such as the flood hazard maps should be used to inform the emergency plan for Hertfordshire in terms of drainage and flooding issues. This should include the identification of properties within the floodplain inhabited by vulnerable people, to ensure they are prioritised should evacuation be required.

The Multi Agency Flood Plan which will assess flood risk in terms of Health, Social, Economic and Environmental issues.

10.3 NEXT STEPS

Hertfordshire County Council, as LLFA, will prioritise the actions of this SWMP. Outcomes of this SWMP will need to be undertaken in conjunction with the LFRMS and HCCs role as LLFA. This will lead to a prioritisation of actions into their workstream, which includes the findings of other SWMPs and Section 19 Flood Investigations, amongst other aspects of the LLFA role.

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

The SWMP should be used to inform and advise the Plans and Policies for the area and emergency planning as well as inform local planning decisions.

A program of further works to include implementation of the elements within the action plan should be prepared and a provisional timetable for completing follow up actions should be agreed. As a SWMP study is considered to be a long-term plan, all stakeholders should continue to work together after the SWMP study has been completed.

The SWMP will inform the LLFA workstream as well as a range of further studies/measures which will include:

- LFRMS evidence base;
- Focus for future projects;
- Strategy for local flood risk management in each district/borough.

11 CONCLUSIONS

WSP | Parsons Brinckerhoff has completed a Surface Water Management Plan (SWMP) for the Borough of Dacorum on behalf of Hertfordshire County Council, as Lead Local Flood Authority. The study has been undertaken in consultation with key stakeholders who are responsible for surface water management and drainage in the area. This SWMP has worked with key stakeholders to understand the causes and effects of surface water flooding and agree the most cost effective processes of managing surface water flood risk for the long term. This SWMP has been 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.

The Defra SWMP Technical Guidance (2010) suggests that a SWMP study will not be required in all locations but rather where areas are "considered to be at greatest risk of surface water flooding or where partnership working is considered essential to both understand and address surface water flooding concerns".

The first stage of the Dacorum Borough SWMP was the Preparation Phase; this identified the need for the SWMP. The need for the SWMP was identified within the Local Flood Risk Management Strategy (LFRMS) for Hertfordshire 2013-2016[15]. The SWMP study was then scoped and the aims and objectives set. The level of assessment needed was identified, as well as the identification of the available information.

The second stage of the SWMP was the Risk Assessment Phase, this was undertaken in two parts; the first, a Strategic and Intermediate Assessment, and the second, a Detailed Assessment. The principle purpose of the Strategic and Intermediate assessment was to identify broad locations which were considered to be vulnerable to surface water flooding. This was undertaken using the best information available, including some GIS analytical techniques. Potential hotspots (areas perceived and identified locally as being at greatest risk of surface water flooding) were identified from this information, and information made available from stakeholders. This list of hotspots was presented to the key stakeholders for discussion and finalisation. It was determined that four were to be taken forward to Detailed Assessment.

The Detailed Assessment part of the SWMP involved detailed hydraulic modelling. Individual hotspot models were constructed to assess the baseline flood mechanisms, pathways and extents. Following the hydraulic modelling, a review of the revised flood extents was undertaken and the numbers of properties in the flood plain determined. From this review it was possible to determine the type of mitigation measures which could be possible to implement for each hotspot to reduce the impacts and damage associated with flooding.

During the Preparation Phase of the SWMP when the objectives were set, one of the aims of this SWMP for the Borough of Dacorum was to determine the economic viability of mitigation schemes. This was undertaken to ensure that HCC could prioritise their future work to focus on measures which not only would reduce flood risk but also be the most attractive in securing funding to facilitate their construction.

All suggested options are considered to be economically viable; however, those with higher cost benefit ratios, third party contributions or demonstrable history of flooding should be progressed first, as these are most likely to attract funding.

[15] Local Flood Risk Management Strategy for Hertfordshire, available at: http://www.hertfordshire.gov.uk/services/envplan/water/floods/floodrisk/lfrmsherts/

The final phase of the SWMP is the Implementation and Review Phase. During this phase an Action Plan is prepared. Action Plans have been developed to cover the measures identified in the Strategic and Intermediate Assessment, and the Detailed Assessment. The detailed action plan is accompanied by a workstream which identifies the process that would need to be undertaken for each element in order to acquire the capital funds to facilitate its implementation.

This Surface Water Management Plan for the Borough of Dacorum is to be a living document that should be reviewed approximately every five years, to ensure the implementation of the agreed actions is correct and that any new issues are addressed. A review may be required following any new flood event, when new flood data becomes available, or new modelling techniques are developed, and when there is a change of policy, which affects the borough.