Hertfordshire County Council
Flood Investigation Report
Acorn Street, Hunsdon
Hertfordshire

Acorn Street in 2010
Aerial Photography © GeoPerspectives.co.uk

Hertfordshire

Table of Contents

Table of Figures

Table of Tables

Revision Schedule

Hertfordshire County Council
Acorn Street, Hunsdon Flood Investigation Report

January 2017
Revision 5 FINAL

Rev	Date	Details	Author	Checked and Approved by
1	27/10/16	For internal FRM team consultation.	Ryan Thomas Partnership Scheme and Development Officer	Andy Hardstaff Flood Risk Management Team Leader HCC
2	10/11/2016	Draft for issue to Risk Management Authorities following comments from FRM team.	Ryan Thomas Partnership Scheme and Development Officer	John Rumble Head of Environmental Resource Planning HCC
3	25/11/2016	Draft for issue to resident and Risk Management Authorities following comments from RMAs.	Ryan Thomas Partnership Scheme and Development Officer	John Rumble Head of Environmental Resource Planning HCC
4	13/12/2016	Edited following consultation with local residents	James Lester Flood Risk Management Project Officer	Ryan Thomas Partnership Scheme and Development Officer
5	20/01/2017	Reviewed	Ryan Thomas Partnership Scheme and Development Officer	Andy Hardstaff Flood Risk Management Team Leader HCC
6	14/02/2017	Final	Ryan Thomas Partnership Scheme and Development Officer	John Rumble Head of Environmental Resource Planning HCC

Explanation of Acronyms

Acronym / Term	Explanation
Adopted Highway	The term has been used in this report to include all highways maintainable at public expense. This includes historic highways as well as those formally adopted through Section 38 of the Highways Act 1980 and preceding powers.
Antecedent	Antecedent moisture is a term that describes the relative wetness or dryness of a catchment, which changes continuously and can have a very significant effect on the flows during wet weather. Antecedent moisture conditions are high when there has been a lot of recent rainfall and the ground is moist. Antecedent moisture conditions are low when there has been little rainfall and the ground becomes dry.
Bund	An embankment which acts as a flood barrier
EHDC	**East Hertfordshire District Council**
FDGiA	**Flood Defence Grand in Aid** – A form of funding for flood and coastal defences which Risk Management Authorities can apply for. Flood and coastal erosion risk management (FCERM) projects and strategies must have technical and financial approval from the Environment Agency before RMAs can claim and spend FCERM grant in aid.
FWMA 2010	**Flood and Water Management Act 2010** – Legislation that was developed and enacted as a result of the review in to the serious flooding in 2007. It brings new powers and duties to local authorities and other regulatory bodies.
HA 1980	**Highways Act 1980** – Legislation that deals with the management and operation of the road network in England and Wales.
HCC	**Hertfordshire County Council**
LDA 1991	**Land Drainage Act 1991** – Legislation that sets out a range of roles and responsibilities relating to flood risk management. It is also the legislation that gives powers to local authorities to manage flood risk and highlights the role of the landowner to manage watercourses on their land to maintain the flow of water.
LLFA	**Lead Local Flood Authority** – This is the role assigned to the unitary or county council for an area with a range of duties and powers to support the management of local flood risk.
LPA	**Local Planning Authority** – This is the local authority or council responsible for deciding whether a development, anything from an extension on a house to a new shopping centre, should go ahead. For Hertfordshire these Local Planning Authorities are the district and borough councils.
PLP	**Property Level Protection** – measures residents can take to protect their properties from flooding.
RMAs	**Risk Management Authorities** – Bodies identified in the FWMA 2010 with roles and powers to manage flood risk. In Hertfordshire this includes the County Council, district councils, Highway Authority, the Environment Agency, the Bedfordshire and River Ivel Internal Drainage Board and water companies.

Executive Summary

This document is the report of the findings of the investigation into the flooding of a property and section of Acorn Street in Hunsdon that took place in February 2014. It identifies the flood mechanisms, the relevant flood risk management authorities and what flood management functions has exercised as per Section 19 (1) of the Flood and Water Management Act 2010. Mitigations have also been explored to understand the potential out of any works that could be undertaken to reduce flood risk at this location.

Flooding to this area of Acorn Street, Hunsdon, during the 2014 flood events was caused by fluvial (watercourse) and pluvial (surface) water flooding. Internal property damage was caused by the flood event. Numerous flood events have affected the area prior to the 2014 flood event, with events recorded since 2004. These have been from watercourse and pluvial sources either individually or in combination.

The 2014 flood event triggered a Section 19 Flood Investigation due to the severity of the flooding (affecting a property internally), the number of repeat incidents and the potential sources of flood water

The cause of the flooding was a series of storms in late 2013 and early 2014 that caused the ground to become saturated. A less intense storm that took place on the morning of 7 February 2016 caused a ‘pooling’ of water in Acorn Street that was unable to drain away to a culverted Ordinary watercourse under the highway due to that culvert being at 100% capacity.

The water on the highway is a combination of two overland flow paths that meet at the topographical low point of the catchment. The first comes down the highway from the north and the second is from a field to the east of the street.

Hertfordshire County Council in its role as Lead Local Flood Authority on becoming aware of a flooding issue arising from surface water flooding has the responsibility to begin an investigation. Hertfordshire County Council instructed Opus International to complete an investigation of the incident site and surrounding catchment area to better understand how and why surface water flooding was occurring.

The main finding of the study verified the updated Flood Map for Surface Water, confirming that road and surrounding properties are within the highest risk category for surface water flood risk. It also identified that a combination of mitigation measures would be required to reduce the pooling of water on the highway.

Currently flood defence mitigation projects are subjected to economic appraisal, using the cost-benefit methodology described in Defra’s Flood and Coastal Defence Appraisal Guidance called Multi-Criteria Analysis. Due to the limited number of properties inundated by flooding, it will be difficult to achieve a positive cost benefit. Therefore the recommendation to alleviate flooding to properties is the installation of property level protection, along with better controlling the surface water flows from the Nine Ashes site and the highway.

1. Introduction

1.1. LLFA Investigation

Under Section 19 of the Flood and Water Management Act (FWMA) 2010, Hertfordshire County Council (HCC) as Lead Local Flood Authority (LLFA), on becoming aware of a flood in its area, must, to the extent that it considers it necessary or appropriate:

- Investigate the incident;
- Identify the Risk Management Authorities (RMAs) with relevant flood risk management functions;
- Establish if the relevant RMAs have responded to the flood event or are proposing to respond;
- Publish its findings; and
- Inform the relevant RMAs of its findings.

As defined under Section 6, subsection 13 of the FWMA 2010, an RMA has certain powers to manage, regulate, assess and mitigate flood risk. We have identified the following RMAs as part of this Section 19 flood investigation for Acorn Street, Hunsdon:

- HCC as LLFA
- East Hertfordshire District Council
- HCC as Highway Authority

1.2. Flooding chronology and justification for a Section 19 Investigation

Acorn Street has had a total of ten reports of flooding on the highway from 2006 up to and including the February 2014 flood event (see Section 2.1). This also included flooding affecting the property on three previous occasions, twice externally in the garden and once internally. Initial reports determined that water was draining from the Nine Ashes site, which is immediately adjacent to Acorn Street. As the flood incident site sits at a topographical low point in Acorn Street, it regularly receives nuisance flooding from the highway during relatively minor rainfall events.

Under the guidelines set out in the Local Flood Risk Management Strategy, Procedure 2 – Recording and Investigation of Flooding Events, the flood of 2014 triggered the following 2 criteria as stated below:

- In the case where internal flooding has occurred at a property on more than one occasion in a ten year period. (Repeat flooding can cause residents extreme hardship and if flooding has occurred on more than one occasion efforts will need to be made to see whether assistance with provision of flood resistance measures, for instance, might be beneficial.)
- Where external flooding of land adjacent to a property has occurred more than five times in a 10 year period. (While external flooding is not as disruptive as internal flooding, the continued vulnerability of property to

external flooding would give rise to a reduction in property value and increased hardship for residents/business owners.)

1.3. Site Location

Acorn Street, Hunsdon is located in the east of Hertfordshire, midway between Ware and Harlow as shown below in Figure 1. The site where this investigation was carried out is located to the south of Hunsdon; see Figure 2, with a contributing catchment as shown in Figure 3.

Figure 1 Acorn Street, Hunsdon, Hertfordshire – Location Map

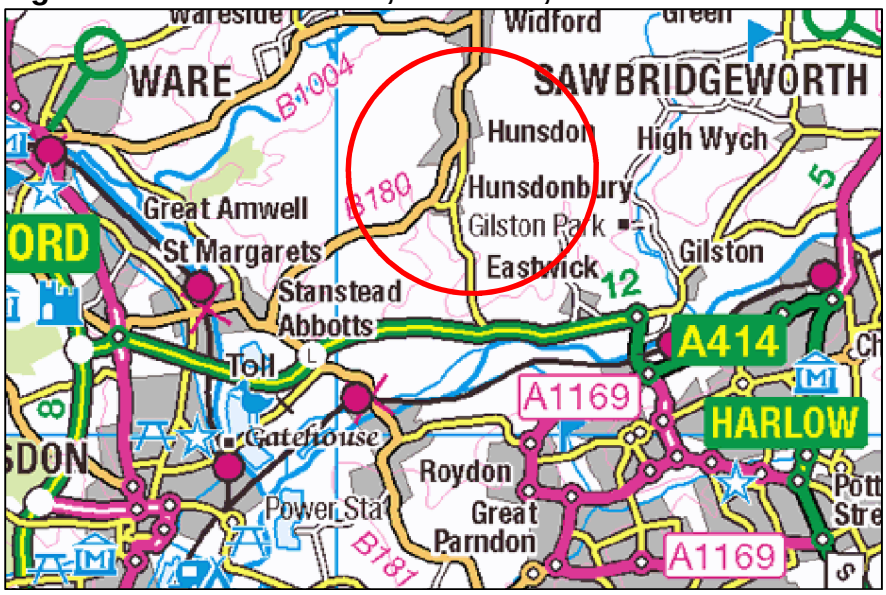


Figure 2 Area of Investigation in Acorn Street, Hunsdon

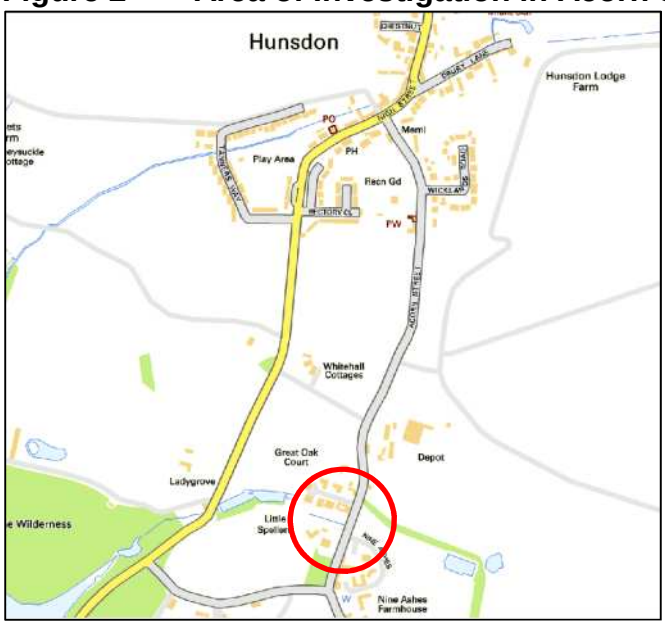
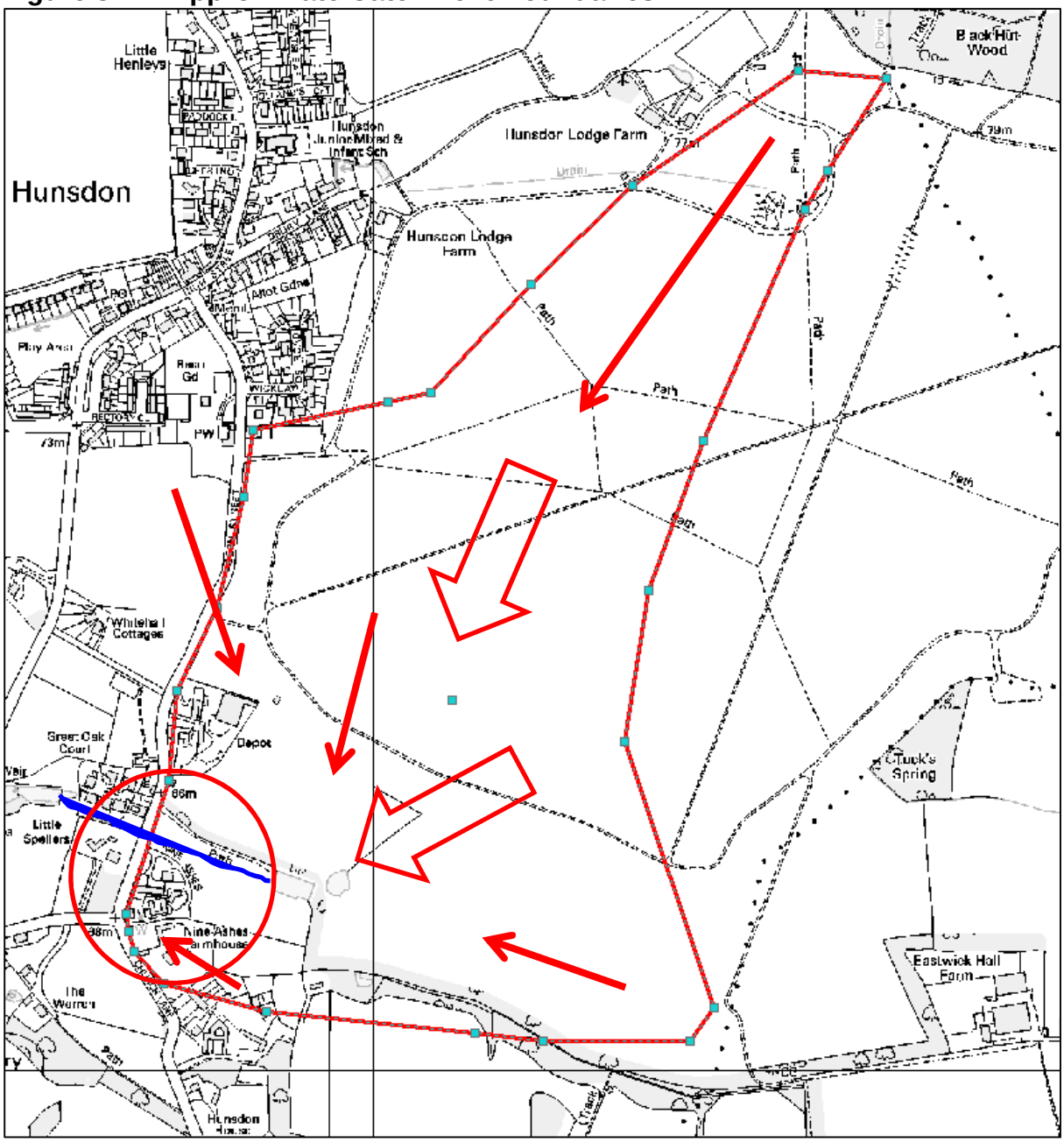


Figure 3 Approximate Catchment Boundaries



1.4. Background mapping information

Figure 4 identifies the surface water risk as identified in the Risk of Flooding from Surface Water map and Figure 5 identifies the Ordinary watercourse.

Figure 4 Surface water flood risk; extract from the Risk of Flooding from Surface Water Map, showing a 0.1% probability flood extent

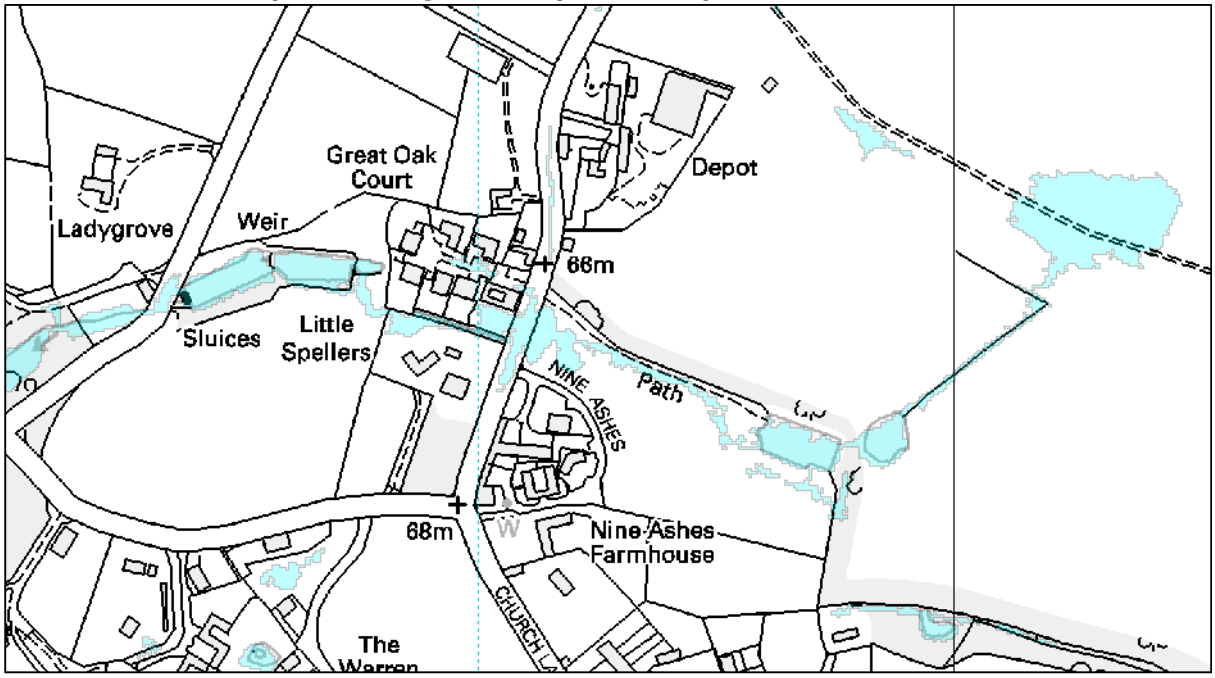
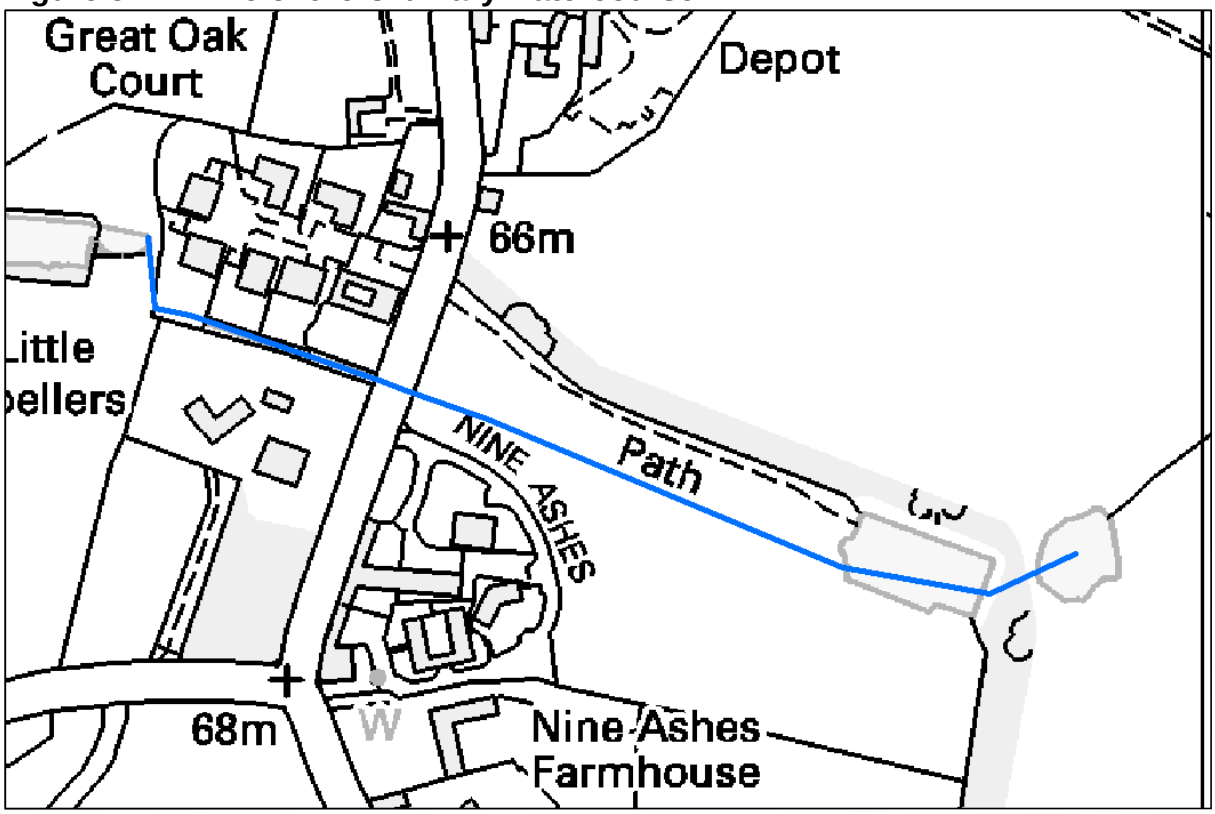


Figure 5 Line of the Ordinary watercourse



2. Background and History of Flooding

2.1. Previous flood events

Records obtained from the Hertfordshire County Council highways reporting system indicate that there has been flooding at the site for a number of years, with residents reporting internal flooding at least once before in February 2009. The historical reports of flooding for the period January 2006 – February 2014 are as follows:

- June 2006 - Road flooded
- January 2007 - Flooding reached property
- February 2009 - Property flooded internally
- February 2010 - Road flooded
- January 2011 - Road flooded
- February 2013 - Property flooded externally
- February 2014 - Property flooded internally

In addition there have been multiple flood events to the road post 2014; however these have not been included in the investigation due to the similar nature to the above.

3. Assessment of the February 2014 flood event

3.1. Observations

During the February 2014 flood event, the antecedent conditions caused the ground within the study catchment to be saturated. The winter months prior to February 2014 received repeat rainfall events, none great enough to cause flooding, until February. During the February 2014 rainfall event, water started to pool in the fields known as Nine Ashes to the east of Acorn Street. This water flowed in a westerly direction, overland, towards Acorn Street. Water built up in the topographical low point of the road. Water in the highway built up, as it was unable to discharge into the culverted Ordinary watercourse that flows under the highway. As the overland flow continued from both Nine Ashes and Acorn Street, water spilled out of the highway towards surrounding properties. This water subsequently caused internal property flooding. This was exacerbated by road traffic causing bow waves, with water being pushed further towards the property as traffic drove through the flood water on the road. Please see Figure 6 which identifies the flow paths.

3.2. Rainfall and antecedent conditions

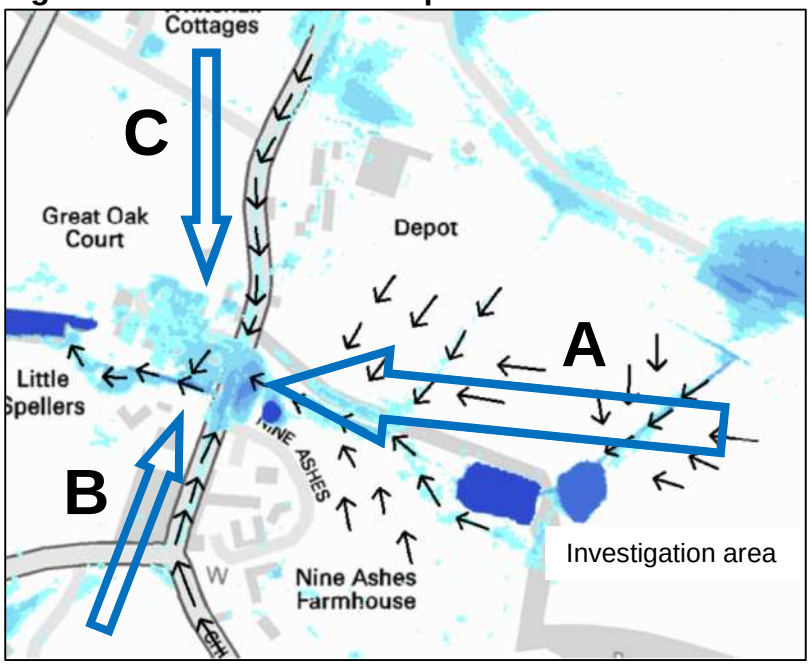
The United Kingdom experienced a period of extreme weather from late January 2014 to mid-February 2014 as a result of a succession of major storms. This brought widespread damage and flooding to the UK. Around six major storms occurred during this period, separated by intervals of three to four days. The sequence of storms was preceded by a stormy period between mid-December 2013

and mid-January 2014. Taken individually, the first two storms were notable but not exceptional for the winter period.

However, the later storms from early to mid-February were much more severe. Overall, the two month period from mid-December 2013 to mid-February 2014 saw at least 12 major winter storms and as a consequence, was the stormiest period of weather the UK has experienced for at least 20 years (source: Met Office). During the evening of 6 February 2014 and into the early hours of 7 February 2014, a severe storm with heavy rainfall impacted a large part of Hertfordshire.

Preceding days of rainfall meant that the surrounding land was already saturated, preventing any further rainfall from infiltrating into the soil.

Figure 6 Indicative flow paths



3.3. Ground conditions

The flooding event recorded in February 2014 followed a long period of saturated ground conditions which started in October / November 2013. The catchment is estimated to be over 95% permeable due to the agricultural areas and grassland. The presence of roads and buildings represent the 5% impermeable area. When saturated, however, the whole catchment would effectively be impermeable and therefore representative of a 100% impermeable catchment.

3.4. Surface water runoff (pluvial)

There is a topographical low point in Acorn Street where surface water pools from both sides of the carriageway and from overland flow from the Nine Ashes site. Figure 7 shows the key structures in the site of study. In close proximity to houses, there is an Ordinary watercourse that has been culverted through the Nine Ashes site (Pipe B) that is fed by a pond used for fishing (Pond E). The watercourse opens

out for 10 metres (Pond H) before it goes back into culvert (Pipe X) that flows under the road. The outlet of this culvert is within a neighbouring residential property's garden. Water spills out of the culvert (due to the culvert's poor condition) throughout the Nine Ashes site.

Figure 7 Map of key structures and the Ordinary watercourse

Figure 8 shows water pooling on the highway. The highway drainage at this point of Acorn Street is connected to the Ordinary watercourse. The pooled water was unable to drain away from the road due to the culverted watercourse being at 100% capacity, so there was no room for the additional flood water to enter the culvert, arising from the highway. Furthermore, due to the surrounding area being used for agriculture, the highway drains and gullies are susceptible to high levels of debris. This increased debris reduces the capacity of the gullies, as well as slowing down the time it takes for the water to drain away from the road.

Figure 8 Water pooling on the highway, unable to discharge in the culverted watercourse, due to the culvert being at full capacity

3.5. Ordinary watercourses

3.5.1. Pipe A and B

Pipe A and B are in poor condition, with the culvert collapsed in places within the Nine Ashes site. This causes water to spill out of the culvert and contributes to the overland flow from the Nine Ashes site towards Acorn Street. On the Nine Ashes site water flows overland, perpendicular to Acorn Street (please see Figure 9).

Figure 9 Collapsed section of watercourse in the Nine Ashes site (arrowed)

3.5.2. Fishing Pond

When the culvert is at 100% capacity, the fishing pond (Pond E) was unable to discharge into the culverted Ordinary watercourse. This causes water to exceed the banks of the pond and flow across the Nine Ashes site towards Acorn Street; following a similar line to Pipes A and B, however flowing as overland flow rather than culverted (please see Figure 10).

Figure 10 The fishing pond (Pond E) during flood

3.5.3. Pond H

The overland flow from both the collapsed culverts and the fishing pond flows towards Pond H. Pond H also receives additional water from other incoming connections. From Pond H, water tries to enter the culvert under the road; however the amount of water during flood events far exceeds the capacity that it can cope with (see Figure 11), and therefore spills over the edge of the pond, and towards the road. Figure 12 shows this ponding of water in the Nine Ashes field, and Figure 13 shows the other side of this pond, with water spilling onto the highway.

Figure 11 Pond H during flood, the outgoing culvert is completely submerged

Figure 12 Flood flow from Pond H creating a pool of water beside Acorn Street

Figure 13 Water spilling from the Nine Ashes site onto the highway

3.6. Possible causes of flooding

The current drainage network within the Nine Ashes site has multiple spill points. These are:

1. The fishing pond (Pond E)
2. The broken sections of Ordinary watercourse culvert (Pipes A and B)
3. Pond H

This failure of the drainage network is adding to the volume of overland surface water flow that discharges onto the highway from the field. Due to the culvert under the road being at full capacity and the highway network being inundated with additional flows, water pools on the road and quickly flows towards the houses. This is further exacerbated by traffic causing a bow movement of water as they drive through the water on the highway.

4. Responsible authorities and landowners

HCC as the LLFA has investigated the flooding at Acorn Street Hunsdon to establish the relevant RMAs that have flood risk management functions in accordance with the FWMA 2010. Those RMAs and their relevant powers and functions are set out in the following subsections.

4.1. Hertfordshire County Council as Lead Local Flood Authority

HCC as the LLFA for Hertfordshire has fulfilled its responsibility to carry out a Flood Investigation under Section 19 of the FWMA 2010, to;

1. Identify the relevant RMAs and
2. Establish if those authorities intend to utilise their own powers and to what extent. The actions that the relevant RMAs have agreed to take are set out in Section 6.

In order to achieve the responsibilities under Section 19, HCC as LLFA must first establish the cause and impacts of the flooding and then, where possible, identify actions to reduce flood risk.

HCC as the LLFA for Hertfordshire has powers to carry out flood risk management works for flooding from surface water runoff and groundwater in accordance with the Local Flood Risk Management Strategy for Hertfordshire.

4.2. East Hertfordshire District Council as Risk Management Authority (with the power to manage flood risk from Ordinary watercourses)

East Hertfordshire District Council has powers under Section 14A of the Land Drainage Act 1991 to carry out work to manage flood risk from Ordinary watercourses, if the work is considered desirable having regard for the Local Flood Risk Management Strategy for Hertfordshire.

4.3. East Hertfordshire District Council as Local Planning Authority

East Hertfordshire District Council are the local planning authority for the Hunsdon area and their role is to determine planning applications for new development, approve and assess any impacts from all sources of flooding and any associated proposed drainage.

4.4. Hertfordshire County Council as Highway Authority

HCC are the responsible authority to maintain and manage adopted highways including associated drainage infrastructure such as gullies, drainage pipes, and soakaways etc. which have been provided for the sole purpose of draining the public highway.

Acorn Street is highway maintainable at public expense and is impacted by the flooding.

HCC as the Highway Authority have powers to manage water falling on the public highway under the Highways Act 1980, however where this water originates from third party land and not from runoff from the highway these powers are limited.

HCC as the Highway Authority is required, as far as is reasonably practicable, to keep highways open and usable by the public.

In extreme flood events the majority of excess surface water will eventually flow onto the highway as roads act as manmade conduits for such water.

4.5. Landowners in the catchment

Owners of land adjacent to Ordinary watercourses are termed riparian owners. The landowners adjacent to the watercourse, which runs from the ponds in the field in the Nine Ashes, east of Acorn Street, to the Ordinary watercourse in the residential properties (and within the flooded property) have riparian responsibilities. These riparian owners need to seek consent from the county council as Lead Local Flood Authority for any works that will affect the channel of the watercourse, including the modification of existing culverts, if consent is not sought the riparian owner can be required to remove unconsented structures and / or reinstate to a condition that existed before the works. In addition, riparian owners are required to maintain the Ordinary watercourse, if the channel is not kept in serviceable condition they can be required to carry out works in order to maintain the flow. This refers to powers held by the county council as Lead Local Flood Authority under Sections 23, 24 and 25 of the Land Drainage Act 1991.

5. Detailed hydraulic modelling

5.1. Introduction

It was decided during the investigation that detailed hydraulic modelling should be conducted in order to better understand the flooding mechanisms at the site of study. The broken culverts carrying the Ordinary watercourse, within the Nine Ashes site, were of particular interest, with an understanding sought on the contribution they have on the flooding to the highway and the flooded property.

In addition to the detailed hydraulic modelling of the study site, options were modelled, in order to better understand if anything could be done to mitigate flood risk.

5.2. Summary of the detailed modelling study

BMT WBM was appointed by Opus International to undertake hydraulic modelling to assess the surface water flood risk at Acorn Street, Hunsdon.

A hydraulic model was constructed using TUFLOW software to improve the understanding of surface water flood risk and determine the surface water flooding mechanisms. The model has been simulated for five flood events for the storm that produces the greatest flood extent and flood depth (critical storm duration). Five storm durations were simulated for the 1% Annual Exceedance Probability (AEP) and the 15 minute storm duration was chosen as it was decided it produced the greatest flood depths and extents for the residential properties of concern.

The results of the hydraulic model predict that flooding of Acorn Street is a result of surface water runoff from the fields to the east as well as runoff from a northerly and southerly direction along Acorn Street, accumulating at the topographical low point (see Figure 14).

A number of tests were undertaken on blockages in the culvert beneath Acorn Street, Hunsdon; this analysis was undertaken within the technical modelling report. Blockages tested included a 90% blocked, 50% blocked and 0% blocked (fully maintained) culvert. The modelling results of the 0% blocked (fully maintained) culvert predicts that Acorn Street will still be inundated. In the 0% blocked analysis, the gullies are not shown to surcharge hence the culvert is determined to be running efficiently. Despite this, flooding of Acorn Street is still predicted, suggesting that the flow conveyed to the culvert is likely to be limited by the capacity of the culvert, reducing the discharge rate from the road gullies.

The model results have been validated against the Environment Agency's Risk of Flooding from Surface Water maps, as well as historic records of flooding provided for Hunsdon. Further calibration of the model was not undertaken as it was outside the scope of the study.

In summary, the detailed modelling identified that there is more than one flood mechanism causing the pooling of water at Acorn Street. In addition to the overland

flows coming from the Nine Ashes site, flood water also flows from the north, with the highway transporting this water to the topographical low point in the road.

5.3. Options modelling

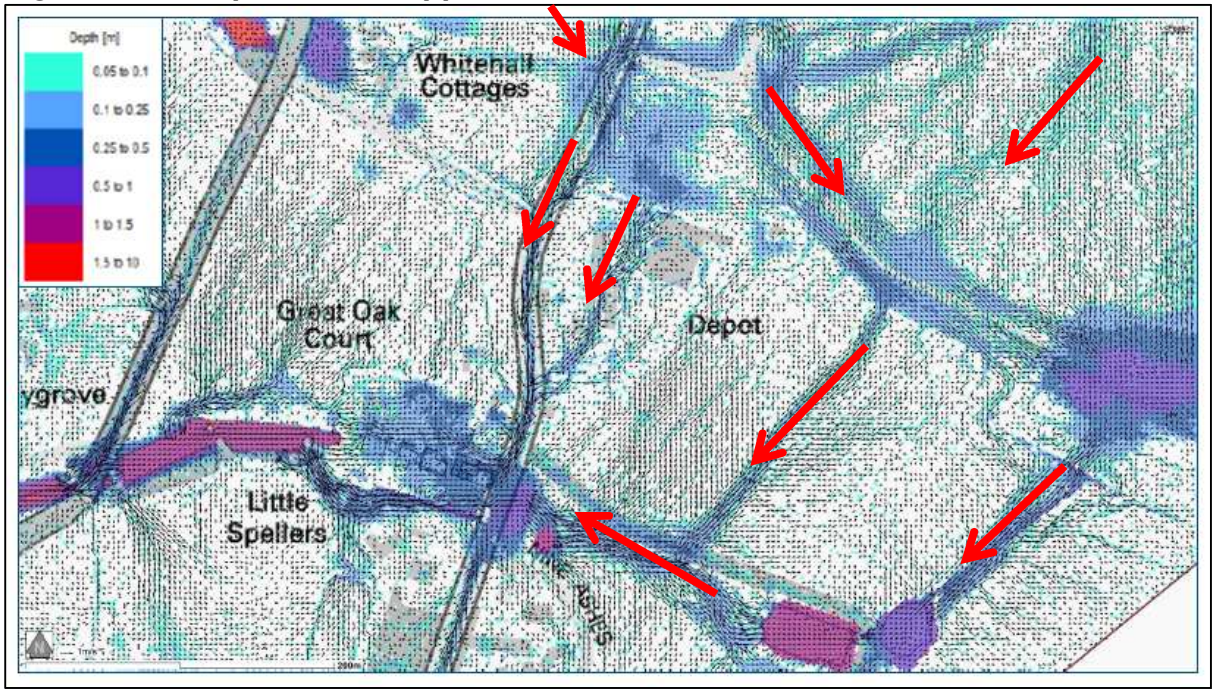
Four potential mitigation options were shortlisted with the aim of identifying an option that eliminates surface water flood risk to Acorn Street and nearby properties for a 3.33% AEP event. Options included:

1. Multiple flood bunds holding back water in areas away from Acorn Street.
2. Upgrading or daylighting of the existing culvert going through the Nine Ashes Site.
3. Increasing pavement heights.
4. Highway storage.

The placing of multiple flood bunds in strategic locations has been identified as having the most benefit for alleviating flooding to Acorn Street. These bunds would be located to stop water flowing from both the Nine Ashes site and also the upper reaches of Acorn Street (see Figure 15). It was also highlighted that the other options either made little difference or increased the flood risk for the road.

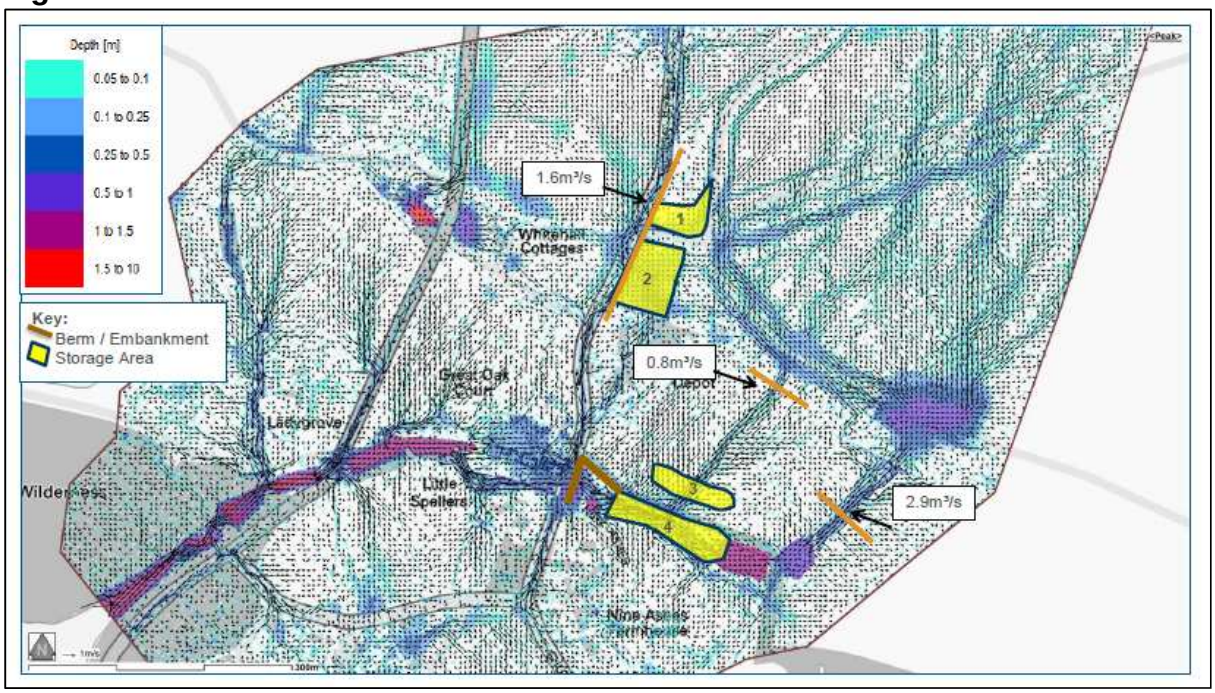
Property Level Protection was recommended on the opposite side of the carriageway to the Nine Ashes site. Due to its complexities, it was not modelled in this study.

Figure 14 Impact of the upper catchment extents at the Nine Ashes site



Red arrows denote flow direction

Figure 15 Location of flood bunds that could attenuate flow



These were modelled to identify which flows contributed to the flood water in Acorn Street.

6. Conclusions and Recommendations

6.1. Conclusions

The 2014 flood event that caused internal flooding and flooding to the highway was a combination of heavy rainfall, saturated ground conditions and a failure of the drainage structures within the Nine Ashes site. Subsequent to the February 2014 event, the highway has flooded numerous times, causing multiple near misses. This highway flooding has caused further external flooding.

Any actions to mitigate flood risk are legally required to be proportionate and risk based. Due to the small number of properties affected by internal flooding in this investigation, it would be extremely unlikely that HCC could develop a case to secure funding. For this reason it is recommended any flooded properties investigate Property Level Protection (PLP), in order to mitigate the impact of the surface water reaching the property.

6.2. Recommendations

Table 1 shows the recommendations of the county council, in its capacity as LLFA and follow from the main findings from the Section 19 Flood Investigation carried out into the flood event in Acorn Street in February 2014.

Table 1: Recommendations for Acorn Street, Hunsdon

No.	Recommendations	Comments	RMAs and other parties to be involved
1.	Repairs conducted to the culverted sections through the Nine Ashes site.	This would need to be conducted by the riparian owner of the culverts. Putting the culverts back into their original state would contain water within the drainage network and stop it contributing to the overland flow of Acorn Street.	Hertfordshire County Council as Lead Local Flood Authority, Riparian Owner.
2.	Upgrade the culvert under Acorn Street.	The detailed model suggests that the current culvert cannot withstand flows during a 3.3% AEP flood event. Upgrading the culvert would increase drainage through the Nine Ashes site, as well as being able to drain the pooling water in the Highway quicker.	Riparian owners of the culvert.
3.	Maintain highway drainage.	1 It is recommended that Hertfordshire County Council as Highway Authority add Acorn Street to the vulnerable gullies list. 2 It is recommended that the mainline connecting pipe from the gullies is investigated to ascertain who is responsible for its maintenance. Currently both Thames Water and the Highway Authority do not have this recorded as their asset.	Hertfordshire County Council as Highway Authority.
4.	Consider planning applications.	Be aware of the flooding problems for any planning applications.	East Hertfordshire District Council as Local Planning Authority.

7. Next Steps and Actions

7.1. Lead Local Flood Authority

The following are agreed actions to be undertaken by HCC in its capacity as LLFA:

1. To distribute final copies of the report to all relevant Risk Management Authorities and other appropriate parties.
2. LLFA to investigate with Hertfordshire County Council as Highway Authority about the feasibility of upgrading the culvert under Acorn Street.
3. LLFA to monitor reinstatement of the Ordinary watercourse culverts and ensure that the riparian owner is aware of and carries out their responsibilities.

8. Disclaimer

This report has been prepared as part of Hertfordshire County Council's responsibilities under the Flood and Water Management Act 2010. It is intended to provide context and information to support the delivery of the local flood risk management strategy and should not be used for any other purpose.

The findings of the report are based on a subjective assessment of the information available by those undertaking the investigation and therefore may not include all relevant information. As such it should not be considered as a definitive assessment of all factors that may have triggered or contributed to the flood event. Hertfordshire County Council expressly disclaims responsibility for any error in, or omission from, this report arising from or in connection with any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the time of preparation and Hertfordshire County Council expressly disclaim responsibility for any error in, or omission from, this report arising from or in connection with those opinions, conclusions and any recommendations.

Hertfordshire County Council does not accept any liability for the use of this report or its contents by any third party.