Hertfordshire County Council Section 19 Flood Investigation Report

Bovingdon

Bovingdon in 2016
Photo courtesy of local resident

December 2019 V8 Final

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Revision Schedule

Hertfordshire County Council
Section 19 Flood Investigation Report

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1	26/07/2018	For internal FRM team consultation	Julia Puton, Sustainable Drainage Officer	Andy Hardstaff Flood Risk Management Team Leader
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4	14/09/2018	Draft following comments	Julia Puton, Sustainable Drainage Officer	Andy Hardstaff Flood Risk Management Team Leader
5	24/10/2018	Draft for consultation with RMAs	Julia Puton, Sustainable Drainage Officer	John Rumble Head of Environmental resource Planning
6	14/01/2019	Draft for public consultation	James Lester, Project Officer	Andy Hardstaff Flood Risk Management Team Leader
7	07/02/2019	Draft for public consultation	James Lester, Project Officer	Matthew King Head of Waste Management & Environmental Resource Planning
8	11/12/2019	Final	James Lester, Project Officer	John Rumble Head of Environmental resource Planning

Explanation of Acronyms and Terms

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.
AEP	Annual Exceedance Probability (AEP) represented as a % (e.g. 1 in 100-year event = 1% AEP).
Antecedent conditions	Antecedent conditions is a term used to describe the relative wetness or dryness of a catchment, which changes continuously and can have a very significant effect on surface water 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.
Attenuation	The processes of water retention on site slowly being released to a surface water/combined drain or watercourse.
FEH	The Flood Estimation Handbook (FEH) and its related software offer guidance on rainfall and river flood frequency estimation in the UK. Flood frequency estimates are required for the planning and assessment of flood defences, and the design of other structures such as bridges, culverts and reservoir spillways.
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.
HCC	Hertfordshire County Council
LLFA	Lead Local Flood Authority (LLFA) – 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.
Return period	An estimate of the likelihood of an event. For example, a 1 in 100-year return period has a 1% likelihood of occurrence within any given year.
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, Highways England, the Environment Agency, the Bedfordshire and River Ivel Internal Drainage Board, Thames Water Utilities Limited and Anglian Water Services Limited.
Storage	An area or structure where surface water flows are retained.
Soakaway	A pit typically filled with aggregate, into which water is discharged so that it drains slowly out into the surrounding soil.
S19	The Section 19 of the Flood and Water Management Act 2010 specifies the actions for the Lead Local Flood Authority to investigate the flood incidents.
TWUL	Thames Water Utilities Limited

Executive Summary

On 16 September 2016 a localised area in and around Bovingdon, Hertfordshire was affected by flooding as a result of exceptionally intense rainfall. Due to the severity of the flooding Hertfordshire County Council (HCC) in its role as Lead Local Flood Authority (LLFA) has used the powers available under Section 19 (s19) of the Flood and Water Management Act 2010 (FWMA) to carry out an investigation. In the area covered by this investigation, 23 properties were flooded; 14 of which flooded internally. The flooding was predominantly overland surface water flows and secondarily water surcharging from the sewers and highway drainage network.

The main findings of this investigation are:

- The rainfall event on 16 September 2016 was uncommon with there being up to 5% chance of rainfall of that intensity and duration happening in any given year.
- It is likely that the rainfall event on 16 September 2016 would have exceeded the design capacity of the surface water drainage infrastructure in the area.
- Surface water contributed to the foul sewer network being surcharged in the area.
- The intensity of the rainfall on 16 September 2016 resulted in the piped drainage systems in this area becoming overwhelmed.

The recommendations from this investigation for reducing the risk of flooding from surface water are:

- Hertfordshire County Council as the Highway Authority (HA) and Thames Water Utilities Limited (TWUL), as the relevant Risk Management Authorities (RMAs) together with the Lead Local Flood Authority should investigate to identify surface water drainage assets within the investigation area in Bovingdon. This would provide enhanced asset information and establish if any assets need maintenance works or potentially upgrading.
- Thames Water to investigate its asset information in Bovingdon including surface water connections / miss-connections into the foul sewer network in Bovingdon.
- The Lead Local Flood Authority should work with local residents and the relevant risk management authorities to increase awareness of any actions that could be taken in Bovingdon to help residents become more resilient to the risks of surface water flooding.
- Hertfordshire County Council as the Highway Authority should investigate the efficiency and effectiveness of their surface water drainage network, including soakaways features, to drain the public highway within the investigation area in Bovingdon.
- Thames Water Utilities Limited should investigate efficiency and effectiveness of the public surface water drainage network including discharge mechanisms within the investigation area in Bovingdon.
- Owners of private soakaways should consider investigating their condition and refurbishing or replacing them as appropriate.

1. Introduction

1.1 LLFA Investigation

Under Section 19 of the Flood and Water Management Act (FWMA) 2010 Hertfordshire County Council 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.

An RMA (as defined under Section 6, subsection 13 of the FWMA 2010) has certain powers to manage, regulate, assess and mitigate flood risk. The activities of the following RMAs have been examined as part of this Section 19 flood investigation for Bovingdon:

- Hertfordshire County Council as the Lead Local Flood Authority (LLFA).
- Hertfordshire County Council as the Highway Authority (HA).
- Thames Water Utilities Limited (TWUL).
- Dacorum Borough Council (DBC).

Following the flood event experienced in Bovingdon on 16 September 2016, it was determined that this incident met the criteria in Policy 2 of HCC's Local Flood Risk Management Strategy for a detailed Section 19 Investigation to be undertaken, that is,

- More than 5 properties flooded in the flood event on 16 September 2016.
- Property flooded more than once in 10 year period.

1.2 Site Location

The S19 investigation area is located in Bovingdon which is in the Dacorum Borough Council area in the county of Hertfordshire; Figure 1 identifies the general location of the investigation site. The extent of the Section 19 Flood Investigation area has been defined following analysis of the results of the HCC questionnaire survey sent to residents following the 16 September 2016 flood event. The following streets are included within the investigation area: Green Lane, Ryder Close, Rymill Close, Eastnor and Hamer Close, the precise extent of the investigation area can be seen in Figure 2.

Figure 3 identifies Bovingdon in relation to areas predicted to be at risk of flooding from surface water on the national Risk of Flooding from Surface Water mapping published by the Environment Agency (EA). This map is available to access at https://flood-warning-information.service.gov.uk/long-term-flood-risk/map. The contributing surface water catchment is shown in Figure 4, flows are directed from west to east.

Figure 1: Location map for Bovingdon in Hertfordshire (McCloy Consulting, 2018)

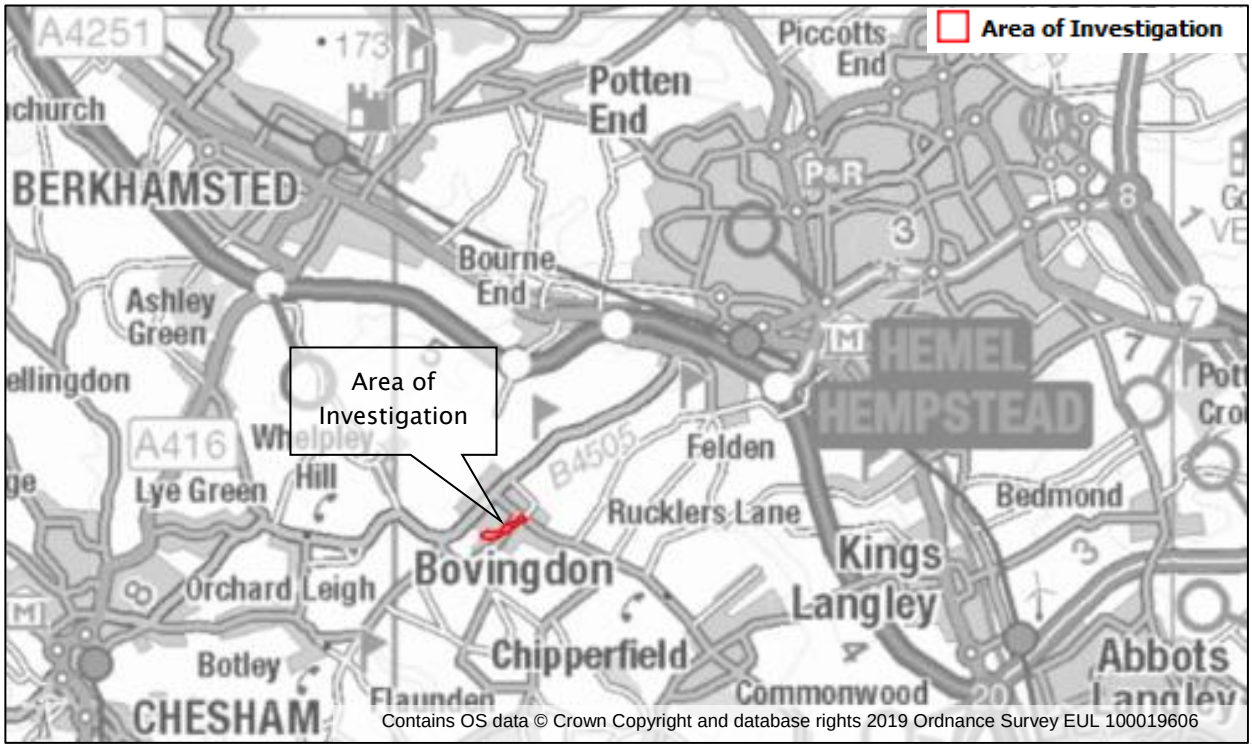


Figure 2: The location of the investigation site in Bovingdon (McCloy Consulting, 2018)

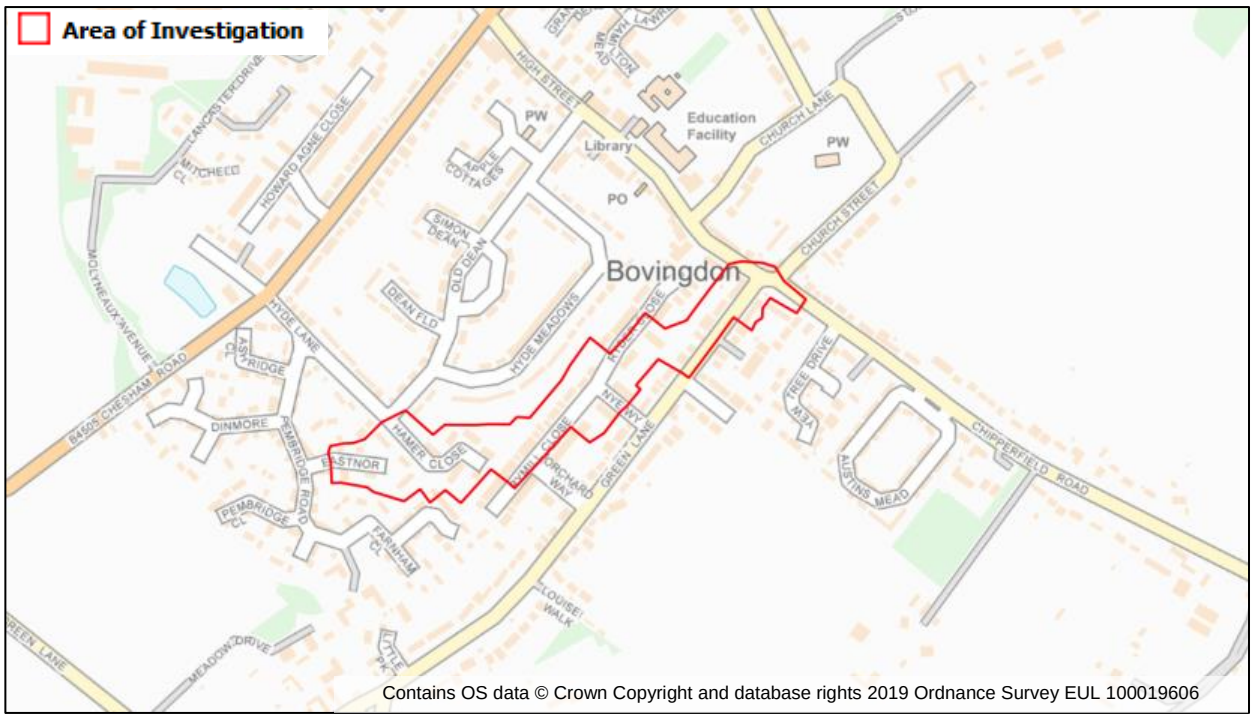


Figure 3: Risk of Flooding from Surface Water map (1 in 100 year) Maximum Extents including the flooded area

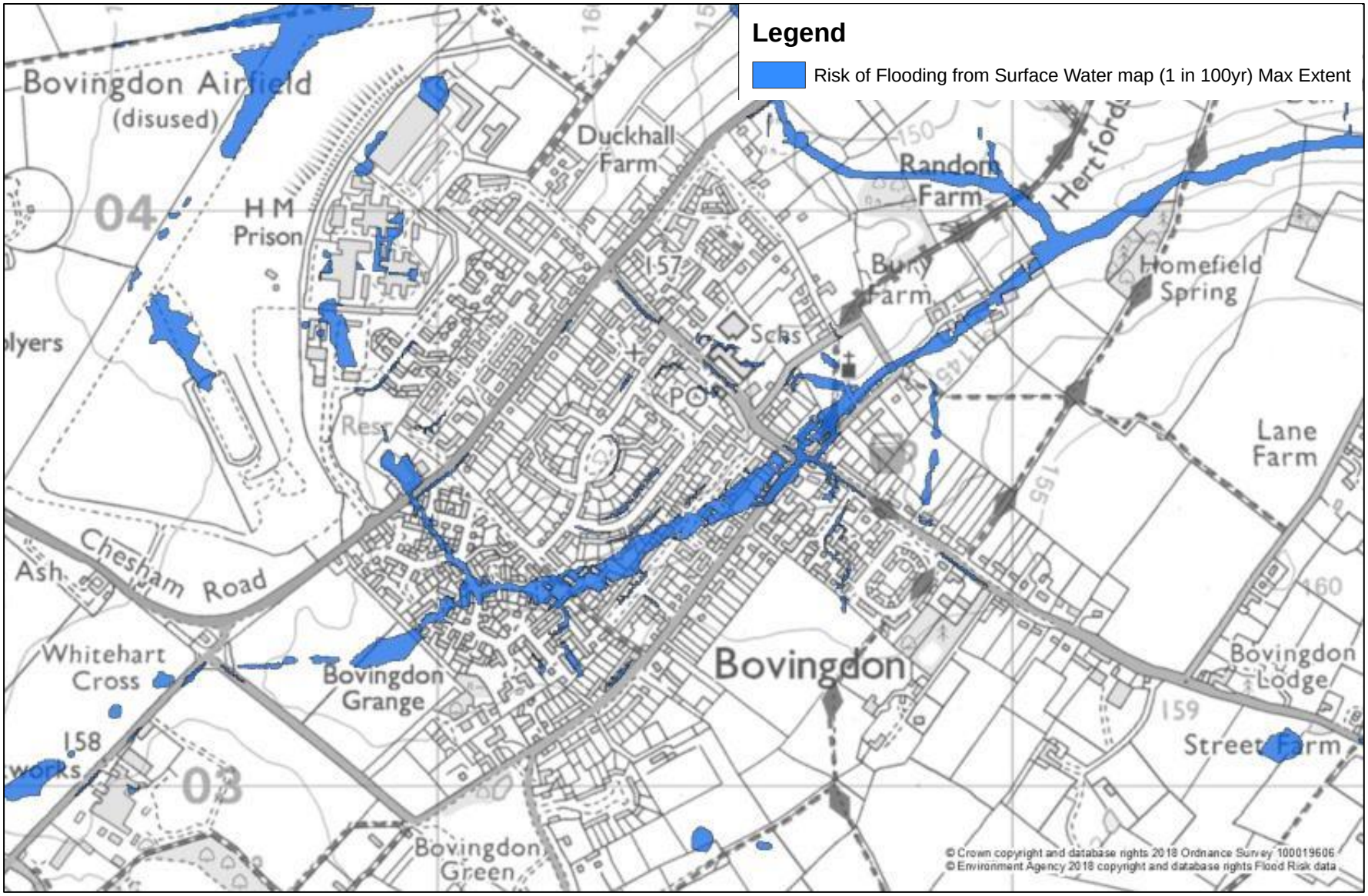
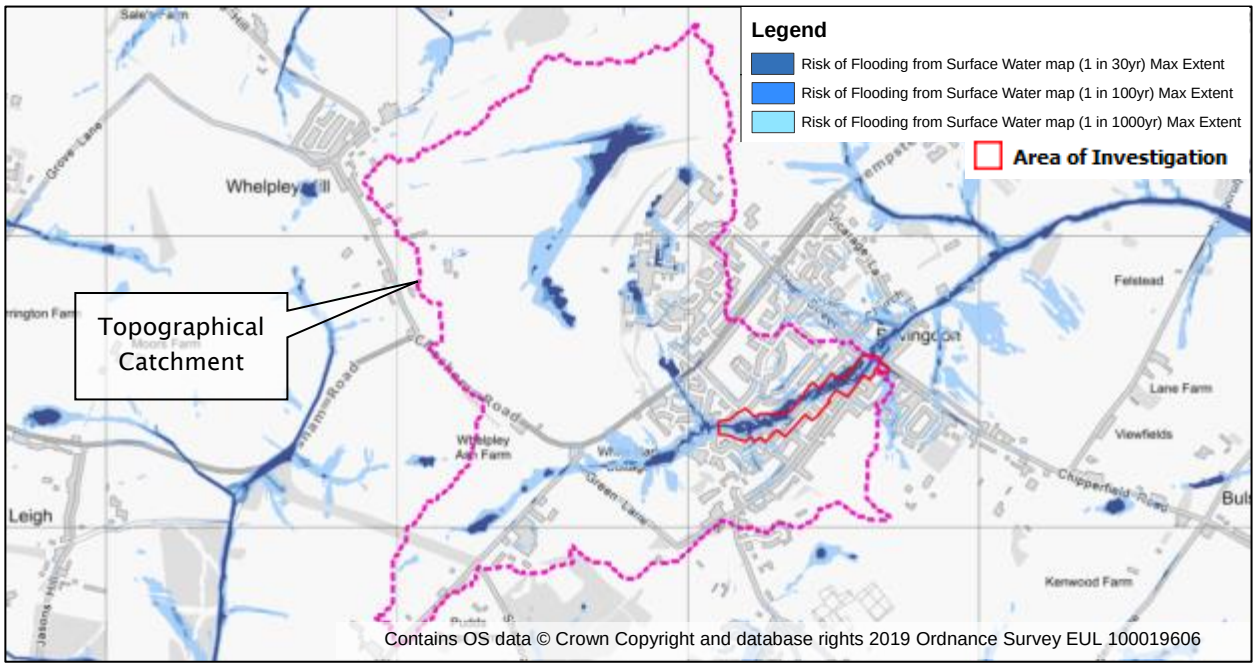


Figure 4: Upstream catchment boundary map (McCloy Consulting, 2018)



The LLFA is aware of the possible development within the area of the upstream catchment indicated on the map above. If a development were to be implemented in line with the current drainage design standards it would create an opportunity for a substantial betterment on surface water management in the area and effectively in Bovingdon.

2. Background and History of Flooding

2.1 Previous flood events

There have been no historical reports to the LLFA of flooding in the investigation area listed in Table 2. The LLFA has only been recording flood events since 2010. Therefore, the LLFA will be unaware of any flood events prior to that date. Flood events prior to 2010 identified by residents as part of this investigation will be added to the LLFA Flood Incident Record. An online media search has confirmed that there was major flooding in Bovingdon in 1946.

Hertfordshire County Council in its capacity as the Highway Authority keeps records of all highway faults reported by members of the public, which includes flooding involving adopted Highways. Previous to this flood event, there have been a number of recorded incidents of historical flooding of the highway within the investigation area (see Table 1).

Table 1: Reported cases of flooding to HCC as the Highway Authority

Road	Date	Incident
Green Lane	January 2014	Road flooded
	January 2014	Road flooded
	February 2014	Road flooded
	November 2014	Road flooded
	December 2015	Road flooded

3. Assessment of the 16 September 2016 flood event

3.1 Summary of 16 September 2016 event for Hertfordshire

On the early morning of 16 September 2016, a period of intense rainfall caused flash flooding in Bovingdon, Hertfordshire. The heaviest rainfall appeared between 5:00 a.m. and 7:00 a.m. which corresponds with flood reports.

3.2 Observations

The LLFA received information about the flood event from local residents and Hertfordshire Fire and Rescue. Secondary sources, such as newspapers and social media have also been explored to gather as much information as possible.

The LLFA received confirmation of reported incidents to Hertfordshire Fire and Rescue regarding this flood event in Bovingdon. From the verbal communication with one of the residents it is understood that Hertfordshire Fire and Rescue services attended near the area known locally as “Bovingdon Docks” during the flooding event.

Thames Water Utilities Ltd (TWUL) have recorded on their flood register two incidents of flooding to dwellings from the public sewers on 16 September 2016. Any TWUL customers who flooded from the public sewer and who have not already made a report to TWUL should complete and send to TWUL the questionnaire which can be found on their website at https://www.thameswater.co.uk/sitecore/content/tw-live/tw-live/sewer-flooding#.

3.2.1 Questionnaire Survey

A questionnaire survey was sent out to all residents in Bovingdon who may have been impacted by the 16 September 2016 flood event. This was conducted by HCC as the LLFA and sent to all residents on 24 January 2017. The purpose of the questionnaire was to establish the extent of the flood event, the number of properties impacted and an indication of the mechanisms that caused flooding to property or critical infrastructure. A second round of questionnaires was sent out on 7 March 2018 to residents, selected as above, to clarify the extent of the flooding.
In Bovingdon, questionnaires were sent to properties that had reported flooding as well as those in the local vicinity that may also have been affected. Properties were identified using reports from media, the Fire and Rescue service and the Highway Authority. This was then cross referenced with the national Risk of Flooding from Surface Water map (see Figure 5).

In total 27 responses were completed and returned, this includes properties confirming flooding, or confirming no flooding. The table below identifies the known details and facts that were derived from the questionnaire analysis (see Table 2).

Table 2: Flood survey summary (McCloy Consulting, 2018)

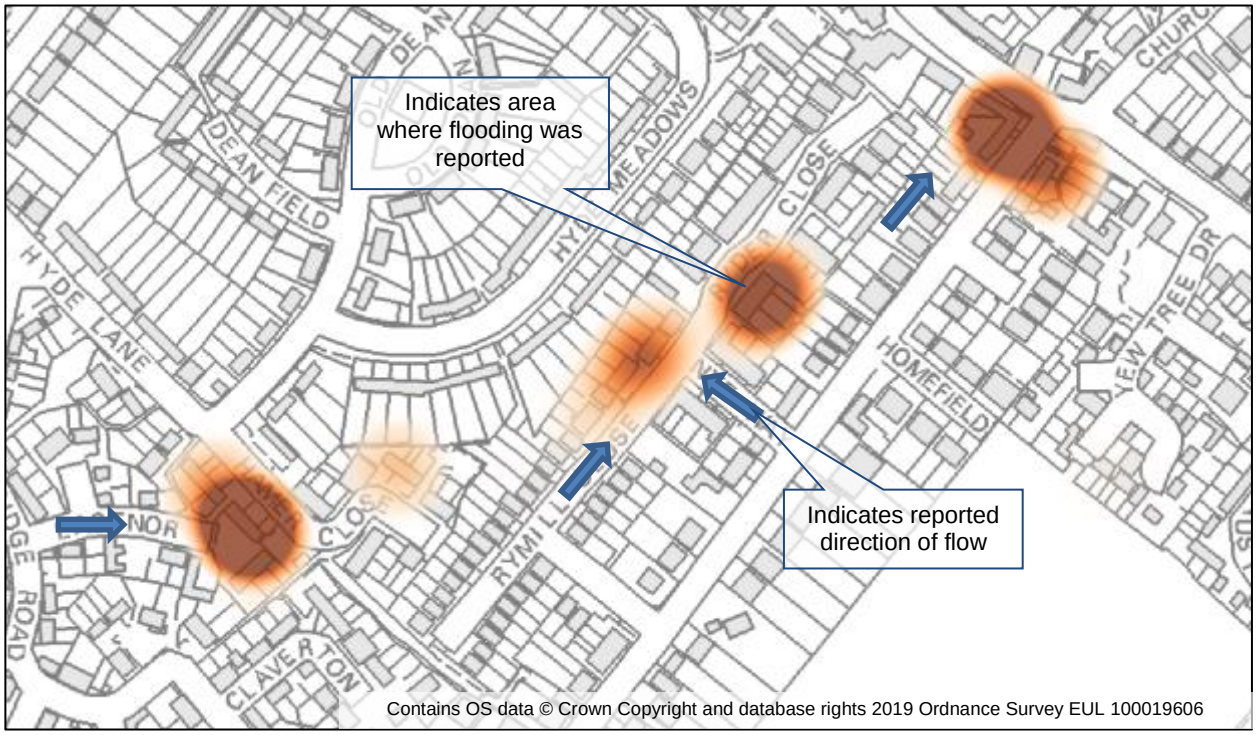
Road/Street	Responses	Flooding Confirmed (internal)	Reported flooding mechanism	Additional notes
Green Lane	6	6 (4)	Surface Water Surcharging Drains	Water flowed from road Foul sewer surcharging
Ryder Close	7	5 (4)	Surface Water Surcharging Drains	Overland flow from higher ground Drains overwhelmed
Rymill Close	7	7 (3)	Surface Water Surcharging Drains	Overland flow from higher ground Foul sewage in gardens
Eastnor	6	4 (3)	Surface Water Surcharging Drains	Overland flow from higher ground Foul sewage within overland flow
Hamer Close	1	1 (0)	Surface Water Surcharging Drains	Water from manholes covers and overland flow from road

Observations and further relevant details provided by residents from the questionnaires or during the investigation are summarised below:

- Properties to the lower lying extent of the catchment along Green Lane recorded the highest flood depths.
- Residents on Eastnor were affected and reported flood depths of up to 0.75m.
- The majority of responses indicated that predicted overland flow routes did manifest and this confirmed the direction water flowed from.
- Many residents reported foul sewer flooding within the investigation area.
- It was also reported by residents that the efficiency of Bovingdon Docks was impeded and a belief was expressed that further maintenance works should be undertaken.
- It has been identified that as a minimum one property from each road, included within Table 2, reported no internal flooding or indicated that they were situated at a higher topographic elevation compared to flooded properties in the area.
- Historical flooding incidents were mentioned in a number of responses.

The flood depths and flow directions reported via the flood incident questionnaires are displayed on Figure 5 in the form of a ‘heatmap’ (with the most severe a darker colour). The arrows represent the flow direction and the darker areas show the greater depth of flood water. Flood depths were deepest at Eastnor and Green Lane. This was closely followed by properties in Rymill Close and Ryder Close.

Figure 5: Flood incident questionnaire results 'heatmap' (McCloy Consulting, 2018)



3.2.2 Public Engagement Meeting

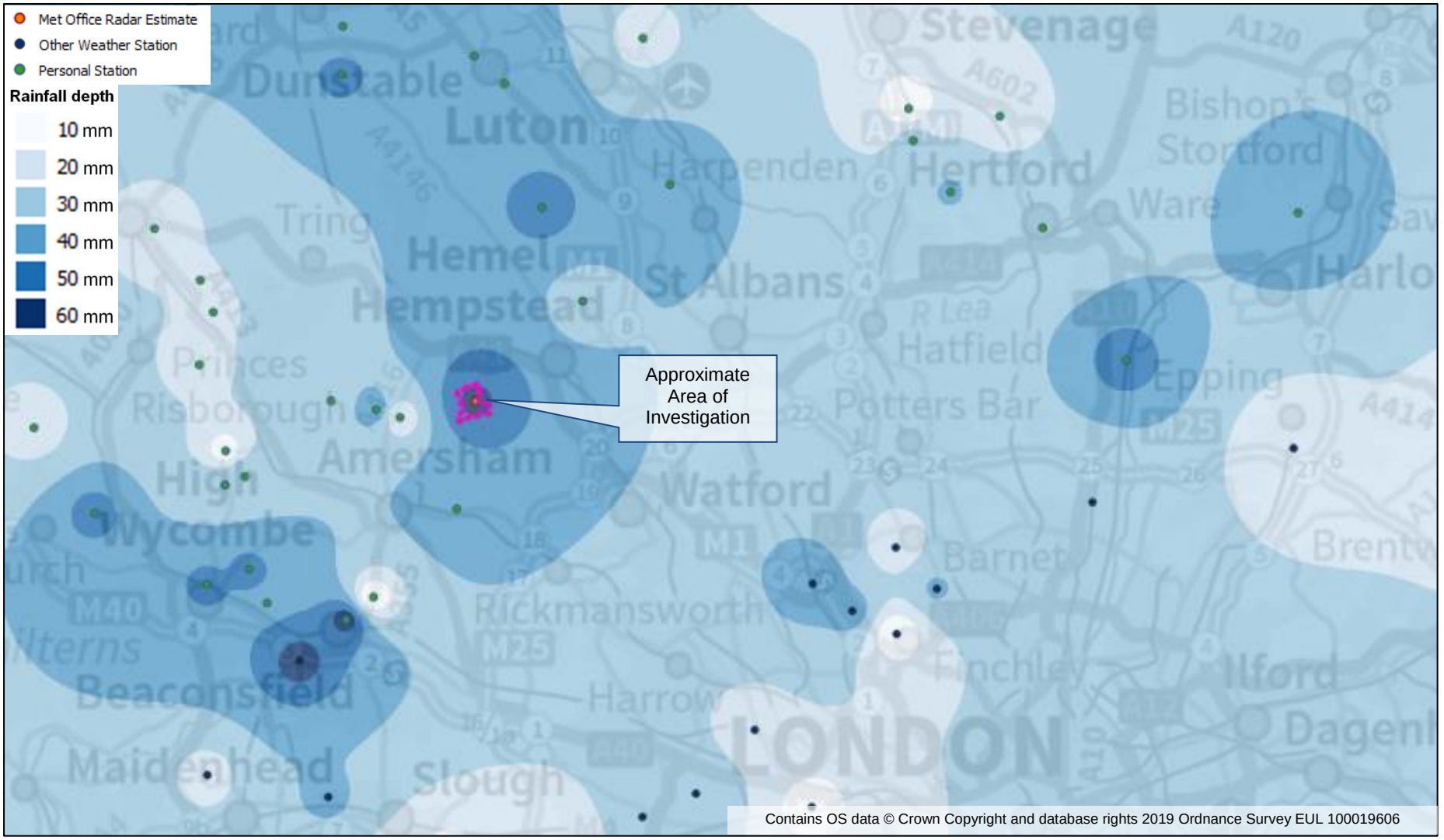
Hertfordshire County Council as the Lead Local Flood Authority engaged further with residents at a meeting held at the Memorial Hall in Bovingdon on 26 February 2019. This provided the LLFA with the following additional information about the flood event:

- Properties on Rymill Close flooded from behind from the Hamer Close car park and houses on Green Street flooded from behind and infront.
- Highway drainage was not operational on Leyhill Road which approaches Bovingdon from the south-west.
- The foul water sewer surcharged on Bovingdon High Street.

3.3 Rainfall and antecedent conditions

It was raining across most of Hertfordshire at the time of the flooding in Bovingdon. However, as can be seen from the rainfall depth map for the 16 September 2016 shown in Figure 6, the areas of the highest rainfall (dark blue) were localised in Hertfordshire including the area of Bovingdon; the approximate location of Bovingdon is highlighted.

Figure 6: Hertfordshire Rainfall Depth Map on 16 September 2016 (Daily Totals) (McCloy Consulting, 2018)



Rainfall data for the site has been taken from both the Met Office and from Third Party Personal Weather Stations (PWS). The Met Office rainfall data used was from the following location:

- Bovingdon (501629, 203566) – 5-minute radar (predicted, site-specific) rainfall; hourly radar (predicted, site-specific) rainfall; daily radar (predicted, site-specific) rainfall

Third Party unverified rainfall data has been gathered from a number of Personal Weather Stations for an approximate radius of 10 km around the investigation area in Bovingdon.

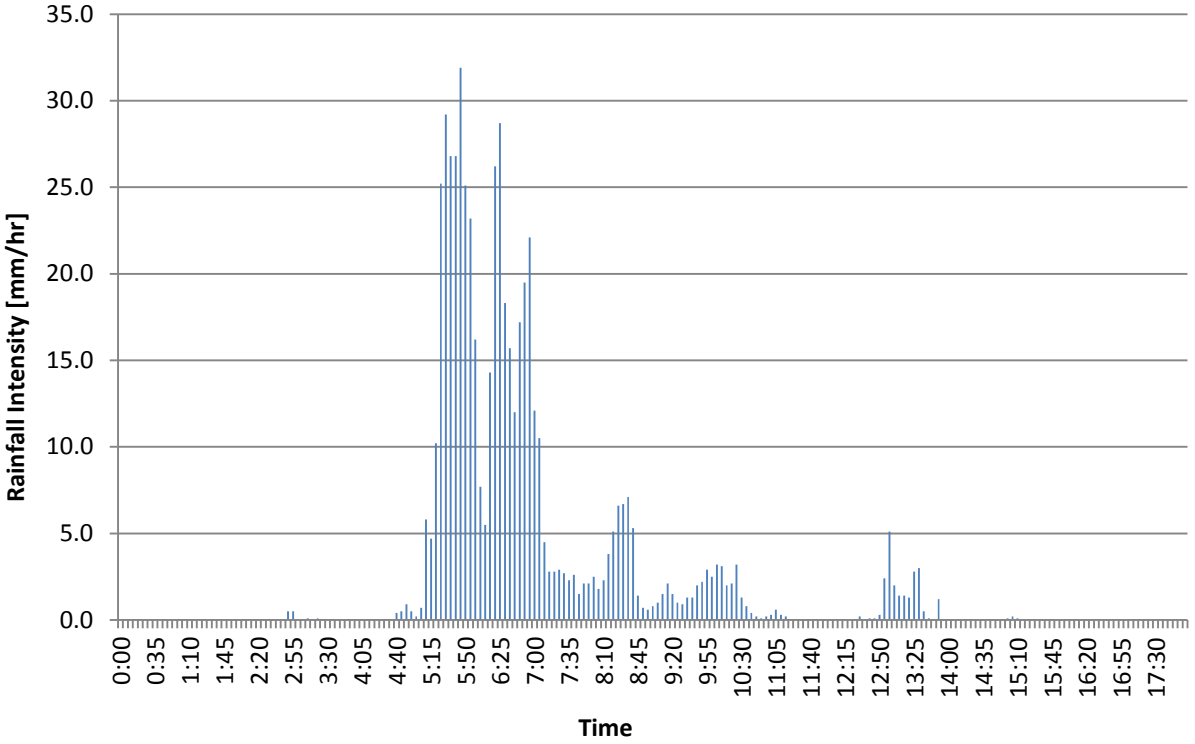
The data, in combination, tends to indicate that the most extreme rainfall experienced was in a relatively confined area within the investigation site. Rainfall was heaviest between 05:00 a.m. and 07:00 a.m. (see Figure 7), which correlates with flood reports and Hertfordshire Fire and Rescue call-out records. The maximum rainfall rate (rainfall intensity) over a 2-hour duration between 05:00 a.m. and 07:00 a.m. was extreme and recorded at 34.9 mm/hr.

Rainfall can be further defined as a return period or likelihood of occurring in any given year, which is an industry standard of assessing the magnitude and probability of a flood event compared to historical data. According to the Flood Estimation Handbook, this rainfall event had a maximum return period of between 15 and 20 years over the 2-hour duration described above. This can be further expressed as a percentage, known as Annual Exceedance Probability (AEP). For this 2-hour duration, the probability of this rainfall occurring in any given year was between 7% and 5% (AEP). Return periods are calculated based on the amount of rain over a duration of time. Therefore, the return period figure will be different depending on the times taken.

However, it is important to note that this is a statistical exercise to gauge the size of the flood event and does not mean that Bovingdon will now not flood for another 15 to 20 years.

Substantial rainfall on 3rd and 10th September 2016 was recorded in Bovingdon. However, it is unlikely that this caused surrounding land to be fully saturated when the 16th September 2016 rainfall event occurred. Moreover, the LLFA is aware that infiltration into the ground in this area is very limited.

Figure 7: Rainfall intensity graph for 16 September 2016 in Bovingdon between 00:00 (midnight) and 18:00 at 5 minute intervals



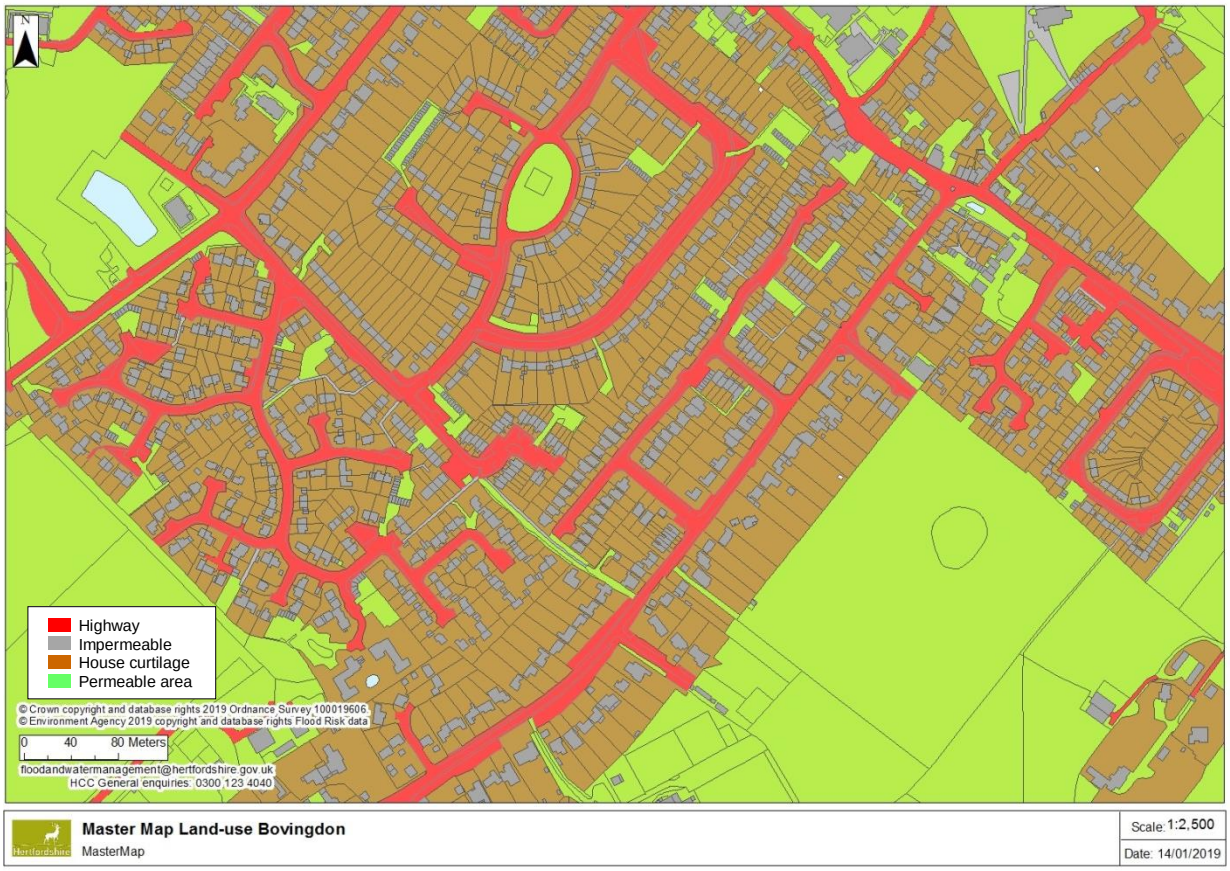
3.4 Surface water drainage network

For surface water drainage residential properties in the Bovingdon area are served by plot level soakaways. Plot level drainage includes private properties' drainage arrangements. No further information regarding any soakaways was available at the time of publishing, however, it is likely these are in poor condition due to a lack of maintenance or they are not efficient in the subsoil.

The surface water and foul water sewer network in Bovingdon is the responsibility of Thames Water Utilities Ltd (TWUL). In Bovingdon the public sewer networks for foul water and surface water are separate. Thames Water have no surface water sewer assets within the area of investigation. The majority of properties drain to private soakaways with assumed infiltration into the ground.

Hertfordshire County Council (HCC) in its capacity as the Highway Authority is responsible for draining the rainfall that falls on the highway but not the overland surface water flows from private land. They have a network of gullies to drain the water which falls on the highway and these gullies are connected to the highway's wider drainage system. According to an assessment of the Ordinance Survey Master Map 26% of the investigation area is roads and footpaths and the rest is private property. An area indicative of what is maintainable by Hertfordshire County Council as the Highway Authority is shown in red in Figure 8 below. Hertfordshire County Council as the Highway Authority only has a role in managing the rain which falls on the HCC maintainable parts of this area of roads and footpaths.

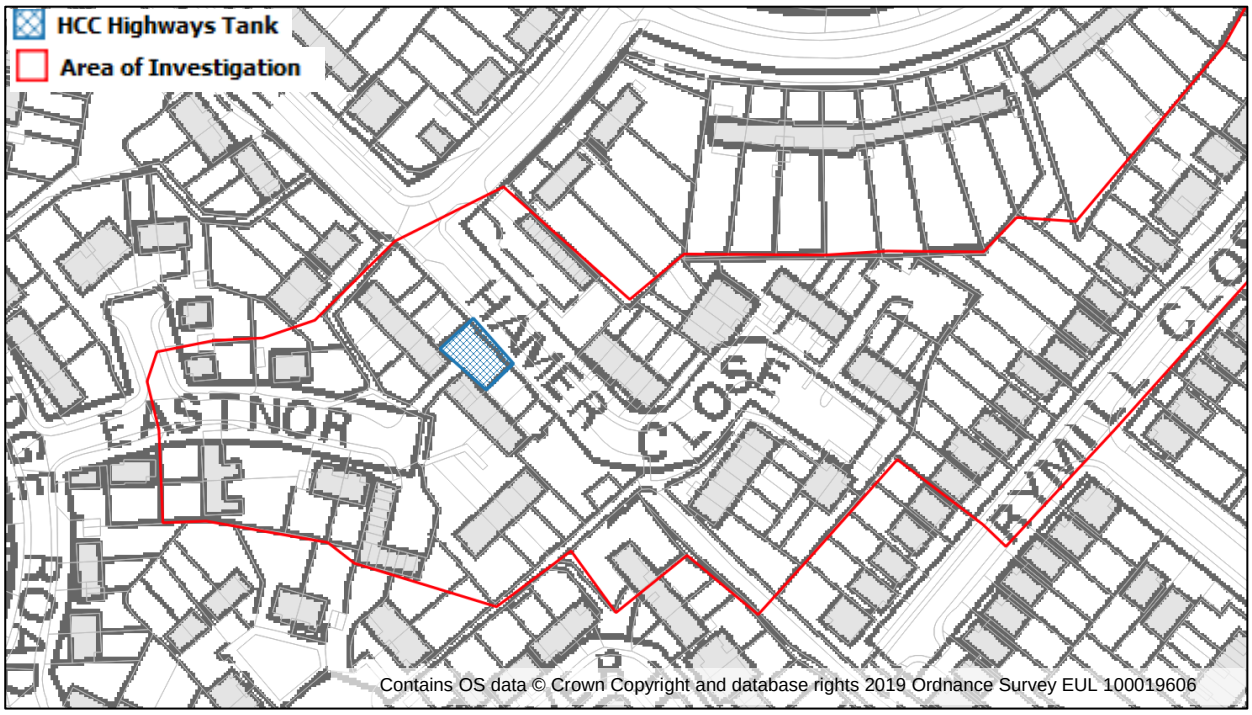
Figure 8: Highway area, additional impermeable, mixed and permeable areas



The highway's drainage network serving the area affected by the flood event in Bovingdon drains to local soakaway/boreholes with assumed infiltration into the ground. The highway network includes two main types of drainage features serving the investigation area. The first type of drainage feature is based on large borehole type soakaways. This is the most common drainage feature used in the Bovingdon area. The second identified feature serving the Highway's drainage network is a large attenuation/ infiltration tank. It has been estimated that its capacity is between 100m^3 and 200m^3. This feature is located beneath the private car parking area between Eastnor and Hamer Close, as shown in Figure 9. The tank would be expected to accommodate the runoff from the highway resulting from a rainfall event with a 10% probability of occurrence. However, it will inevitably receive water from a wider area than just the highway. Highway drainage systems can be expected to be receiving surface runoff from private property (e.g. driveways) and overflowing private drainage.

It is likely the highway drainage network was running at or near design capacity. Highway drainage networks are only designed for managing a certain level of rainfall falling on the public highway. Highway gullies are designed to capture and drain moderate rainfall from the highway. Estimates are that more rain fell on 16 September 2016 than the highway drainage system had capacity to manage, that being a storm with a 10% annual exceedance probability.

Figure 9: Eastnor infiltration tank location (McCloy Consulting, 2018)



Gullies ability to drain water is affected by the volume and velocity of water running over the gullies. Even where gullies are placed to receive large volumes of water the volume that they can discharge is limited by the outlet pipe sizes, the available capacity in the downstream network, ability to soak-away and potential blockages. Overland flow that enters the highway from adjacent land adds to the volumes of water that the gully network is required to drain away.

During this flood event, gullies would not have been able to drain the large volumes of water that fell on the highway in such a short amount of time and the additional overland flows from private land, property, gardens and driveways would have exacerbated the situation and overwhelmed the whole drainage network. The secondary issue is the speed of the surface water in the channel that will jump or bypass the road gullies.

In Bovingdon the amount of surface runoff coming on to the highway when it rains has increased. This is partly due to an increase in the area of impermeable surfaces (such as driveways) in the urban area. As a result, a greater proportion of rainfall will now cause surface runoff. Private drainage systems exist to manage surface runoff but anything in excess of what these can capture will flow onto the road network and this is water which the road network was not designed to drain.

Additionally, any defects to the highway's drainage network could have limited its design capacity for storage and soak-away. If any soakaway or infiltration devices have become silted then their ability to drain water into the subsoil would have been reduced. This would have impacted as well on the amount of surface runoff entering the highway. However, any maintenance improvements would have only resulted in marginal improvements and would not have increased capacity enough to capture the large quantity of water created by the storm event 16 September 2016.

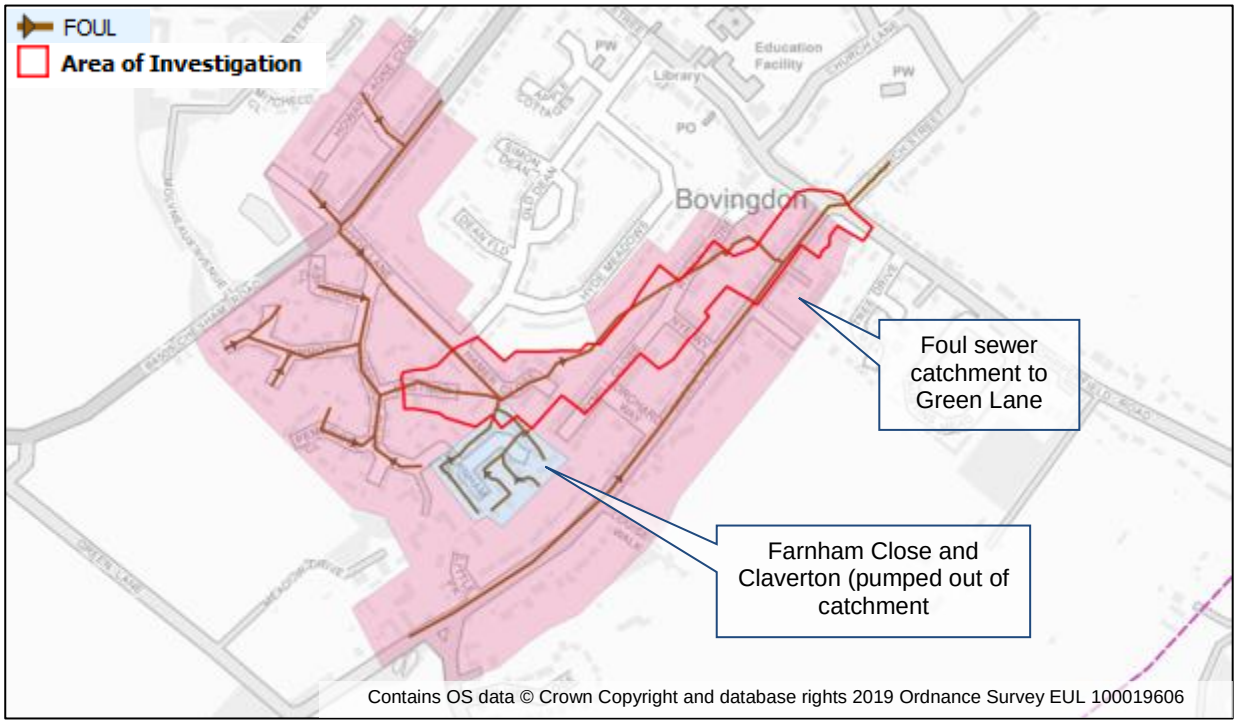
Highway drainage from Green Lane and the High Street discharges to the Bovingdon Docks. This is the only open water feature in the vicinity of the investigation area. From the available information, it is unclear what the exact function of this feature is. The ownership and responsibility for maintenance of Bovingdon Docks is currently under investigation.

3.5 Foul sewer drainage network

TWUL received reports during and after the flood event caused by the surcharging of foul water sewer network inside and outside properties. Based on the available information it is likely that surface water discharges into the foul water sewage network through cross connections from roofs, driveways and patios.

The foul sewer network in the investigation area is mainly separated into two catchments shown on Figure 10. The first catchment is contained around Farnham Close and Claverton Close. It is understood that the foul sewer from this area drains to a pumping station, which is then pumped out into the wider network. The second catchment includes the majority of the investigation area and is indicated below.

Figure 10: Main foul sewer network with indicated network catchments (McCloy Consulting, 2018)



3.6 Pipeline from airfield

A concern was also raised at the public engagement meeting by local residents about a historical asset which was thought might have discharged surface water from the Bovingdon airfield to Hamer Close during the flood event. Historically there were large surface water pipes coming from the airfield down what is now Hyde Lane and discharging to deep bore soakaways where Hamer Close is today.

Following on from the engagement meeting, Hertfordshire County Council as the Lead Local Flood Authority conducted a site investigation to clarify whether the culvert still forms a pathway for surface water. The Lead Local Flood Authority also consulted historical information and asked the Bovingdon Parish Council for their help in collecting information.

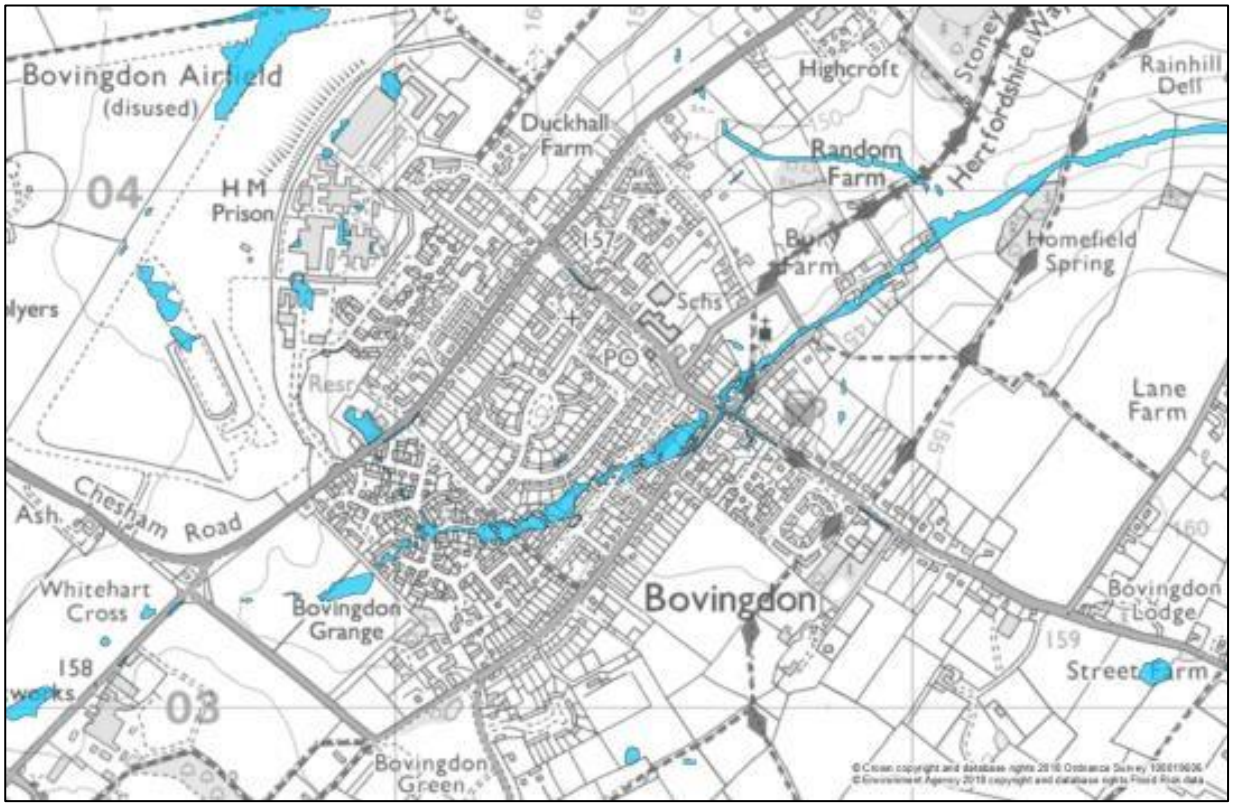
The investigation concluded that the culvert was capped off and the land where the soakaways were was built over in 1993. Currently three foul water sewer lines meet at this point (as shown in Figure 10) and there is a pumping station to move foul water out of the catchment. The LLFA could find no evidence of any current surface water connections and does not consider these pipes further in this document.

3.6 Surface runoff (pluvial)

The intensity of the rainfall on 16 September 2016 was such that water would not have been able to soak into the ground as quickly as it fell. As a result, water would have pooled and flowed to the lowest local points. Surface runoff would have been collected by drainage systems where it was able to enter them and to the extent that the systems were able to accept any flows and volumes.

The paths which surface runoff was observed to have taken during the flood event broadly corresponded with the surface water flow routes predicted by the Environment Agency's Risk of Flooding from Surface Water map (RoFfSW) for the 3.3% AEP event, see Figure 11. This is a less likely and bigger storm scenario than the rainfall that occurred on 16 September 2016 that had an AEP of between 5% and 7%. This means that the topographical drainage routes within the investigation area match with the properties that reported flooding. The RoFfSW map is a predictive map produced at a national scale based on a number of assumptions therefore there may be anomalies in the mapping that could be refined with more detailed hydraulic modelling.

Figure 11: National Risk of Flooding from Surface Water Map (RoFfSW) (3.3% AEP)



Surface water flow routes are likely to have been locally exacerbated by obstructions to flow paths, such as fences and walls between buildings, which would have caused water to be held back, resulting in locally raised water levels.

As the LLFA we are aware that infiltration is not a feasible discharge option in the area. This means that there is a limited ability of water soaking into the ground. Therefore, the effectiveness of infiltration features, like soakaways, may be limited. Moreover, any future potential development in the area should have to consider storage, attenuation on site and an alternative discharge mechanism.

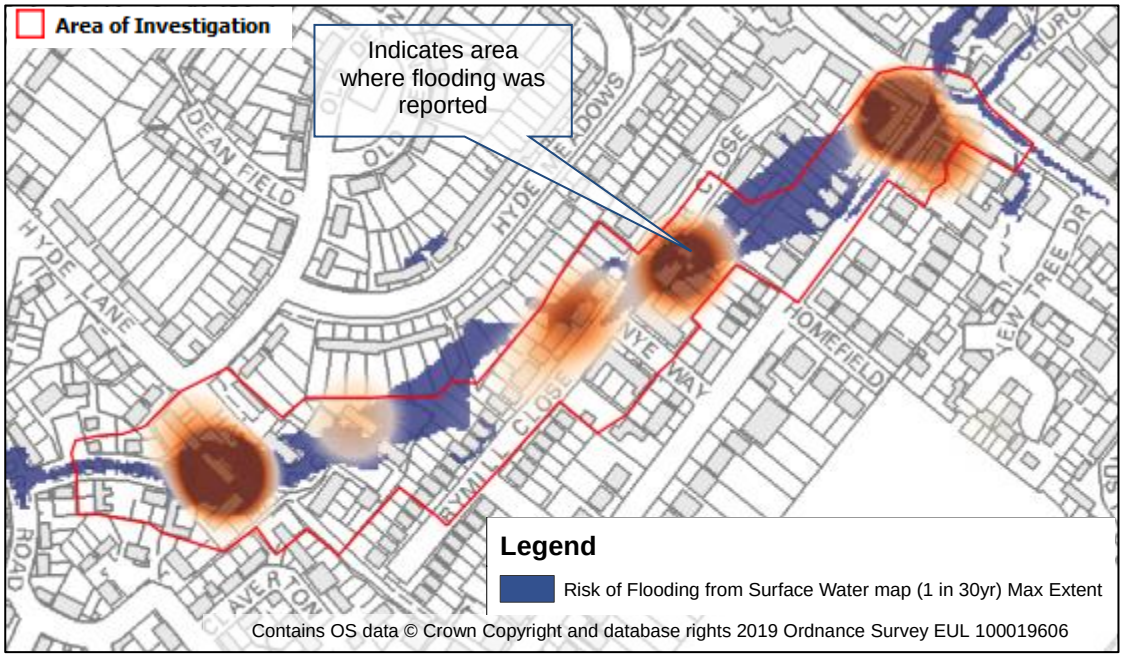
Where drainage system surcharging occurred, emerging water or water which would otherwise have been captured would have contributed to surface water flows. Runoff in excess of sewer capacity would have followed the flow routes indicated by the EA's Risk of Flooding from Surface Water map (Figure 11).

Flood risk may also have changed over time, as there will have been an increase in the extent of impervious areas due to development such as extensions and the paving of gardens. This increases the potential for surface water to runoff into the sewer system rather than this infiltrating through the ground. This could have an effect on surface water flood risk for the area. There will also be occasions where spaces between properties that would have previously allowed water to flow freely around properties have now been filled in with property extensions. This is likely to have a direct impact on the movement of water potentially increasing the number of properties at risk of flooding.

3.7 Causes of flooding

The rainfall information discussed in Section 3.3 highlights that the volume of water that fell in such a short amount of time would have likely exceeded capacity of the urban drainage network for the area identified in the study. This will have substantially contributed to overland flows that drained towards low lying properties in Bovingdon. A similar extent of flooding to what is shown on the Risk of Flooding from Surface Water map would have occurred because the recorded rainfall event on 16 September 2016 (which had an AEP of 5 to 7 %) was of approximately the same magnitude as the rainfall used to create the 3.3% AEP Risk of Flooding from Surface Water Map. Figure 12 shows the EA predicted surface water flood extent resulting from a rainfall event with a 3.3% AEP in any one year overlain with the 'heatmap' of observed flood depths. The Risk of Flooding from Surface Water map is published on the GOV.UK website.

Figure 12: EA's RoFfSW (3.3% AEP) with the observed flooding heatmap (McCloy Consulting, 2018)



Given the reasonable correlation between the recorded rainfall, observed flooding, and associated surface water flood extent mapping, it can be concluded that surface water flooding is a significant contributing factor to flooding experienced on 16 September 2016. Also it is understood that it is likely that at the property level, surface water had an influence on the foul sewage network which is then conveying a surface water flow. This could occur by miss-connections in the surface water drainage, flooded manholes or infiltration of surface water into the foul sewage network within the investigation area. The local foul sewer network was not designed to carry surface water so would not make a significant contribution to draining surface water from the investigation area. In the area along the main sewer line in Bovingdon it is reasonable to state that flooding at those locations was partially caused by sewer flooding. This also correlates with a topographical depression.

The collective of private property creates the largest surface runoff. Where surface water drains from private property onto the highway and where private drainage systems were overloaded the highway network would have received the excess surface water. The combined effect of surface water flows and surcharging sewers would have directly limited the ability of the surface water to enter over-full gullies within the roads. Possibly low infiltration into the ground in the area would have increased the amount of run-off entering the drainage network. There could have been localised blockages or silted infiltration features in the highway drainage network or Thames Water sewer network. This could have had an impact on the overall efficiency of the systems in the investigation area and could have impacted on the flooding incident on 16 September 2016. During the flooding event, the Bovingdon Docks that serves the highway drainage was full and was overflowing. This shows that the Bovingdon Docks would have been overwhelmed in the flood event and could have had a limited potential for discharge from this area.

4. Responsible authorities and landowners

Part of the role of HCC as the LLFA in accordance with S19 of the FWMA 2010 is to identify the Risk Management Authorities (RMA's) that have flood risk management functions relevant to the flooding which took place. Those RMA's and their relevant powers and functions are set out below.

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 of this report.

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 the flood risk.

HCC as the LLFA for Hertfordshire has powers to carry out flood risk management works, in accordance with the Local Flood Risk Management Strategy for Hertfordshire, for flooding from surface runoff and ground water. The LLFA is also required to maintain a register of structures and features that have a significant effect on local flood risk.

This Flood Investigation has been commissioned by HCC as the areas reported as being affected by flooding are fully within their jurisdiction as LLFA.

4.2 Hertfordshire County Council as the 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.

The roads and public highway are maintainable at public expense by HCC as the Highway Authority and are also 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.

4.3 Thames Water Utilities Limited (TWUL)

TWUL manages the public surface water and foul water sewer networks; it therefore has been identified as a relevant RMA. TWUL manages flooding from their network in line with their business plan approved by OfWAT.

TWUL, like all water companies, are required to keep a register of all instances of internal and external flooding of properties, this is referred to as the DG5 register. This register is used as the evidence to justify improvements to the drainage network.

Only TWUL has the authority to alter the surface water and foul sewers and to manage the flood risk associated with it.

4.4 Dacorum Borough Council

Dacorum Borough Council is a risk management authority. However, as there are no ordinary watercourses within the investigation area, no further actions and responsibilities have been identified at the moment.

5. Conclusions, potential mitigation options and recommendations

5.1 Conclusion

The main cause of flooding was surface water resulting from an intense 2 hour rainfall event. Overall the pattern of flooding was broadly as predicted in the map of predicted surface water flooding for a 1 in 30-year return period rainfall event of RoFfSW published by the Environment Agency and shown on Figure 11. The observed flooding was of a magnitude up to 1 in 20 year return event in peak intensity. Direct surface runoff is the principle mechanism causing flooding with some contribution from water emerging from surcharged highways drainage and foul sewers. This surcharging could have been a consequence of surface water entering the foul sewerage and surface runoff entering the highway drainage network. A combination of those factors overwhelmed and exceeded the design capacity of the drainage system in the catchment.

There is no single action that would significantly reduce flood risk in the area and the potential to mitigate the flood risk is limited as the upper parts of the catchment are owned by third party landowners. A range of measures to reduce the impact of heavy rainfall in the area should be considered and this will need to include actions which are aimed at improving the flood resilience of individual properties.

A collaborative approach between the relevant Risk Management Authorities; HCC as LLFA, HCC as Highway Authority, Thames Water, Dacorum Borough Council and other stakeholders will be needed to manage and improve flood risk most effectively in the area.

5.2 Potential mitigation options

The technical assessment report provided by McCloy Consulting (2018) suggested a range of actions to be considered to contribute to the overall reduction of flood risk in the area (see Table 3).

Table 3: Suggested recommendations from the Technical Report

Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
a. Target improved public awareness of Property Level Flood Resilience measures.	1. There will always be a level of flood risk to some properties in the area. Property owners should be made aware of the risk and the actions that they can take to reduce the probability of properties flooding internally.	Yes **Recommendation 1**
b. Potential for investigation of a catchment management surface water interception scheme / flood alleviation scheme in the upper hydrological catchment, with a view to seeking to reduce pressure on the downstream drainage network.	2. There is limited scope but an initial appraisal of the opportunities is available to see below. 3. Flood alleviation strategy could include new or improved drainage network and flood detention / interception scheme (green infrastructure). 4. It will need to be demonstrated that flood risk to properties is significantly reduced.	Yes **Recommendation 2**
c. Identification of existing local surface water drainage assets within the investigation area in Bovingdon including surveys of property level infiltration features like soakaways. This should include resolving the ownership of Bovingdon Docks.	5. There is very little knowledge of the existing drainage assets. 6. This investigation is to improve asset information; identify assets requiring maintenance; understand drainage capacity in the area; and optionally permit any possible flood alleviation schemes. 7. Current performance or functions of Bovingdon Docks is unknown. 8. HCC as the LLFA is currently undertaking some investigation works to identify the ownership of Bovingdon Docks. 9. The relevant authority will identify performance of the structure and consider improvement and maintenance works to suitable design standards and appropriate conditions.	Yes **Recommendation 3** Yes **Recommendation 3**

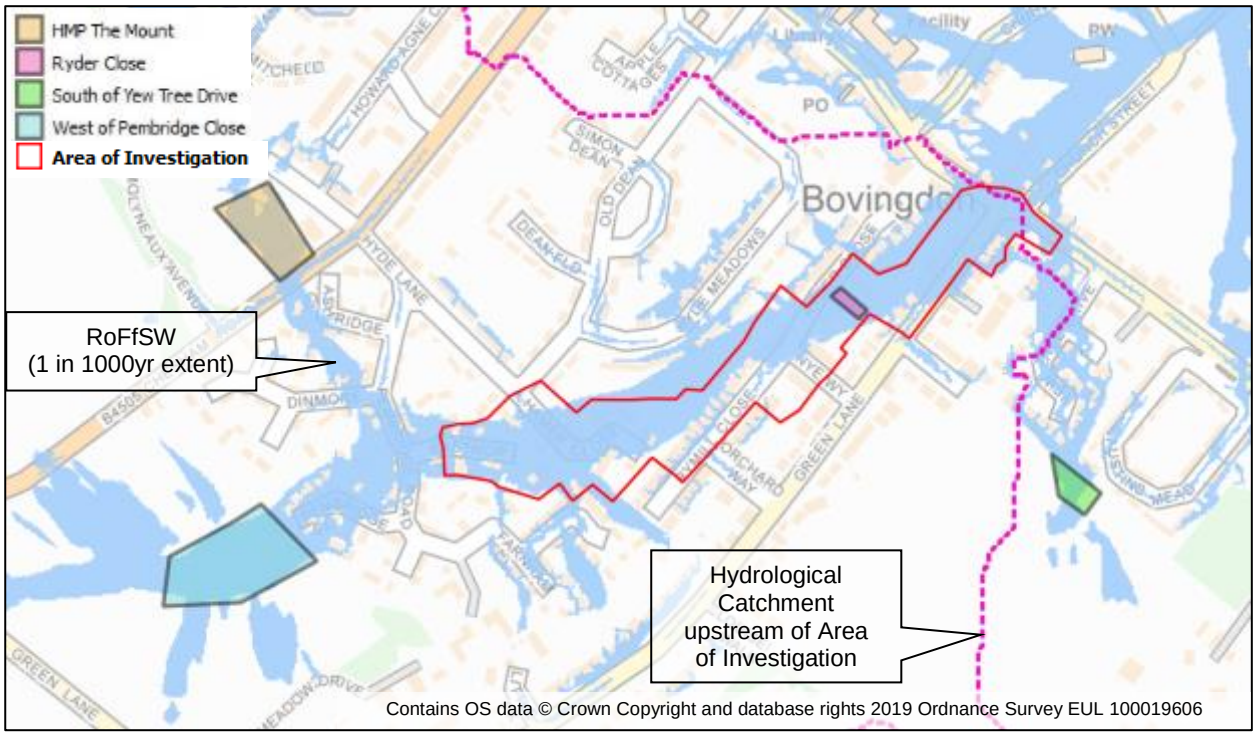
Actions suggested by the technical assessment report	Comments	Take forward as a recommended action?
Additional potential measures to seek to alleviate flooding, likely to involve funding and considered capital works, have been identified as follows:		
d. Potential for investigation of all soakaways and infiltration features serving the highways within the investigation area, to identify the existing condition of assets.	10. No information is available about the condition of highways drainage assets including soakaways serving the network and other infiltration features like infiltration tank within the investigation area in Bovingdon. 11. Should identify the effectiveness and efficiency of the existing highway's drainage network. 12. Could identify needs for maintenance works.	Yes **Recommendation 4**
e. Undertake a review of Thames Water assets condition within the investigation area and information accuracy and investigate miss-connections or infiltration of surface water into the foul sewer network.	13. No information is available about the existing condition of the network, miss-connections and possible discharges of surface water into the foul sewerage network. 14. Should identify the effectiveness and efficiency of the surface and foul sewer network within the investigation area in Bovingdon. 15. Could identify remedial measures. 16. TWUL have procedures agreed with OfWAT to review the performance of the public surface water sewers based on reports of property flooding from customers.	Yes **Recommendation 5**
f. Potential for further investigation of surface water capacity in the catchment to identify predicted performance related to flood protection standards and measure.	17. This is for the local community to identify maintenance works at property level soakaways, increase awareness of flood risk, identify available resilience, report problems with drainage network and help to create community flood plan. 18. Thames Water has procedures agreed with OfWAT to review the performance of the public sewers based on reports of property flooding from customers.	Partially **Recommendation 3** Yes **Recommendation 5**

5.2.1 Potential locations for surface water attenuation schemes within the investigation upper catchment

Bovingdon has four potential green areas that could be used to store the surface water flow routes identified within this report. These features would essentially be landscaping elements that would be designed to store water during heavy rain. The land could still be used for other purposes other than in times of flooding. Runoff would be diverted into these features which would release the water slowly.

Some areas have already been identified that could propose the use of open spaces to attenuate water. These are identified on Figure 13. It is suggested to conduct a feasibility study to explore if these and any more green areas could be used to attenuate water in Bovingdon and to identify if this would provide a benefit in reducing the risks posed by surface water flooding.

Figure 13: Potential areas for Green Infrastructure (McCloy Consulting, 2018)



As stated in section 1.2 of this report, the LLFA is aware of the possible future development within the area of the upstream catchment of the investigation area. If a development were to be implemented in line with the current drainage design standards it would create an opportunity for a substantial betterment on surface water management in Bovingdon.

5.2.2 Recommendations

A. Identify relevant stakeholders, Risk Management Authorities, and landowners, and as may be appropriate seek to implement flood management measures; including in particular increased public awareness, uptake of Property Level Protection, and identification of key drainage asset maintenance needs.
B. Investigate potential flood alleviation options. Any flood alleviation option(s) selected will require a technical assessment by the relevant authority and / or landowner and approval (if required) prior to any implementation on site. Please note that these are not in a priority order.

All other recommendations can be seen below in Table 4.

Table 4: Recommendations for identified RMAs and key stakeholders

No.	Recommendation	Comments	RMAs and other parties involved
1.	Individual property owners review the flood risk to their property and consider steps they could take to reduce the probability of flooding together with the benefits of installing Property Level Flood Resilience.	• Even if found to be viable, any proposals for general flood risk management schemes will not eliminate flood risk and would be medium term actions (5 – 10 years) and so property owners may wish to take steps to manage flood risk at a property level. • Whatever other steps are taken there will always be a residual level of flood risk. In some cases there may be relatively simple actions such as modification to boundary features that will reduce the probability of flooding. • Flood plans for individual properties can help guide actions that will reduce the impact of flooding and promote recovery.	Individual property owners supported by HCC as LLFA.
2.	An initial proposal is carried out into the viability of the creation of surface water management scheme with an area of surface water storage in the upper part of the catchment at different locations.	• Funding will be an issue. Conventional sources would require the flood risk benefit of the scheme to be demonstrated and this balanced against the cost. Also assumes that a flood risk scheme will be acceptable to the relevant landowners.	Landowners supported by HCC as LLFA, HCC as Highway Authority and Thames Water.
3.	The relevant authorities should help to identify local surface water drainage assets. This should include investigation of the ownership of Bovingdon Docks. Individual property owners should identify the existing drainage arrangements and infiltration features within their properties in the investigation area. This should	• In line with Thames Water network condition investigation this will allow to understand the real storage capacity available in the catchment, investigate required maintenance works and optionally permit any possible flood alleviation schemes. • To consider and allow any survey, investigation or improvement works the owner of the Docks needs to be known.	Landowners supported by HCC as LLFA and Thames Water.

No.	Recommendation	Comments	RMAs and other parties involved
	include identification of predicted performance related to flood protection standards and measure.	• Before any works, full condition and functions of Bovingdon Docks need to be identified. • Investigate the condition of the interception trench and borehole to the rear of Yew Tree Drive and the LLFA add it to the asset register.	
4.	Hertfordshire County Council as the Highway Authority should investigate the condition of their drainage assets. This should include efficiency and effectiveness investigation of soakaways and any infiltration features draining the highways with confirmed discharge mechanisms within the investigation area in Bovingdon.	• The existing condition, efficiency and effectiveness of the drainage network needs to be understood before any further actions can be undertaken. This could provide appropriate information about the network. • Available storage volumes within the drainage features should be given and justified its design. • Discharge mechanism from the surface water drainage should be confirmed to fit for purpose. For infiltration features purpose infiltration rate should be confirmed. • Any necessary maintenance and repair work should be carried out. • If required, upgrades of the network should be considered. • In particularly, the soakaways on Rymill Close, Ryder Close and Nye Way are old and should be investigated and considered for improvement if appropriate.	HCC as Highway Authority
5.	Thames Water should investigate the surface water and foul sewer network in the investigation area. This should include a survey to accurately record the asset and identify any miss-connections or infiltration of surface water into the foul sewer network. In addition the performance of sewer networks should be reviewed to	• The operational network needs to be understood before any further decisions can be taken. • Any necessary maintenance and repair work should be carried out. • Upgrades of the network to reduce flood risk will need to be assessed in line with OfWAT approved procedures. • Residents should inform Thames Water about any	Thames Water supported by residents.

No.	Recommendation	Comments	RMAs and other parties involved
	determine if any repair work is needed or if improvements can be carried out. Thames Water should be supported by residents.	events and existing impact on foul sewer. Thames Water prioritises action to reduce flood risk based on information provided by their customers.	
6	Owners of private soakaways should consider refurbishing or replacing them.	• The majority of surface water comes from private property therefore it is important that private drainage systems are functional. • As part of localism, property owners also have responsibilities. • Property owners should investigate their drainage assets and complete any repairs and maintenance.	Property owners

6. Actions Undertaken by RMA's

The following sections set out the actions that are in progress to be completed or were completed between 16 September 2016 and the release of the Final version of this investigation.

6.1 Hertfordshire County Council as the Lead Local Flood Authority

1. Have carried out an investigation using their powers under Section 19 of the FWMA 2010.
2. The extent of the flooding was confirmed through resident questionnaires and consultants were engaged to carry out a technical assessment of the area.
3. Commissioned McCloy Consulting Ltd to provide technical advice on the production of the Section 19 Investigation.
4. Draft Section 19 flood investigation report published to RMA's and residents of Bovingdon.
5. Ongoing investigation to identify the ownership of Bovingdon Docks.
6. The LLFA organised a public engagement meeting which took place on 26 February 2019 to receive comments from residents. Comments were mainly about local infrastructure.
7. Published the final Section 19 flood investigation report informed by feedback from the RMA's and residents.

6.2 Hertfordshire County Council as the Highway Authority

1. Have preliminarily reviewed the operation of the highway drainage in the area.

6.3 Thames Water Utilities Limited

Bovingdon was attended by TWUL staff at the time of the flooding on 16 September 2016. The staff on site identified flooding as being caused by surface water getting into and overwhelming the foul network.

After the flood event, a CCTV and de-scale operation was completed on various networks across the village. No defects with the pipes were identified, although sewer abuse was evident with fat, oil and grease. A cleaning operation was completed that removed the fat, oil and grease and scale. This would have increased the capacity and operational flow of the network.

TWUL completed educational leaflet drops in the area on what not to put down the sewer due to blockages and evidence from the CCTV investigations.

7. Next Steps and Proposed Actions

7.1 Hertfordshire County Council as Risk Management Authority

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

1. Sharing the final report with residents in the areas of flood risk and the relevant RMAs and other parties.
2. Investigate the feasibility of the options for managing flood risk in the investigation area.
3. Finalise investigation of the ownership of Bovingdon Docks and include within the Register of Structures and Features.
4. Investigate the condition of the Yew Tree Drive interception trench and deep bore soakaway and add the assets to the Hertfordshire County Council asset register.

7.2 Hertfordshire County Council as the Highway Authority

The following are recommended actions to be undertaken by HCC in its capacity as Highways Authority;

1. Investigate efficiency and effectiveness of highways drainage network including soakaways and any infiltration features draining the highways within the investigation area.
2. Justify the storage volume available to manage any run-off falling into the highways with confirmed discharge mechanism of the network.
3. Investigate the feasibility of the optional upgrades of the drainage system within the investigation area.
4. Programming remedial action for any blocked or damaged highways drainage assets. Any local defects should be delivered via the Cat 2/6 highway work programmes if they are a priority.
5. Jet clean the highways pipework at the Bovingdon Docks.
6. Continuing to monitor reported faults through the highway reporting system.

7.3 Thames Water Utilities Limited

TWUL continue to monitor on a reactive basis with reports from the public and alarms at the sewer pump stations with waste operational control.

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. HCC expressly disclaims responsibility for any error in, or omission from, this report arising from or in connection with any of the assumptions being incorrect.

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