

19th Dec 2018

Buckinghamshire County Council

Flood Investigation Report

Buckingham, 10th March 2016



River Great Ouse beneath the Tingewick Road Bridge (provided courtesy of Mr P. Wallace)

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Revision Schedule

Buckinghamshire County Council Flood Investigation Report

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V3

Rev	Date	Details	Author	Checked and Approved by
1	20/12/2016	Version 1 – draft	Abigail Alderson	
2	10/01//2017	Version 2 – draft	Abigail Alderson/ Andrew Waugh	Karen Fisher
3	19/12/2018	Version 3 – final	Andrew Waugh	Karen Fisher

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1 Executive Summary

This report has been produced by Buckinghamshire County Council (BCC) to investigate the flooding that occurred in Buckingham between the 9th and 10th March 2016. The report provides details of the event and makes recommendations for Risk Management Agencies (RMAs) to undertake to prevent a repeat in the future.

A Section 19 Investigation is a statutory requirement for Lead Local Flood Authorities (LLFA) under the Flood and Water Management Act (FWMA) 2010. On becoming aware of a flood in its area, the LLFA must, to the extent that it considers it necessary or appropriate, investigate:

- Which RMA have relevant flood risk management functions; and
- Whether each of those RMAs has exercised, or is proposing to exercise, those functions in response to the flood.

It was deemed necessary to produce this report as the flood event in Buckingham exceeded BCC's criteria for carrying out a Section 19 Investigation.

The aim of the Section 19 Investigation is to give an explanation of what happened in the flood event and what were the RMAs' responsibilities during the event. It is not intended to identify which properties flooded, nor to provide an exhaustive hydraulic analysis of the event. The recommendations are there to help the RMAs learn lessons from the event and to move forward with management of the flood risk in the future.

The flood event in Buckingham occurred as a result of almost a month's worth of rainfall falling on already near-saturated ground during an 11-hour period. Water levels in the River Great Ouse rose rapidly through the morning of the 9th March 2016, first peaking around in the late afternoon, then rising further that evening and into the early hours of the 10th. The river peaked around 2am, with overtopping of the banks in low lying areas of Buckingham. River levels, as recorded by the EA's Buckingham gauge, were only 10cm below the record level of 2007, yet the impacts were much less severe. It is now thought that the peak level recorded in 2007 may have been under-read by the gauge – see section 2.2 below, though it is also probable that the installation of property level protection to vulnerable properties in the intervening years mitigated the property impacts that may otherwise have occurred.

A list of recommendations is included in the report which is intended to ensure that the

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flood management, warning and response to events are improved going forward. All the RMAs will be involved in taking forward these recommendations.

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2 Introduction

2.1 Background to investigation

BCC as the LLFA has a responsibility to record and report flood incidents as detailed within Section 19 of the FWMA 2010:

Section 19

- (1) On becoming aware of a flood in its areas, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate-
 - (a) Which risk management authorities have relevant flood risk management functions, and
 - (b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.
- (2) Where an authority carries out an investigation under subsection (1) it must-
 - (a) Publish the results of its investigation, and
 - (b) Notify any relevant risk management authorities.

BCC has established criteria for section 19 flood investigations which can be found in the appendix.

It was deemed necessary to complete an investigation into the flood incident in Buckingham because it meets the following threshold:

- Internal flooding of two of more business premises within an area of 1km²

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2.2 Site Location

Buckingham is a town in Aylesbury Vale District in the north of Buckinghamshire as shown in Figure 1, close to the borders of Northamptonshire and Oxfordshire.

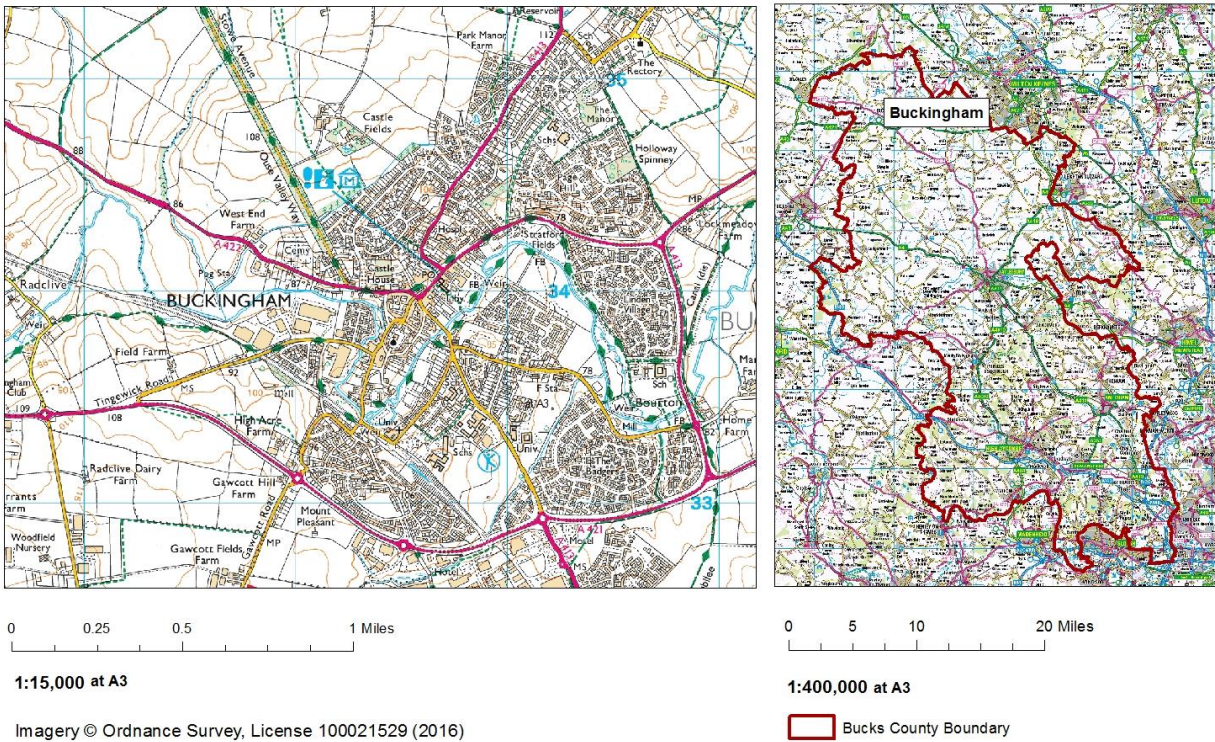


Figure 1: Location of Buckingham at local and county level.

2.3 Drainage system and river network

The River Great Ouse flows for 150 miles from its source until it discharges into the North Sea at the Wash. It flows through Northamptonshire, Buckinghamshire, Bedfordshire, Cambridgeshire and Norfolk.

The Buckinghamshire stretch of the river flows along the county border with Northamptonshire to Brackley and then the border with Oxfordshire. It then passes close to the communities of Westbury and Water Stratford before flowing through Buckingham. Downstream it passes Thornton before becoming the Buckinghamshire border with Milton Keynes and passes close to Beachampton before leaving Buckinghamshire. The detailed river network around Buckingham is shown in Figure 2.

The Environment Agency (EA) is the Risk Management Authority (RMA) for the main rivers, as defined in section 4.3. The EA has permissive powers to work on main rivers

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and the sea to manage flood risk. Buckinghamshire County Council, as Lead Local Flood Authority for Buckinghamshire, is the RMA for ordinary watercourses.

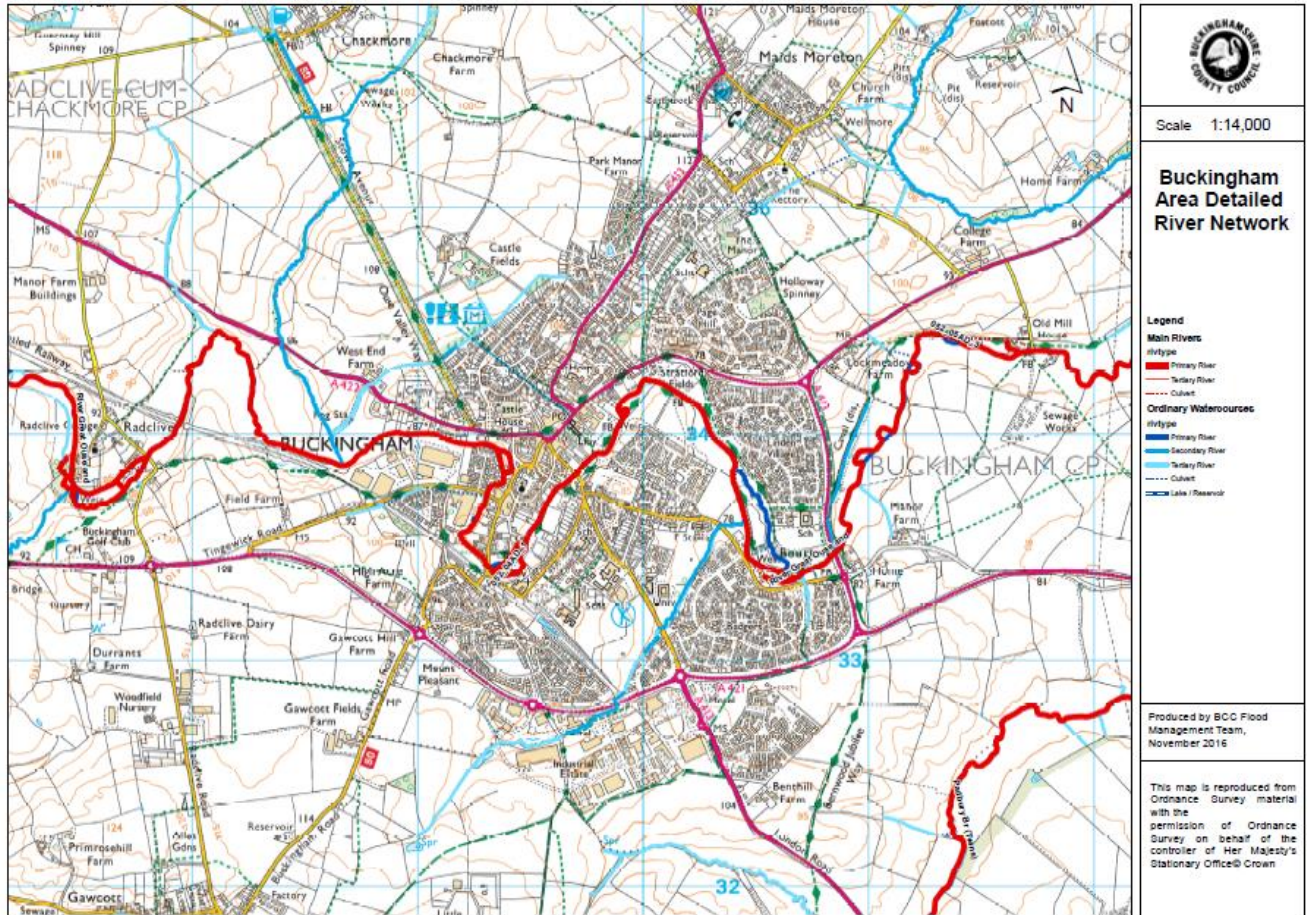


Figure 2: Buckingham Detailed River Network

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3 Background

3.1 Catchment characteristics

The River Great Ouse drains a large catchment area consisting, in the upstream reaches, of relatively impermeable gravely clays overlying mudstone and limestone. Generally, rainfall infiltrates fairly slowly into the ground and runs across the surface to the nearest river. Rivers in this part of the catchment area therefore tend to react fairly quickly to rainfall. Buckingham itself is situated on clay, silt, sand and gravel along the line of the Great Ouse, with no superficial deposits outside of the alluvium areas.

Buckingham is at risk of both fluvial and surface water flooding, but the principal source of flood risk is from fluvial sources. The publicly available fluvial Flood Map for Planning (see Figure 3) models the area which could be flooded from rivers by a flood with a 1 in 100 (1%) chance of occurring each year (medium blue/ Flood Zone 3), and by a flood with a 1 in 1000 (0.1%) chance of occurring each year (light blue/ Flood Zone 2). (Please note that the information indicates the flood risk to areas of land and is not sufficiently detailed to show whether an individual property is at risk of flooding, therefore properties may not always face the same chance of flooding as the areas that surround them).

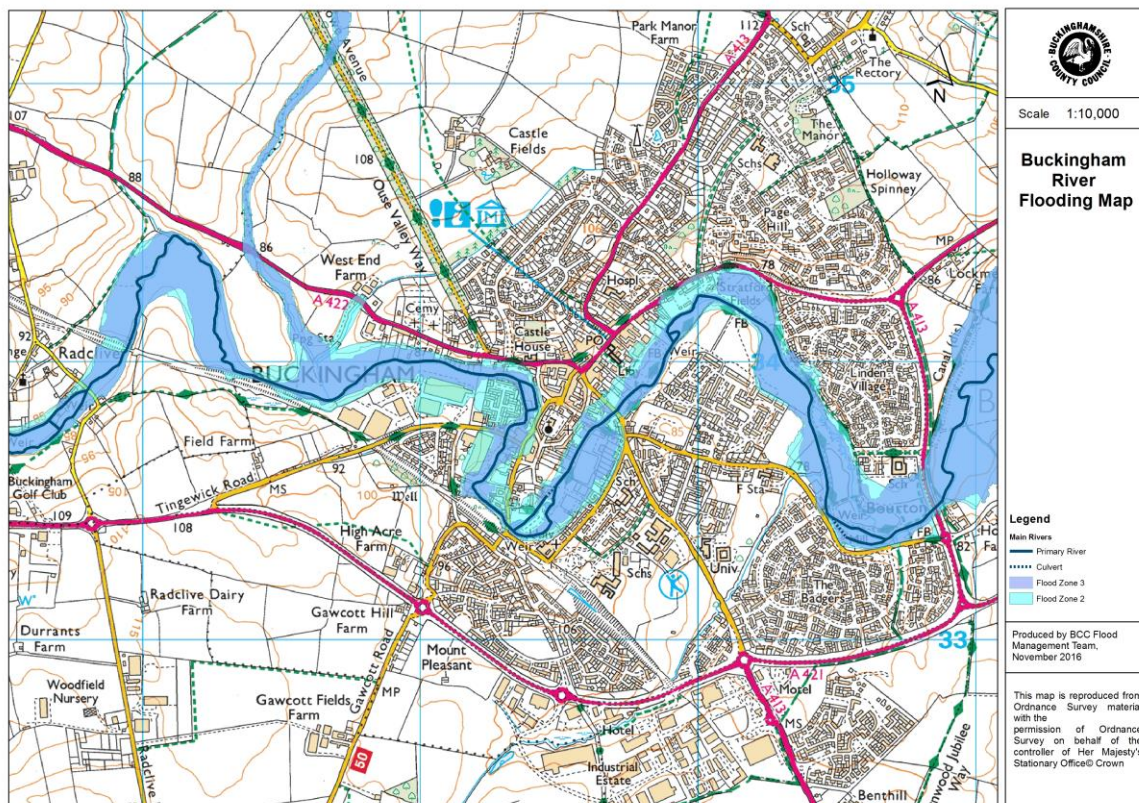


Figure 3: Flood Map for Planning

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Figure 4 shows the publicly available “Flood Risk from Surface Water” flood mapping, shown here for a flood event with a 1 in 1000 (0.1%) chance of occurring in any given year. Surface water flooding occurs when extreme or prolonged rainfall cannot infiltrate into saturated ground, or flow into the rivers and/or highways drainage due to high volumes of water. The Flood Risk from Surface Water mapping is viewable at: <https://flood-warning-information.service.gov.uk/long-term-flood-risk/map>. It has not been possible to reproduce this mapping at a closer scale for the purposes of this report, but different scenarios of depth, velocity and extent can be viewed at various scales via the above link.

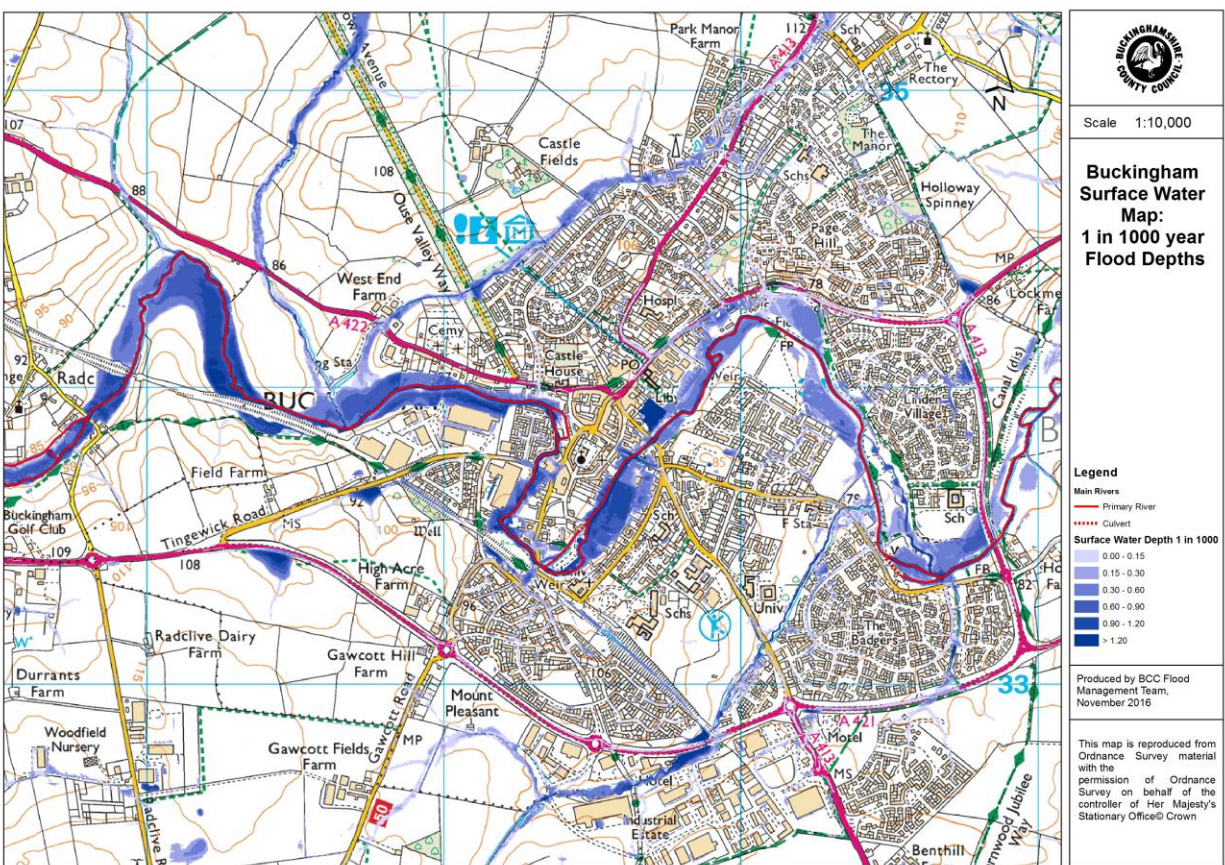


Figure 4: Risk of Flooding from Surface Water map, showing modelled depths in a 1 in 1000 year flood

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3.2 Previous flood events

There have been four significant flood events in Buckingham; March 1947, December 1979, April 1998 and July 2007. April 1998 saw extensive flooding of the River Great Ouse at Buckingham, with the flooding of 75 properties.

The most recent previous flood event in Buckingham occurred in July 2007, when 118.4mm of rain fell on Buckingham, almost three times the average rainfall of July. Extremely heavy and prolonged rainfall caused the catchment of the Upper Ouse to become saturated and river levels to rise rapidly. Flood water spread throughout the low lying areas of the town, much of which had already seen some flooding from surface water which had overwhelmed the drainage system in places. 96 properties in total were flooded (Environment Agency). The peak water level at the Buckingham river gauge reached a new record at 80.66 mAOD. However, it should be noted that the Environment Agency have advised that the gauge may have “drowned out”¹ and under-read the actual levels in 2007. If this was the case, then the peak water level in 2007 may in reality have been higher than this recorded value.

Following the 2007 flood event, the Buckingham Property Level Flood protection scheme was delivered by Aylesbury Vale District Council (AVDC) in partnership with Buckingham Town Council (BTC) and the Environment Agency, protecting 87 properties. These events also led to the creation of a community flood action group, “Flood Action 4 Buckingham”, and raised community awareness.

¹ A gauging structure becomes “drowned out” when the water level downstream of the structure rises to the point where it affects the upstream water levels. When a structure is “drowned out”, gauging accuracy can be negatively affected.

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4 Analysis of March 2016 flood event

4.1 Conditions at the time

By March 2016, monthly rainfall totals across England had been above average for a fifth consecutive month.

Following this wet winter, soil moisture deficits² (SMDs) around Buckingham were just 4mm prior to Wednesday 9th March 2016 (Environment Agency, 2016), indicating that the ground was already saturated and had capacity to store only 4mm more water.

Over the period of 2-8th March 2016, weekly precipitation exceeded 40mm in many parts of the country, including in the vicinity of Buckingham (Figure 5).

4.2 What happened?

The EA's river gauge at Castle Bridge, Buckingham, recorded water levels rising through the 9th March, first peaking at 17:15. It is likely that this first peak was due to the effects of the local rainfall. It then rose further through the evening and early hours, with a second higher peak of between 01:30 to 02:15 on Thursday 10th March. This second peak was likely due to the rainfall making its way down through the catchment from Brackley.

The peak river level as recorded by the gauge was 80.56 mAOD. This is only 10cm below the record level of July 2007.

Water levels recorded at the EA's Buckingham river gauge between 8th March to 13th March, together with rainfall at the nearest EA rain gauge at Foxcote, are shown in the hydrograph in Figure 6, below.

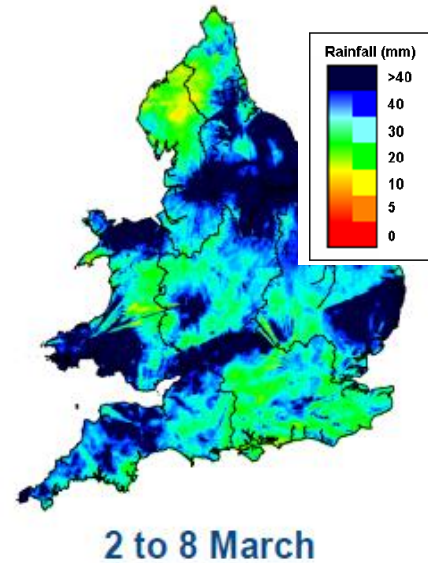


Figure 5: Rainfall totals over the period 2-8th March 2016. Note that radar beam blockages caused anomalous totals in some areas, such as the linear striping in west Wales and south Midlands (EA, 2016).

² Soil moisture deficit levels provide a measure of the capacity of the ground to store water: the higher the number, the greater the capacity.

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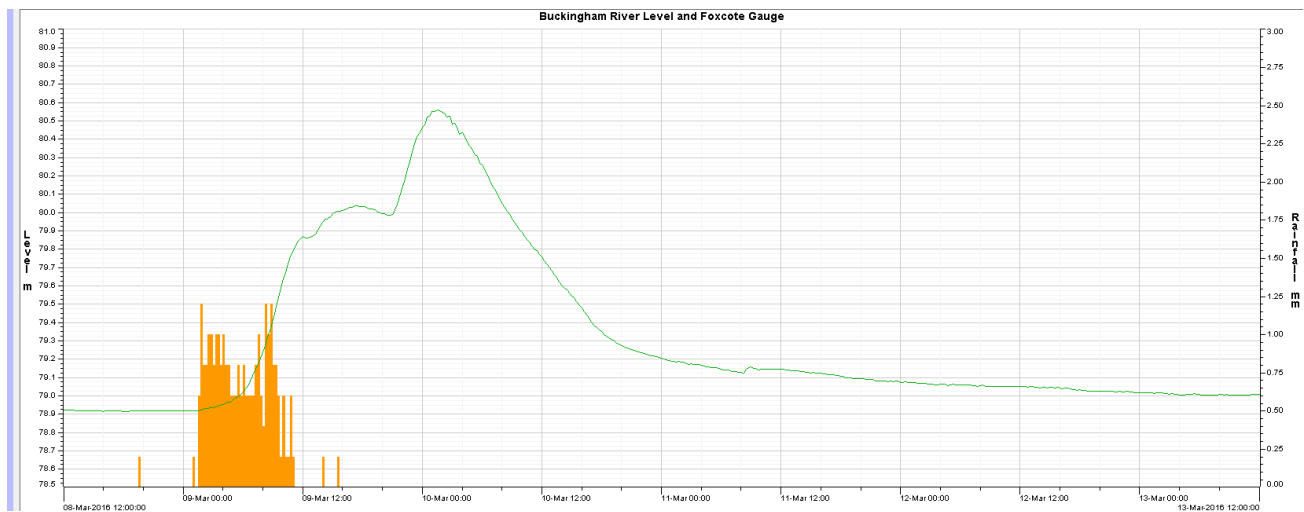


Figure 6: Hydrograph and rainfall between 8th March to 13th March. The green line shows the level of the river level gauge at Castle Bridge, Buckingham, and the orange bars indicate rainfall at the nearest EA rain gauge to Buckingham at Foxcote (Environment Agency).

Figure 7, below, shows the hydrograph and rainfall upstream in the catchment at Brackley over the month from 25th February to 24th March 2016, showing the intense rainfall on 9th March 2016 and the subsequent rise in levels.

There were some reports from local residents that water was surcharging out of drains, which could potentially have resulted from the surface water drainage system being unable to discharge into the Great Ouse due to the high river levels. Other drains were simply overwhelmed by the volume of runoff. There were also problems with vehicles driving too fast through flood waters, causing a bow wave to ingress into property boundaries. However, the principal source of flooding to properties was overtopping of the Great Ouse, with floodwater inundated low-lying areas of Buckingham.

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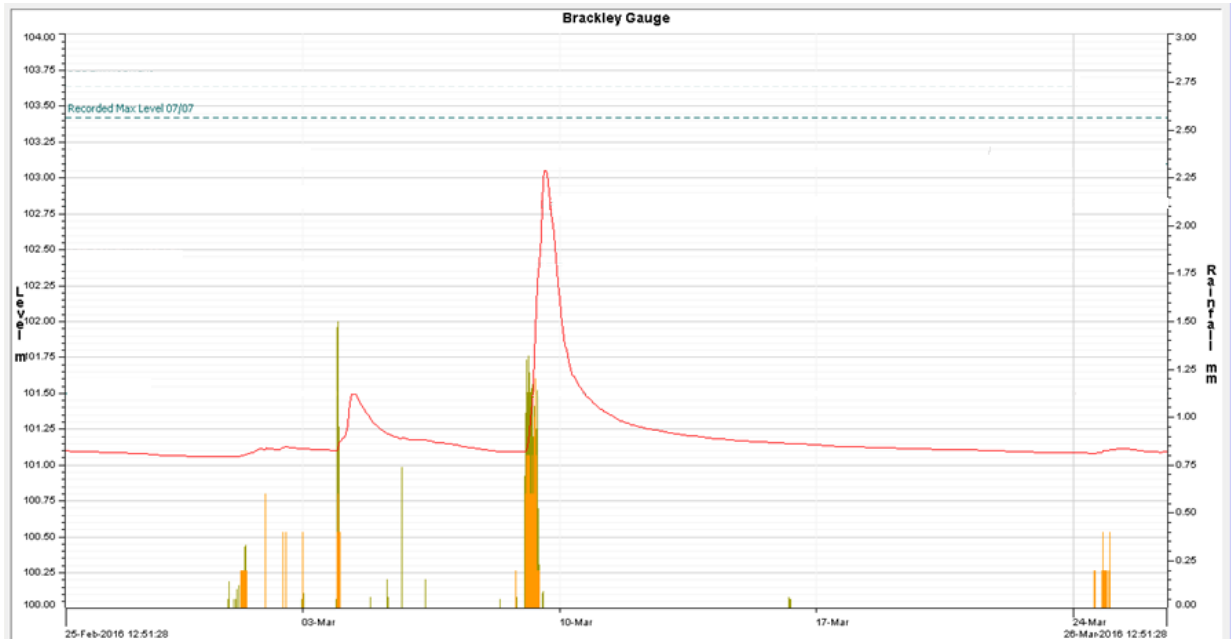


Figure 7: Hydrograph and rainfall at Brackley between 25th Feb to 24th March 2016. The red line shows the level of the river at the river gauge at Brackley and the orange and green bars indicate rainfall at the nearby EA rain gauge, also at Brackley (Environment Agency).

Six properties within Buckingham were affected by floodwater, including four residential properties. However, of the 86 properties previously fitted with property level flood protection products as part of the Buckingham Property Level Protection (PLP) flood scheme (2010), only 3 reported internal property flooding.

Follow-up correspondence between BCC, local residents and other RMAs has suggested that not all properties with PLP deployed their equipment during this event, as in some cases it was clear to the resident that it was not required. In other cases, PLP was deployed but not needed in the event.

Though levels recorded at the EA's Buckingham river level gauge were only 10cm below the record level of 2007, the impacts were much less severe. In 2016, 6 properties were affected by floodwater, compared with 2007 where 96 properties were flooded. It may be possible that the 10cm difference sufficiently explains the significantly less damage.

However, anecdotal evidence from local residents suggests that in reality, there was a much greater difference in levels between those of 2007 and those of 2016. In light of this, the Environment Agency have reviewed their data and have subsequently

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suggested that in 2007, the gauge may have “drowned out”¹ and under-read the actual levels in 2007. If this was the case, then the peak water level in 2007 may in reality have been higher than the gauge record suggested, and therefore there could indeed have been more of a difference in levels than a mere 10cm between 2007 and 2016.

It is also possible that the implementation and deployment of some of the PLP measures may have mitigated some property damage that may otherwise have occurred. Though it is difficult to firmly establish to what extent the PLP was required or deployed in the 2016 event, either way this has highlighted the excellent partnership working undertaken to deliver this project by all the organisations and local community involved.

One further potential factor in the large difference in consequences between the 2007 and 2016 events may have been the influence of Padbury Brook. In 2007, levels on the Padbury Brook recorded at the EA gauge at Bourton were 20cm higher than in 2016, indicating that more water was entering the Great Ouse downstream of Buckingham in 2007 than in 2016. This may have caused water levels in the Great Ouse to ‘back up’ towards Buckingham in 2007, perhaps until this effect was progressively mitigated by the channel gradient and larger structures (eg. the cascade weir beside Buckingham University). Any such influence would therefore not be apparent from the gauge at Buckingham, situated further upstream beyond such influences, and so theoretically it may be possible that any higher levels downstream of the gauge in 2007 might not have been recorded. However, this is essentially conjecture, and further more detailed analysis beyond the scope of this report would be required to investigate further.

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4.3 Possible causes

Total 48-hr rainfall accumulations at three nearby rain gauges are provided below (Table 1).

Rain gauges in the region	Total on 9-10 th March 2016 (mm)	Grid Reference
Byfield	34.9	SP 52347 52534
Brackley	40.2	SP 60115 36084
Foxcote	29	SP 70253 35862

Table 1: Rainfall totals across the Upper Great Ouse catchment region, 9-10th March 2016.

Between midnight and 11:00am on Wednesday 9th March, 39.7mm of rainfall³ was recorded at the Environment Agency's (EA) rain gauge upstream of Buckingham at Brackley. Such rainfall figures are equivalent to the entire average rainfall of the month of March. BCC have calculated the probability of such a rainfall event occurring in any given year at this location as approximately 1 in 5 (20%), using the Flood Estimation Handbook (FEH) methodology.

Figure 8, below, gives the 15 minute rainfall interval totals from the Brackley rain gauge. The data shows that relatively high intensities of rainfall (over 0.8mm every 15 minutes) were maintained between 01:45 on 9th March to 10:00 9th March.

³ Note that this total is slightly less than the value for Brackley given in Table 1. The 39.7mm was recorded between the 11-hour period between midnight and 11:00am on the 9th March (the period of continuous heavy rainfall), whereas the 40.2mm was recorded in the 48-hour period between midnight on 9th March until midnight on 11th March.

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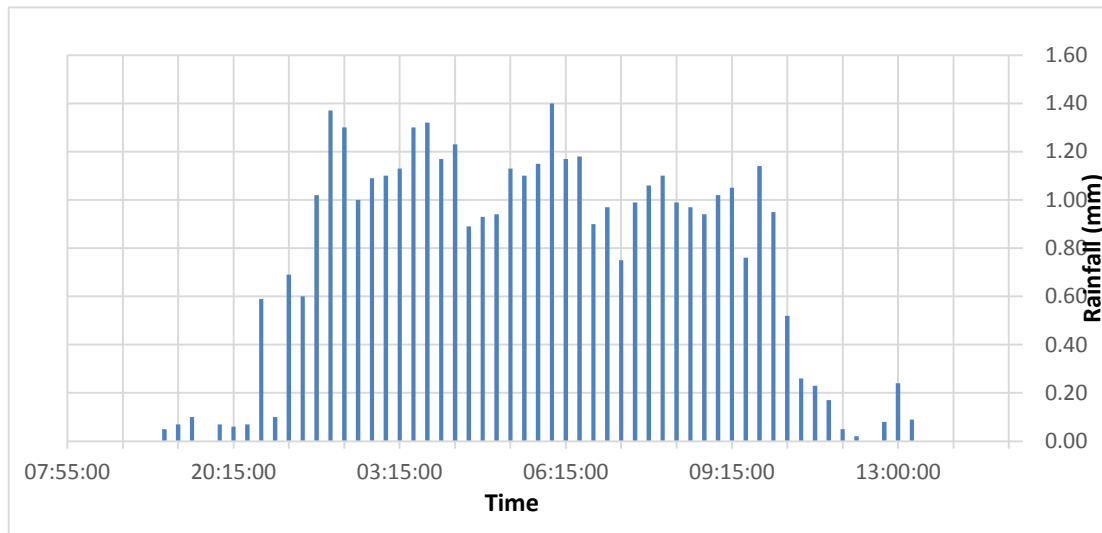


Figure 8: Brackley rain gauge data for the period 07:55 07/03/16 to 19:55 09/03/16 in 15minute intervals.

HYRAD rainfall radar data (courtesy of the EA) show persistent heavy rainfall countrywide leading up to the main flood event, with some areas in the region receiving 6mm of rain in a 15 minute period (Figure 9).

Given that the soil was already near-saturated (with an SMD of 4mm, as noted above), very little of the storm's rainwater could have been retained within the soil. Water would likely have rapidly arrived into the stream channels via quick throughflow downslope beneath the ground surface, with rapid displacement of 'old' stored soil water pushed out from the bottom of the hillslopes into the channels by new water infiltrating at the top of the slope. There would also likely have been some surface saturation in parts of the catchment, leading to some contributions to the river flow from overland surface flows.

In summary, the flooding occurred following a month's worth of rainfall falling within 11 hours onto an already saturated catchment, leading to a fairly rapid river response with high peak flow.

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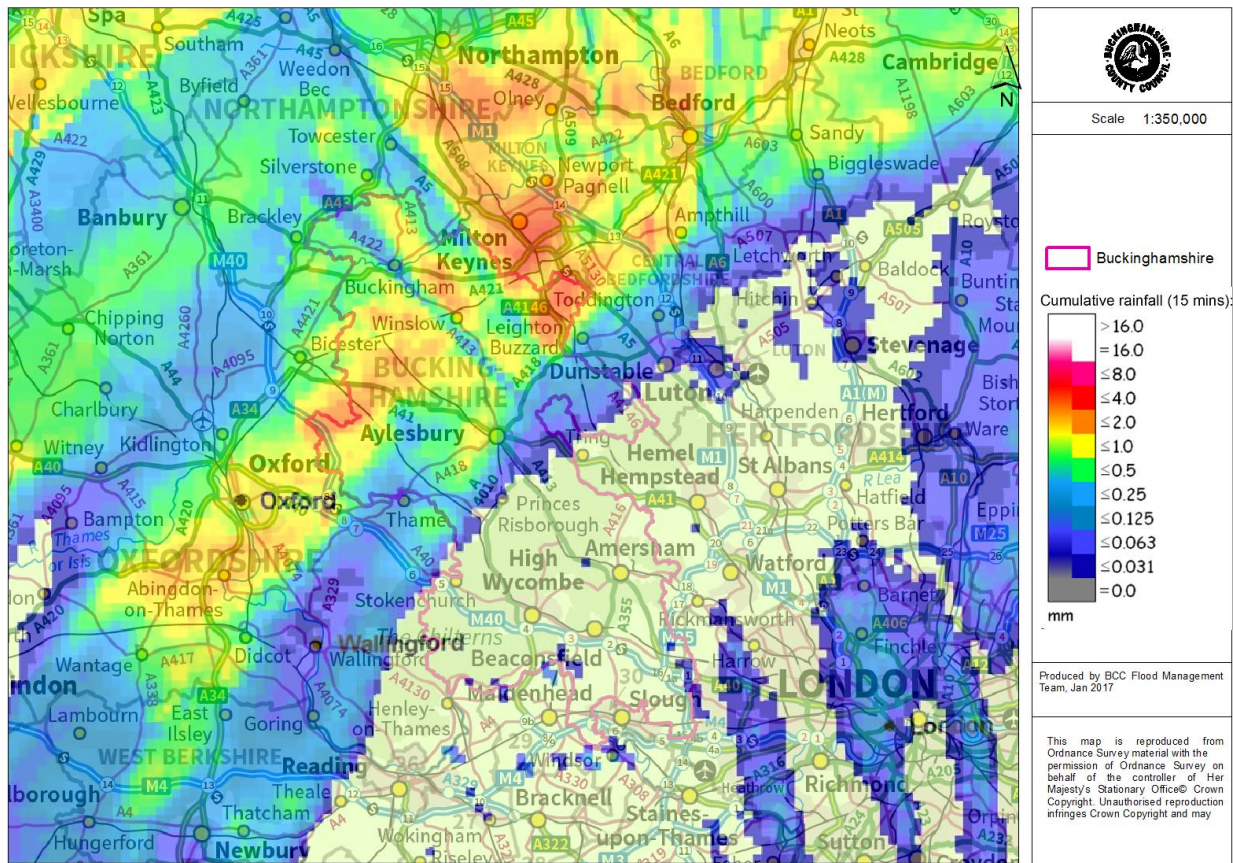


Figure 9: HYRAD rainfall radar imagery of Buckinghamshire and the surrounding area for 08:30am 9th March 2016 (provided by EA, 2016). The linear “stripe” of blue colours to the north-east of Buckingham (between heavier rainfall denoted by yellows and reds) is likely to be a radar anomaly.

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4.4 Incident response

Environment Agency

- Flood Alert for Great Ouse issued 09:00 on 09/03/16
- Flood Warning issued 14:02 on 09/03/16
- Advised partners at adverse weather teleconference at 15:30 that the river level was forecast to reach approximately 1.65m above the Buckingham gauge site datum (80.25mAOD). Further advice given at follow up teleconferences at 18:00 and 20:00. (Actual maximum levels reached were 1.96m above site datum [80.56mAOD] between 01:30 and 02:15).
- Flood support officers visited the town on 10th March 2016 and talked to residents about the flooding, heard their experiences and collected valuable data and information.

Transport for Buckinghamshire

- Following the heavy rain on the 9th March 2016, Transport for Buckinghamshire (TfB) closed a number of roads in the area (see table 2). Stratford Road was closed on recommendation of Thames Valley Police.
- Three TfB crews were putting out signs and sandbags throughout the day and 2 crews on standby overnight whilst the levels were being monitored. Team had 500 sandbags loaded up ready to be deployed if necessary but rain subsided quickly.
- The main concern was the Great River Ouse. The A422, Stratford Road, had to close where the river had risen by 1.6m.
- Other locations in the area including Beachampton and Leckhampstead also faced flooding incidents.

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Table 2: Transport for Buckinghamshire response sites across the area on 9th March 2016.

Date	Request taken by	CRN Number	Order Number	Time (hrs)	Defect	Address 1	Address 2	Depot	Time Passed (hrs)	Comments
09 March 2016	DF	46016053	5021121	9.17	2hr/Flood	Lillingstone Road	Akley	Gawcott	9.30	COMPLETE
09 March 2016	DF	46016054	5021124	9.18	2hr/Flood	Grenville Road	Buckingham	Aylesbury	9.45	COMPLETE
09 March 2016	DF	46016049	5021129	9.04	2hr/Flood	Church Road	Edgcott	Aylesbury	10.00	COMPLETE
09 March 2016	DF	46016081	5021150	10.33	2hr/Flood	Nash Road	Beachampton	Gawcott	10.38	COMPLETE
09 March 2016	DF	46016066	N/A	9.47	2hr/Flooding	Church Lane	Edgcott	Aylesbury	10.15	COMPLETE
09 March 2016	DF	46016090	N/A	11.01	2hr/Flooding	Winslow Road	Padbury	N/A	11.16	COMPLETE
09 March 2016	DF	46016089	N/A	11.12	2hr/Flooding	Buckingham Road	Newton Purcell	N/A	11.18	COMPLETE
09 March 2016	DF	46016087	5021215	10.43	Flooding	Church Hill	Akeley	Aylesbury	11.35	COMPLETE
09 March 2016	DF	46016093	5021199	11.20	2hr/Flooding	Edgcott Road	Grendon Underwood	Aylesbury	11.50	COMPLETE
09 March 2016	DF	46016092	5021202	11.06	2hr/Flooding	Winslow Road	Nash	Gawcott	12.02	COMPLETE
09 March 2016	DF	46016129	N/A	12.32	2hr/Flooding	Stratford Road	Buckingham	N/A	12.53	COMPLETE
09 March 2016	DF	46016119	N/A	12.17	2hr/Flooding	Main Street	Gawcott	Gawcott	12.58	COMPLETE
09 March 2016	DF	46016137	5021234	13.28	2hr/Flooding	Stratford Road	Leckhampstead	Gawcott	13.39	COMPLETE
09 March 2016	DF	46016130	N/A	12.38	Flooding	Ford Street	Buckingham	Gawcott	14.15	COMPLETE
09 March 2016	DF	46016142	5021243	14.32	2hr/Flooding	Verney Road	Addington	Gawcott	14.33	COMPLETE
09 March 2016	DF	N/A	5021245	14.38	2hr/Road Closure	Main Street	Beachampton	Gawcott	14.35	COMPLETE
09 March 2016	LM	46016136	5021236	13.22	2hr/Flooding	Tingewick Bypass	Tingewick	Gawcott	13.44	COMPLETE
09 March 2016	DF	46016175	N/A	16.44	2hr/Flooding	Fulwell Road	Westbury	N/A	7.01	COMPLETE

Aylesbury Vale District Council

- Made contact at approximately 16:00 on 09/03/16 with the remaining members of the Buckingham Flood Action Group and advised to put property level protection in place.
- Carried out street cleansing on the 10th March with AVDC staff checking streets for cleanliness on 11th March.

Buckinghamshire and Milton Keynes Fire and Rescue Service:

- Thursday 10 March, 1.54pm: Flooding in basement, Bridge Street, Buckingham. One appliance and crew from Buckingham attended. Firefighters isolated the electricity and used a portable pump.
- Attended several other flooding incidents across the county during the period, but no other incidents in the town of Buckingham.

Anglian Water

- 3 customer related jobs in the period around the flooding: one was related to a blockage, at another no problem was identified, and the third was related to the wet weather but there was no flooding present when they attended (Moreton Road).
- Attended a number of high level alarms at their pumping stations due to the wet weather.
- No properties were added to the DG5 register following this incident

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5 Responsible Authorities and landowners

There are different responsibilities for flood management depending on the type of flooding. Organisations responsible for flooding are known as Risk Management Authorities (RMAs) and their responsibilities are detailed below. Riparian landowners also have responsibilities for watercourses across their land and these are also detailed below. These are summaries of the details included in the Buckinghamshire County Councils Local Flood Risk Management Strategy (due to be published 2017).

5.1 Lead Local Flood Authority

The Lead Local Flood Authority in this area is Buckinghamshire County Council. Buckinghamshire County Council has a role as a RMA in coordinating management of local flood risk from surface water, ground water and ordinary watercourses in the county.

5.2 Aylesbury Vale District Council

Aylesbury Vale District Council have responsibilities to inspect and maintain watercourses on District Council land, respond to requests for assistance during flood events and have the power, if instructed by Buckinghamshire County Council, to carry out flood risk management work which will benefit management of surface runoff, groundwater and ordinary water courses.

5.3 Environment Agency

The Environment Agency is one of the RMAs as defined by the Flood and Water Management Act 2010. Protecting the river environment and managing flood risk is part of their job. The EA is the RMA for flooding from main rivers.

5.4 Highways Authority – Transport for Buckinghamshire

Any flooding from highways is managed by the Highways Authority which is BCC and the highways function is managed by TfB.

5.5 Water Utility Company – Anglian Water

Anglian Water is responsible for flooding from foul sewers and surface water sewers

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which they own. Whilst undertaking this they must manage flood risk from sewers.

5.6 Landowners and riparian owners

Landowners and riparian owners must maintain any culvert, or the bed and banks of any adjacent watercourse. They should clear away any debris from the watercourse or culvert even if it did not originate from their land.

Riparian owners can find further guidance on their responsibilities as landowners in the Environment Agency document 'Living on the Edge' which can be found online at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297423/LI_T_7114_c70612.pdf.

5.7 Residents

Residents have a responsibility to take measures to protect themselves and their property when flooding is imminent.

5.8 Emergency Responsibilities

The emergency responsibilities are outlined in Table 3 below. Please note that Parish and Town Councils do not have a legal obligation to respond to emergencies. Whatever service they provide is voluntary and unique to each Parish or Town Council.

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Table 3 Roles and responsibilities in an emergency, during and after a flood event

<p>Local (County and District) Authorities</p> <ul style="list-style-type: none"> • Coordinate emergency support within their own functions • Deal with emergencies on 'non main rivers' • Coordinate emergency support from the voluntary sector • Liaise with central and regional government departments • Liaise with essential service providers • Open rest centres • Manage the local transport and traffic networks • Mobilise trained emergency social workers • Provide emergency assistance • Deal with environmental health issues, such as contamination and pollution • Coordinate the recovery process • Manage public health issues • Provide advice and management of public health • Provide support and advice to individuals • Assist with business continuity 	
<p>Police Force</p> <ul style="list-style-type: none"> • Save life • Coordination and communication between emergency services and organisations providing support • Coordinate the preparation and dissemination <p>Fire and Rescue Service</p> <ul style="list-style-type: none"> • Save life rescuing people and animals • Carry out other specialist work, including flood rescue services • Where appropriate, assist people where the use of fire service personnel and equipment is relevant <p>Ambulance Service</p> <ul style="list-style-type: none"> • Save life • Provide treatment, stabilisation and care at the scene 	<p>Utility Providers</p> <ul style="list-style-type: none"> • Attend emergencies relating to their services putting life at risk • Assess and manage risk of service failure • Assist with recovery process, that is, water utilities manage public health considerations <p>Internal Drainage Board</p> <ul style="list-style-type: none"> • Operate strategic assets to reduce flood risk in partnership with RMAs and public <p>Town and Parish Councils</p> <ul style="list-style-type: none"> • Support emergency responders • Increase community resilience through support of community emergency plan development <p>Voluntary services</p> <ul style="list-style-type: none"> • Support rest centres • Provide practical and emotional support to those affected • Support transport and communications • Provide administration • Provide telephone helpline support
<p>Environment Agency</p> <ul style="list-style-type: none"> • Issue Flood Warnings and ensure systems display current flooding information • Provide information to the public on what they can do before, during and after a flood event • Monitor river levels and flows • Work with professional Partners and stakeholders and respond to requests for flooding information and updates • Receive and record details of flooding and related information • Operate water level control structures within its jurisdiction and in line with permissive powers • Flood event data collection • Arrange and take part in flood event exercises • Respond to pollution incidents and advise on disposal • Assist with the recovery process, for example, by advising on the disposal of silt, attending flood surgeries 	

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6 Conclusions and Recommendations

6.1 Conclusions

The flood event in Buckingham occurred as a result of almost a month's worth of rainfall falling on already near-saturated ground. Water levels in the River Great Ouse rose rapidly through 9th March 2016, prompting a Flood Warning to be issued by the Environment Agency and the River Great Ouse to overtop its banks and flood low lying areas of Buckingham. Six properties within Buckingham were affected by floodwater, including four residential properties. Recorded river levels at the EA's Buckingham gauge were only 10cm below the record level of 2007, but the impacts were much less severe. It is possible that the peak level recorded in 2007 was under-read, though it is also probable that the installation of property level protection to vulnerable properties in the intervening years mitigated the potential property impacts.

This investigation has helped inform proactive flood risk management by BCC, working with our partners in other RMAs and the local community. The following provides a brief overview of specific recommendations and activities, some of which are already underway. The Strategic Flood Management Team will regularly monitor the delivery of these recommendations.

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6.2 Recommendations

Authority / Stakeholder	Recommended Actions	Further comments
All RMAs	<ol style="list-style-type: none"> 1. Work together to look at the catchment to reconsider options for flood management, eg. <ol style="list-style-type: none"> a. flood attenuation upstream b. land management practices c. slowing the flow 2. Identify and make suggestions for flood betterment opportunities presented by strategic transport links in the area 	<ol style="list-style-type: none"> 1. There may be linkages here with the EA's Great Ouse Strategic NFM Investigation
BCC	<ol style="list-style-type: none"> 1. Continue to support Buckingham Town Council with updating the Buckingham Flood Action Plan (and help integrate with a wider emergency plan). 2. Continue to progress the Community Flood Toolkits project in partnership with the EA. 3. Progress discussions with Buckingham Town Council (BTC) on the Community Flood Toolkits project (inc. legal agreement, support with training) 4. Facilitate sharing of information between RMAs and the community. 5. Support with any future training (eg. PLP deployment) to be set up as part of the Flood Plan 6. In planning consultee responses via AVDC, continue to ask that new development must seek opportunities to reduce overall level of flood risk at and downstream of the site, for example through reducing volume and rate of surface water runoff to at or below greenfield rates. 	<ol style="list-style-type: none"> 1. Begun Nov 2016 – ongoing 2. The aim of the Community Flood Toolkits project is to allow volunteer flood groups or town/parish councils to respond effectively during a flood event using appropriate equipment. These toolkits include items such as Hydrosnakes, high-vis jackets, "road flooded" warning signs, loudhailers, two way radios, emergency blankets, etc. Communities are able to tailor the contents of the flood kit to their needs. A flood/emergency plan must be in place before the kit can be received. 3. Ongoing 4. Ongoing 5. Ongoing 6. Ongoing

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EA	<ol style="list-style-type: none"> 1. Continue to work in partnership with BCC and BTC on the Community Flood Toolkits project 2. Continue to support BTC with updating the Buckingham Flood Action Plan 3. Use the information from the flood within future updates to the fluvial modelling or flood forecasting models on the River Great Ouse to calibrate against observations. 4. Continue to work to improve flood warnings issued in this area, and encourage residents to sign up to received Flood Warnings. 5. Take opportunities to publicise 'Living on the Edge' to residents and landowners. 6. Continue to undertake maintenance of the Great Ouse through a risk-based approach 	<ol style="list-style-type: none"> 1. Ongoing 2. Ongoing 3. Ongoing 4. Ongoing 5. Ongoing 6. Ongoing
TfB	<ol style="list-style-type: none"> 1. For TfB culverts, including South End Bridge on Church End, Limes End Bridge on Wicken Road: <ul style="list-style-type: none"> - Continue inspecting culverts above 900mm in diameter in line with current codes of practice, which entail general inspection every two years and principal inspection every 6 years. - For culverts below 900mm in diameter, TfB to continue using the expertise of local area-based teams who look at all road infrastructure aspects in their area. Upon noticing issues, these will be raised as concerns or as work orders. 2. Continue to carry out cleansing of all gullies and highway drainage as part of the ongoing maintenance schedule. 	<ol style="list-style-type: none"> 1. Ongoing 2. Ongoing
Buckingham Town Council	<ol style="list-style-type: none"> 1. Continue to liaise with BCC and the EA on updating the Buckingham Flood Action Plan 	<ol style="list-style-type: none"> 1. Ongoing

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	2. Discuss the Community Flood Toolkits project further with BCC and the EA.	2. Ongoing
Riparian Landowners	<ol style="list-style-type: none"> 1. Ensure that the River Great Ouse banks are maintained in a suitable manner. The guidance given in the EA's 'Living on the Edge' guide regarding riparian owner responsibilities should be followed. 2. Undertake clearance of vegetation and debris on the Great Ouse with guidance from relevant RMAs. 	
Residents	<ol style="list-style-type: none"> 1. Sign up for the Environment Agency's flood warning service, where available. 2. Residents are not to move emergency flood measures deployed by agencies (e.g. sandbags). 3. Take measures to protect themselves and their property against flooding. 4. Continue to document and photograph flood incidents where possible and report to the EA and BCC. 	All ongoing

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7 Glossary

Acronym	Definition
AVDC	Aylesbury Vale District Council
BCC	Buckinghamshire County Council
BMKFRS	Buckinghamshire and Milton Keynes Fire & Rescue Service
BGS	British Geological Survey
BTC	Buckingham Town Council
CFMP/ Flood Plan	Catchment Management
	Catchment Flood Management Plans are produced by the Environment Agency to give an overview of the flood risk in the two primary catchments in BCC's area: Great Ouse and Thames.
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency, which has a Strategic overview role for flood and coastal erosion risk management
Flood	The temporary inundation by water of property or land not normally covered with water
Flood & Water Management Act 2010 (FWMA)	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which (partly) is to clarify the legislative framework for managing local flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a river.
Groundwater flooding	Occurs when water levels in the ground rise above the natural surface. Low lying areas underlain by permeable strata (e.g. Chalk) are particularly susceptible.
HYRAD imagery	Standard radar display system for flood warning across England, Wales, Scotland, Northern Ireland and Belgium
IDB	Internal Drainage Board. Applicable to only one area in Buckinghamshire for which the Buckingham and River Ouzel Internal Drainage Board has flood risk management responsibilities.
LLFA / Lead Flood Authority	Local Authority responsible for taking the lead on local flood risk management
Local Flood Risk	Flooding from sources other than Main Rivers, which principally concerns surface runoff, groundwater and ordinary watercourses. BCC has a responsibility under the

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	Flood & Water Management Act to manage flooding from these sources.
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers.
Ordinary Watercourses	All watercourses that are not designated Main River, and which are the responsibility of local authorities or IDBs
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Risk Management Authorities (RMA)	Organisations that have a key role in flood and coastal erosion risk management as defined by the Flood & Water Management Act 2010. These are BCC (the Lead Local Flood Authority and Highways Authority), District Councils, Environment Agency, Buckingham and River Ouzel Internal Drainage Board, Anglian Water and Thames Water
SFRA	Strategic Flood Risk Assessment. These are produced by each District to give an assessment of flood risk from all sources and its implications for land use planning.
Soil moisture deficits (SMDs)	Soil moisture deficit levels provide a measure of the capacity of the ground to store water: the higher the number, the greater the capacity
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations; includes the public and communities.
Strategy	Under the Flood & Water Management Act 2010, BCC have a duty to develop, maintain, apply and monitor a strategy for local flood risk management
Sustainability	In the context of this Strategy, the risk of flooding must be reduced now, but in a way which does not compromise the interconnected needs of the economy, society and environment in the future.

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SuDS / Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface water/runoff	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer. The term 'surface water' is used generically to refer to water on the surface and is often associated with periods of intense rainfall.
SWMP	Surface Water Management Plan
TfB	Transport for Buckinghamshire

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8 References

Reference in document	Refers to:
Environment Agency, 2016	Flooding in Buckingham: March 2016 Flood Event Summary community newsletter. Environment Agency. (Unpublished).
EA water situation reports	https://www.gov.uk/government/collections/water-situation-reports-for-england
Environment Agency ‘Living on the Edge’	https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities
Flood and Water Management Act (FWMA) 2010	https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities

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9 Contacts

Lead Local Flood Authority



Flood Management Team
Buckinghamshire County Council
County Hall
Walton Street
Aylesbury
Bucks HP20 1UY

Telephone: 084537 08090

Email: FloodManagement@buckscc.gov.uk

Website: www.buckscc.gov.uk/flooding

Environment Agency



**Environment
Agency**

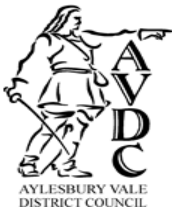
National Customer Contact Centre
PO Box 544
Rotherham
S60 1BY

Telephone: 03708 506506

Email: enquiries@environment-agency.gov.uk

Website: <http://www.gov.uk/government/organisations/environment-agency>

District Council



Aylesbury Vale District Council
The Gateway
Gatehouse Road
Aylesbury
Bucks HP19 8FF

Opening times

Monday - Thursday
8.45am – 5.15pm
Friday
8.45am – 4.45pm*

Telephone: 01296 585858

*Customer service centre closes at 4pm on Friday

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Highways Authority

Transport for Buckinghamshire

Telephone: Transport and roads – 0845 2302882

Out of hours emergencies (Highways) – 01296 486630

Email: tfb@buckscc.gov.uk

Website: <http://www.transportforbucks.net/Transport-and-roads.aspx>

Water Utility

 Anglian Water
PO Box 4994
LANCING
BN11 9AL

Telephone: 03457 91 91 55

Website: <http://www.anglianwater.co.uk/help-and-contact-us/contact-us/>

Emergency Response:

Buckinghamshire Fire and Rescue Service

Address: Buckinghamshire Fire & Rescue Service, Brigade HQ, Stocklake, Aylesbury, Bucks, HP20 1BD

Telephone: 01296 744400

Website: <http://www.bucksfire.gov.uk/BucksFire/Contact+Us/>

Thames Valley Police

Telephone: 101 in non-emergency, 999 in emergency

Website: <http://www.thamesvalley.police.uk/contactus-phone.htm>

Buckinghamshire Ambulance Service

Telephone: 111 in non-emergency, 999 in emergency

Website: <http://www.southcentralambulance.nhs.uk/content/press-release/buckinghamshire/flooding-advice.ashx>

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10 Appendices

Appendix A: BCC criteria for a Section 19 Investigation

- Internal flooding (including to basements) to five or more residential properties within an area of 1km²
- Internal flooding of two or more business premises within an area of 1km²
- Internal flooding (including to basement) of at least one property for one week or longer
- Flooding of one or more items of critical infrastructure, which could include hospitals, health centres, clinics, surgeries, colleges, schools, day nurseries, nursing homes, emergency services (police, fire, ambulance) stations, utilities and substations.

- Caused a transport link to be impassable for the following periods:
 - Motorways, trunk roads and major rail links – 2 hours or more
 - Class A and B highways and other railway links – 4 hours or more
 - Class C highways – 10 hours or more unless the route is the only means of access, or is primary route for critical infrastructure then reduce to 4 hours
 - Class U highways – 24 hours or more unless the route is the only means of access, or is primary route for critical infrastructure then reduce to 4 hours

- Any flooding event that a risk management authority deems significant does not meet the agreed thresholds should be brought to the next strategic flood management committee for consideration.

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Appendix B: Photographs from event



Nelson Street 10th March 2016 (photo provided by resident).



Flooding on Clarence Park site, 10th March 2016, as seen from gardens of Glynswood Road (photo provided by Mr Argles).



Flooded River Great Ouse adjacent to Fishers Field, 9th March 2016 (photo provided by Mr Wallace).

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Ford Street, Buckingham at 12.15am, 10th March 2016. Property level flood protection board (blue barrier) in operation (photo provided by Buckingham Flood Action Group).

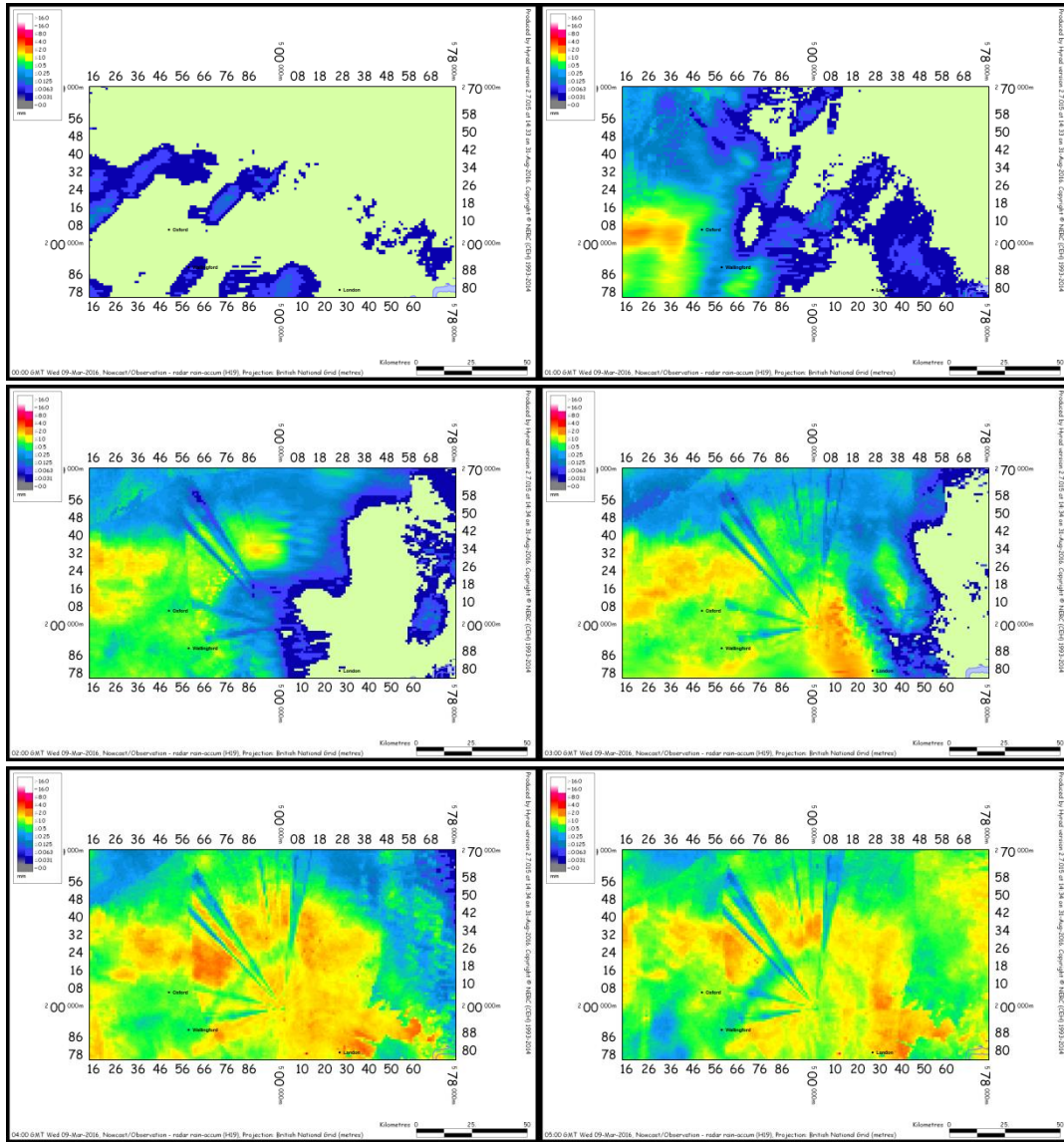


Flooded Chandos Park (photo via R Stuchbury twitter).

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Appendix C: HYRAD rainfall radar

Area surrounding Buckingham 09/03/2016 00:00 – 11:00 (at hourly intervals).
Data provided by the EA.



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