

# Buckingham Section 19 Flood Investigation

## Final Technical Report

February 2022

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## Revision History

Revision Ref/Date	Amendments	Issued to
Draft v1 / 12 August 2021	Draft for professional partners	Buckinghamshire Council, Environment Agency, Anglian Water, TfB
Draft v2 / 24 September 2021	Draft for wider stakeholders	Buckinghamshire Council, Council Members, Environment Agency, Anglian Water, TfB
Final /22 February 2022	Draft for publication	Buckinghamshire Council

## Contract

This report describes work commissioned by Andrew Waugh, on behalf of Buckinghamshire Council, by an email dated 15 March 2021. Buckinghamshire Council’s representative for the contract was Andrew Waugh. Anna Beasley and James Fitton of JBA Consulting carried out this work and it was collaboratively reviewed and edited by Andrew Waugh.

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## **Acknowledgements**

We would like to thank the following people for their input and support with the investigation: Councillor Warren Whyte; Paul Hodson and Claire Molyneux of Buckingham Town Council; Hayley Baldock, Adam Foster, Harry Chalk and Katie Loades of the Environment Agency; Rosie Tunnard and Paul Foot of Transport for Buckinghamshire; Tom Birch, Mick Daniels and Jonathan Glerum of Anglian Water; Vikki Keeble and Jordane Bates of Buckinghamshire LLFA SuDS team; Dean Jones of University of Buckingham.

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## Executive summary

### Background

Following flooding in Buckingham on 23rd and 24th December 2020, Buckinghamshire Council (BC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010<sup>1</sup>. It is a statutory requirement for a LLFA to investigate flooding to the extent that it considers it necessary or appropriate.

Buckingham is located in the north of Buckinghamshire. The town is situated on the River Great Ouse, which flows through the centre of the town. The flooding that occurred in Buckingham caused internal flooding to at least 72 properties and fulfils one of the criteria for a Section 19 investigation (internal flooding to five or more residential properties within an area of 1km<sup>2</sup>). Buckinghamshire Council has appointed JBA Consulting to undertake this investigation on its behalf.

For more information see Section 1.

### Stakeholder engagement

As part of the Section 19 investigation, we engaged with multiple local stakeholders in Buckinghamshire, including residents, Council Members, a local educational establishment, other Council departments, and Risk Management Authority partners. The objectives of engagement were to: gather facts, opinions, and data to aid the understanding of the investigation; enable the involvement of the community in the investigation; provide a more technical debrief with Risk Management Authority and operational partners.

For more information see Section 2.

### Catchment characteristics and long-term flood risk information

Section 3 describes the watercourses, urban drainage network, topography, and geology of Buckingham. Section 4 summarises the existing long-term flood risk information on flood risk from rivers, surface water and groundwater.

Buckingham has previously been flooded several times. In recent years, there have been floods of similar magnitude to December 2020 in April 1998 (75 properties flooded) and July 2007 (96 properties flooded). Smaller events which have still resulted in smaller numbers of property flooding have occurred in November 2012 and March 2016. For more information see Section 4.2.

### Flood risk management

Responsibility for flood risk can be divided into “flood risk management” and “emergency response”. Section 5 describes the roles and responsibilities of the various bodies involved in flood management and emergency response. Section 5.3 describes the existing flood risk management activities undertaken, including: flood warning; maintenance of the river channel; flood alleviation schemes; natural flood management; property flood resilience; Community Flood Plan; and planning and development control activities.

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<sup>1</sup> Flood and Water Management Act 2010 Section 19 (accessed 17 May 2021); <https://www.legislation.gov.uk/ukpga/2010/29/section/19>

## The 23 December 2020 event

A month's worth of rain fell in the period of December up until the event on 23 December. The total rainfall during the 23 December storm event had a 15% chance of occurring in any one year (return period of 5-9 years). This is not especially extreme, but given that the soils were already saturated from the high rainfall over the previous months, the catchment was very sensitive to heavy rainfall.

There is no flow gauge at Buckingham, and the level gauge was 'drowned out' during the event. Estimates of the river flow and its probability of occurring for the Great Ouse at Buckingham are therefore very uncertain. Based on analysis of previous studies and events, as well as analysis within this study, the estimated probability of the 23 December 2020 flood event at Buckingham occurring in any given year is between 3.33 and 1% (30 and 100 years return period) and it is likely that it was of a similar magnitude to the April 1998 event and July 2007 flood events.

For more information see Section 6.

## Incident response

During the event, organisations worked separately in accordance with their operating instructions.

The Environment Agency issued a Flood Warning for Buckingham only after many properties had already flooded. This limited the response capabilities of individual residents and the community. The Environment Agency made immediate improvements to their flood warning triggers for Buckingham the day after the event, which will increase confidence that a warning will be received in time if a similar event were reoccur. The amendment will remain in place until further analysis of the property flooding is completed, when the trigger and the area covered by each flood warning will be updated.

Buckinghamshire Council implemented their Incident Management Process (IMP) and staff from these teams were deployed across the County to aid and support to the local community. Local Authority Liaison Officers (LALOs), staffed of volunteers from Buckinghamshire Council staff, were deployed along with Buckinghamshire Council Councillors and Town Council officers and members, to gather information and provide reassurance to the community from the ground.

Transport for Buckinghamshire managed a large number of road closures across Buckingham and the wider area during the event. They also issued sandbags, prioritising these on the basis of greatest need.

Anglian Water managed very high flows in its network across Buckingham and the wider area. Pumping stations were running at full capacity and all pumping stations were working throughout the incident. Staff visited locations where flooding from surface water and foul sewage was experienced and issued advice to residents of some areas not to flush their toilets.

Members of the community stepped in to help those impacted using pumps and buckets to help protect properties from advancing floodwaters. Social media was used to ask for and offer help informally. Volunteers ran the Community Centre which was open for food, drinks and rest. The University of Buckingham also responded to the flooding, ensuring that University buildings at risk were sand-bagged and electrical equipment was moved. Following the event, the University of Buckingham offered emergency accommodation to a number of students whose homes had been flooded, and set up a fund which offered grants to local residents of Buckingham and surrounding villages who had been flooded.

For more information see Section 7.



## Source-pathway-receptor analysis

The sources, pathways and receptors of flooding were as follows:

- Sources – high river levels on the Great Ouse were the primary source, combined with extreme rainfall generating runoff, and possible high groundwater levels close to the river.
- Pathways – exceedance of channel capacity on the Great Ouse, surface water runoff forming on roads and pavements, overwhelmed highway drainage and surface water and combined sewer systems.
- Receptors – internal flooding to at least 72 properties (including at least 11 non-residential), external flooding to at least 15 properties. Displacement of residents, damage to possessions and stock, stress and mental health impacts, financial costs of flood damage to buildings and vehicles, flooding to roads and car parks.

For more information see Section 8.

## Conclusion and recommendations

A high-level appraisal of possible flood risk management options has been undertaken, which includes consideration of measures such as improvements to data collection and evidence; flood warning and incident management; community, property and infrastructure flood resilience; maintenance and minor works; asset maintenance and refurbishment and flood risk management capital scheme options. This assessment helped to shape our recommendations.

Doing nothing was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Buckingham. The options which scored the highest were those that could ultimately result in a scheme to reduce flood risk to people and property:

- Appraise a suite of capital options for flood risk management in Buckingham, including revisiting the viability for flood storage upstream of Buckingham and considering the viability of further Property Flood Resilience measures (Environment Agency) (Rank 1)
- Measure success of Upper Great Ouse NFM project and consider feasibility of further NFM interventions (Buckinghamshire Council) (Rank 2)
- Appraise and implement options to prevent/reduce the occurrence of sewer flooding at March Edge (Anglian Water) (Rank 3)

As the impact of flooding experienced by people in Buckingham was strongly linked to advanced warning, preparedness for flooding, and the effectiveness of the response, there are a number of actions around data and evidence, community preparedness which are also key priorities. Many of these are relatively quick-wins and have already been significantly progressed by the relevant authority since the event. The highest ranked options and recommendations are summarised here:

- Verify and implement flood warning area extents and triggers improvements considering the flooding in Buckingham in December 2020 (Environment Agency, temporary update complete, full verification in progress, due to be completed by winter 2022/23)
- Use sewer flow monitor alarms to speed up response to flooding at March Edge, Red flag 2-hour response time to resident reports of flooding at March Edge (Anglian Water, complete)

- Complete the update of the Community Flood Plan and publish and provide community training and exercising of the new Community Flood Plan (in progress) (Buckingham Town Council, in progress)
- Raising/relocating level gauge at Buckingham (Environment Agency, planned)
- Invest in further flood modelling and mapping for the River Great Ouse at Buckingham (Environment Agency, planned)
- Develop a catchment-wide Flood Response Framework to ensure consistency in response between the different Local Resilience Forums which cover the Great Ouse catchment (Environment Agency, planned)
- Determine the ownership of the March Edge, Linden Village flood embankment, and take appropriate action to ensure there is a maintenance plan in place (Environment Agency, supported by Buckinghamshire Council)

For more information, and the full list of recommendations, see Section 9.



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## Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGS	British Geological Society
BC	Buckinghamshire Council
CCTV	Closed Circuit Television
CRT	Canal and River Trust
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FIDO	Flood Incident Duty Officer

FWDO	Flood Warning Duty Officer
GIS	Geographic Information Systems
JBA	Jeremy Benn Associates
LALO	Local Area Liaison Officer
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
LRF	Local Resilience Forum
MAFP	Multi-Agency Flood Plan
MFDO	Monitoring and Forecasting Duty Officer
NGR	National Grid Reference
PAT	Partner Activated Teleconference
PFR	Property Flood Resilience
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water (Environment Agency mapping)
STW	Sewage Treatment Works
TW	Thames Water
TfB	Transport for Buckinghamshire
TVLRF	Thames Valley Local Resilience Forum
WFD	Water Framework Directive

## Definitions

Culvert	Where a watercourse flows through a pipe, often underground.
Flap valve	Hinged valve placed on a pipe outlet into a river. Stays open during normal flow but closes when it is submerged, to prevent flow from backing up the pipe.
Foul sewer	Sewer which carries wastewater (e.g. from toilets, sinks, showers and kitchen appliances) to a sewage works for treatment.
Gully	Drainage pit covered by an open metal grate, located at the edge of a road. Drains rainwater from the road into either the Thames Water surface water sewer or into nearby watercourses.
HYRAD	Real-time radar display system for weather.
Lead Local Flood Authority	County councils and unitary authorities which lead in managing local sources of flood risk (i.e. flooding from surface water, groundwater and ordinary watercourses)
Internal Drainage Boards	A public authority that managed water levels within an Internal Drainage District.
Main river	A large river or stream designated on the Main River Map. The Environment Agency has permissive powers to maintain and carry out improvements on main rivers, to manage flood risk.

Culvert	Where a watercourse flows through a pipe, often underground.
Ordinary Watercourse	All rivers which are not designated as 'Main rivers'. Lead local flood authorities and internal drainage boards can carry out flood risk management work on ordinary watercourses.
Public sewer	Sewers owned and maintained by a Sewerage Company (e.g. Thames Water). Are usually located in roads or public open spaces but may run through private gardens.
Riparian owner	The owner of land that is next to a watercourse or has a watercourse running through or beneath it.
Soil moisture deficit	The difference between the amount of water actually present in the soil and the amount of water which the soil can hold.
Surface water sewer	Sewer which carries rainwater directly to a watercourse.
Telemetry	Instruments used to monitor the level of water in a watercourse.
Weir	A small dam structure built across a watercourse to raise the water level or to divert flow.

# 1 Introduction

## 1.1 Background to investigation

Following flooding in Buckingham on 23<sup>rd</sup> and 24<sup>th</sup> December 2020, Buckinghamshire Council (BC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010<sup>2</sup>.

It is a statutory requirement for a LLFA to investigate flooding to the extent that it considers it necessary or appropriate. Buckinghamshire Council has outlined its criteria for undertaking a Section 19 investigation in its Local Flood Risk Management Strategy<sup>3</sup>.

- Internal flooding (including to basements) to five or more residential properties within an area of 1km<sup>2</sup>.
- Internal flooding of two or more business premises within an area of 1km<sup>2</sup>.
- Internal flooding (including to basements) of at least one property for one week or longer;
- Flooding of one or more critical infrastructure assets, which could include hospitals, health centres, clinics, surgeries, colleges, schools, day nurseries, nursing homes, emergency services (police, fire, ambulance) stations, utilities and substations; and
- Any flooding event that a risk management authority deems significant but does not meet the agreed thresholds may be assessed for consideration by the strategic flood management group.

The flooding that occurred in Buckingham caused internal flooding to at least 72 properties and fulfils these criteria. Buckinghamshire Council has appointed JBA Consulting to undertake this investigation on its behalf.

## 1.2 Aims of the investigation

Section 19 of the Flood and Water Management Act 2010 sets out that a Lead Local Flood Authority (LLFA) must, to the extent that it considers it necessary or appropriate, investigate which risk management authorities have relevant flood risk management functions, and whether each of those authorities has exercised, or is proposing to exercise, those functions in response to the flood.

Within Buckinghamshire, the aims of such an investigation are extended to providing an overview of the flooding incident and its impact, any history of flooding, a rainfall analysis, and determining the main factors and mechanisms involved in the flooding. This investigation also seeks to outline the actions of the relevant authorities, with some discussion of what went well and where improvements could be made in future. However, it is not within the remit of a Section 19 Flood Investigation to apportion blame to any organisation nor hold any risk management authority to account for their response to the floods.

We have also proposed a list of recommendations to help the various stakeholders learn from the event and improve the management of flood risk locally. We have undertaken a high-level appraisal of these recommendations, focussing on benefit, practical and viability considerations. However, it is not within the remit of a Section 19 Flood Investigation to provide designed solutions. The investigation process does not provide Buckinghamshire Council, nor any other authority, with the funding or mandate to undertake flood management works on the ground. It will be for the relevant responsible body to assess

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<sup>2</sup> Flood and Water Management Act 2010 Section 19 (accessed 17 May 2021): <https://www.legislation.gov.uk/ukpga/2010/29/section/19>

<sup>3</sup> Buckinghamshire Local Flood Risk Management Strategy (2017): <https://www.buckscc.gov.uk/media/4511603/bcc-lfrms-final-version-may-2017.pdf>



these recommendations in terms of their legal obligation, resource implications, priority and the costs and benefits of undertaking such options.

### **1.3 Site location**

Buckingham is located in the north of Buckinghamshire. The town is situated on the River Great Ouse, which flows through the centre of the town. Several villages surround the town, including Gawcott, Tingewick, Leckhampstead, Thornton and Thornborough were also impacted by flooding in the December 2020 event. Separate Section 19 Flood Investigations are being carried out in these locations

### **1.4 Data collection**

A wide range of different data has been collected and assessed to inform the Section 19 investigation. This has been used to understand the causes and impacts of flooding in Buckingham and to establish the context of the area. This includes the following:

- Open-source data from GOV.UK – for example the Risk of Flooding from Surface Water mapping (RoFSW), the Flood Map for Planning, LiDAR etc.
- Local geographical data e.g. sewer network data, highway asset data
- Historic flood records
- Rainfall data
- Questionnaires
- Data from the event, such as photographs, observations/notes, newspaper articles, road closure announcements and flooded property information

## 2 Stakeholder engagement

We engaged with multiple local stakeholders, including residents, community representatives, landowners, other Council departments, Council Members and Risk Management Authority (RMA) partners.

The objectives of engagement were to:

- Gather facts, opinions and data to aid the understanding of the investigation
- Enable the involvement of the community in the investigation
- Provide a more technical debrief with RMAs and operational partners

A list of key stakeholders and how we engaged with them is given in Table 2-1. The engagement terminology is taken from Environment Agency’s ‘Working with Others’ (2013) methodology:

- Inform - provide information
- Consult - receive, listen, understand and feedback
- Involve - decide together
- Collaborate - act together
- Empower - support independent action

An online questionnaire was distributed via a leaflet drop in affected areas and Town Council social media, to enable affected residents to provide input directly. A dedicated email address was set up to allow residents to send further information such as photos and additional detail.

**Table 2-1: Key stakeholders**

Role	Organisation	How to engage	Type of engagement
Town Council	Buckingham Town Council	Consult	Invitation to contribute, site visit, online survey distribution, correspondence
Water and Sewerage Company	Anglian Water	Involve	Invitation to contribute, correspondence, meetings, data provision
Highways Authority	Transport for Buckinghamshire	Involve	Invitation to contribute, correspondence, data provision
Environment Agency	Environment Agency (Anglian)	Involve	Site visit, debrief, correspondence, data provision
Property and Street Scenes Teams	Buckinghamshire Council	Involve	Correspondence
Council Members	Buckinghamshire Council	Consult	Invitation to contribute, site visit, online survey distribution, correspondence
Local educational establishment	University of Buckingham	Consult	Invitation to contribute, correspondence, meeting, data provision
Residents	N/A	Consult	Online questionnaire, correspondence

### 3 Catchment characteristics

#### 3.1 River network

The River Great Ouse flows for 240km 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. At Buckingham it has a contributing catchment area of 143km<sup>2</sup>.

There are several ordinary watercourses within and around the town, including Badgers Brook, which joins the Great Ouse from the south. The disused Buckingham Arm of the Grand Union Canal runs eastwards from the east side of Linden Village. Figure 3-1 shows the watercourses within Buckingham.

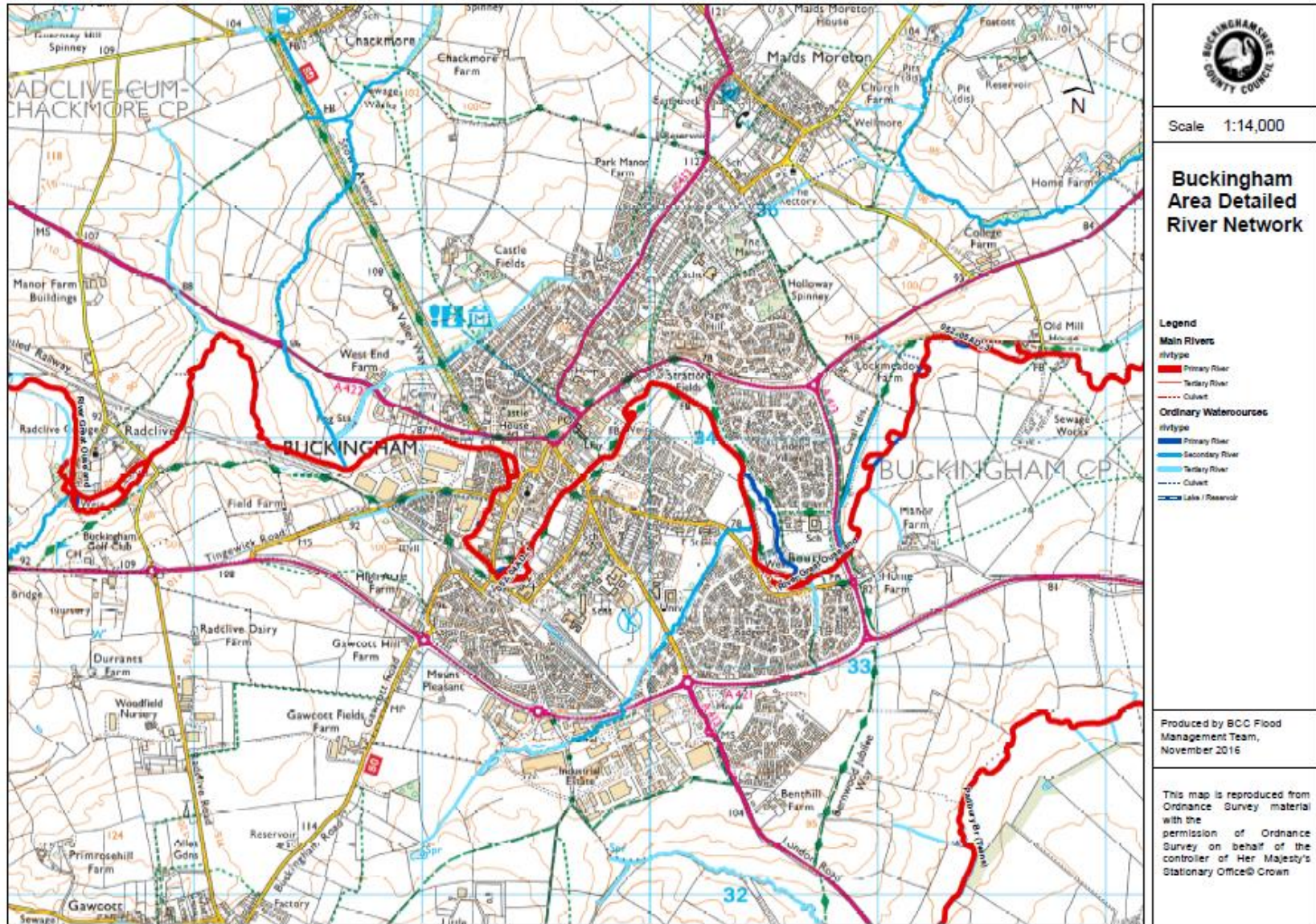
#### 3.2 Urban drainage system

Buckingham's sewerage system is made up of both foul sewers and combined sewers. If a sewer is 'combined' it carries foul sewage and will also take some surface water, for example from connected highway gullies.

Anglian Water's sewer network data shows that the older town centre of Buckingham is drained by combined sewer systems, with more newly built areas drained by separate foul and surface water networks. Foul sewers in newer areas such as Page Hill and Linden Village drain into combined sewers further down the system.



Figure 3-1: Watercourses in Buckingham

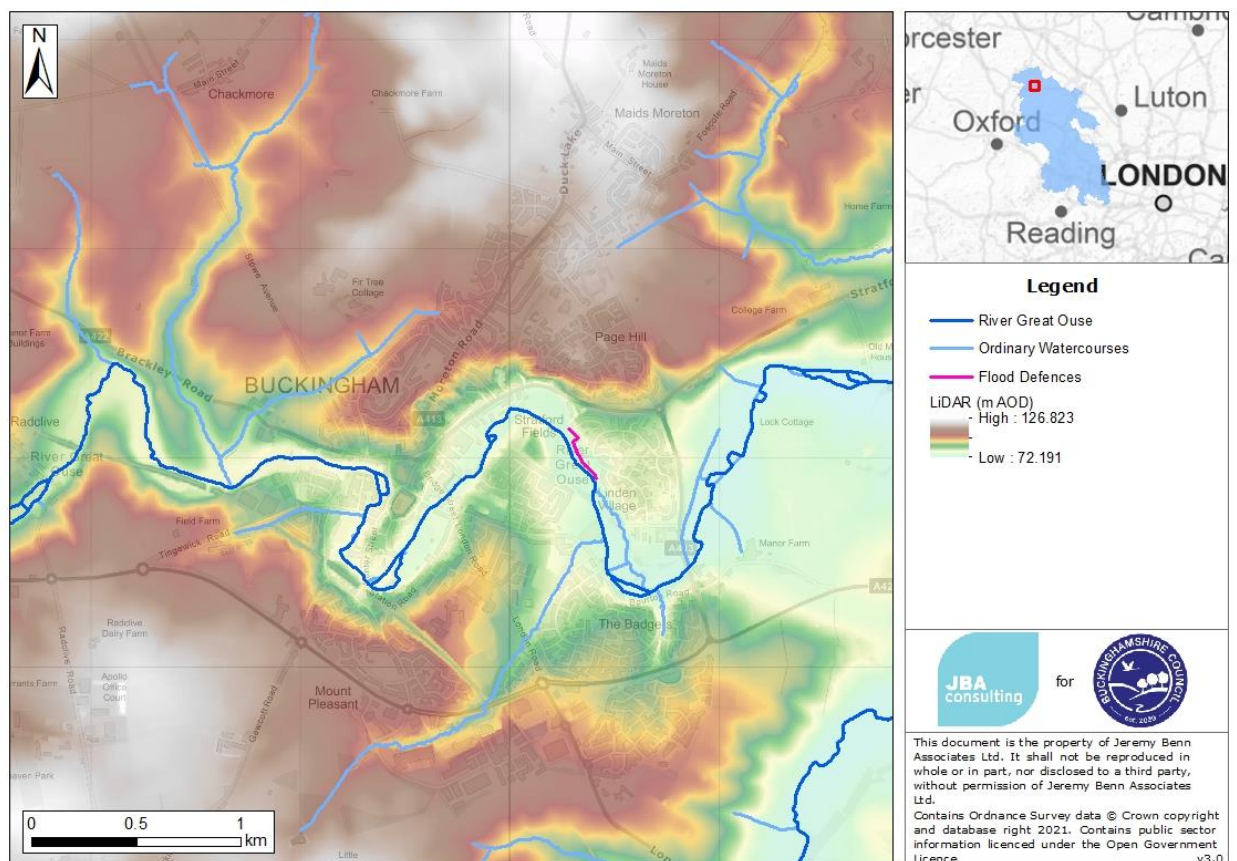




### 3.3 Topography

Central Buckingham is located within the River Great Ouse floodplain. Lowest elevations are found towards the river and range from approximately 80m AOD in the west to approximately 74m AOD in the east. The lowest areas include green space such as Clarence Park, Stratford Fields and Bourton Park, the University of Buckingham and areas of the town centre. Elevations increase to the south and north of Buckingham, away from the river towards Maids Moreton to the north and the A421 to the south. LiDAR (Light Detection and Ranging) data showing ground elevations at a 2m resolution is shown in Figure 3-2.

**Figure 3-2: Topography of Buckingham**



### 3.4 Geology

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.

Across Buckingham itself, British Geological Survey data shows varying bedrock types. Along the river, the main bedrock geologies are generally White Limestone Formation and Forest Marble Formation. Higher elevation areas of Buckingham have a Cornbrash Formation bedrock geology. Superficial deposits also vary across Buckingham, with main deposits of Glaciofluvial and River Terrace deposits, Alluvium and Till. These are formed of sands, silts, clays and gravels<sup>4</sup>.

<sup>4</sup> BGS Geology of Britain viewer: <https://mapapps.bgs.ac.uk/geologyofbritain/home.html>

Close to the river, soils are loamy and clayey floodplain soils with naturally high groundwater. The remainder of Buckingham sits on slightly acid, loamy and clayey soils with impeded drainage<sup>5</sup>.

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<sup>5</sup> Cranfield University soilscapes mapping: <http://www.landis.org.uk/soilscapes/>



## 4 Flood risk

### 4.1 Long-term flood risk information

Maps of long-term flood risk information are available from the Environment Agency in England (Learn more about flood risk - GOV.UK (flood-warning-information.service.gov.uk)).

Figure 4-1 shows the Environment Agency’s Flood Map for Planning within Buckingham. The map shows that Tingewick Road up to the junction with Nelson Street, parts of the University of Buckingham, parts of Chandos Park, parts of Well Street, Cornwalls Meadow, Stratford Fields and March Edge are at medium risk of flooding from the Great Ouse (Flood Zone 3, up to a 1 in 100 annual probability event). Newcombe Crescent, Foundry Drive, Treble Close, Hamilton Close, Fishers Field, Nelson Street, Hunter Street, Norton’s Place, more of the University of Buckingham, Ford Street, more of Well Street, Bridge Street, Candleford Court, Stratford Road, Wharf House Yard and Wharfside Place, are shown as at low risk of flooding (Flood Zone 2, events between a 1 in 100 and 1 in 1,000 annual probability event).

**Figure 4-1: Flood Map for Planning**

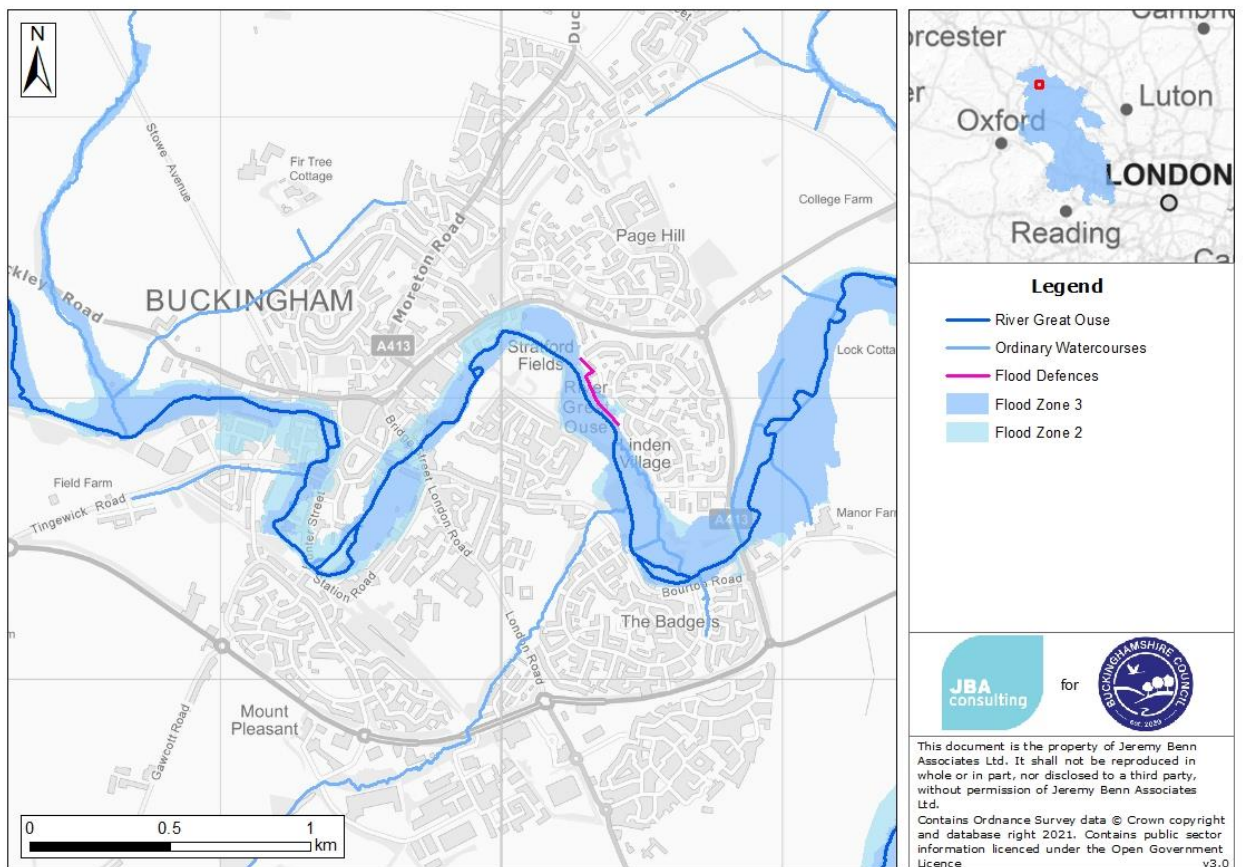


Figure 4-2 shows the Risk of Flooding from Surface Water (RoFSW) within Buckingham. Aside from the risk shown within the fluvial floodplain of the Great Ouse and along the ordinary watercourses, there are a number of locations at risk from surface water flooding, including Stratford Road, Addington Road, Moreton Road, Highlands Road, Page Hill, Linden Village (March Edge, Redshaw Close, Valley Road), Mitre Street and Badger Way.

**Figure 4-2: Risk of Flooding from Surface Water**

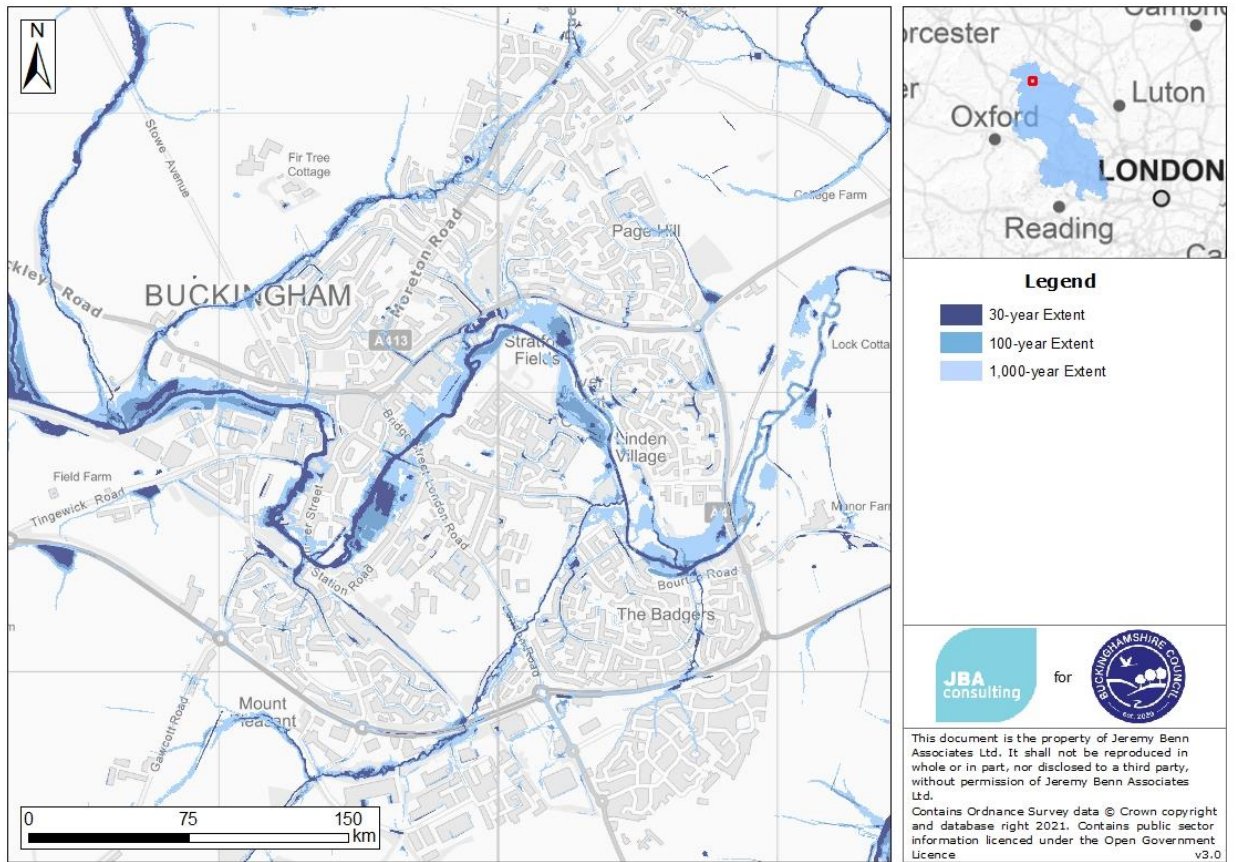
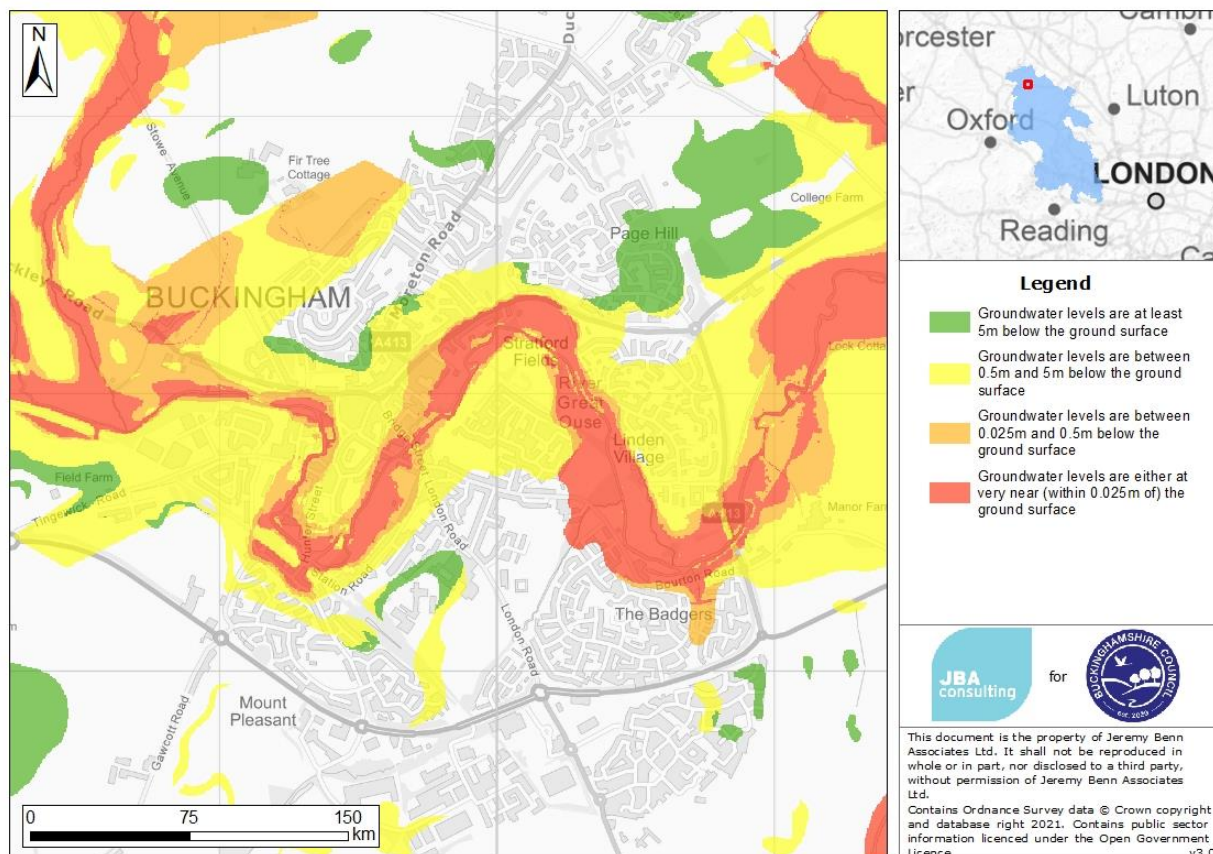




Figure 4-3 shows the risk of flooding from groundwater within Buckingham based on the JBA Groundwater Flood Map. The areas with the highest risk, where groundwater levels are predicted to be within 0.025m of the surface during a 1 in 100-year event, are located along the River Great Ouse, due to superficial river gravel deposits. Groundwater flood risk decreases away from the river corridor.

**Figure 4-3: Risk of Flooding from Groundwater**



## 4.2 Flood history

There have been several previous flood events in Buckingham. Table 4-1 summarises the known flood history.

The most severe 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. This fell on a catchment that was already saturated from prolonged wet weather, and river levels rose 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. A total of 96 properties were flooded (as recorded by the 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 “drowned out and under-read the actual peak level in 2007. 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.

**Table 4-1: Flood history**

Date	Source of flooding	Description of impacts
1823	Main River – River Great Ouse	'a great flood overflowed the banks' <sup>6</sup>
1875	Main River – River Great Ouse	Greater flooding than 1823. Rainfall 9th October, flooding of houses 'after midnight' (9/10th October) – 'waters increased until about eight o'clock at which time we think the water had risen to its highest point and at which however it remained without the least abatement for some hours' <sup>6</sup>
1908	Main River – River Great Ouse	'A flood unequalled for half a century did much damage. Five public-houses were inundated and compelled to close....gasworks flooded.....' <sup>6</sup>
March 1947	Main River – River Great Ouse	Widespread regional flood event. Major impact regionally
December 1979	Main River – River Great Ouse	Flooding less severe than 1998, 2007 and 2020 but affected town centre <sup>7</sup> and Bridge Street <sup>8</sup>
April 1998	Main River – River Great Ouse	75 properties within Buckingham were flooded <sup>9</sup>
Jan 1999	Main River – River Great Ouse	Chandos Park and Buckingham Tennis Club, Buckingham Town Football Club's Ford Meadow flooded <sup>10</sup>
January 2003	Main River – River Great Ouse	Widespread regional flood event. Town centre flooding <sup>7</sup>
July 2007	Main River – River Great Ouse Surface water	Widespread regional flood event. 118.4mm of rain fell on Buckingham. 96 properties within Buckingham were flooded <sup>9</sup>
November 2012	Main River – River Great Ouse	Chandos Park, Cornwalls Meadow Car Park, 1 property flooded <sup>11</sup>
March 2016	Main River – River Great Ouse Surface Water	6 properties within Buckingham were flooded <sup>9</sup>

Several more minor flood incidents have also been reported by residents within Buckingham, causing flooding to roads and gardens.

6 Chronology of British Hydrological Events (<https://www.cbhe.hydrology.org.uk/>)

7 Jacobs, 2013, Buckingham SWMP Phase 1 (<https://www.buckscc.gov.uk/services/environment/flooding/strategic-flood-management/documents/>)

8 Questionnaire response

9 Buckinghamshire Council, 2016, Buckingham Flood Investigation Report March 2016 (<https://www.buckscc.gov.uk/services/environment/flooding/strategic-flood-management/flood-investigations/>)

10 Great Ouse Modelling Study, 2019, Jacobs CH2M.

11 Post-Installation\_Effectiveness\_of\_Property\_Level\_Flood\_Protection\_\_final\_report.pdf ([publishing.service.gov.uk](https://publishing.service.gov.uk))

## 5 Flood risk management

Responsibility for flood risk can be divided into “flood risk management” and “emergency response”. The following section describes the roles of the various bodies involved in flood management, with roles and responsibilities for emergency response described in Section 5.2.

### 5.1 Flood risk management roles and responsibilities

Flood risk management in England is managed by a range of different Risk Management Authorities (RMAs)<sup>12</sup>. The Flood and Water Management Act places a duty on all flood risk management authorities to co-operate with each other. The act also provides Lead Local Flood Authorities and the Environment Agency with a power to request information required in connection with their flood risk management functions.

#### 5.1.1 Environment Agency

The Environment Agency is sponsored by the Government’s Department for Environment, Food & Rural Affairs (Defra), and is tasked with the protection and conservation of the water environment in England, the natural beauty of rivers and wetlands and the wildlife that lives there.

The Environment Agency’s responsibilities include: water quality and resources; fisheries; conservation and ecology; and operational responsibility for managing the risk of flooding from main rivers (usually large streams and rivers), reservoirs, estuaries and the sea.

Flood risk management work can include: constructing and maintaining ‘assets’ (such as flood banks or pumping stations) and works to main rivers to manage water levels and make sure flood water can flow freely; operating flood risk management assets during a flood; dredging the river; and issuing flood warnings.

The Environment Agency can also do work to prevent environmental damage to watercourses, or to restore conditions where damage has already been done.

The strategies for flood and coastal erosion risk management show how communities, the public sector and other organisations can work together to manage this risk.

#### 5.1.2 Buckinghamshire Council – Lead Local Flood Authority

Lead Local Flood Authorities (LLFAs) are responsible for coordinating the mitigation of risk of flooding from surface water, groundwater (water which is below the water table under the ground) and ordinary watercourses (non-main rivers). The LLFA is also responsible for developing, maintaining and applying a strategy for local flood risk management in their area and for maintaining a register of flood risk assets. LLFAs also have a statutory duty to investigate significant flood events to the extent they consider necessary.

Buckinghamshire Council is the LLFA for the whole of Buckinghamshire, including this area.

#### 5.1.3 Internal Drainage Board (IDB)

Internal drainage boards (IDB) are independent public bodies, established in areas of special drainage need known as drainage districts. The IDB is responsible for the supervision of land drainage, water level management and flood risk management works and regulation of ordinary watercourses within their Drainage District. The IDB also plays an important role in the areas they cover (approximately 10% of England at present) in working in partnership with other authorities to actively manage and reduce the risk of flooding.

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12 <https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities>

Buckingham falls partially within the Buckingham and River Ouzel IDB drainage district from Bridge Street downstream along the River Great Ouse, including the downstream part of Badger Brook.

#### **5.1.4 Water and Sewerage Company**

Water and sewerage companies are responsible for the provision of wastewater collection and treatment systems, including for managing the risks of flooding from surface water and foul or combined public sewer systems providing drainage from buildings and yards.

Anglian Water is the Water and Sewerage company for Buckingham.

#### **5.1.5 Highway Authority**

The Highway Authority for Buckingham is Buckinghamshire Council, and the highways function is managed by Transport for Buckinghamshire. It is responsible for maintaining the highway drainage system to an acceptable standard and ensuring that road projects do not increase flood risk.

#### **5.1.6 Canal and River Trust**

The Canal and River Trust is the charity entrusted with the care of waterways in England and Wales. The Trust is a navigation authority, and therefore has a statutory obligation to maintain navigation, through the inspection, maintenance and operation of water control structures within its ownership. The Trust does not have any specific statutory responsibilities in relation to flooding, but has responsibilities as an owner and operator of canals and other waterways. As a reservoir undertaker, the Canal and River Trust also has responsibility for the safety of the reservoirs under its control.

#### **5.1.7 Riparian landowners**

Riparian landowners who own land or property crossed by or next to a river, stream or ditch, (including where this runs through a pipe or culvert), have rights and responsibilities over the management of the land including: a responsibility to let water flow through the land without any obstruction, pollution or diversion which affects the rights of others; keeping banks clear of anything that could cause an obstruction and increase flood risk; maintaining the bed and banks of the watercourse; and keeping structures clear of debris. There is more information on these rights and responsibilities in the Environment Agency guide 'Living on the Edge'<sup>13</sup> and on Buckinghamshire Council's Guidance for Riparian Owners<sup>14</sup>.

#### **5.1.8 Local residents**

Local residents should find out about any flood risk in the area, sign up for the Environment Agency's free flood warnings and make a written plan of how they will respond to a flood situation. Business owners should also make a flood plan for their business. There are measures that can be taken to reduce the amount of damage caused by flooding and properties at risk should be insured. Local residents can find out if their property is at risk, prepare for flooding, get help during a flood and get help after a flood.

### **5.2 Emergency roles and responsibilities**

<sup>13</sup> Living on the Edge, Environment Agency, 2016

<sup>14</sup> Guidance for Riparian Owners, Buckinghamshire Council (<https://www.buckscc.gov.uk/services/environment/flooding/apply-for-land-drainage-consent/maintenance-for-rivers-and-ditches/>)



The emergency responsibilities of different organisations are outlined in Table 5-1. Town Councils do not have a legal obligation to respond to emergencies. Whatever service they provide is voluntary and unique to each Town Council.

**Table 5-1: Roles and responsibilities in an emergency, during and after a flood event**

<b>Local Authorities (Buckinghamshire Council)</b>	
Coordinate emergency support within their own functions 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	
<b>Police Force</b>	<b>Utility Providers</b>
Save life Coordination and communication between emergency services and organisations providing support Coordinate the preparation and dissemination	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
<b>Fire and Rescue Service</b>	<b>Internal Drainage Board</b>
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	Operate strategic assets to reduce flood risk in partnership with RMAs and public
<b>Ambulance Service</b>	<b>Town and Parish Councils</b>
Save life Provide treatment, stabilisation and care at the scene	Support emergency responders Increase community resilience through support of community emergency plan development

### Voluntary Services

- Support rest centres
- Provide practical and emotional support to those affected
- Support transport and communication
- Provide administration
- Provide telephone helpline support

### Environment Agency

- Manage the risk of flooding from main rivers, reservoirs, estuaries and the sea
- Operate Environment Agency flood defence assets
- 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

#### 5.2.1 Local Resilience Forum (LRF)

Local resilience forums (LRFs) are multi-agency partnerships made up of representatives from local public services, including the emergency services, local authorities, the NHS, the Environment Agency and others. These agencies are known as Category 1 Responders, as defined by the Civil Contingencies Act.

LRFs are supported by organisations, known as Category 2 responders, such as the Highways Agency and public utility companies. They have a responsibility to co-operate with Category 1 organisations and to share relevant information with the LRF. The geographical area the forums cover is based on police areas.

The Local Resilience Forum is not a legal entity, nor does a Forum have powers to direct its members. Nevertheless, the Civil Contingencies and the Regulations provide that emergency responders, through the Forum, have a collective responsibility to plan, prepare and communicate for emergencies in a multi-agency environment.

The Local Resilience Forum for Buckingham is the Thames Valley Local Resilience Forum (TVLRF), but the Great Ouse catchment is covered by a further six Local Resilience Forums.

TVLRF have Emergency Response Arrangements which provides the response framework for a multi-agency response. The current arrangements for TVLRF require a Partner Activated Teleconference (PAT) to be convened by any TVLRF agency or organisation who feels that this is necessary, or an event meets the trigger criteria. A PAT is not Command and Control but could identify the need for the implementation of Command and Control structures. The purpose of a PAT is information sharing and situational awareness.

The TVLRF Multi-Agency Flood Plan (MAFP) provides the framework for the multi-agency response to a flooding incident in the TVLRF area.

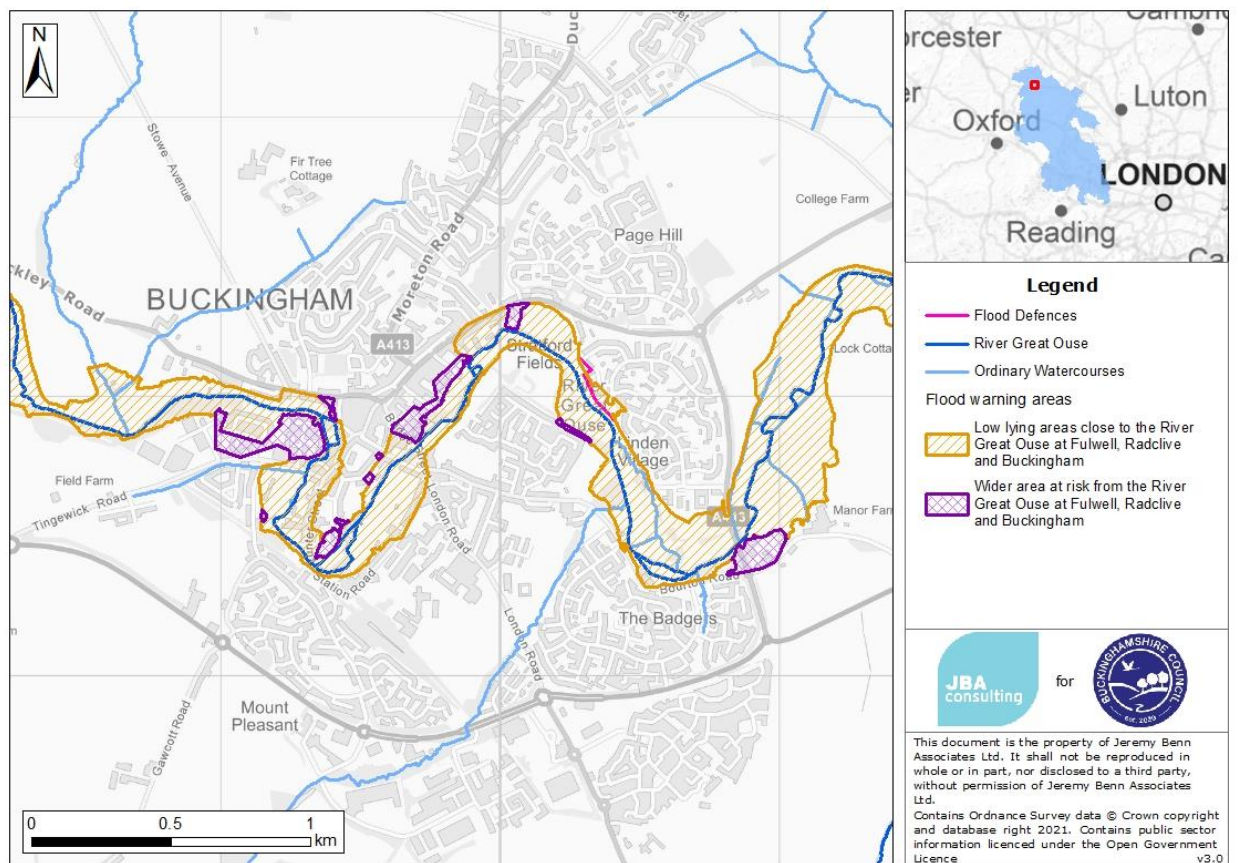
### 5.3 Existing flood risk management activities

#### 5.3.1 Flood warning information service

The Environment Agency’s Flood Warning Information Service has two flood warning areas covering areas at risk from the River Great Ouse in Buckingham. Their coverage is shown in Figure 5-1.

- Low lying areas close to the River Great Ouse at Fulwell, Radclive and Buckingham, covering Fulwell, Tingewick Mill, Radclive, and Brackley Road, Newcombe Crescent, Foundry Drive, School Lane, Nelson Street, Hunter Street, Chandos Road, Victoria Row, Ford Street, Stratford Road and Marsh Edge in Buckingham
- Wider area at risk from the River Great Ouse at Fulwell, Radclive and Buckingham covering Fulwell, Water Stratford, Radclive, and West Street, Fisher's Field, Candleford Court, Cornwall's Meadow and Wharfside Place in Buckingham

**Figure 5-1: Flood Warning Areas**



#### 5.3.2 Maintenance of the river channel

Aside from a number of weirs and old mill races through the centre of Buckingham, the river has a relatively natural channel and tree-lined banks, considering it is in an urban area. The weirs serve no operational or flood risk management purpose. During a site visit in May 2021, there were a number of locations where natural debris (tree branches etc) and man-made debris (e.g. road signs) was observed in the channel (Figure 5-2). There were a number of locations where localised siltation and re-vegetation had occurred. There were also a number of obstructions in the floodplain such as fences observed, which are



likely to be unconsented by the Environment Agency. However there were no major blockages to flow and it is not thought that these would have had a significant impact on water levels in the extreme flows experienced in December 2020.

**Figure 5-2: Debris in the channel in Buckingham**



The Environment Agency has powers to work on main rivers to manage flood risk. These powers are permissive, which means they are not a duty. The EA's powers allow them to carry out a variety of works to maintain main river channels, assets and structures in order to manage or reduce flood risk to people and property, and to safeguard the health and safety of our staff and other river users.

Nationally, the Environment Agency's maintenance works can include: weed and grass cutting by hand/machine, channel maintenance, obstruction removal, vermin control, tree/bush work, defence repair, flood reservoir work, structure maintenance and some works to improve habitat and biodiversity. Their maintenance work may include de-silting or dredging where this is proven to be the most cost-effective way of managing flood risk to people and property, without causing a deterioration of the water body as defined through the Water Framework Directive (WFD).

The Environment Agency undertake a visual inspection of any structures and defences through Buckingham that have a flood risk management purpose, approximately every twelve months. The last asset inspection was undertaken in November 2020, one month before the flood event. We have been advised that at the time of the last inspection, the EA found the channel to be at target condition. There were no intermittent projects flagged or any conditions that required a change to the frequent maintenance programme. Any obstructions to flow, such as fallen trees or blockages are flagged and reported by the Environment Agency to the riparian landowner, where known. At the time of writing (February 2022), the next inspection is currently due.

The Environment Agency's recurring maintenance programme for Buckingham involves inspecting, and where needed, grass cutting high flow cuts (such as at the University) and flood berms. This is undertaken a minimum of twice per year.

In addition to these recurring activities, further intermittent works may be carried out where there is a justified need and funding available. The Environment Agency have advised us that since 2007, they have undertaken the following additional maintenance works in the Buckingham area:

- 2008/09 – De-silting various locations through Buckingham



- 2012/13 – Bourton Park back channel bushing, from NGR SP7063 3338 to SP7055 3350
- 2012/13 – Back channel along The Moorings: bushing and access clearance from NGR SP6940 3387 to SP6936 3392

The Environment Agency will also respond to reports of blockages and obstructions and will carry out patrols of specific locations during flood events, where resources are available.

### 5.3.3 Flood alleviation schemes

A proposal for a flood defence scheme, including an upstream flood storage area and raised defences, was produced by the Environment Agency in 2005. However, this could not be taken forward because the scheme would not have qualified for grant funding from central government. Even though the preferred options did appear to have a positive benefit-cost ratio, the economic case was not positive enough, and had a relatively low priority under Defra's funding criteria at the time.

The scheme was reviewed in 2008 following the July 2007 floods. However, it was again found to be not viable for funding.

There is a formal flood defence at Linden Village, in the form of a flood embankment which runs along the river at March Edge (shown in Figure 4-1). The ownership of this structure is currently a matter of discussion between different parties. However, Buckinghamshire Council's Street Scenes team carries out grass-cutting on this embankment 13 times a year between March and August. The Environment Agency undertook a visual inspection of it in March 2021, reporting that it was at target condition with no defects found.

**Figure 5-3: Flood defence embankment at March Edge, Linden Village**



### 5.3.4 Natural flood management

Natural flood management (NFM) includes a range of techniques for 'slowing the flow' in upper catchments to manage flood risk downstream, particularly from smaller, more frequent flood events. Buckinghamshire Council is funding an ongoing project<sup>15</sup> to identify NFM options in the Great Ouse catchment upstream of Buckingham, currently in Year 2 of a three-year programme. It is currently being delivered through the River Thames Conservation Trust, funded through Section 106. The Trust are conducting landowner

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15 <https://riverthame.org/our-projects/upper-great-ouse-natural-flood-management-project/>

engagement, baseline hydraulic modelling to prioritise delivery areas, and an options appraisal. The project aims to deliver a number of small-scale flow attenuation measures across the catchment, which may help reduce flood risk from lower intensity and higher frequency flooding if scaled up across the catchment. However, NFM schemes generally have limited effectiveness on their own against more extreme floods.

### 5.3.5 Property flood resilience (PFR)

In early 2010 Buckingham was selected as one of the 63 sites chosen across England under Defra's 2-year pilot property level protection grant scheme, securing £325k of funding. A further £250k of Local Levy funding was secured from the Regional Flood and Coastal Committee. (Note that property level flood protection is now termed Property Flood Resilience (PFR)).

The scheme was promoted and delivered by Aylesbury Vale District Council, in partnership with the Environment Agency and Buckingham Town Council, and included 8787 properties. The scheme was well received, with residents having the option of the type of product provided and installed at their property. Residents own the measures, but they are also tied to the property. Products provided included barriers for doorways, portable puddle sucker pumps and sump pumps with associated drainage outlets. It is understood the scheme was tested in November 2012, when 90 properties deployed their measures - although water only reached one of these where ingress was minimised<sup>11</sup>.

### 5.3.6 Community flood group and Flood Plan

In conjunction with the pilot PFR scheme, in 2010 a community Flood Group (Flood Action 4 Buckingham – FA4B) was established in with support and guidance from the National Flood Forum. FA4B volunteers underwent training provided by the National Flood Forum and a community emergency flood plan was developed, led by the community Flood Group itself. For some years, the plan involved contacting volunteers upon receipt of an Environment Agency Flood Alert to check volunteers' availability to support anyone in need of help installing their PFR measures. Upon receipt of a Flood Warning, the Plan then required the flood wardens to hold a meeting, and then email people to advise whether to install their Property Level Protection barriers. The wardens would also liaise with an emergency committee group via teleconference and would commence door-knocking if safe.

In the first few years after establishment of the flood group and flood plan, FA4B organised a number of flood information days in the town to enable residents to gain information, learn more about the emergency plan, discuss any flood concerns, and held an annual exercise and rehearsal of the flood plan. We understand that as time progressed, there were increasing issues around levels of engagement, with some residents opting not to participate in some of the practice and test events, and with issues around storage and maintenance of the PLR products with some residents.

Over time, as community engagement and support for the Flood Group dwindled, Buckingham Town Council assumed a leadership role with the Buckingham Flood Plan. The Flood Plan is now under review following the December 2020 flooding.

### 5.3.7 Planning and development control

Local Planning Authorities (LPAs) must take the probability of flooding from all sources and the risks involved into account when determining planning applications. Flood risk is considered within the planning process in two main ways: using the planning system to avoid locating unnecessary new development in areas of high flood risk, and mitigating the flood risk and surface run-off impacts of new development on downstream areas through planning policies.

#### River flood risk



With regard to river flood risk, the Environment Agency is a statutory planning consultee in relation to applications within Flood Zones 2 and 3 (other than where their Flood Risk Standing Advice is applied by the LPA). Through their role, the EA seek to provide technical advice to LPAs to ensure that developments are safe for their users and do not increase flood risk off-site to other areas.

### **Surface water flood risk pre-2015**

In relation to the surface water drainage of developments, prior to the implementation of the Flood and Water Management Act (2010) in 2015, the Environment Agency was also responsible for providing technical advice and guidance to the LPA on matters relating to surface water drainage.

In line with the National Planning Policy Framework (and its preceding guidance 'Planning Policy Framework 25' and 'Planning Policy Guidance 25'), the Environment Agency would ensure that an appropriate Flood Risk Assessment (FRA) was produced, addressing the risks of flooding arising from the development (mitigating any increase in surface water run-off) in addition to the risks of flooding to the development. For development sites over 1 hectare, the Environment Agency would provide a bespoke response to the LPA on surface water matters.

In order to receive approval, an FRA was required to demonstrate the development would not result in any increase in surface water run-off (both in terms of volumes and rates) compared to the pre-development 'greenfield' rates. This would have to be supported with appropriate calculations and catchment specific data. Management of surface water was encouraged (although not mandatory) through the design and implementation of a sustainable drainage scheme including Sustainable Drainage (SuDS) elements with attenuation, storage and treatment capacities as detailed in the CIRIA SuDS Manual (C697). SuDS are an approach to managing surface water run-off which seeks to mimic natural drainage systems and retain water on or near the site as opposed to traditional drainage approaches which involve piping water off site as quickly as possible.

### **Surface water flood risk post-2015**

Since 2015, Lead Local Flood Authorities (LLFA), in this case Buckinghamshire County Council and later Buckinghamshire Council from 2020, have assumed the statutory consultee role on surface water aspects of developments that was previously held by the Environment Agency. As with the Environment Agency, the LLFA continues to require that developers demonstrate that runoff rates and volumes are designed to be controlled either at or below those pre-development, and that surface water is managed through SuDS in accordance with the NPPF, the Defra Non-statutory SuDS Technical Standards<sup>16</sup> and our local requirements as set out in our SuDS guidance and developer advice<sup>17</sup>. The LLFA work to ensure that developments take account of existing surface water flood risk within a site by also requiring that sites are designed to locate development in the areas of lowest surface water risk within each site.

The implementation of any planning conditions relating to river flooding or surface water recommended by statutory consultees is the responsibility of the Local Planning Authority. Similarly, the overall responsibility for ensuring that flood mitigation and surface water drainage systems are built in accordance with the agreed plans lies with the Local Planning Authority.

Section 9.7 contains a brief discussion of possible improvements in planning policy that might be considered at a national level, as well as some brief commentary on the question

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16 Sustainable drainage systems: non-statutory technical standards - GOV.UK ([www.gov.uk](http://www.gov.uk))

17 What is sustainable drainage? | Buckinghamshire Council ([buckscc.gov.uk](http://buckscc.gov.uk))

of whether development around Buckingham could have impacted on flood flows in the Great Ouse.

## 6 The 23 December 2020 event

### 6.1 Conditions at the time

At the beginning of the autumn in September, rainfall and catchment soil dryness were about normal for the time of year. However, Storm Alex at the beginning of October brought a significant amount of rain and total rainfall for the month was about three times greater than the monthly average. The soil became much wetter than normal for the time of year. A month's worth of rain fell in the period of December up until the event on the 23 December. This led to the soil being wetter than normal ahead of the event on 23 December. Soil moisture deficits were 0mm, indicating that the catchment had minimal capacity to store additional rainfall by the time of the storm event.

River levels recorded at the Buckingham Gauge on Tingewick Road bridge show that levels were already raised following several events in November and December. River levels had initially risen on 22 December, following rainfall on the 21 December, and were starting to drop when the storm event of the 23 December occurred.

The rain gauge at Brackley (approximately 9.5km west of Buckingham) shows that rainfall started slowly at about 07:30 on the 23 December, becoming more intense at 10:00.

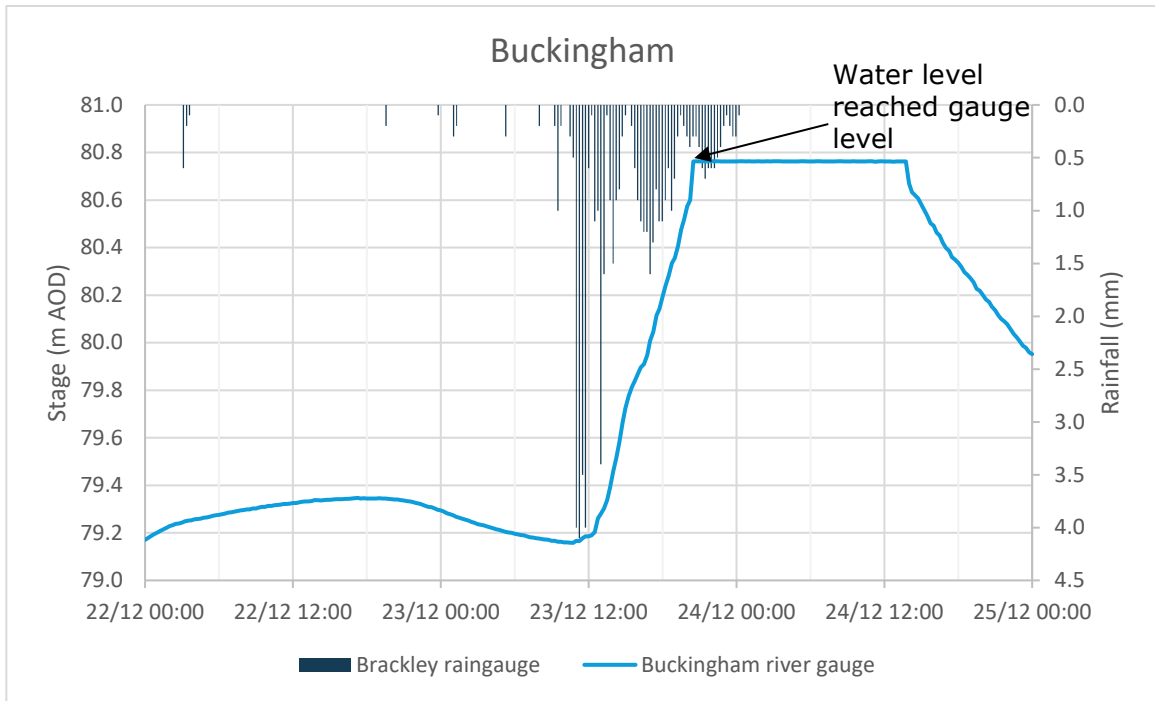
The main body of the storm event happened in two periods of rainfall. The first, and greater, period of rainfall occurred between about 10.30 and 15:00, with two main peaks at around 11:30 and 13:00. The second rainfall period occurred between 15.30 and 20:00, with the peak around 17:00.

The rainfall event ended at about midnight of 23/24 December with an approximate total of 52mm recorded at Brackley over the preceding 16-17 hours. The Brackley gauge is located in the catchment upstream of Buckingham and gives an idea of the rainfall falling in the area that drains into Buckingham.

Given that the soil was already completely saturated, very little of the storm's rainwater could have been absorbed and retained within the soil, and so water would have rapidly arrived into watercourses.

River levels started to rise almost immediately from about 11:00 on 23 December and continued to do so until 20:30. At this time, the water level reached and overwhelmed the gauge and it was unable to record any further rise in water level (shown as a flat line in Figure 6-1). Peak recorded water level was 80.8mAOD (higher than the peak recorded in 2007). The river level gauge shows that at about 13:45 on the 24 December river levels had fallen enough for the gauge to record water level correctly.

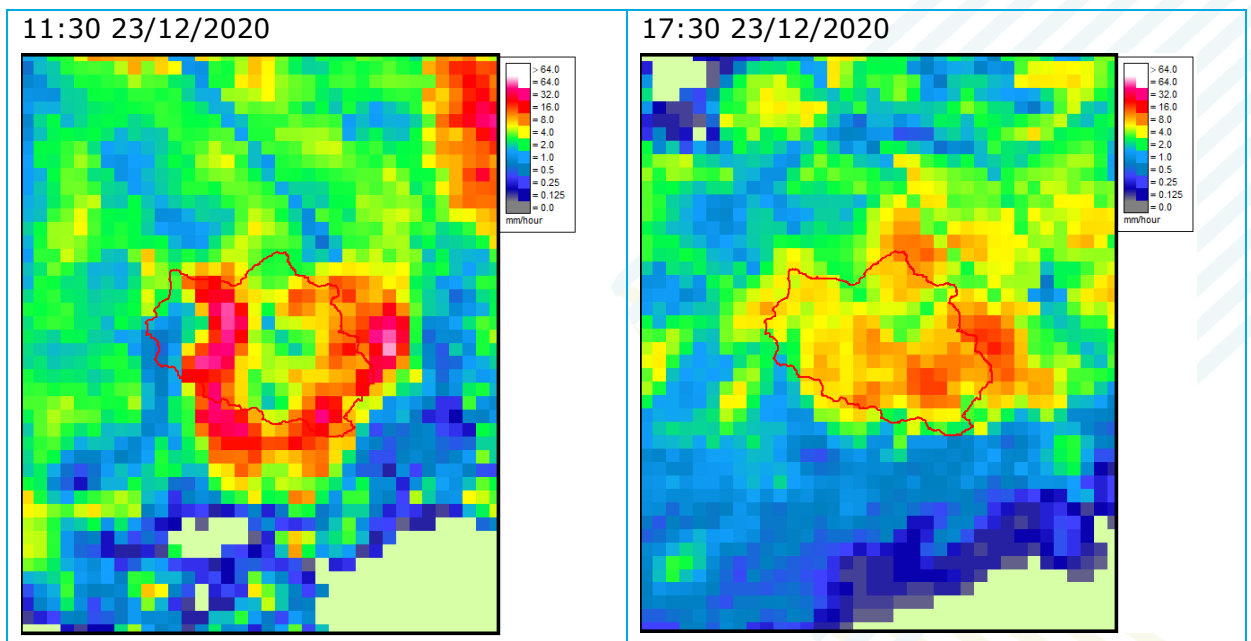
**Figure 6-1: Rainfall and river level data**



HYRAD observed radar rainfall data from the Met Office shows that for the majority of the event the storm passed from south to north across the catchment. After about 17:00, as the weather system turned, the storm passed in a southerly direction.

The images below show the HYRAD observed radar rainfall for the Buckingham catchment (red boundary line in the centre of the image). Colours show rainfall rate at the time shown. Total HYRAD radar rainfall for the storm event, averaged across the catchment, was 39mm.

**Figure 6-2: Hyrad (radar) rainfall for the Buckingham area**



**Table 6-1: Rainfall totals in the Buckingham area on 23/24 December**

Rain gauge	Distance from centre of Buckingham catchment	17-hour total on 23/24 December	Grid reference
Brackley	3km	52mm	460115, 236084
Foxcote	9km	28mm	471278, 235758
Buckingham (catchment average) TBR*	-	46mm	462203, 237828
Buckingham (catchment average) HYRAD	-	39mm	462203, 237828

\*catchment average based on rain gauges at Brackley and Foxcote

### 6.2 Rainfall return period estimation

The total rainfall during the 23 December storm event had a 15% chance of occurring in any one year (return period of 5-9 years). This is not especially extreme, but given that the soils were already completely saturated from the notably high rainfall over preceding months, the catchment was very sensitive to heavy rainfall.

### 6.3 Flow return period estimation

A number of previous studies have tried to estimate the return period of flows for the Great Ouse at Buckingham. Due to the lack of flow gauging, estimates are very uncertain. These studies have been used to compare the 23 December 2020 event with other events in order to derive a 'best estimate' of the return period for the event. Based on this, the estimated probability of the 23 December 2020 flood event at Buckingham occurring in any given year is between 3.33 and 1% (30 and 100 years return period) and it was of a similar magnitude to the April 1998 event and July 2007 events.

Further details of how this has been derived are given in Appendix A.

## 7 Incident response

A timeline of the incident is given in Table 7-1.

**Table 7-1: Timeline of incident**

Date	Time	Activity/event	Agency
22/12/2020	07:45	Flood Alert issued for the "Upper River Great Ouse in Northamptonshire, Oxfordshire and Buckinghamshire"	Environment Agency
23/12/2020	12:24	Crew sent to Western Avenue with sandbags	Transport for Buckinghamshire
23/12/2020 – 24/12/2020	12:24 – 07:01	Sandbag requests received for multiple locations within Buckingham	Transport for Buckinghamshire
23/12/2020	15:00	Flooding along Moreton Road and Western Avenue receives sandbags	N/A
23/12/2020	16:00	Flooding to gardens at March Edge	N/A
23/12/2020	17:00	First property floods at March Edge. Garden flooding at Glynswood. Flooding starts at Well Street.	N/A
23/12/2020	18:00	Police request road closure for Stratford Road. Nelson Street, Tingewick Road and Fishers Field flood. Water enters properties at Nelson Street and Bridge Street.	Transport for Buckinghamshire
23/12/2020	19:00	Floodwater enters first property at Victoria Row. More flooding to properties at Nelson Street.	N/A
23/12/2020	20:00	Internal flooding at Well Street and Nelson Street.	N/A
23/12/2020	~20:00	Resident reports river flooding to Environment Agency	N/A
23/12/2020	20:27	Road closures requested for Ford Street and Well Street.	Transport for Buckinghamshire
23/12/2020	20:30	Property at Chandos Road floods	
23/12/2020	21:00	Fishers Field starts to flood. Levels peak at March Edge. Further flooding to properties at Nelson Street and Victoria Row.	N/A
23/12/2020	21:40	Buckinghamshire Council Strategic Flood Management Team staff informed EA FWDO of river flooding	Buckinghamshire Council
23/12/2020	22:00	Further flooding to properties at Ford Street, Chandos Road and Victoria Row.	N/A
23/12/2020	23:00	Tingewick road impassable	N/A
23/12/2020	23:19	Flood Warning issued for the "Low lying areas close to the River Great Ouse at Fulwell, Radclive and Buckingham" catchment.	Environment Agency
24/12/2020	01:00 – 03:00	Water levels peak at Fishers Field, March Edge, Nelson Street and Well Street.	N/A



Date	Time	Activity/event	Agency
24/12/2020	03:00-07:00	Further flooding to properties at Chandos Road.	N/A
24/12/2020	07:00-12:00	Flood waters start to recede.	N/A
24/12/2020	Afternoon	Sandbags arrive at Wharfside Place	Transport for Buckinghamshire

The following sections describe the response of authorities, organisations and the community, both during the event and immediately following it.

### 7.1 Thames Valley Local Resilience Forum

Multi-agency flood incident response for the Upper Great Ouse catchment is coordinated by the Thames Valley Local Resilience Forum. This covers a very large geographical area - Milton Keynes, Buckinghamshire, Oxfordshire and Berkshire.

On the evening of the incident, Milton Keynes Council instigated a Partner Activated Telecon (PAT) at 20:00 and invited Buckinghamshire Council and other TVLRF partners. This meeting was focused on information sharing and situational awareness on the issues across the whole Great Ouse catchment.

A PAT has the option to identify the need for implementation of formal command and control structures centrally. In this incident, this did not happen, with organisations responding to the incident as per their own operational instructions.

### 7.2 Buckinghamshire Council

Buckinghamshire Council implemented their Incident Management Process (IMP), which was led by a Corporate Director and supported by the Civil Contingencies Unit. As part of this process, an Incident Management Team (IMT) was established consisting of a number of Council Services and Teams.

Staff from these teams were deployed across several concurrent flood incidents across the county, including to Buckingham, to aid and support the local community.

Local Authority Liaison Officers (LALOs), staffed of volunteers from Buckinghamshire Council staff, were deployed along with Buckinghamshire Council members and Town Council officers and members, to gather information and provide reassurance to the community from the ground.

Local elected members from Buckinghamshire Council worked on the ground throughout the flood incident to support local residents and to help to coordinate the response from the various organisations involved. Local Buckinghamshire Council members also worked to set up an Immediate Impact Flood Fund to provide funding from the Buckingham and Villages Community Board for affected residents. A total of £10,000 was provided through this fund to provide hotel accommodation, food, heating, pumps and Christmas presents to those families worst affected. Buckinghamshire Council members also distributed presents on Christmas Eve to some impacted families.

Staff from the Lead Local Flood Authority team do not have a specific operational role, but volunteered to assist with interpreting the data from Environment Agency and Met Office, and liaising with the Environment Agency's virtual Local Area Incident Room.

Buckinghamshire Council's Community Safety Adviser worked alongside Town Council staff assessing the impacts of flooding and coordinating the relief effort the following day.

The Council provided some help to residents with waste collection following the event.

### 7.3 Environment Agency

### 7.3.1 Flood warning information service

A Flood Guidance Statement indicating Low overall flood risk, was issued by the Flood Forecasting Centre on Tuesday 22nd December. This triggered a Flood Advisory Service Tele-conference (FASTCon) between partner responders, including the Environment Agency and Buckinghamshire Council. A Flood Alert was issued for 'Upper River Great Ouse in Northamptonshire, Oxfordshire and Buckinghamshire'.

Prior to the FASTCon call, the Environment Agency had rostered up their response staff, and under the developing situation had also requested additional resources to be called in to provide further support to the Flood Warning Duty Officers (FWDOs).

This was a unique incident in that it occurred during a period of COVID-19 restrictions. Under normal circumstances the Environment Agency's responding staff would facilitate their response to the event from the Area Incident Room in Brampton, Huntingdon. During this event, staff worked remotely and communicated in a virtual environment. Initially there were fewer duty staff available to the Environment Agency to call upon due to the festive holiday period. The event was widespread across the region, with flooding in multiple locations. Between 16:00 on 23 December and 21:00 on 25 December a total of 41 Flood Alerts and 50 Flood Warnings were issued.

The Environment Agency set up a virtual Area Incident Room - an 'open all hours' online meeting (in fact, this eventually lasted three weeks). This was the first Environment Agency Area to use a virtual incident room in this way and provided staff with structured way to raise issues and seek outcomes quickly during the face paced event.

The FWDOs liaise with their Monitoring and Forecasting Duty Officer (MFDO) colleagues to examine rain forecast and river level data, assessing these against pre-defined trigger levels for considering and then issuing flood alerts and warnings.

As the event unfolded in Buckingham on 23 December, a number of residents phoned the Environment Agency's national Floodline to report the flooding in the afternoon and early evening. Some early reports of flooding in Buckingham were missed or classified as surface water flooding rather than flooding from the Great Ouse.

The Environment Agency were informed by Buckinghamshire Council at 21:40 of high river levels on the River Great Ouse causing property flooding in Buckingham.

In a subsequent FASTCon held at 22:00 on Wednesday 23 December a decision was made to issue the flood warning for 'Low Lying River Great Ouse at Buckingham'. The warning was issued at 23:19. The flood warning for 'Wider area at risk from the River Great Ouse at Fulwell, Radclive and Buckingham' was not issued during this event although some of these areas were flooded.

At the time of the event, flood warnings for Buckingham were triggered solely from the gauge upstream at Brackley, with no triggers set at the Buckingham level gauge. Typically, this is suitable as it provides a sufficient 2-hour lead time following the issue of the flood warning to onset of flooding. However, in this event, much of the rainfall fell in the parts of the catchment between Brackley and Buckingham meaning the trigger at Brackley was not reached.

As a result, properties in Buckingham were flooded before a flood warning was issued. As such, it limited the response capabilities of the community; members of the public in Buckingham had already started to experience flooding, and although the earlier Flood Alert enabled the community to 'Prepare,' the trigger to 'Act' was too late.

The Environment Agency acted quickly to set a new trigger for the Buckingham gauge, based on reports of the time at which the first property flooded internally. This trigger was put into procedures from 24 December 2020. It is currently being used for both Buckingham Flood Warning areas.

### 7.3.2 Flood incident operational response

Operational response protocols such as early inspections and checks for blockages at assets were enacted, and the response was aligned with Flood Incident Duty Officer (FIDO) procedures.

There are no operational assets such as sluices upstream of Buckingham. Downstream of Buckingham, there are automated sluice gates at Thornborough Mill (3.6km downstream) and Stony Stratford (11km downstream). These operate automatically to maintain the normal water ('retention') level and to manage flood risk in the immediate vicinity. The sluice gates open and close instantaneously in increments as flow increases and decreases. These sluices have no impact on flood flows or levels through Buckingham.

On 23 December 2020, the sluices opened automatically as normal to allow water to flow faster through the system.

### 7.4 Transport for Buckinghamshire

Transport for Buckinghamshire managed a large number of road closures across Buckingham and the wider area during the event. They also issued sandbags, prioritising these on the basis of greatest need. Sandbags were delivered to the following locations within Buckingham:

Western Avenue, Highlands, Mitre Street, Poplars Road, Bath Lane, Medway, Stratford Road, A422 Castleford Bends, Gilbert Scott Road, Portfield Close, March Edge, Moreton Road, Hunter Street, Gawcott Road, and Springfields Lodge.

### 7.5 Anglian Water

Anglian Water was managing very high flows in its network across Buckingham and the wider area. Pumping stations were running at full capacity and all pumping stations were working throughout the incident with no failures. The Riverside terminal pumping station ran at full capacity 24 hours a day for 3 days.

However, flood water from the river did ingress into the sewer network through manholes, or via backing up of surface water outfalls meaning capacity was overloaded and sewer flooding was experienced in some locations. Anglian water staff visited locations including Overn Crescent and March Edge where flooding from surface water and foul sewage was experienced but residents were told there was little they could do. Anglian Water issued advice to residents of some areas not to flush their toilets (e.g. Fishers Field).

### 7.6 Buckinghamshire Fire and Rescue Service

Buckinghamshire Fire and Rescue Service (BFRS) dealt with a high volume of calls during the afternoon and evening of 23 November, dealing with multiple flood incidents in villages around Buckingham and Milton Keynes. Flooding of the roads made the response difficult, with a number of communities cut off. Main roads, including the A422 and A421 were impassable in places. BFRS stood up their Operational Support Room which remained in place until 23:30.

As the event progressed, the main activity focussed on Buckingham as the river level reached its peak, and attendance was prioritised to incidents focussing on risk to life. There were a number of occasions throughout the period when BFRS was unable to pump out water from properties simply because the water table was too high and there was nowhere to pump it.

BFRS attended 161 incidents, most of which were flood related, during this period, with a number of these flooding incidents involving multiple rescues and multiple properties.

### 7.7 Town Council

The Town Council does not have any statutory obligations in regard to flooding and civic emergencies. It must consider the health and safety implications of its staff (volunteers and

councillors) who are not trained or equipped to be an emergency service. However, it does act as coordinator of the Buckingham Flood Plan, and its staff volunteered to provide support to the community during the event.

The Town Council also stores and maintains the Community Flood Toolkit. This was provided for Buckingham Town Council through funds provided by the Regional Flood and Coastal Committee, and followed a recommendation made by Buckinghamshire County Council in its Section 19 Investigation into the March 2016 flooding in Buckingham. The Environment Agency administered the purchasing of equipment for Buckingham, which is stored and maintained by the Town Council. The aim of the Community Flood Toolkits is to allow volunteer flood groups or Town/Parish councils to respond effectively during a flood event using appropriate equipment. Equipment includes items such as Hydrosnakes, high-vis jackets, "road flooded" warning signs, loudhailers, two-way radios, emergency blankets, etc.

By the time the Town Council had become aware of the seriousness of the event, staff had returned home and many live outside of Buckingham. With roads either dangerous or officially closed, most staff could not return safely. However, a member of Town Council staff acted as coordinator for the Buckingham Flood Plan remotely from home.

It was not possible to enact the full Flood Plan as at the time of the event there were no volunteers signed up to carry out the planned tasks such as door-knocking. One Town Council staff member was able to return to the office and access the Town Council's equipment and go out in a 4x4 vehicle to distribute it under the guidance of the coordinator. By this point there was no real requirement to spread the warning as the event was well underway, the main aim was to try and assist those being flooded.

The coordinator used social media, local contacts and Councillors on the ground to coordinate where equipment should be distributed, and vulnerable residents should be checked on e.g. Linden Village. All the Flood Toolkit equipment held by the Town Council was used, including sandbags and 'flood snakes'. The flood snakes were found to be ineffective as they were washed away by the force of the water.

On the morning of 24 December, the flood had receded enough that Town Council coordinator was able to access Buckingham. A survey of the impacts was carried out alongside Buckinghamshire Council's Community Safety Adviser. Together they accessed affected areas on foot, coordinating the relief effort and establishing the extent of the damage.

Since the event, the Town Council has been reviewing and updating the Flood Plan. The new flood plan is designed to be safe and effective with much of the traditional door knocking replaced by phone calls. This will improve health and safety aspect for staff and volunteers and allow staff on the ground to target the vulnerable and those who cannot be contacted by phone. Following the event an appeal was launched for volunteers and there has been a reasonable response. The Town Council are currently preparing some training for new volunteers.

## **7.8 Community**

During the event members of the community stepped in to help those impacted using pumps and buckets to help protect properties from advancing floodwaters. Social media was used to ask for and offer help informally.

Volunteers ran the Community Centre which was open until 14:30 on 24 December for food, drinks and rest. They had been supplying the vulnerable with meals for the week before Christmas. They were located at Well Street originally but had to move their entire operation overnight due to the flood water. The Community Centre is a designated rest centre for Buckinghamshire Council.

The Partnerships and Outreach Manager for the University of Buckingham also set up a community crowd fundraiser ("Buckingham Flood Victim Support Fund") in his capacity as a



private resident. A total of £18,500 was raised, with donations from over two hundred local residents. The funds raised were held in a holding account administered by Buckingham Town Council, with support from Town Council and Buckinghamshire Council members. An independent panel assessed applications and agreed on grants provided. In total, twenty-one grants were paid out, using up all available funds by April/May 2021. Many of the claimants were uninsured. The grants provided helped pay toward the costs of temporary accommodation, home repairs, and insurance excess for some of the worst affected residents in Buckingham, as well as some of the surrounding villages.

In addition, as mentioned above in Section 7.2, local Buckinghamshire Council members set up an Immediate Impact Flood Fund to provide immediate funding to affected residents from the Buckingham and Villages Community Board. A total of £10,000 was provided through this fund. The fund was managed through the local parish and town councils, churches, local community groups and businesses working with those affected by the flooding. The funding was used to provide hotel accommodation, food, heating, pumps and even presents to some of those families worst affected. Restaurants were also given access to the funding to provide hot meals.

### 7.8.1 Property Flood Resilience

Those properties which were part of the 2010 pilot Property Flood Resilience (PFR) scheme had the opportunity to deploy their PFR. A national report written in 2014 had assessed the Buckingham PFR scheme as an example of good practice in how effective community support and partnership can build flood resilience and help individuals take responsibility for their own flood protection, with the support of community emergency plans<sup>18</sup>.

It is not known how many residents deployed their PFR during the event. A comparison with the July 2007 flood (when 96 properties were flooded at a slightly lower peak water level) suggests that some properties successfully deployed their PFR and prevented internal flooding in December 2020.

However, the original installations are now 10 years old, and the online questionnaire and liaison with stakeholders gave some suggestion that the scheme may not have been as effective as it could have been:

- One property reporting that the manufacturer has reported that the original installation of the flood barrier, by a separate company, was not done correctly and therefore is at risk of being bypassed by flood water
- One property's flood barrier was accidentally disposed of post-flood by waste collectors, so property now has no protection
- At least three reports of barriers being deployed but property flooding occurring
- PFR was not deployed in a number of student residences. Many of the residents are students who were not present at the time of flood as it occurred during the Christmas holiday.

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<sup>18</sup> [https://assets.publishing.service.gov.uk/media/6034e365e90e07660e26e9b0/Post-Installation\\_Effectiveness\\_of\\_Property\\_Level\\_Flood\\_Protection\\_\\_final\\_report.pdf](https://assets.publishing.service.gov.uk/media/6034e365e90e07660e26e9b0/Post-Installation_Effectiveness_of_Property_Level_Flood_Protection__final_report.pdf)

**Figure 7-1: PFR deployed at Nelson Street, 23 December 2020 (photo credit: Sharon Oaks)**



PFR effectiveness may be affected by the age of the products, the knowledge of the residents (particularly in rented properties or where properties have changed owners), or by alterations to the property introducing new ingress routes. For example, it is known that many of the houses on Nelson Street and Hunter Street are rented accommodation. The timeliness of a flood warning will also impact how quickly PFR can be deployed.

At Candleford Court, which is a relatively recent development of flats within the flood plain, it was reported that there is no emergency flood plan for the building in place. Although the undercroft car park is designed to accommodate flood waters in a flood event, no plan was in place for residents to move their cars upon issue of the Flood Alert, meaning they were unable to act to protect their property from flooding.

## **7.9 University of Buckingham**

Many of the University's staff and students were on leave for the Christmas break. The Partnerships and Outreach Manager for the University of Buckingham led the University's response to the flooding. He had previous experience and knowledge of the flood risk in Buckingham and acted quickly to ensure the University buildings at risk were sand-bagged

and moved some electrical equipment. He then joined the community response in Linden Village.

Following the event, the University of Buckingham provided three dwellings, free of charge for up to three months, to accommodate three impacted families. The University also offered emergency accommodation to a number of students whose homes had been flooded.

## 8 Source-pathway-receptor analysis

We analysed all of the information available to determine the main sources of the flood water, the pathways it took and the main receptors. These are summarised in Figure 8-3 to Figure 8-5 and Table 8-1, and described in the following sections.

### 8.1 Source

#### 8.1.1 River

The primary source of flooding of the majority of the receptors in Buckingham was high river levels on the Great Ouse. The river rose rapidly in response to rainfall falling on the saturated river catchment upstream, which has an area of 143km<sup>2</sup>. Aside from a small embankment at Linden Village, the majority of the town has no river flood defences, and high river levels are therefore a direct source of flooding.

#### 8.1.2 Extreme rainfall

The intense rainfall experienced in Buckingham itself caused a large volume of water to fall directly onto the ground surface in the urban area. A total of 52mm of rain fell over 17 hours at Brackley (see section 0). This event had a 15% chance of occurring in any one year (return period of 5-9 years). This results in direct runoff from urban surfaces and green space.

#### 8.1.3 Groundwater

A number of questionnaire responses note groundwater as a source of flooding. Given the alluvial gravel deposits close to the river it is likely that there would have been a rise in groundwater in response to rising river levels. When groundwater in the alluvial gravels rises, it may exceed the ground surface, or ingress into properties through the foundations and floors. This was noted anecdotally at the very old cottages on Victoria Row, but it is difficult to verify if this was the main source of flooding. Groundwater flooding was also reported at Moreton Road, Well Street, Nelson Street, Hunter Street, Victoria Row and Chandos Road.

### 8.2 Pathway

#### 8.2.1 Exceedance of river capacity

The river level exceeded bank level and spilled out into the floodplain. This is sometimes referred to as 'fluvial' flooding. This occurs first at low points such as Chris Nichols Walk and Bourton Park.

#### 8.2.2 Surface water flow and the surface water drainage system

Impermeable surfaces such as roads became direct pathways for surface water flow to run off e.g. Addington Road, Gawcott Road, Mitre Street and Moreton Road. This is sometimes referred to as 'pluvial' flooding.

The surface water drainage network includes highway gullies and drains (Transport for Buckinghamshire responsibility), and surface water sewers (Anglian Water responsibility). These are designed to drain rainwater underground and outlet directly into the River Great Ouse. In some locations, the surface water drainage system became overwhelmed by the volume of water and water surcharges from manholes, or where highway gullies become blocked by leaves and debris, leading to flooding e.g. Addington Road, Stratford Road, Moreton Road, Well Street.

There are a number of locations where the surface water drainage network would normally discharge to the river through surface water outfalls, but cannot when river levels are high, causing surface water to back up through the system and surcharge out of gullies and manholes. The drainage system also provided a pathway for river water to back up and



inundate low lying areas, reaching locations such as Nelson Street/Hunter Street, March Edge and Wharfside Place. Locations where the drainage system was reported to be surcharging are located on Figure 8-4 and Figure 8-5.

### 8.2.3 Combined and foul sewer system

All the foul and combined sewers in Buckingham, and some surrounding villages, flow to the Riverside terminal pumping station, which is just downstream of March Edge. From here the sewage is pumped to Buckingham Sewage Treatment Works. Combined sewers carry some surface water and Anglian Water confirmed that during the event the whole sewer catchment was struggling to cope with incoming flows. The Riverside terminal pump station ran 24 hours a day for 3 days.

The river levels were also very high meaning that river water was entering the sewer network through manholes, and the emergency overflow from the Riverside terminal pumping station could not discharge effectively. As a result, the whole catchment was backing up within the system leading to hydraulic overloading and surcharging of manholes. This was particularly an issue at March Edge, which is immediately adjacent to a 375mm combined sewer which takes flows from a large area of eastern Buckingham including Page Hill and Linden Village, and is 500m upstream of the Riverside terminal pumping station. Foul sewage was observed bubbling up from manholes here.

## 8.3 Receptors

### 8.3.1 People

During the event, flood water posed a risk to people's safety. Water was deep and fast flowing close to the river, for example in the University grounds (although there were few staff and students present at the time). Some water was polluted with foul sewage posing a health risk, for example in Linden Village. Residents had no time to take action with regards to the rising water levels, due to the Flood Warning not being issued until after flooding to properties occurred.

There have been lasting impacts on people with some residents still unable to return to their homes and living in temporary accommodation 6 months later. The long recovery times for some are similar to that of the 2007 event.

Flooding has impacted heavily on mental health, with periods of heavy and prolonged rainfall creating anxiety in residents and fears of repeat flood events leading to sleepless nights as they check water levels are not rising towards their properties.

In the aftermath, the clean-up process caused stress and grief as ruined possessions are disposed of and repairs, retrofits and replacements are made. Financial burdens are placed on residents and there were uncertainties around insurance pay-outs, made worse by the timing of the flooding in the run up to Christmas. As a result of the flooding, insurance premiums of properties affected have increased and some residents are concerned they will not be able to renew their flood insurance in the future.

In response to the flooding, financial support was provided from both a community crowdfunding campaign, as well as the Community Board, Buckingham Town Council and the University of Buckingham.

Floodwaters also pose a risk to animals and pets. There was one reported case of a pet becoming ill after walking in and drinking flood water.

Several comments from residents on how the floods have impacted them, received through the online questionnaires, are quoted below.

*"It was very stressful as we did not know if it was going to enter the property, so we raised everything that could be damaged off the ground floor."*

*"My family hate it when it rains now, especially prolonged or heavy, it is now a continuous worry."*

*"I had to leave my home as the whole of the downstairs was under water and all my possessions removed and disposed of.. I found the experience extremely upsetting. Having to leave my home of 63 years has severely affected my mental health to the effect that I have had panic attacks and been admitted to hospital."*

*"This is the 4th time I have been flooded in the 48 years I have lived here and each time it gets more stressful. I have been to meetings after each flood to see what is going to be done to try and stop this but nothing appears to help. Every time we get heavy rain I am sick to my stomach. This is not a good way to live."*

*"Get very anxious now when there is heavy or prolonged or constant rainfall or wet periods, always checking drain for flooding."*

### **8.3.2 Property**

In total, at least 72 properties were internally flooded during the December flood event with a further six still to be confirmed with suspected basement flooding by the Environment Agency. At least 11 were non-residential. Some properties were able to deploy PFR flood gates before flooding occurred, however not all were able to, and several of those who did deploy gates still flooded internally. There were at least 15 properties flooded externally, including 5 garages.

Commercial properties impacted included two pubs, a beauty salon, newsagent, takeaway, car dealership, fireworks store, construction store, printing shop, petrol station, University buildings and several garages. Flooding to some of these properties was costly with weeks of business lost, large amounts of stock destroyed, and expensive refitting and repairs of buildings required in some cases.

At the University of Buckingham, over £180,000 of damage was caused from lost goods in storage areas, basements flooded which contained IT equipment, and vehicles written off, including three new electric vehicles.

Flooding also impacted garages, gardens, roads and driveways at Cecil's Yard, Moreton Road, Greenfields, High Street, Glynswood, Meadway, Balwen, Bath Street, Gilbert Scott Road, Lincoln, Poplars Close, Gawcott Road and Portfield Close.

Several vehicles were written off by floodwaters, many of these at Candleford Court, where the undercroft car park flooded. This car park is open to the sides and is designed to accommodate flooding as it is located within the flood plain. However, a flood plan should be in place for Candleford Court to notify residents to move their cars ahead of flooding. No such flood plan was in place at the time of the flooding. Mechanical and electrical systems within the building, such as the lifts, were damaged by the flooding. Significant costs were incurred for subsequent repair work, with some repairs still ongoing at Candleford Court as of December 2021.

**Figure 8-1: Well Street, 24 December 2020 (photo credit: anonymous )**



### **8.3.3 Infrastructure**

Many roads within Buckingham were impacted by surface water and the River Great Ouse throughout the 23 and 24 December. Road closures were issued at Well Street, Ford Street, Nelson Street, Stratford Road, and Tingewick Road.

**Figure 8-2: Tingewick Road, 23 December 2020 (photo credit: Tyne Marshall)**



High river levels caused flood water to enter the sewer system in low-lying locations. On the morning of 24 December, several areas of Buckingham such as Fishers Field and Marsh Edge were flooded from sewers, or unable to use toilets. Advice was received from Anglian Water to limit flushing during the morning.

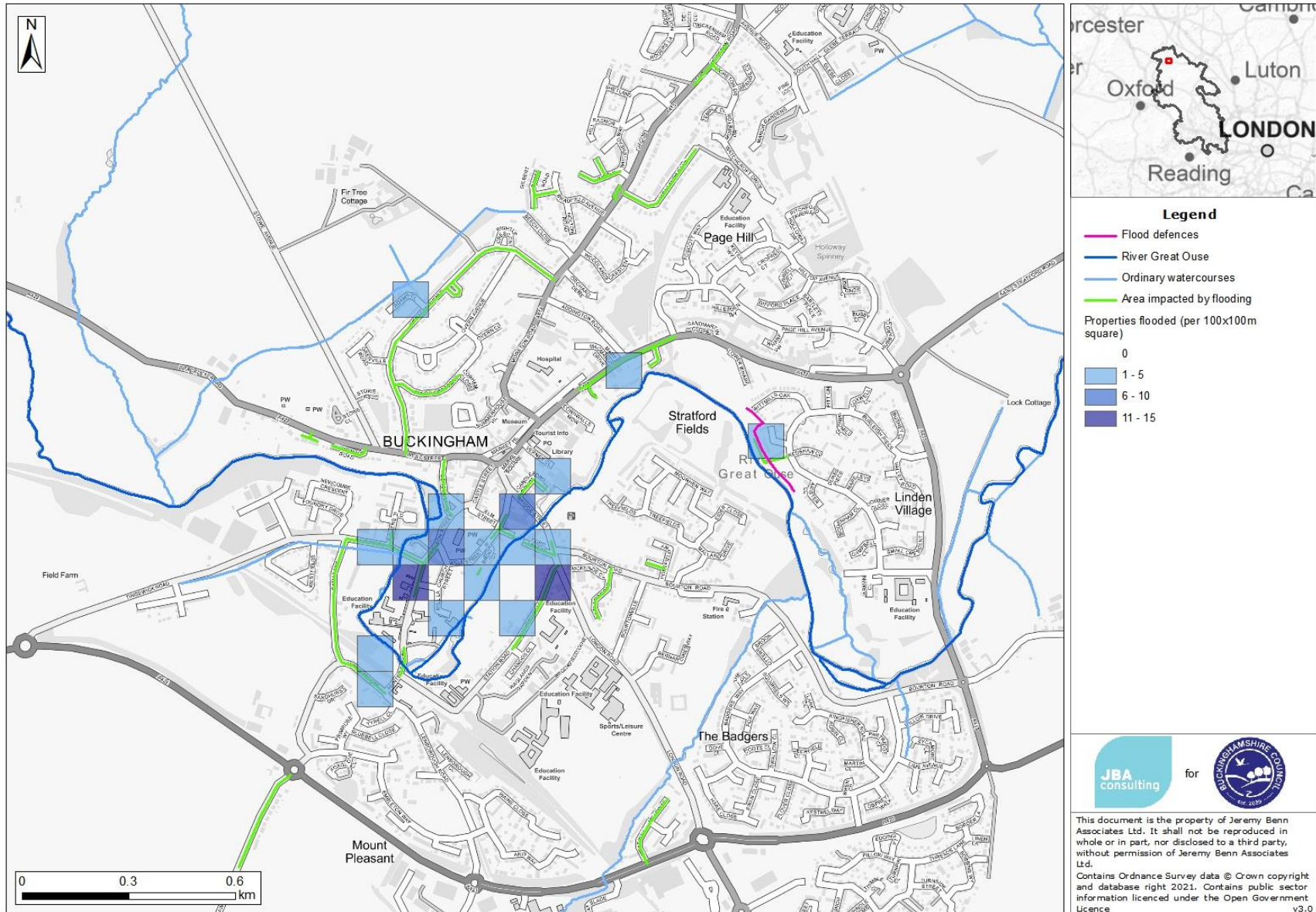
#### **8.3.4 Services**

The Brooks Court Residential Home experienced ponding at the front of the property, though managed to deploy flood gates. Recreational areas such as the Bridge Street play area, Chandos Park, Stratford Fields, and Bourton Park were flooded. Depths within the play area were measured at 0.76m.

The Cornwalls Meadow car park (the main public car park in the town) was completely flooded by floodwater from the River Great Ouse, resulting in damage to parking meters and the electric scooter scheme.



Figure 8-3: Overview of flooding within Buckingham



JBA consulting for

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Figure 8-4: Map of sources, pathways and receptors in central Buckingham

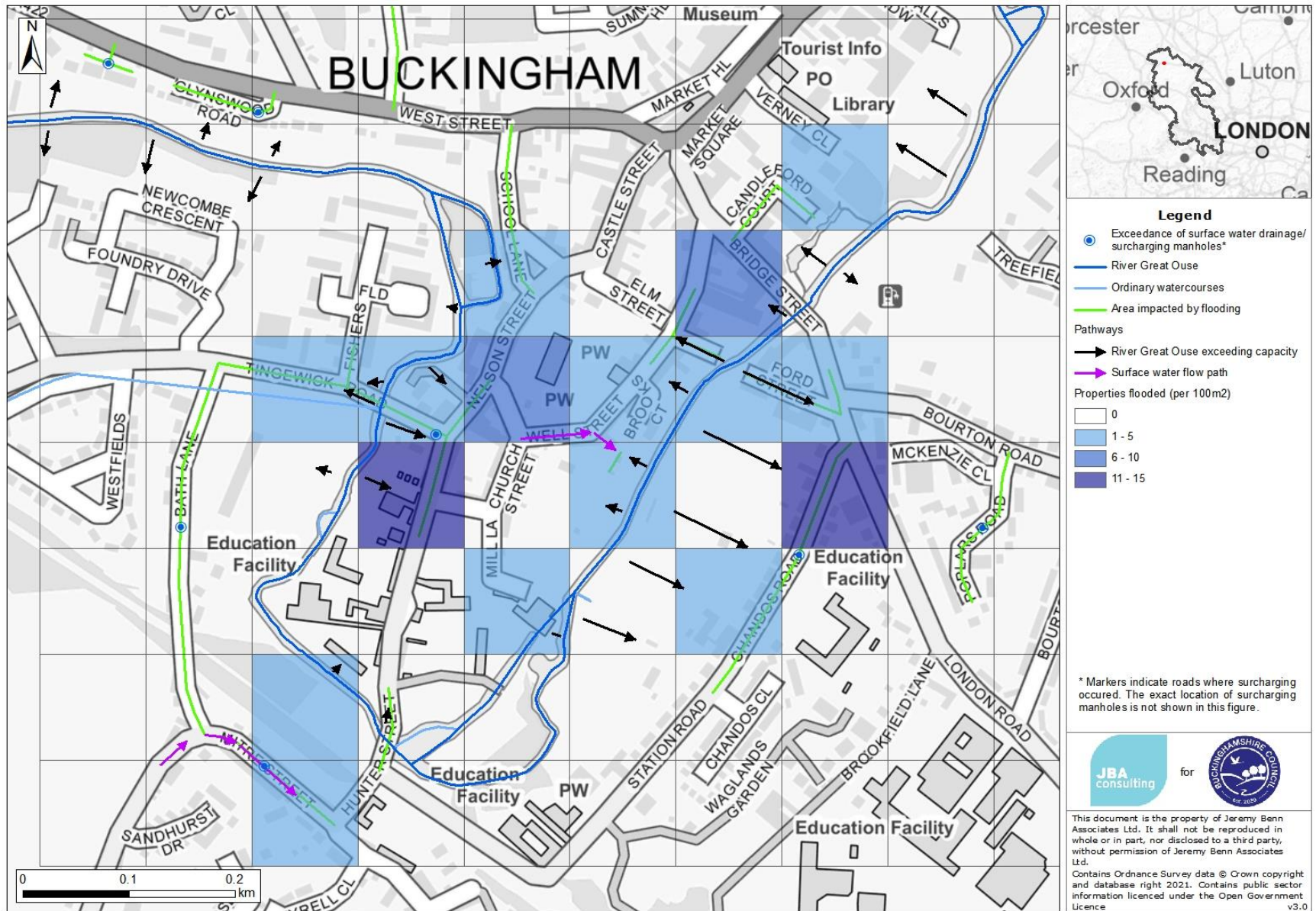
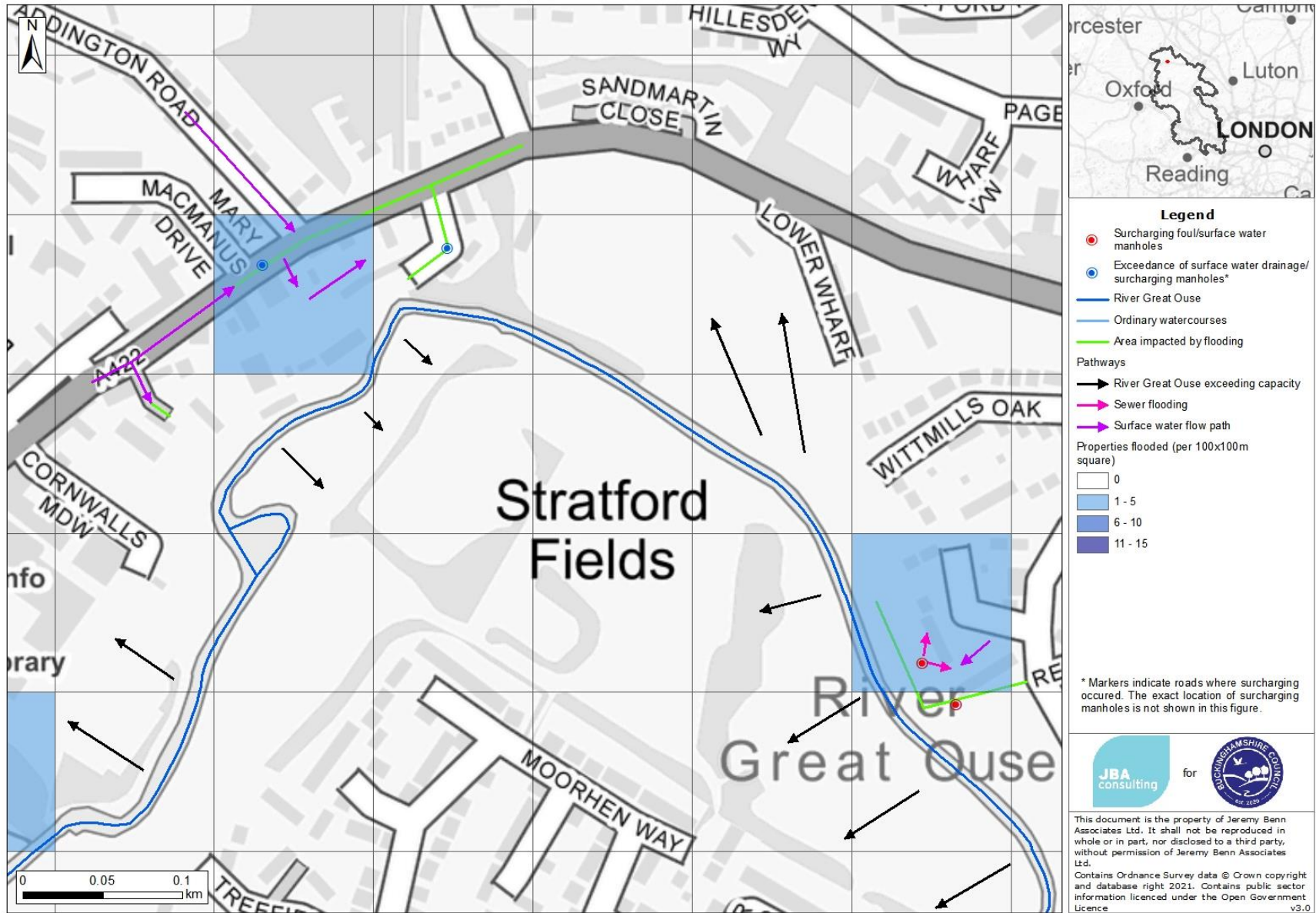




Figure 8-5: Map of sources, pathways and receptors at March Edge and Stratford Road



**Table 8-1: Source-pathway-receptor by location**

Street Name	Source	Pathway	Receptor (No. of properties flooded internally)	Observed depths	Description
Bridge Street	River	Capacity exceeded	3 (plus 1 unconfirmed)	~30-90cm	Internal flooding from River Great Ouse. Water starts to flood basement living areas through the floor first, then through back doors as it rises.
Candleford Court	River	Capacity exceeded	1	100cm+	Flooding of underground carpark (designed to flood). Damage to cars not able to be removed in time, and to lifts and electrics.
Chandos Road	River/surface water drainage	Capacity exceeded	17	Up to 45cm	Internal flooding to basements from River Great Ouse. Drains on the road were unable to cope with volume of water and caused garden flooding.
Cornwalls Meadow	River	Capacity exceeded	1	15cm+	Car park, Shopmobility, public toilets flooded. Electric scooters damaged.
Fishers Field	River	Capacity exceeded	0	40-50cm	Entrance/ Exit to Fishers Field flooded. Flooding to garages. Deep water from 9pm with peak lasting until 7am. Water receded quickly. Foul sewer flooding also reported in questionnaires.
Ford Street	River	Capacity exceeded	2	~60cm	Internal flooding from River Great Ouse.
Highlands Road	Rainfall	Surface water drainage capacity exceeded	0	Unknown	Surcharging drainage system caused flooding to a garage.
Hunter Street	River	Capacity exceeded	2	Unknown	Flooding to university building and car park from River Great Ouse
March Edge	Rainfall	Combined sewer capacity exceeded / surface water flow	2	Up to 30cm	Properties flooded due to surcharging combined sewer and surface water flows. In addition, properties sit within a topographic hollow, leading to surcharged water ponding in the area. Property and gardens flooded. There have been several reports that water was seeping through the river embankment, but this has not been verified.
Mill Lane	River	Capacity exceeded	1	Unknown	Flooding to university building from River Great Ouse.



Street Name	Source	Pathway	Receptor (No. of properties flooded internally)	Observed depths	Description
Mitre Street	Rainfall	Surface water flow	2 (plus 1 unconfirmed)	Unknown	Surface water flowed off the fields behind Bath Lane, down Gawcott Road, and onto Mitre Street. Foul sewer flooding also reported in questionnaires.
Nelson Street	Rainfall / river	Surface water drainage and river capacity exceeded	18 (plus 1 unconfirmed)	Up to 120cm	Highway gullies that drain into the River Great Ouse backed up. River Great Ouse overtopped onto Tingewick Road and flowed towards Nelson Street. Foul sewer flooding also reported in questionnaires.
Overn Crescent	Rainfall	Surface water drainage capacity exceeded	0	Unknown	Surcharging of manholes caused flooding to a garage
School Lane	River	Capacity exceeded	3	Unknown	Internal flooding from River Great Ouse.
Stratford Road	Rainfall	Surface water flows	3	Unknown	Surface water flowing down Stratford Road and Addington Road ponded in the petrol station forecourt and flooded several other buildings. Surface water flowed east to Wharfside Place
Tingewick Road	River	Capacity exceeded	2 (plus 1 unconfirmed)	~42cm on bridge	Tingewick road flooded by the River Great Ouse from junction of Nelson Road to Fishers Field. Road impassable by 23:00. Flooding lasted into the 24 <sup>th</sup> and water starts receding by mid-morning/early afternoon.
Victoria Row	River / groundwater	Capacity exceeded / water rose through the ground	5	~15cm to 33cm	Internal flooding from River Great Ouse. Reports that water rose through foundations. Access and egress difficult due to narrow pathways and surface water along Well Street
Well Street	River / rainfall	Capacity exceeded / surface water flow	8 (plus 1 unconfirmed)	~5cm to 90cm	Internal flooding from River Great Ouse. Surface water flowed down Well Street from the west. Foul sewer flooding reported in questionnaires from surcharging manholes. Basements/cellars experienced deep flooding (up to 6ft deep).
Western Avenue	Rainfall	Surface water flow / surface water	2	Unknown	Cars driving along the road caused waves of water to flow up driveways and flooded properties and garages.

Street Name	Source	Pathway	Receptor (No. of properties flooded internally)	Observed depths	Description
		drainage capacity exceeded			
Wharfside Place	Rainfall	Surface water drainage capacity exceeded	0	10cm-40cm	Surface water drainage backed up from River Great Ouse. Flooding to a garage, driveways and gardens.
Total:			72 (plus 6 unconfirmed)		

## 9 Discussion, appraisal and recommendations

### 9.1 Introduction

In this section, we discuss in more detail some of the aspects of flood risk management in Buckingham, what worked well and not so well, and we consider potential options to mitigate flood risk and reduce damages caused by flooding.

This includes consideration of measures such as improvements to data collection and evidence; flood warning and incident management; community, property and infrastructure flood resilience; maintenance and minor works; asset maintenance and refurbishment and flood risk management capital scheme options.

We undertook a high-level option appraisal focussing on benefit, practical and viability considerations. We carried out a multi-criteria analysis to compare each option which included consideration of:

- Contribution towards reducing flood risk to property
- Contribution towards reducing flood impacts on people/communities
- Contribution to improving the availability of data, evidence and modelling to support option development or flood incident response
- Deliverability (including construction complexity, access, designations, services, space, land ownership, available materials and expert equipment or advice required)
- Community / resident acceptability
- Contribution towards biodiversity and water quality betterment
- Contribution towards amenity benefits
- Contribution to carbon reduction
- Maintenance requirements

Relative costs and timescales are provided for information only and are not included in the scoring.

The scoring criteria and full results are described in more detail in Appendix B. Options with a score of 7 or above were taken forward to become recommendations. Recommendations have been listed in order of priority according to the multi-criteria analysis score. Each recommendation has been given a timescale based on discussion with RMAs, and colour-coded depending on the following:

	Not started
	Planned
	In progress
	Complete

It is important to note that whilst JBA and Buckinghamshire Council have liaised with partner organisations regarding this assessment, this is a high-level, preliminary assessment undertaken by and on behalf of Buckinghamshire Council. Therefore, it is for the relevant responsible body or persons to assess these recommendations in terms of their legal obligation, resource implications, priority and the costs and benefits of undertaking such options.

In particular, where taking forward a recommendation is likely to be reliant on securing grants from central government to fund the project<sup>19</sup>, significant further work by the responsible authority will be required to assess the costs/benefit of the proposals, and consideration will need to be given to the timing and availability of funding. This is likely to be the case for the recommendations within Section 0. For such projects to be taken forward to design and construction, a business case may need to be made into a national programme, with the success of the bids dependent on the following:

- Any works are cost beneficial and financially viable
- The works will provide a sufficient level of benefit for the residents at flood risk
- Any project has considered all sources of flood risk
- The project does not increase flood risk to others (people, property, business)
- The works do not cause environmental harm
- Any proposals are accepted by the community and residents

Buckinghamshire Council will monitor progress on these recommendations through the Buckinghamshire Strategic Flood Committee, but do not have powers to enforce their delivery by others.

## 9.2 Data and evidence

Progress with flood risk management interventions in Buckingham by any RMA is at present limited by a lack of good quality and reliable data and evidence.

The flood risk mapping for the River Great Ouse at Buckingham has limitations. Several attempts to improve the model have been limited by the lack of hydrometric data from river gauges, good quality survey and problems with calibration. The level gauge in Buckingham drowns out in high flows, meaning evidence of the peak water level of the event is not recorded, and maximum flows cannot be estimated with confidence.

It is understood that the Environment Agency have added gauge improvements to the Hydrometry and Telemetry capital programme, and are examining options for raising the level gauge in Buckingham and the best location for installing a new flow gauge.

The Environment Agency are currently commissioning work to rebuild the model based on the December event, and are hoping to include new survey. Improving hydraulic modelling would improve the quality of the flood risk mapping, Flood Warning Areas, Flood Zones for Planning, and give much more information about levels, depths, velocities, hazards and economic damages to set better flood warning triggers and evidence any capital scheme.

In terms of risk from surface water drainage and sewers, further investigation is needed by Anglian Water into the causes of the flooding at March Edge. Sewer manholes have surcharged again since the December 2020 event (during heavy rain on 18 June 2021), when river levels were low, and so the flooding here cannot solely be caused by high river levels at the Riverside pumping station. This should include installing flow monitors at March Edge to understand how the combined and surface water systems are responding to rainfall, and surveying surface water connections from the highway or properties to the combined sewer. The system should be modelled to understand the mechanisms and test potential options to improve the situation. We understand that some progress has been made already with these actions – see Section 9.5 for more information.

Transport for Buckinghamshire have already carried out CCTV survey and further investigation of the condition of the highway drainage network at Hunter St/Nelson St/Tingewick Road junction. This has indicated some damage to a highway drainage pipe,

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<sup>19</sup> For further information regarding funding of flood risk management, please see: <https://www.local.gov.uk/topics/severe-weather/flooding/paying-flood-and-coastal-erosion-risk/funding-arrangements>



which is likely to be restricting the drainage of runoff through the pipe, causing water to back up and surcharge out of the highway gullies near the junction. As of the time of writing (February 2022), Transport for Buckinghamshire have planned further works to determine the remedial works required to repair the pipe. Such works could help to alleviate some of the frequent ponding of surface water that is routinely experienced at this location. However, in extreme events such as December 2020 when river levels are very high, this network will likely still back up due to the outfalls becoming unable to discharge freely when submerged by the water levels. This is an issue common to both other locations across Buckingham and nationwide (see Section 9.5).

**Table 9-1: Recommendations for data and evidence**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Raising the level gauge at Buckingham	Environment Agency	9	Not yet confirmed
Invest further in flood modelling and mapping	Environment Agency	9	Not yet confirmed
Install a flow gauge at Buckingham or upstream	Environment Agency	8	Not yet confirmed
Consider how to capture aerial footage of key locations during a flood event	Environment Agency	8	Not yet confirmed
Install flow monitors on combined and surface water sewer systems at March Edge	Anglian Water	7	In progress
Model the sewer system and undertake further surveys into surface water connections to the combined sewer if appropriate	Anglian Water	7	In progress
Investigation of condition of highway network at Hunter St/Nelson St/Tingewick Road junction	Transport for Buckinghamshire	7	In progress

### 9.2.1 Flood warning information service

As set out in Section 7.3.1, properties in Buckingham had received a Flood Alert, which enabled them to 'Prepare'. The Flood Warning, which should trigger residents to 'Act', was received only after many properties had already flooded. This limited the response capabilities of individual residents and the community.

The Environment Agency regularly review flood warning areas (including trigger levels) as further information, data, modelling is gathered. Validation of flood warning areas is also undertaken after a flood event has occurred to also inform these improvements.

The Environment Agency made immediate improvements to their flood warning triggers for Buckingham the day after the event, setting a new trigger at Buckingham gauge (79.913mAOD) for both the 'Low-lying areas' and 'Wider area at risk' flood warning areas. The new flood warning trigger was based on the river level three hours before the onset of flooding (80.475mAOD) from the December 2020 hydrograph.

This amendment will increase confidence that a warning will be received in time if a similar event were to occur again. In the short-term, it could result in an increase in 'false alarms' for the 'Wider area at risk' flood warning area. The new trigger level will remain in place until further analysis of the property flooding is completed. As of February 2022, we understand that the Environment Agency are currently undertaking this analysis to update the trigger and the area covered by each flood warning. The Buckingham river level gauge will continue to be used to issue flood warnings in the future.

**Table 9-2: Recommendations for flood warning information service**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Verify and implement flood warning area extents and triggers improvements considering the flooding in Buckingham in December 2020	Environment Agency	12	In progress (temporary update complete, full verification complete by winter 2022-23)

### 9.2.2 Multi-agency incident management

The Great Ouse catchment is covered by seven different Local Resilience Forums (LRFs). Buckingham falls on the edge of the Thames Valley LRF, which is extremely large. There can be difficulties caused by different partner organisations' boundaries within TVLRF area, and the uniquely complicated make-up of the LRF across a wide geographic area.

However, the Thames Valley LRF is currently updating its Multi-Agency Flood Plan, following guidance from Defra issued in September 2020, and responders are contributing to this. Once signed off, this will be followed up with TV LRF training and exercising.

Since the event, the Environment Agency have secured funding from the Regional Flood and Coastal Committee to fund positions to work on behalf of all Risk Management Authorities to develop multi-agency planning and response awareness and training. The RFCC has supported the proposal to develop a catchment-wide Flood Response Framework, based on the Multi-Agency Flood Plan guidance and principles, to provide an overarching consistency in response between the different Local Resilience Forums which cover the Great Ouse catchment. This Flood Response Framework will support collaborative training and exercises across the catchment. It is envisaged this will aid communication and engagement with those directly involved in incident response, particularly those working across multiple LRFs, and those indirectly involved to better understand the processes, key contacts and sources of information.

Dynamic virtual incident management is likely to become more common place in the future and it is therefore important that appropriate preparations are made to support this. This may include suitable training and exercising opportunities, enabling office-based Category 1 responders to rehearse their actions, plans and procedures in a virtual setting in a safe environment, and build on the successes and lessons learned of this event.

**Table 9-3: Recommendations for multi-agency incident management**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Develop a catchment-wide Flood Response Framework to ensure	Environment Agency	8	In progress

consistency in response between the different Local Resilience Forums which cover the Great Ouse catchment			
Develop virtual incident management and provide training and exercising preparations for ongoing incident management in an entirely virtual or mixed environment	Thames Valley Local Resilience Forum	7	Not yet started (<2 years)

### 9.3 River and flood defence maintenance

Maintenance of the river and build-up of debris is of concern to local residents. However, given the capacity of the channel through Buckingham, and the large magnitude of the river flows, it is not thought that the visible areas of deposition and debris (e.g. branches, areas of silt build up) would have had a significant impact overall on water levels experienced in the 23 December event.

Wholesale dredging of the channel would not only be difficult because of the weirs in Buckingham, but would also be expensive, environmentally damaging and produce a lot of waste material. In our opinion, based on the information available to us, dredging or desilting would be unlikely to make a significant difference to the overall capacity of the channel and therefore would be unlikely to impact on flows experienced in flood events of the magnitude that occurred in December 2020. Dredging can also increase flood risk for areas downstream by speeding up the movement of flood water through the river and drainage network. Therefore, careful consideration needs to be given to whether any benefits outweigh both the risks and the costs of such work.

We understand that the Environment Agency have commissioned a new channel survey and hydraulic model of the Great Ouse through Buckingham, which they will use to help inform and evidence decisions around maintenance through Buckingham in future, including the effectiveness of maintenance and dredging. In the event that the modelling results indicate meaningful benefits to people or property from desilting or dredging through Buckingham, the Environment Agency can make a bid for funding and undertake works where funding is available.

Notwithstanding the Environment Agency’s forthcoming review of the maintenance regime through Buckingham in light of the above, it is important that any large obstructions or blockages are removed and bridge openings are kept clear of debris (e.g. the smaller arch at London Road Bridge).

The Environment Agency have advised that they undertook inspections of all the main rivers in this catchment following the event, in addition to their regularly scheduled inspections. This included checking the channel for blockages and debris. They have advised us that any reports of blockages and fallen trees in the area underwent a site visit for assessment. Where the Environment Agency deemed action necessary, this was highlighted to the riparian owner, where known. It is beyond the scope of this investigation to provide further detail on individual reports or the actions taken since the flood event – the Environment Agency may be able to provide further detail on request.

Our site visit in May 2021 did identify a number of minor obstructions in the floodplain such as fences, which are likely to be unconsented, where the Environment Agency could consider enforcement action where they deem necessary.

The ownership of the flood embankment at March Edge, Linden Village is currently a matter of discussion between different parties. This is an important flood risk asset which protects March Edge from river flooding, and its ownership should be confirmed, and an appropriate maintenance and inspection plan should be made clearly identifying who is responsible.

In the event that the embankment is determined to be privately owned, the Environment Agency can consider “designating” the structure under Section 30 and Schedule 1 of the Flood and Water Management Act 2010. Designation is a form of legal protection for key structures that are privately owned and maintained and that contribute to the management of flood and coastal erosion risks. Designation would mean that the structure cannot be altered, removed or replaced without careful consideration and consent of the designating authority. The Environment Agency currently inspect this embankment in the wider interest of the community to ensure it meets the correct standard and condition. The Environment Agency undertook a visual inspection of it in March 2021 and reported that it was at target condition with no defects found.

**Table 9-4: Recommendations for river and flood defence maintenance**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Determine the ownership of the March Edge, Linden Village flood embankment, and take appropriate action to ensure there is a maintenance plan in place	Environment Agency, supported by Buckinghamshire Council	13	Not yet started (<1 year)
Review regular inspection and maintenance regime for the River Great Ouse through Buckingham in light of forthcoming results from new channel survey and hydraulic modelling. Should modelling indicate reduction in risk to people and property from enhanced channel conveyance, consider de-silting or dredging through Buckingham. Consider removal of obstructions in floodplain e.g. fences	Environment Agency	10	In progress
Review regular inspection to ensure that bridge openings (particularly London Road Bridge) are kept clear of debris	Transport for Buckinghamshire	10	Not yet started (<1 year)

#### 9.4 Community flood resilience

There is an ongoing review of the Buckingham Flood Plan in progress by Buckingham Town Council. Community events, training and exercising of the new plan will ensure that all stakeholders and residents are aware of it. This could include engagement with residents around the use of PFR. In the longer term, ownership of the Flood Plan by the community itself through the formation of a new community flood group should be encouraged.

At Candleford Court, councillors are taking ongoing action to ensure there is an appropriate Flood Plan in place. This should ensure that residents are informed of the risk and act to protect their cars when a Flood Alert is issued.

**Table 9-5: Recommendations for community flood resilience**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Complete the update of the Community Flood Plan and provide community training	Buckingham Town Council and local	9	In progress



Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
and exercising of the new Community Flood Plan. This could include engagement with residents around the use of PFR.	community – supported by Environment Agency and Buckinghamshire Council		
Ensure there is an appropriate Flood Plan in place for Candleford Court	Buckinghamshire Council	7	In progress
Form a new community flood group to take ownership of the Buckingham Flood Plan	Local community	7	Not yet started (<5 years)

### 9.5 Sewer network resilience

There are a number of locations, particularly March Edge, where there is pressure on the combined and surface water sewer networks, which causes local exceedance of sewer capacity. In several locations the surface water drainage system could not perform effectively as river levels were high and discharge from the surface water system was not possible or severely constrained. This caused surface water to back up through the system and surcharge out of gullies and manholes, or provided a pathway for river water to back up into locations such as Nelson Street/Hunter Street, Stratford Road and Wharfside Place (see Section 8.2 for further information). The pumping stations in the town have resilience measures in place, for example the Town Centre pumping station is raised 1.2m above the level of Cornwall's Meadow car park.

Historically, it has been general practice to design surface water systems with the assumption that drainage systems will drain with a free discharge through outfalls, whether it is a gully into a receiving pipe, or highway drain or sewer draining into a watercourse. However, this assumption is not always appropriate, as highlighted by the numerous instances of outfalls being constrained by water levels in downstream receiving systems or rivers. Drainage design is now changing, but there is a need to further embed a change in practice nationally with clear design guidance and tools.

In the short-term, Anglian Water have been investigating the particular issues at March Edge and Buckingham Riverside Terminal pumping station. They have reported that all telemetry points and controls have been checked and tested and are working as expected. All three pumps were operating and forwarding flows as expected; however, Pump 2 was an older style pump, which has been replaced since December 2020 to match the others. The emergency overflow flap valve from the station has been inspected and the area around the associated screen has been cleared and cleaned. The screen does restrict the operation of the flap valve, so Anglian Water are investigating an adjustment to the screen. Remedial works have also been undertaken to the screen to allow the flap valve to operate more efficiently.

A full CCTV survey has been undertaken of the combined sewer from March Edge to the pump station. This found that there are no structural defects within the sewer to the pump station, nor any build-up of silt, fats, oil or grease. However, it was identified that a gate valve on the sewer in the inlet chamber to the pump station had historically been left in a partially closed position. Anglian Water's operational teams had not been aware of this until this point, and so the gate has not been operated in recent years. Anglian Water have since undertaken initial works on this valve to remove the gate valve to ensure the inlet is fully open. Due to the complexity of this work (the valve is 9m deep and the design of the

manhole chamber creates access issues) and health and safety concerns, this work has been passed to another specialist contractor for completion.

The investigations indicate that the flooding to March Edge was principally from this combined sewer rather than the surface water sewer that also runs past the area. A level monitor has been installed to the combined sewer downstream of March Edge to give an early warning of rising levels in the system and help speed up Anglian Water’s response to flooding there, although their response will depend on conditions at the time. Anglian Water also have implemented a 2-hour response time to resident reports of flooding there, although their response will depend on conditions at the time. Finally, Anglian Water have raised the manholes that overflowed in March Edge to give some additional protection to local properties.

Once Anglian Water’s investigations into the causes of sewer flooding at March Edge are completed, it may be possible to identify some longer-term solutions. For example, if surface water connections to combined sewers are identified as a cause, then there may be the potential to work to reduce the amount of surface water entering the combined sewer by using Sustainable Drainage Systems (SuDS) to reduce the volume and speed of runoff entering the sewerage systems. Other options for March Edge and any other areas at risk may include installing no-leak manhole covers, provided this could be shown not to increase flooding elsewhere.

Preliminary suggestions have been made by the Buckingham Canal Society<sup>7</sup> for a surface water drainage interception scheme to divert surface water from the west side of Linden Village across the development and instead discharge to the east of Linden Village with the aim of helping fill the disused canal whilst reducing pressure on the existing surface water network. Significant further work would be required to assess the feasibility, costs and any benefits of such a scheme, which is beyond the remit of a Section 19 Flood Investigation. The costs of such a scheme could potentially be very high and disproportionate to the actual flood risk benefits, though may have other amenity benefits in providing water to the canal. The proposals would require support from Anglian Water as they would involve significant modifications to Anglian Water’s network.

**Table 9-6: Recommendations for sewer network resilience**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Appraise and implement options to prevent/reduce the occurrence of sewer flooding at March Edge	Anglian Water	12	Not yet started (<2 years)
Use sewer flow monitor alarms to speed up response to flooding at March Edge and red flag 2-hour response time to resident reports of flooding at March Edge	Anglian Water	10	Complete
Complete improvements at Buckingham Riverside pumping station (replacement of pump 2, adjust screen around emergency overflow, remove gate valve on inlet chamber)	Anglian Water	8	Pump 2 replacement complete, works on valve in progress
Consider installing no-leak manholes or raising manholes at locations where river water enters sewer	Anglian Water	8	Complete at March Edge

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
network			
Clear guidance on how to design future drainage networks for submerged conditions to be incorporated into existing design guides (e.g. SuDS Manual, Design Manual for Roads and Bridges, CIRIA guidance notes).	CIRIA and/or relevant design guides	8	Not yet started (>5 years)

### 9.6 Flood risk management schemes

The Environment Agency have recently commenced a study (Flood Storage Options and Flow Conveyance in the Great Ouse Catchment) investigating the technical and economic viability of large scale and strategic flood storage options in the Upper and Middle parts of the Great Ouse river catchment. The study will also look at how to optimise the management of existing flood risk infrastructure, in particular understanding the movement of water and sediment and pinch points within the system. The aim is to produce a programme of projects. Alongside this, the business case and preferred design for a storage scheme upstream of Buckingham should be revisited in the light of the December 2020 flood event.

There are a number of questions around the effectiveness of the PFR scheme, now over 10 years old. Ideally, the effectiveness of the existing scheme should be measured, auditing and summarising the current package of measures at each property, any maintenance issued notes (decaying seals etc.), and any changes to the property since the original installation. This could inform a business case for funding to enhance or replace PFR measures and to raise and maintain the understanding of residents of how and when to deploy, as necessary. Alternatively, consideration could be given to developing a new PFR for Buckingham. This investigation has identified around 30 properties that flooded internally in this event that were not part of the 2010 PFR scheme, which could benefit from a new PFR scheme.

Buckinghamshire Council are carrying out a NFM project in the Upper Great Ouse catchment, which may help reduce flood risk to the town centre from lower intensity and higher frequency flooding. However, it will have limited effectiveness on its own against more extreme floods. The outcomes of this project should be measured and feasibility of the continuation or expansions of NFM interventions considered.

Retrofitting of SuDS in highways and public open space in specific local catchments draining to surface water hotspots like March Edge, Stratford Road and Wharfside Place, Mitre Street and Gawcott Road and Moreton Road, would be desirable, as they would help to slow down surface water flow routes and remove surface water from highway drainage.

Unfortunately, due to the relatively low numbers of properties at risk from this source of flooding and relatively high costs and a lack of open space, such measures alone would be difficult to fund through the current Defra funding approach for flood risk schemes.

However, they could be considered alongside any other future highways works or public space improvements in these areas.

**Table 9-7: Recommendations for flood risk management schemes**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
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<p>Appraise a suite of capital options for flood risk management in Buckingham. To include: Revisiting the viability for flood storage upstream of Buckingham, informed by the current study, "Flood Storage Options and Flow Conveyance in the Great Ouse Catchment". Consideration of the viability of a new PFR scheme to augment existing scheme. (This could be informed by an study into the effectiveness of the existing PFR measures).</p>	<p>Environment Agency, working in partnership with BC, Anglian Water, Town Council.</p>	<p>15</p>	<p>Not yet started (&lt;5 years)</p>
<p>Measure success of Upper Great Ouse NFM project and consider feasibility of further NFM interventions</p>	<p>Buckinghamshire Council</p>	<p>14</p>	<p>Not yet started (&lt;5 years)</p>

### 9.7 Planning and development control

The National Planning Policy Framework and associated guidance, and the consultee roles of the Environment Agency and LLFA on flood risk and surface water drainage (see section 5.3.7) are intended to minimise the impact of new development on flood risk. The National Planning Policy Framework (NPPF) requires that developers must demonstrate that new developments will regulate surface water release to downstream drainage systems or watercourses to the estimated greenfield (or pre-development) condition. This is now standard practice at the planning stage.

Once new developments are under construction or completed, the overall responsibility for ensuring that flood mitigation and surface water drainage systems are built in accordance with the agreed plans lies with the Local Planning Authority. It is beyond the scope of this investigation to comment in detail on the effectiveness of national planning policy regarding flood risk management. However, it is worth noting that Schedule 3 of the Flood and Water Management Act (2010) proposed the establishment of "SuDS Approving Bodies" (SABs) within each Lead Local Flood Authority (such as Buckinghamshire Council) to inspect, adopt and maintain approved new sustainable drainage systems that serve more than one property. Whilst the majority of the Act was implemented, central government decided in 2014 that Schedule 3 would not be enacted in England (although it was enacted in Wales in 2019). Instead, the government made amendments to the NPPF to stipulate that major planning applications (i.e. those of ten dwellings or more) would include SuDS, unless demonstrated to be inappropriate. However, there remains no provision within national policy for a specific function for monitoring their uptake or effectiveness, nor for any routine inspection to ensure that SuDS are installed and maintained correctly. Maintenance is currently typically reliant on private management companies.

It would be preferable for a system to be introduced at a national level, backed by legislation, to allow verification that schemes are built as designed and to ensure that they are appropriately maintained.

With regard to the impact of recent development on flood risk in Buckingham, it is outside the scope of this investigation to revisit the fluvial flood risk assessments and surface water drainage proposals for approved developments. Furthermore, it is not within the remit of the LLFA to inspect or assess the as-built drainage systems of built developments, as noted



above. However, we are not aware of any specific cases where recent development has led to the internal flooding of properties. Each approved planning application in the Buckingham area that the LLFA was consulted on since beginning its statutory consultee role in 2015 has met the requirements of the National Planning Policy Framework at the time.

We are aware that there is some concern locally around whether development in and around Buckingham could have exacerbated flood flows on the Great Ouse. We therefore attempt to provide some commentary on this, as follows. As noted in Section 8.1, flooding in Buckingham was predominately driven by exceptional flows in the main river as a result of exceptional rainfall falling on its largely rural and already saturated catchment. Only 5% of the 143km<sup>2</sup> catchment area upstream of Buckingham is built on, with Buckingham itself being the main urban area. Analysis by JBA using UK industry-standard flood estimation techniques suggests that even if the area of Buckingham were to increase by 50%, and even without any control of surface water release (as should be the case with modern developments), there would be little impact on peak flows in the Great Ouse through Buckingham in a flood with a 1 in 100 chance of occurring in any given year: we suggest such a worse-case scenario would result an increase of just 0.05% in peak flows on the river through Buckingham. Further detail is given in Appendix A.

However, it is nonetheless critical that flood risk continues to be considered effectively within the planning process, in order to manage flood risk at both the wider scale and local level. The planning system should ensure that new development manages surface water run-off through the design, effective implementation, and maintenance, of SuDS schemes, in order to mitigate the impact of any increase in surface water runoff. As mentioned above, we recommend that nationally, legislation is modified to provide for a system to verify that sustainable drainage schemes are built as designed and maintained appropriately.

**Table 9-8: Recommendations for planning and development control**

Recommendation	Organisation(s) responsible	Multi-criteria analysis score	Timescale
Allocate roles and resource for inspection and sign off of surface water drainage/SuDS systems in new developments, backed with national legislation/policy	UK Government	8	Not yet started (<10 years)

## 10 Conclusion

The flooding that occurred on 23 December 2020 internally impacted at least 72 properties in Buckingham, including at least 11 commercial properties. Buckinghamshire Council, as the Lead Local Flood Authority for Buckingham, has exercised its power to undertake a Section 19 investigation as this fulfilled its criteria of 'significant flooding' (Section 1.1).

The predominant source of the flooding was due to the very high flood levels and flows on the Great Ouse, caused by an exceptional combination of unusually heavy, prolonged rainfall falling on the already saturated catchment. The flooding was further exacerbated by extreme rainfall generating surface water runoff locally. There were also reports of elevated groundwater levels in the gravel deposits near to the Great Ouse (Section 8.1)

The channel capacity of the Great Ouse was exceeded, and flood water spilled out of bank and spread across the floodplain, first occurring at Chris Nichols Walk and Bourton Park. Impermeable surfaces, such as roads and pavements, also became pathways for surface water to runoff, and the surface water drainage system became overwhelmed, which also contributed to the flooding. The foul and combined sewer system also became overloaded due to the high river levels, backing up from outflows to the river, and by river water entering through manholes, causing surcharging and foul sewage flooding (Section 8.2). At least 72 properties were flooded internally, and flood water caused damage to possessions, commercial stock, buildings and vehicles. It also caused stress and mental health impacts to those affected (Section 8.3).

A Flood Warning was issued for Buckingham only after many properties had already flooded (Section 7.3). This limited the response capabilities of individual residents and the community as the trigger to "act" was too late. The Environment Agency made immediate improvements to their flood warning triggers for Buckingham the day after the event, which will increase confidence that a warning will be received in time if a similar event were reoccur (Section 9.2.1). The amendment will remain in place until further analysis of the property flooding is completed, when the trigger and the area covered by each flood warning will be updated.

Multiple organisations responded to the event (Section 7), following their own operating instructions. Buckinghamshire Council implemented their Incident Management Process (IMP) and staff from these teams were deployed across the County to aid and support the local community. Transport for Buckinghamshire managed a large number of road closures across Buckingham and issued sandbags to those in greatest need. Anglian Water staff managed the operation of the sewer network, visited locations where flooding from surface water and foul sewage was experienced, and provided advice to residents. The University of Buckingham managed flooding at the University buildings, offered emergency accommodation to students, and set up a £20,000 fund for local residents who had been flooded. Members of the community also stepped in to help those impacted using pumps and buckets to help protect properties from advancing floodwaters. Volunteers ran the Community Centre which was open for food, drinks and rest.

Analysis of the rainfall and river levels recorded during the event (Section 0) indicates that one month's worth of rain fell in the period of December up until the event on the 23 December. The total rainfall during the 23 December storm event had a 15% chance of occurring in any one year (return period of 5-9 years). This is not especially extreme, but given that the soils were already saturated from the high rainfall over the previous months, the catchment was especially sensitive to heavy rainfall.

Due to the lack of flow gauging, estimates on the return period of flows for the Great Ouse at Buckingham are very uncertain. Based on analysis of previous studies and events, as well as analysis within this study, the estimated probability of the 23 December 2020 flood event at Buckingham occurring in any given year is between 3.33 and 1% (30 and 100 years return period) and it is likely that it was of a similar magnitude to the April 1998 event and July 2007 flood events.

A high-level appraisal of possible flood risk management options has been undertaken (Section 9), which includes consideration of measures such as improvements to data collection and evidence; flood warning and incident management; community, property and infrastructure flood resilience; maintenance and minor works; asset maintenance and refurbishment and flood risk management capital scheme options. This assessment helped to shape our recommendations.

Doing nothing was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Buckingham. The options which scored the highest were those that could ultimately result in a scheme to reduce flood risk to people and property:

- Appraise a suite of capital options for flood risk management in Buckingham, including revisiting the viability for flood storage upstream of Buckingham and considering the viability of further Property Flood Resilience measures (Environment Agency) (Rank 1)
- Measure success of Upper Great Ouse NFM project and consider feasibility of further NFM interventions (Buckinghamshire Council) (Rank 2)
- Appraise and implement options to prevent/reduce the occurrence of sewer flooding at March Edge (Anglian Water) (Rank 3)

The timescales involved for the appraisal of capital schemes are likely to be several years, and more work is needed to determine benefit-cost and funding routes. It should be noted that several of the options identified would require further investigation and feasibility studies by a particular authority, such as Transport for Buckinghamshire, the Environment Agency and Anglian Water. The outcomes of these investigations may result in a more beneficial solution being identified.

As the impact of flooding experienced by people in Buckingham was strongly linked to advanced warning, preparedness for flooding, and the effectiveness of the response, there are a number of actions around data and evidence, community preparedness which are also key priorities. Many of these are relatively quick-wins and have already been significantly progressed by the relevant authority since the event. The highest ranked options and recommendations are summarised here:

- Verify and implement flood warning area extents and triggers improvements considering the flooding in Buckingham in December 2020 (Environment Agency, temporary update complete, full verification in progress, due to be completed by winter 2022/23)
- Use sewer flow monitor alarms to speed up response to flooding at March Edge, Red flag 2-hour response time to resident reports of flooding at March Edge (Anglian Water, complete)
- Complete the update of the Community Flood Plan and publish and provide community training and exercising of the new Community Flood Plan (in progress) (Buckingham Town Council, in progress)
- Raising/relocating level gauge at Buckingham (Environment Agency, planned)
- Invest in further flood modelling and mapping for the River Great Ouse at Buckingham (Environment Agency, planned)
- Develop a catchment-wide Flood Response Framework to ensure consistency in response between the different Local Resilience Forums which cover the Great Ouse catchment (Environment Agency, planned)
- Determine the ownership of the March Edge, Linden Village flood embankment, and take appropriate action to ensure there is a maintenance plan in place (Environment Agency, supported by Buckinghamshire Council)

A number of other minor recommendations are also made in Section 9.

**A Appendices**  
**FEH calculation record**



## B Multi-Criteria Analysis

We have considered potential options to mitigate flood risk and reduce damages caused by flooding.

This includes consideration of measures such as improvements to data collection and evidence; flood warning and incident management; community, property and infrastructure flood resilience; maintenance and minor works; asset maintenance and refurbishment and flood risk management capital scheme options.

We undertook a high-level option appraisal focussing on benefit, practical and viability considerations. We carried out a multi-criteria analysis to compare each option which included consideration of:

- Contribution towards reducing flood risk to property
- Contribution towards reducing flood impacts on people/communities
- Contribution to improving the availability of data, evidence and modelling to support option development or flood incident response
- Deliverability (including construction complexity, access, designations, services, space, land ownership, available materials and expert equipment or advice required)
- Community / resident acceptability
- Contribution towards biodiversity and water quality betterment
- Contribution towards amenity benefits
- Contribution to carbon reduction
- Maintenance requirements

Relative costs and timescales are provided for information only and are not included in the scoring.

The scoring criteria and full results are shown below. Options with a score of 7 or above were taken forward to become recommendations.

### Multi-criteria analysis scoring criteria

Flood risk benefit to property	Likely change in internal flood risk to property	
	-2	Increase in flood risk to any property
	-1	N/A
	0	No perceived change
	1	Reduction in flood risk to 1 - 10 properties
	2	Reduction in flood risk to 10 - 30 properties
	3	Reduction in flood risk to 30 - 70 properties
	4	Reduction in flood risk to 70-100 properties
5	Reduction in flood risk to >100 properties	
Flood risk benefit to people	Likely change in flood impacts on people/communities. Encompassing community preparedness and resilience; stress, health, mental health impacts; nuisance flooding (gardens, roads etc); disruption to access and egress; vehicle damages; risk to life and evacuation costs.	
	-2	Major negative change in flood impacts on people/communities

	-1	Minor negative change in flood impacts on people/communities
	0	No perceived change
	1	Minimal positive change in flood impacts on people/communities (e.g. reduction in nuisance flooding)
	2	Minor positive change in flood impacts on people/communities (e.g. reduction in disruption to toilet use)
	3	Minor positive change in flood impacts on people/communities (e.g. improvements to access and egress)
	4	Medium positive change in flood impacts on people/communities (e.g. increasing community flood preparedness and ability to act)
	5	Major positive change in flood impacts on people/communities (e.g. reduction of risk to life and evacuation costs)
Contribute to improving the availability of data, evidence and modelling to support option development or flood incident response	This criterion focusses on the benefits of further data collection and evidence studies to support option development	
	0	Does not improve the availability of data, evidence and modelling
	1	
	2	Will provide additional data, evidence or modelling, helpful in development of interventions
	3	
	4	
	5	Improvement to data, evidence and modelling which is essential to the development of a capital scheme
Deliverability	Likely deliverability of the intervention considering construction complexity, access, designations, services, space, land ownership, available materials and expert equipment or advice required.	
	-2	Deliverability is at high risk of complexity/constraints
	0	Not known/not applicable
	-1	
	0	Not known/not applicable
	2	Deliverability is at low risk of complexity/constraints

Community / resident acceptability	Community buy in or perceived residents' opinion.	
	-2	Community/residents are likely to have objections
	-1	Community/residents may not be receptive
	0	No known objections / constraints
	1	Community/residents are likely to be receptive but may have some constraints
	2	Community/residents are likely to be receptive and have no constraints
Contribute towards biodiversity and water quality betterment	Potential for the intervention to provide creation of habitats and river restoration, as well as improving existing water quality.	
	-2	Significant detriment
	-1	Some detriment
	0	No perceived change
	1	Some betterment
	2	Significant betterment
Contribute towards amenity benefits	Potential for the intervention to improve the amenity value of the surrounding area.	
	-2	Significant detriment
	-1	Some detriment
	0	No perceived change
	1	Some betterment
	2	Significant betterment
Contribute to carbon reduction	Potential for the intervention to contribute towards carbon reduction via sustainable construction techniques or carbon sequestration from increased planting.	
	-2	Significant net carbon increase
	-1	Some net carbon increase
	0	Not known/no effect
	1	Some net carbon reduction
	2	Significant net carbon reduction
Maintenance	High level assessment of maintenance requirements.	
	-2	N/A
	-1	High cost/frequency maintenance, requires new and specialised maintenance routines
	0	Not known/no effect

	1	Low-cost maintenance, can be completed as part of existing maintenance routines
	2	No active maintenance required (passive maintenance designed)
Timescale	1	Long term strategic aim (>10yrs to progress, funding route unclear)
	2	
	3	Likely to be able to progress in next 1 - 5 yrs. e.g. through FCERM partnership funding programme
	4	
	5	Quick win (<1yr), BC able to fund directly
Cost	High level assessment of cost of implementing	
	1	£>2m
	2	£1m to 2m
	3	£500k-£1m
	4	£100-500k
	5	<£100k



**Buckinghamshire Section 19 Investigations**  
Multi-Criteria Appraisal Matrix

Reference	Opportunities	Lead RMA	1 Flood risk benefit to property	2 Flood impact on people	3 Data and evidence	4 Deliverability	5 Community/resident acceptability	6 Biodiversity and water quality betterment	7 Amenity benefits	8 Carbon reduction	9 Maintenance costs	10 Timescale	11 Cost (for information only)	TOTAL
1	Do nothing	N/A	-2	-2	0	0	-2	0	0	0	2	0	5	-4
2	Business as usual	All	0	0	0	0	-2	0	0	0	0	0	5	-2

Data and evidence														
3	Raising/relocating level gauge at Buckingham	Environment Agency	0	0	5	1	2	0	0	0	1	4	5	9
4	Install ultrasonic flow gauge at Buckingham or upstream	Environment Agency	0	0	5	0	2	0	0	0	1	4	5	8
5	Invest in further flood modelling and mapping for the River Great Ouse at Buckingham	Environment Agency	0	0	5	2	2	0	0	0	0	4	5	9
6	Consider how to capture aerial footage of key locations during a flood event	Environment Agency	0	0	5	1	2	0	0	0	0	4	5	8
7	Install flow monitors around sewer flooding locations, particularly March Edge (in progress)	Anglian Water	0	0	3	2	2	0	0	0	0	4	5	7
8	Further investigations into sewer network problems, e.g. CCTV, impermeable area survey, sewer modelling study	Anglian Water	0	0	3	2	2	0	0	0	0	4	5	7
9	Investigation of condition of highway network at Hunter St/Nelson St/Tingewick Road junction	Transport for Buckinghamshire	0	0	3	2	2	0	0	0	0	5	5	7

Flood warning and incident management														
10	Verify and implement flood warning area extents and triggers improvements considering the flooding in Buckingham in December 2020	Environment Agency	0	4	4	2	2	0	0	0	0	5	5	12
11	Develop virtual incident management etiquette and provide training	Thames Valley Local Resilience Forum	0	1	2	2	2	0	0	0	0	4	5	7
12	Provision of Critical Incident Stress training and support.	Environment Agency	0	1	0	2	2	0	0	0	0	4	5	5



Reference	Opportunities	Lead RMA	Flood risk benefit to property	Flood impact on people	Data and evidence	Deliverability	Community/ resident acceptability	Biodiversity and water quality betterment	Amenity benefits	Carbon reduction	Maintenance costs	Timescale	Cost (for information only)	TOTAL
<b>Maintenance and minor works</b>														
22	Determine the ownership of the March Edge, Linden Village flood embankment, and take appropriate action to ensure there is a maintenance plan in place	Environment Agency, supported by Buckinghamshire Council	0	0	4	2	2	0	0	0	0	5	5	8
23	Review regular inspection and maintenance regime for the River Great Ouse through Buckingham, consider enhanced maintenance channel conveyance, removal of unconsented obstructions in floodplain e.g. fences	Environment Agency	1	2	1	2	2	0	0	0	-1	5	5	7
24	Review regular inspection to ensure that bridge openings (particularly London Road Bridge) are kept clear of debris	Transport for Buckinghamshire	1	2	1	2	2	0	0	0	-1	5	5	7
<b>Capital schemes</b>														
21	Appraise feasibility of retrofit SuDS/surface water disconnection in catchments draining to surface water hotspots e.g. Wharfside Place, March Edge, Stratford Road	Buckinghamshire Council	1	2	2	-2	0	2	1	0	0	1	3	6
22	Appraise feasibility of Buckinghamshire Canal Society's proposed surface water drainage interception scheme	Buckinghamshire Canal Society	1	1	2	-2	2	1	1	0	0	3	3	6
23	Appraise a suite of capital options for flood risk management in Buckingham. To include: Revisiting the viability for flood storage upstream of Buckingham, informed by the current study, "Flood Storage Options and Flow Conveyance in the Great Ouse Catchment". Consider the viability of a new PFR scheme to augment existing scheme	Environment Agency	5	5	3	-1	2	2	1	-1	-1	3	4	15
24	Measure success of Upper Great Ouse NFM project and consider feasibility of further NFM interventions	Buckinghamshire Council	1	2	3	1	2	2	1	1	1	3	3	14
<b>Planning system</b>														
25	Allocate a role and resource for inspection and sign off of surface water drainage/SuDS systems in new developments, to be enforced through the LPA	UK Government	0	0	4	0	2	1	1	0	0	2	5	8

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