Gawcott Section 19 Flood Investigation

Final Technical Report

April 2022

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Buckinghamshire Council

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Revision History

Revision Ref/Date	Amendments	Issued to
S3-1 December 2021	Draft Report	Andrew Waugh
S3-2/S3-3 February 2022	Draft Report for stakeholders	Andrew Waugh
S4-1/A1-1 April 2022	Final Report	Andrew Waugh

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. Peter Rook, Emily Jones and Lisa Chatterjee of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

We would like to thank Buckinghamshire Council, the Environment Agency, Anglian Water, the River Thame Conservation Trust and Gawcott with Lenborough Parish Council for their input and support. We would also like to thank the wider community for their engagement with the investigation.

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Executive summary

Background

Following flooding in Gawcott on 23 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[1]. It is a statutory requirement for LLFAs to investigate flooding to the extent that it considers it necessary or appropriate.

Gawcott is a village located in the north of Buckinghamshire. It is situated approximately 1.5km south-west of Buckingham.

The flooding that occurred in Gawcott on 23 December 2020 caused internal flooding to at least 14 properties in Gawcott and fulfils one of the criteria for a Section 19 investigation (internal flooding to five or more residential properties within an area of 1km^2). 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 local stakeholders in Gawcott, including residents, community representatives and other Risk Management Authorities.

The objectives of engagement are to:

- Gather facts, opinions and data to aid the understanding of the investigation
- Enable the involvement and buy-in of the community in the investigation
- Disseminate the findings of the investigation to the community

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 Gawcott. Section 4 summarises the existing long-term flood risk information on flood risk from rivers, surface water and groundwater. Flooding has previously occurred in Gawcott, with records of flooding between 2002 and 2016. Two events (2007 and 2016) were noted to be similar to the 23 December 2020 event although less severe.

For more information see Sections 3 and 4.

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.

Hydrological analysis of 23 December event

The total rainfall during the 23 December storm event had a 14% chance of occurring in any one year (return period of 7 years). This is not especially extreme but given

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

that the soils were already completely saturated from the notably high rainfall over preceding months, the catchment was very sensitive to heavy rainfall.

For more information see Section 6 and Appendix A.

Incident response

A number of authorities including Buckinghamshire Fire and Rescue Service and Transport for Buckinghamshire responded to the flooding in Gawcott and provided assistance to affected residents. Information from the relevant authorities detailing their response to the flooding has been collected as part of the investigation and a timeline of the incident response has been determined.

For more information see Section 7.

Source-pathway-receptor analysis

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

- Sources – extreme rainfall, ordinary watercourse
- Pathways –overland flow, culverted watercourse, surface water drainage
- Receptors – internal flooding of 14 residential properties, resident displacement, loss of possessions, negative mental and physical health impacts.

For more information see Section 8.

Hydraulic modelling

A surface water model was developed, in InfoWorks ICM, to better understand the flood risk of Gawcott. Full details on the model development and results are in the Modelling Technical Note.

For more information see Section 9 and Appendix B.

Condition assessment

The condition of the culverted watercourse running through Gawcott was reviewed based on information provided in the CCTV survey. Both structural defects and service/operational condition were taken into consideration.

For more information see Section 10.

Discussion, appraisal and recommendations

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

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 a range of different factors, for example the potential contribution towards reducing flood risk to property, people and communities.

For more information see Section 11 and Appendix C.

Conclusion

A series of recommended actions for the Risk Management Authorities and stakeholder organisations are presented below.

For more information on options, recommendations and conclusions see Section 12.

Recommended actions	Risk Management Authority/Stakeholder
Short-term targeted repairs to culvert	Buckinghamshire Council (TfB)
Form a Flood Action Group	Community / Gawcott with Lenborough Parish Council
Create a community flood action plan and formalise any existing arrangements	Community / Gawcott with Lenborough Parish Council
Prepare a "flood preparedness" information pack for current and future residents	Community / Gawcott with Lenborough Parish Council
Investigate opportunities for installing PFR	Property owners or community scheme
Appraise the feasibility of culvert improvement options, upstream attenuation and NFM	Buckinghamshire Council (LLFA)
Consider increasing the frequency of gully cleansing	Buckinghamshire Council (TfB)
Continue with agreed maintenance regime of downstream ordinary watercourse and ponds	Riparian owners
Take opportunities to disconnect or slow down roof water drainage	Property owners
Investigate foul misconnections between domestic properties into surface water culvert	Anglian Water
Consider increasing / improving highway drainage	Buckinghamshire Council (TfB)

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Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGS	British Geological Society
BC	Buckinghamshire Council
CCTV	Closed Circuit Television
DTM	Digital Terrain Model

EA	Environment Agency
FEH	Flood Estimation Handbook
GIS	Geographic Information Systems
JBA	Jeremy Benn Associates
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
PFR	Property Flood Resilience
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water (Environment Agency mapping)
TfB	Transport for Buckinghamshire

Definitions

Culvert	Where a watercourse flows through a pipe, often underground.
Non-return 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 grated, located at the edge of a road. Drains rainwater from the road into the sewerage system.
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)
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.
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 by 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.

1 Introduction

1.1 Background to investigation

Following flooding in Gawcott on 23 and 24 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[2].

It is a statutory requirement for LLFAs 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[3].

- Internal flooding (including to basements) to five or more residential properties within an area of 1km^2;
- Internal flooding of two or more business premises within an area of 1km^2;
- 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 should be assessed at the next strategic flood management group for consideration.

The flooding that occurred in Gawcott caused internal flooding to at least seven properties in Gawcott 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.

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

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

The intention is instead to provide a clear understanding of the issues, since this is the first step towards being able to help address a flooding problem.

Given that the scope of the investigations is limited to developing a preliminary high-level screening of options, the reports should not be viewed as an action plan nor strategy that will set out definitive flood management actions that will be taken. Instead, the report recommends that over the long term, Buckinghamshire Council and its partners undertake further appraisals into the feasibility and financial viability of several of the options identified. However, it also makes several recommendations that may be actioned in the short to medium term.

It will be for the relevant responsible body to assess these recommendations in terms of their legal obligation, resource implications, priority and the costs and benefits of undertaking such options. It is therefore important for stakeholders to view the Section 19 Flood Investigation report as a first step in a process, rather than a final solution.

1.3 Site location

Gawcott is a village located in the north of Buckinghamshire. It is situated approximately 1.5km south-west of Buckingham. The village is mostly surrounded by agricultural land with other small villages, such as Tingewick and Preston Bissett nearby.

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 Gawcott 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;
- Historic flooding datasets;
- Rainfall data;
- Residents' questionnaires
- Asset datasets – for example, the Anglian Water sewer network and Transport for Buckinghamshire's highway drainage system;
- CCTV survey undertaken by Anglian Water in January 2021, and by Buckinghamshire Council in July 2021;
- Other data such as photos, newspaper articles and notes from the event.

2 Stakeholder engagement

We engaged with multiple local stakeholders in each location, including residents, community representatives, landowners, other Council departments, Council Members and RMA partners.

The objectives of engagement are to:

- Gather facts, opinions and data to aid the understanding of the investigation
- Enable the involvement and buy-in of the community in the investigation
- Disseminate the findings of the investigation to the community

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

Table 2-1: Key stakeholders

Role	Organisation	How to engage	Type of engagement
Parish/Town Council	Gawcott with Lenborough Parish Council	Consult	Invitation to contribute, site visit, online survey distribution, correspondence, public engagement meeting
Riparian landowner	Landowners of the duck ponds	Consult	Invitation to contribute, possible site visit
NFM coordinator	River Thame Conservation Trust	Consult	Invitation to contribute, possible meet on site
WASC	Anglian Water	Involve	Invitation to contribute, correspondence, data provision
Council Members	Buckinghamshire Council	Consult	All - Invitation to contribute. Buckingham - invitation to attend site visit
Residents	N/A	Consult	Site visit, online questionnaire, correspondence

3 Catchment characteristics

3.1 Drainage system and river network

3.1.1 Watercourses

Two unnamed ordinary watercourses flow towards the village in a westerly direction, as shown in Figure 3-1 (one flows between Buckingham Road and Radclive Road, and the other flows alongside Hillesden Road). These two watercourses are each culverted as they enter the village, and then converge into a single, main culvert near the junction of Main Street with Radclive Road. This main culvert flows below or alongside Main Street, before entering an open channel near Preston Road. The watercourse passes through a series of small ponds before continuing to flow west and north where it ultimately discharges to the River Great Ouse approximately 1.9km north of Gawcott.

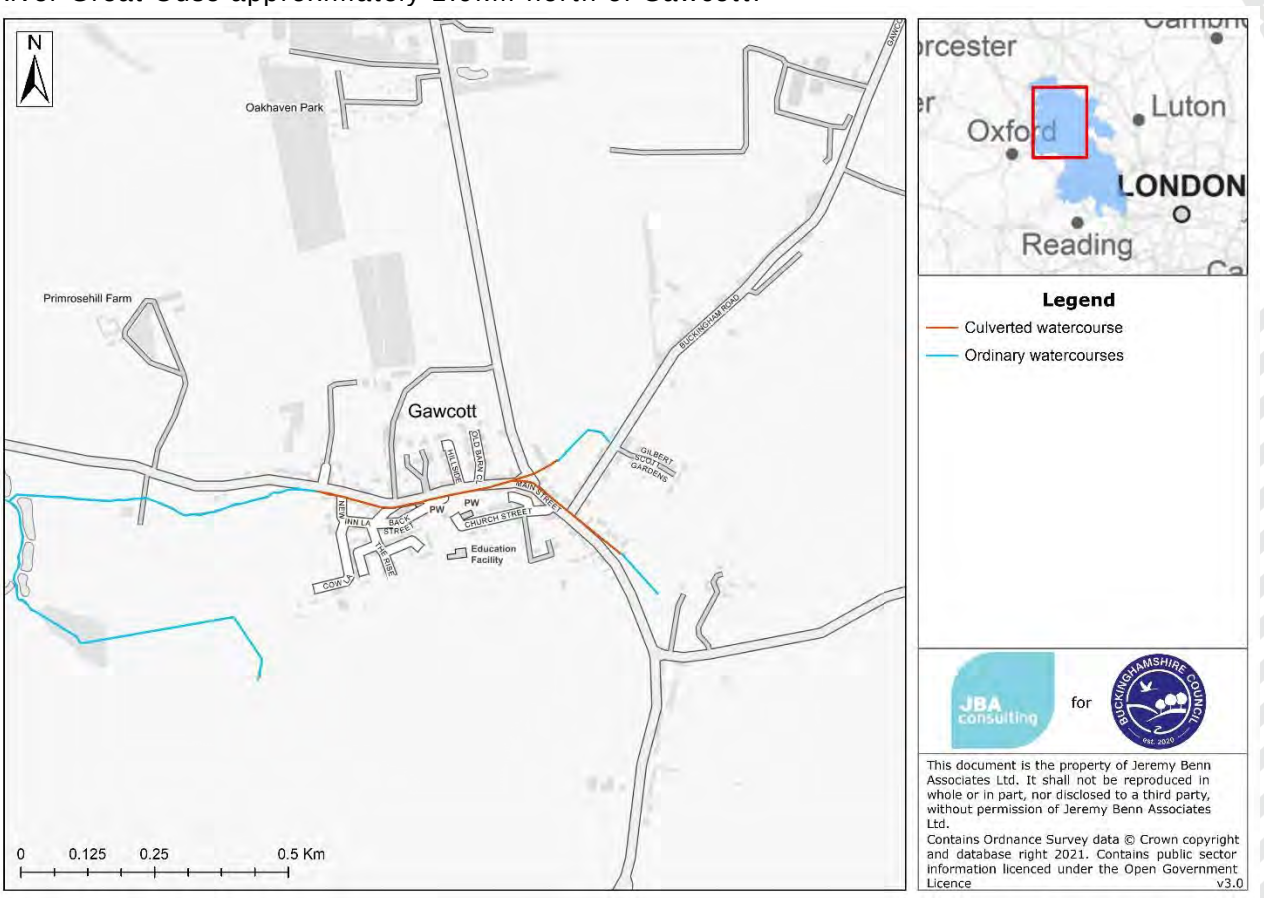

Figure 3-1: Watercourses in Gawcott and the surrounding area

3.1.2 Sewers

The sewer network data, shown in Figure 3-2, was provided by Anglian Water. Throughout the village, the data shows mostly only combined and foul systems, with small sections of surface water pipes in the newer developments at Gilbert Gardens and Guildford Close. There is a combined sewer running along Main Street, which flows into a pumping station west of the village. This pumping station also receives flow from Tingewick to the north-west. It is then pumped towards Buckingham along the line to the south of the village. The data shows that there is an emergency overflow from the pumping station to the ordinary watercourse.

There are also the two upstream culverts and the single main culvert under Main Street (as described in Section 3.1.1 above), which convey water from the natural open ordinary

watercourses upstream, as well as some highway and surface water drainage. However, these pipes are not recorded as Anglian Water assets and are not recognised as part of the public sewer system. It appears likely that the culverting is following the route of former open watercourses, which were presumably culverted historically as the village developed. Therefore, the maintenance of these culverted watercourses is likely to legally rest with the riparian landowners. Since the culverting appears to flow under the public highway for significant lengths, Buckinghamshire Council as the Highways Authority are a principal riparian owner.

From the data available, it is assumed that the private surface water runoff from properties is discharged into either the combined sewer or the surface water culvert.

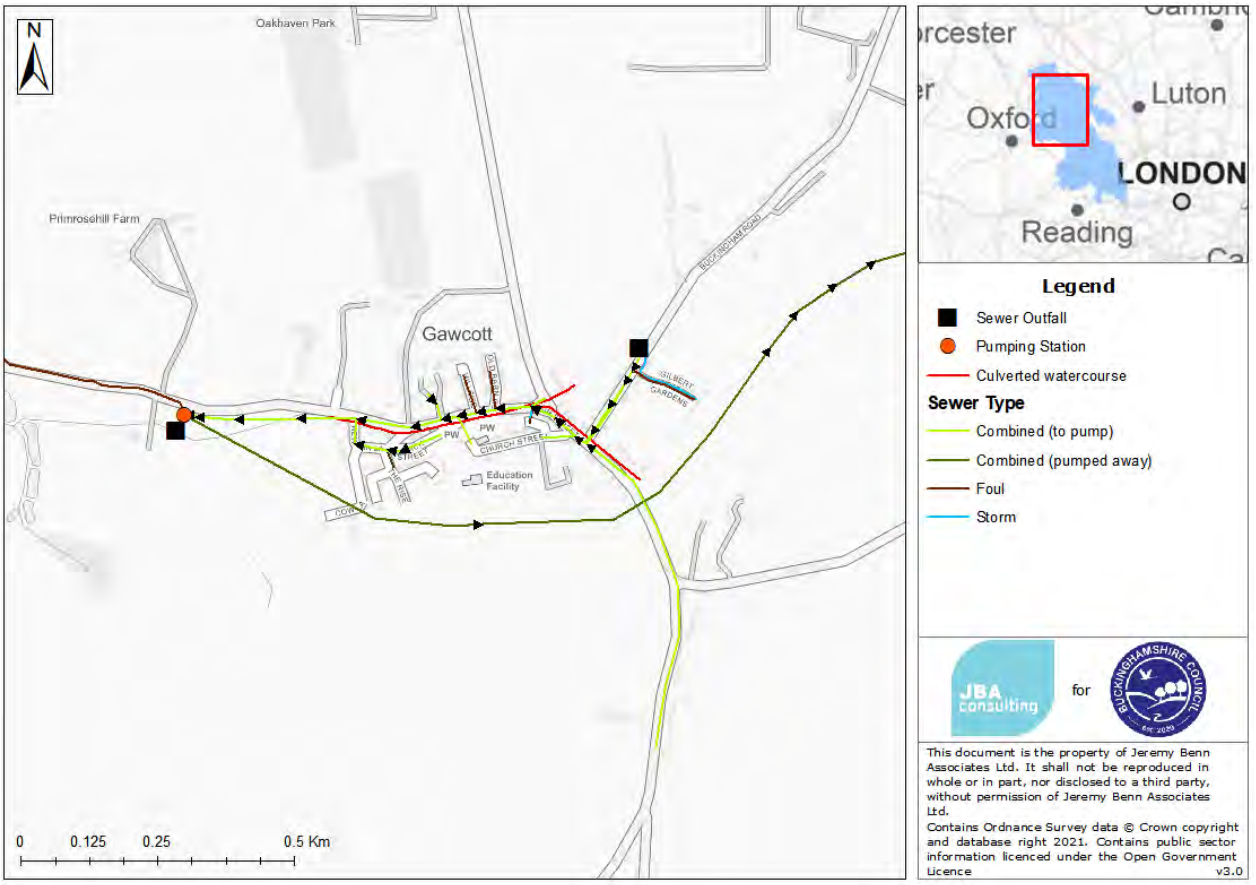

Figure 3-2: Anglian Water sewer network in Gawcott

3.1.3 Highway drainage

Highway drainage data has been provided by Transport for Buckinghamshire. Figure 3-3 shows that, within the village itself, there are many highway gullies. The data made available to us prior to this investigation does not show where these gullies connect to. However, as part of this investigation, Buckinghamshire Council commissioned a survey of the culverted watercourses and highway drainage system. The results of this survey indicate that the highway gullies drain into the culverted watercourses, rather than the combined sewer.

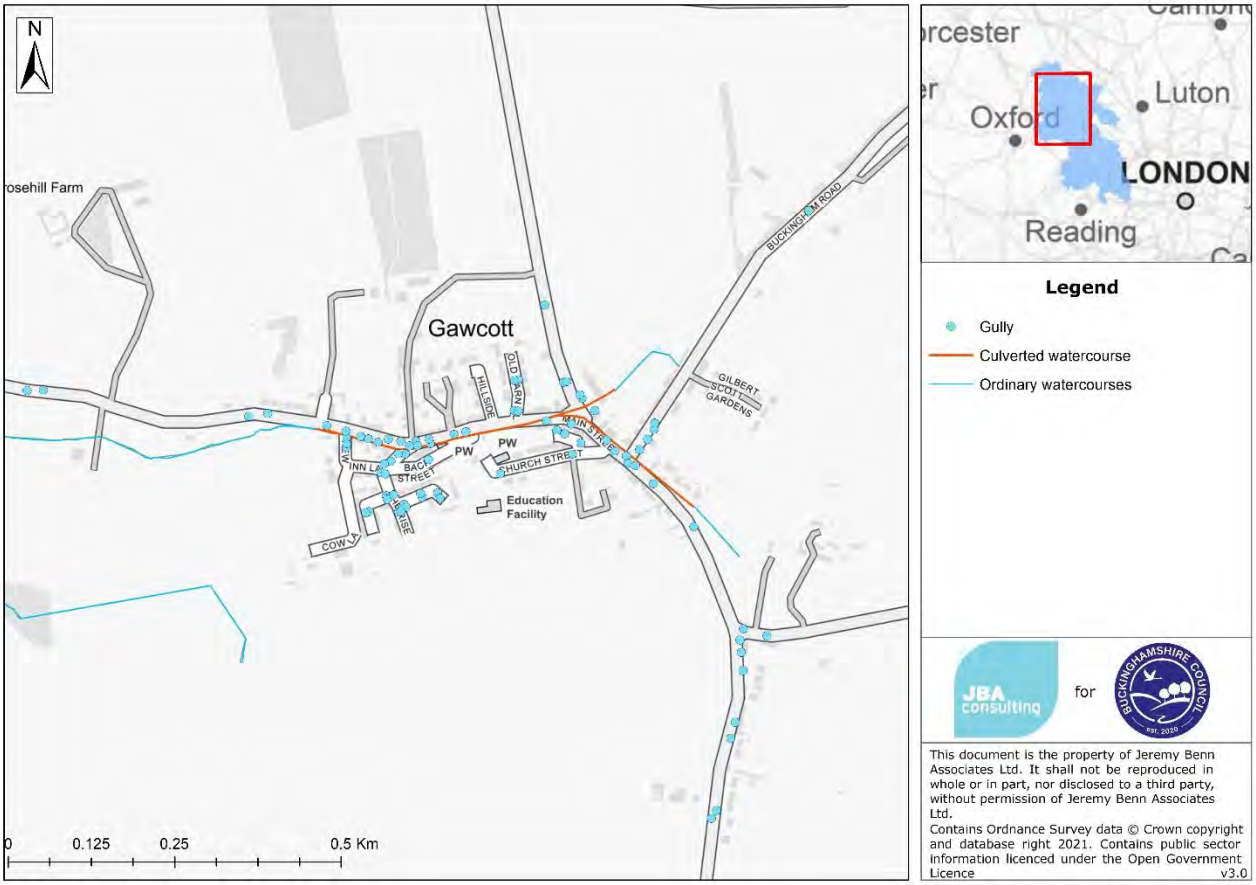

Figure 3-3: Highway drainage system in Gawcott

3.2 Catchment characteristics

3.2.1 Topography

Gawcott is situated in a small headwater valley, shown in Figure 3-4. The highest elevations are found in the east, near Gilbert Gardens, at approximately 113 mAOD. The elevation decreases by around 10m through the village.

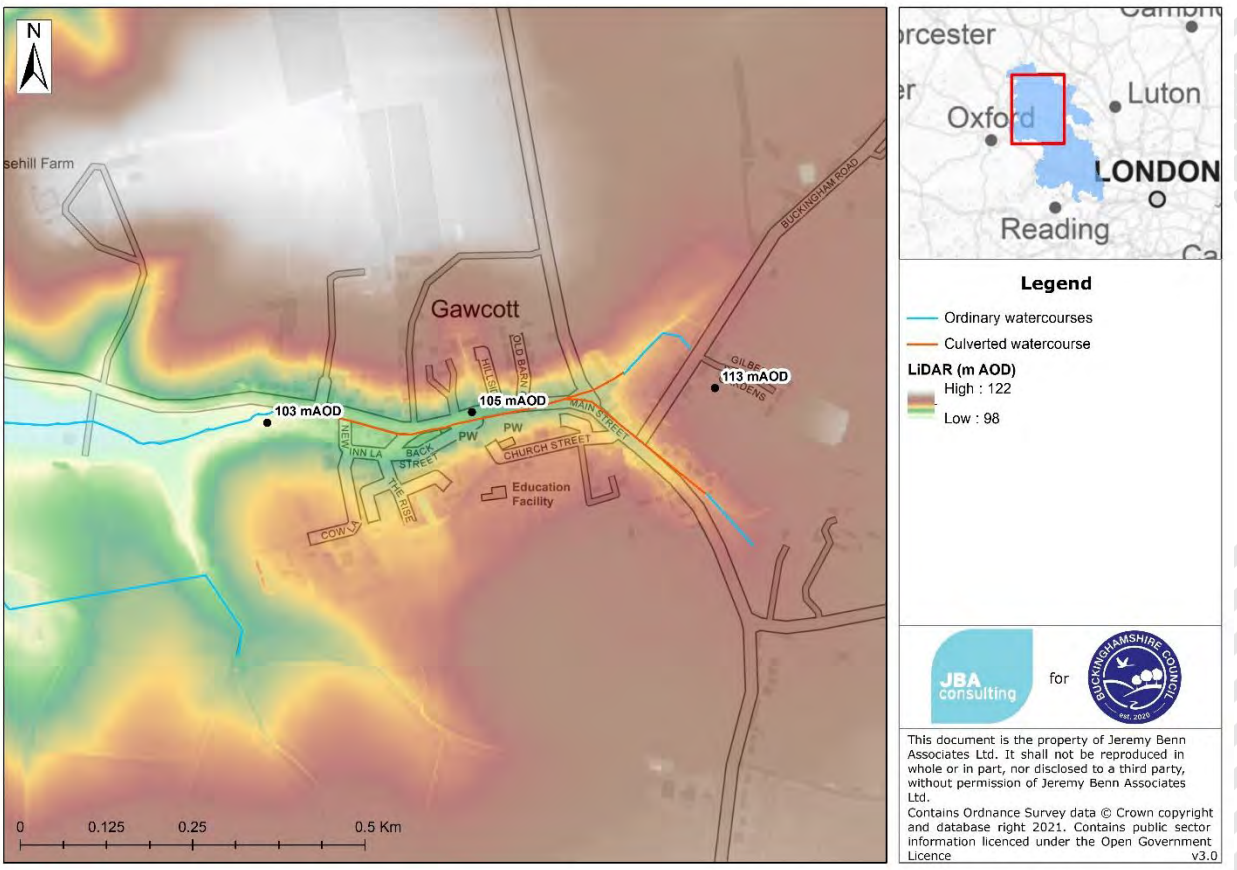

Figure 3-4: Gawcott topography, from 2m resolution LiDAR Digital Terrain Model (DTM)

3.2.2 Geology

BGS data indicates that the underlying bedrock is the Peterborough Member, which is comprised of mudstone in this area. The entire area is underlain by superficial deposits including diamicton, glaciofluvial deposits, alluvium and head deposits. These superficial deposits consist of silts, clays, sands and gravels and may have variable permeability[4]. Soilscapes mapping[5] characterises the soil types in Gawcott as 'Slightly acid loamy and clayey soils with impeded drainage'.

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

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

4 Long-term flood risk information

4.1.1 Risk of flooding from rivers and sea

Figure 4-1 shows that there are no existing fluvial Environment Agency Flood Zones for the small ordinary watercourse in Gawcott. This is because its catchment area is less than 3km², meaning it was too small to be modelled in the Environment Agency's national Flood Zone mapping. In this situation, the Risk of Flooding from Surface Water (RoFSW) mapping is usually used as a proxy (Section 4.1.2). To better understand the flood risk, modelling has been completed as part of this study (see Section 10).

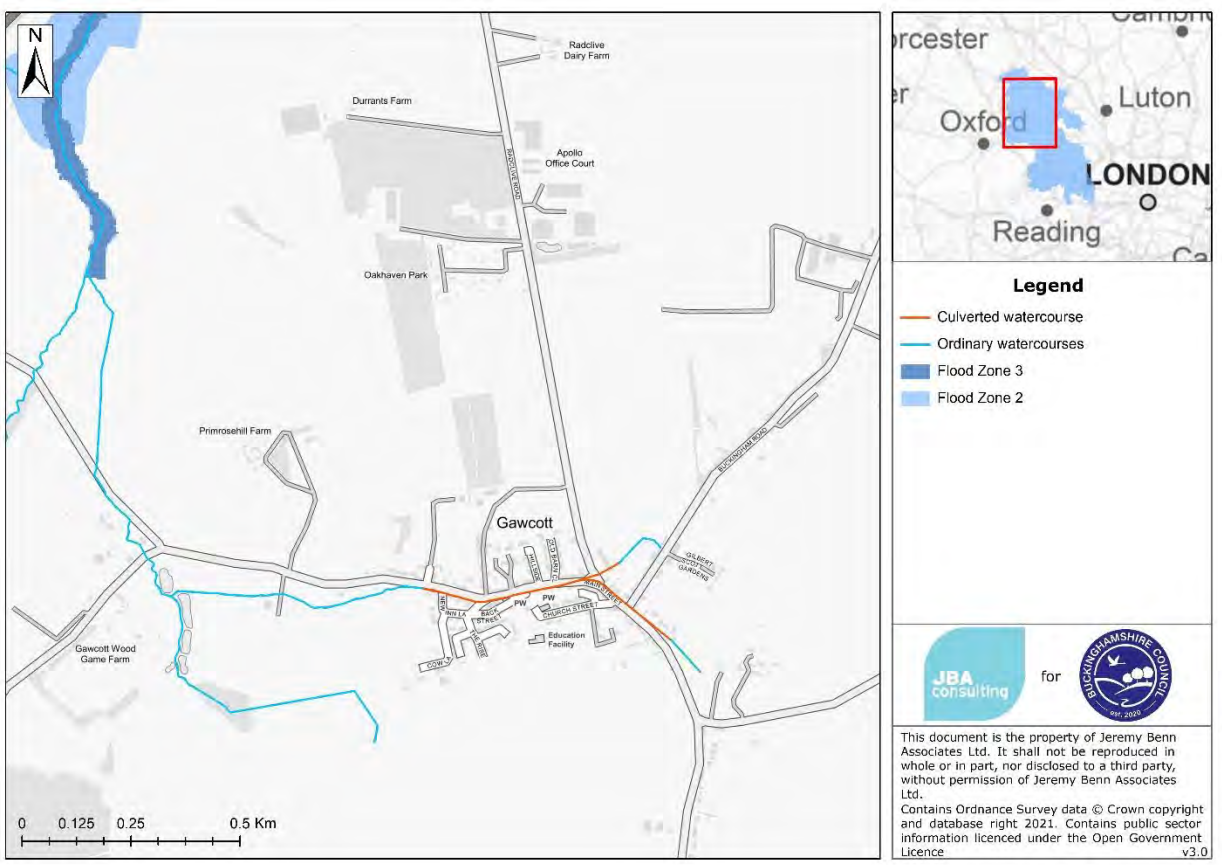

Figure 4-1: Flood zones in the vicinity of Gawcott

4.1.2 Risk of flooding from surface water

The Environment Agency's Risk of Flooding from Surface Water (RoFSW) mapping is shown in Figure 4-2. The mapping shows that there is a high risk of surface water flooding (3.33% AEP) along Main Street. A flow path originates at the section of open channel between Radclive Road and Buckingham Road and continues along the route of the open watercourse. There is also a flow path along Hillesden Road, which flows towards Main Street. It should be noted that RoFSW mapping does not account for the presence of culverted systems, which would in reality convey some of this water underground.

In order to provide a fuller understanding of the functioning of the drainage system, including the interactions between surface water runoff, highway drainage and the culverted watercourses, we undertook hydraulic modelling of the drainage system within Gawcott (see Section 10).

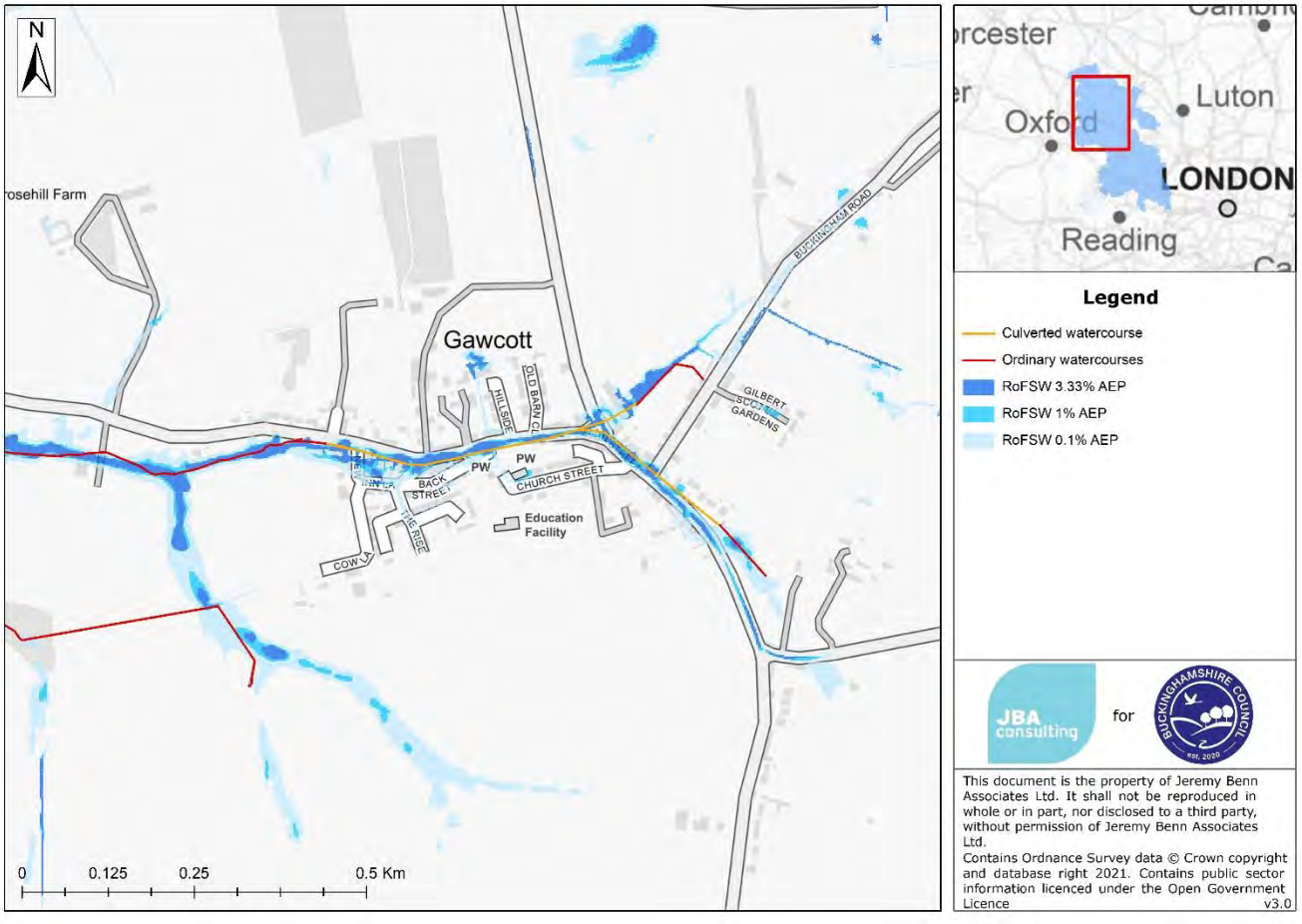

Figure 4-2: Risk of flooding from surface water at Gawcott

4.1.3 Risk of flooding from groundwater

Figure 4-3 shows the risk of flooding from groundwater in and around Gawcott. Through the centre of the village, following Main Street, there is negligible risk of groundwater emergence. Elsewhere, there is a low-moderate risk where groundwater is between 0.5m – 5m of the ground surface during a 1% AEP event.

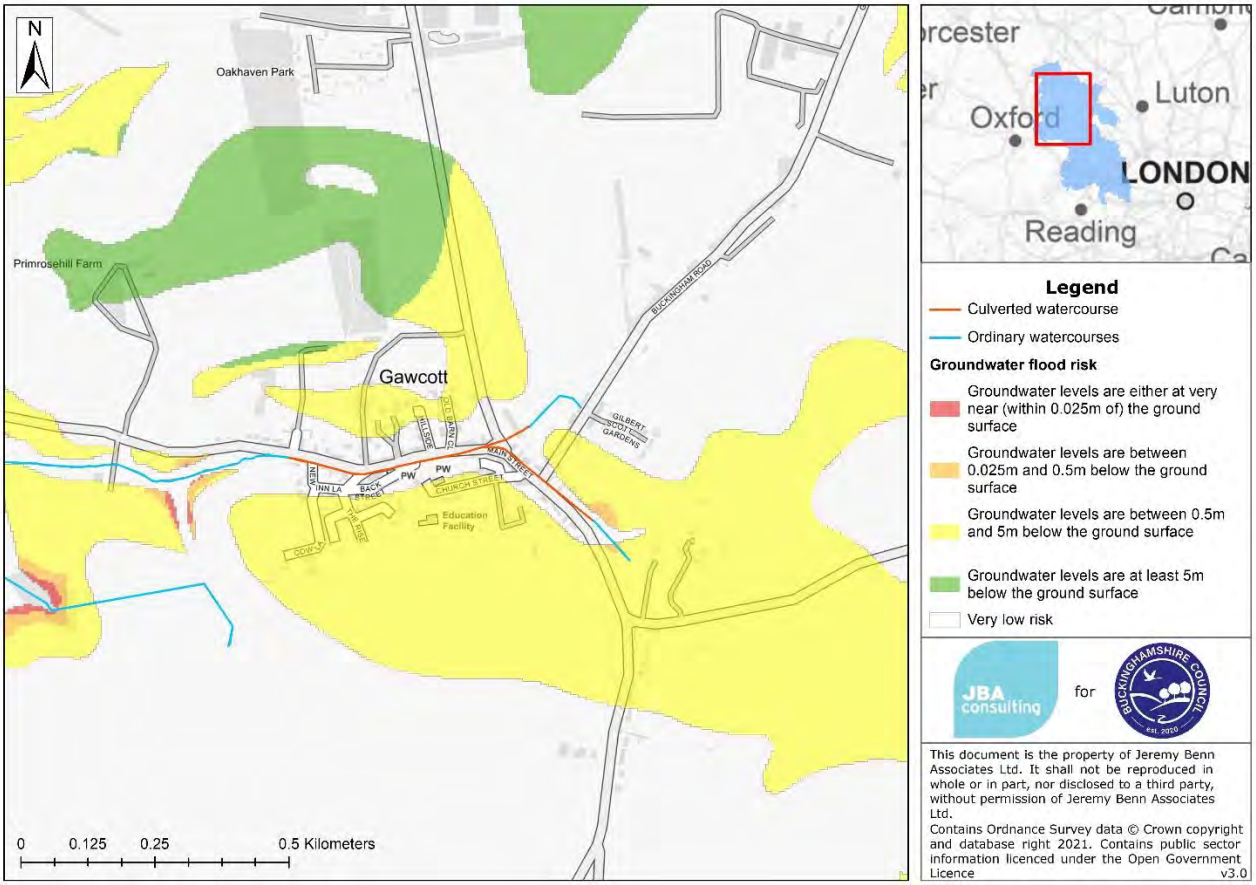

Figure 4-3: Risk of flooding from groundwater during a 1 in 100 annual chance event at Gawcott

4.2 Flood history

Details of flood history were collected using Buckinghamshire Council's flood records, the online stakeholder engagement surveys and from speaking to residents during the site visit to Gawcott on 6 May 2021. Table 4-1 details the known flood history in Gawcott.

Table 4-1: Flood history

Date	Source of flooding	Description of impacts
Jan 2002	Ordinary watercourse	Flooding records from Buckinghamshire Council indicate that Gawcott flooded in Jan 2002 from the ordinary watercourse. And that this may have been related to the maintenance of the culvert and the ditch. No further details are available.
May 2006	Ordinary watercourse/surface water	Described as similar to the Dec 2020 flooding.
Jul 2007	Ordinary watercourse/surface water	Described as similar to the Dec 2020 flooding, although flood waters were not as deep, and the rain had a shorter duration (2 – 3 hours). This event also impacted the River Great Ouse and the wider area including Buckingham.
Jan 2008	Ordinary watercourse/surface water	Overnight event, further details are unknown
Dec 2013	Ordinary watercourse/surface water	Overnight event, described as similar to Dec 2020 flooding but flood waters were not as deep
2016	Ordinary watercourse/surface water	Further details of impacts in Gawcott are unknown This event also impacted the River Great Ouse and the wider area including Buckingham.

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 risk management, with roles and responsibilities for emergency response described in Section 5.2.

5.1.1 Lead Local Flood Authority (LLFA)

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 Gawcott.

5.1.2 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.

In the case of Gawcott, the Environment Agency do not have a specific flood management role as the watercourses are classed as "ordinary watercourses", rather than main rivers, and are therefore within the remit of the LLFA. However, the Environment Agency are still the regulator for water quality and pollution issues on ordinary watercourses, including at Gawcott.

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.

5.1.3 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. 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.

Gawcott is not within a IDB drainage district.

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 Gawcott.

5.1.5 Highway Authority

The Highway Authority for Gawcott is Buckinghamshire Council, and the highway 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 Riparian landowners

Riparian landowners who own land or property 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 'Owning a watercourse'[6].

5.1.7 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

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

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

Local (County and District) Authorities
Coordinate emergency support within their own functions
Deal with emergencies on 'non main rivers'
Coordinate emergency support from the voluntary sector
Liaise with central and regional government departments
Liaise with essential service providers
Open rest centres
Manage the local transport and traffic networks
Mobilise trained emergency social workers
Provide emergency assistance
Deal with environmental health issues, such as contamination and pollution
Coordinate the recovery process
Manage public health issues
Provide advice and management of public health
Provide support and advice to individuals

6 Owning a watercourse (https://www.gov.uk/guidance/owning-a-watercourse)

Assist with business continuity

Police Force	Utility Providers
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

Fire and Rescue Service	Internal Drainage Board
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

Ambulance Service	Town and Parish Councils
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
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 Gawcott 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

Gawcott is not covered by the Environment Agency's national flood warning information service, which mainly covers Main Rivers. There is no national flood warning service for ordinary watercourses or surface water flooding.

5.3.2 Maintenance

Highway drains are cleaned annually by Transport for Buckinghamshire.

The open watercourses in the area are currently managed locally by residents and riparian owners, by way of maintaining ditches, watercourses and drains.

In 2014, as a gesture of good will, Anglian Water undertook some de-silting and re-grading of the open channel between the culvert outfall and the ponds downstream of New Inn Lane. The relevant landowners also replaced mesh at the entrance to the ponds downstream of New Inn Lane. Following this work, a maintenance schedule was agreed by Buckinghamshire Council with the landowners as follows:

- Fences and crossing checked and cleared of debris following every significant rainfall event
- Overgrown vegetation to be cleared annually in September/October
- Excess silt to be cleared every two to three years to ensure the watercourse can flow freely.

However, there have since been long-standing concerns amongst the local community regarding sewage contamination of the open channel downstream of the outfall. Concerns about the health and safety implications of this have at times led to some reluctance from some of the riparian owners to fully undertake the maintenance schedule as initially agreed. Buckinghamshire Council understand that

Anglian Water and the Environment Agency have undertaken some investigations over subsequent years to try to identify the source of this contamination, without resolution to date. Further investigations are ongoing.

5.3.3 Upper Great Ouse Natural Flood Management Scheme

Natural flood management (NFM) involves working with natural processes such as altering or restoring landscape features to 'slow the flow' within upper catchments in order to manage flood risk downstream, particularly from smaller, more frequent flood events. Slowing flows, increasing infiltration and deposition can also help to filter pollutants, improve water quality, and create new habitats which support greater biodiversity.

Buckinghamshire Council is funding an ongoing project[7] to identify NFM options in the Great Ouse catchment upstream of Buckingham, which includes Gawcott. It is currently in Year 2 of a three-year programme. It is currently being delivered through the River Thame Conservation Trust, funded through Section 106. The Trust are conducting landowner 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.

5.3.4 Property Flood Resilience

At least one property is known to have had flood doors installed prior to the event, although it was noted that water still entered the property. Following the event, at least one other property had flood doors installed.

5.3.5 Flood alleviation schemes

There are currently no formal flood risk management schemes in Gawcott or its upstream catchment.

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

6 Hydrological analysis of the 23 December 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. This also led to a decrease in soil moisture deficit (an indication of soil dryness) to below normal levels, indicating that the soil was already wetter than normal for the time of year. Though November was slightly drier than average, a month's worth of rain fell in the period of December up until the event on the 23 December. This led to notably low soil moisture deficit (within the 0-10mm band), indicating that the catchment had minimal capacity to hold additional rainfall by the time of the storm event on 23 December.

6.2 The event

The rain gauge at Brackley (approximately 9km north-west of Gawcott) shows that rainfall started slowly at about 07:30 on 23 December, becoming more intense at 10:00. The main body of the storm event happened in two waves. The first, and greater, wave of rainfall occurred between about 10.30 and 15:00, with two main peaks at around 11.15 and 12.45. The second wave occurred between 15.30 and 20:00, with the peak around 17:00.

The rainfall event ended at about 00:00 of 23/24 December with an approximate total of 52mm recorded at Brackley over the preceding 17 hours.

Another nearby rain gauge at Foxcote recorded a lower total of 28mm rainfall. A weighted average between Brackley and Foxcote for the Gawcott catchment indicates an average of 36mm. However, the Foxcote rain gauge is thought to have under-recorded the actual rainfall due to over-shadowing effects, and therefore the gauge at Brackley may be more representative of the actual totals.

A further source of relevant rainfall data is from observed radar rainfall system ("HYRAD") from the Met Office. This recorded an average total of 46mm across the Gawcott catchment.

The HYRAD radar rainfall data shows that for the majority of the event the storm passed in a northerly direction 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 Gawcott 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 was 46mm.

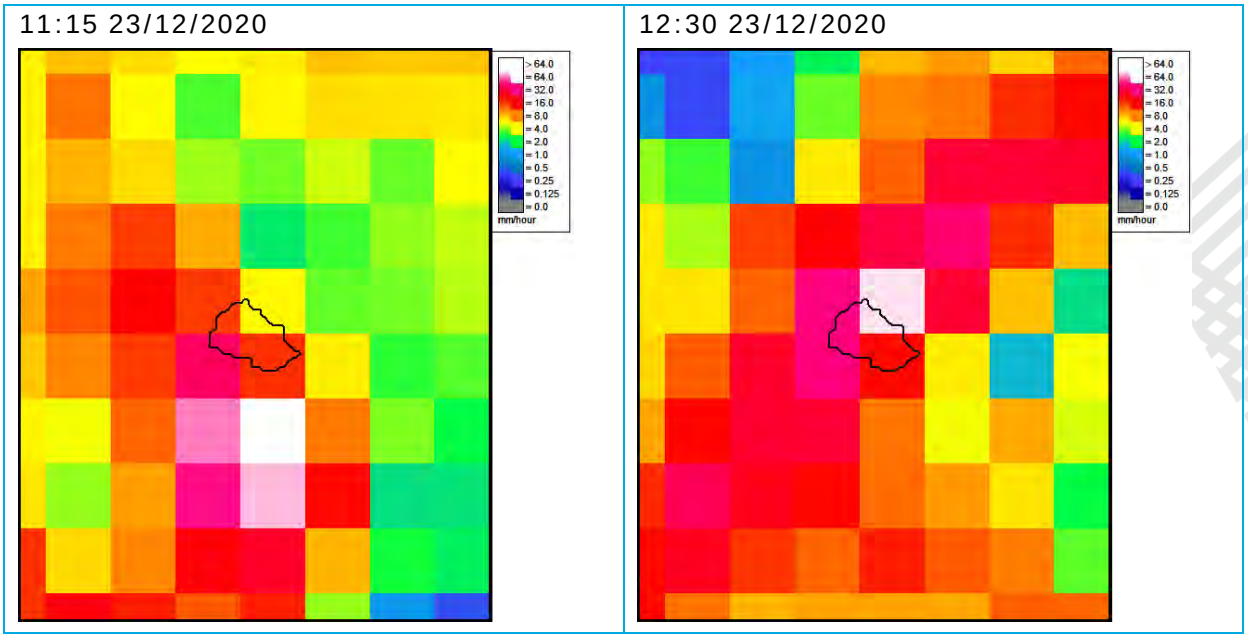

Figure 6-1: HYRAD (radar) rainfall for the Gawcott area

Table 6-1: Rainfall totals in the Gawcott area on 23 December 2020

Source of rainfall data	Distance from Gawcott	17-hour total on 23/24 December 2020	Grid reference
Brackley	9km	52mm	460115, 236084
Foxcote*	5km	28mm	471278, 235758
Gawcott catchment average (rain gauge)**	-	36mm	468170, 231935
Gawcott catchment average (HYRAD)	-	46mm	468170, 231935

*possible under-recording at Foxcote due to overshadowing effects

**catchment average based on raingauges at Brackley and Foxcote

6.3 Rainfall return period estimation

The total rainfall during the 23 December storm event had a 14% chance of occurring in any one year (return period of 7 years). This is based on the HYRAD radar rainfall total for Gawcott itself, which was considered to be more reliable than the catchment average based on the rain gauge data due to the poor data quality at Foxcote gauge and the distance of both gauges from the village. This return period is not especially extreme, but it occurred in combination with soil that was already completely saturated from the notably high rainfall over preceding months, meaning the catchment was very sensitive and quick to respond to the heavy rainfall.

6.4 Flow return period estimation

The estimation of flow return period is very uncertain as there are no flow gauges on the ordinary watercourse. A hydraulic model has been built in order to represent flood levels and extents during the event (see Section 10 for further information on the modelling).

Based on results from this modelling, an approximate return period of 50-75 years is estimated. This corresponds to a peak flow estimate of 0.9m^3/s. Further details of how this has been derived are given in Appendix A.

7 Incident response

A number of authorities including Buckinghamshire Fire and Rescue Service and Transport for Buckinghamshire responded to the flooding in Gawcott and provided assistance to affected residents. Information from the relevant authorities detailing their response to the flooding has been collected as part of the investigation and a timeline of the incident response is given in Table 7-1.

Table 7-1: Timeline of incident response

Date	Time	Activity/event	Agency
23 December	12:00 – 13:30	Flooding started in Gawcott, with water flowing down Main Street and New Inn Lane.	
23 December	13:30	Residents contact fire service at 13:30, but they inform residents that they are unable to attend until the evening.	Buckinghamshire Fire and Rescue Service
23 December	15:44	Transport for Buckinghamshire close Main Street, Gawcott due to ongoing flooding	Transport for Buckinghamshire
23 December	Afternoon – evening (exact times unknown)	Flooding continues throughout the afternoon and evening, causing internal property flooding, with water pooling in Main Street and New Inn Lane where there is a low spot. Sandbags delivered by TfB to affected residents.	Transport for Buckinghamshire
23 December	Afternoon – evening (exact times unknown)	The Environment Agency attend Gawcott and provided sandbags to affected residents	Environment Agency
23 December	18:00	Thames Valley Police request a road closure in Gawcott due to the ongoing flooding.	Thames Valley Police/ Transport for Buckinghamshire
23 December	20:30	Fire service arrive to provide assistance. They begin pumping flood water from the low spot, into the watercourse as there was capacity in the channel to receive and convey flows.	Buckinghamshire Fire and Rescue Service
23 December	22:00 – 23:00	Rainfall stops and water levels rapidly decrease following this.	
23 December	22:30	Thames Valley Police post an update on social media informing the public to avoid Gawcott due to flooding	Thames Valley Police
24 December	01:00	Remaining flood water recedes	
24 December	04:00	Gawcott Parish Council and local residents arrange for a skip to be delivered, for affected residents to dispose of damaged furnishings and items	Gawcott Parish Council

Following the event	Exact days and times unknown	TfB undertake gully clearance following the event	Transport for Buckinghamshire

7.1 Transport for Buckinghamshire

Transport for Buckinghamshire managed a large number of road closures across Buckingham and the wider area during the event, including Main Street in Gawcott. They also issued sandbags, prioritising these on the basis of greatest need. Sandbags were delivered to Main Street in Gawcott.

TfB undertook gully clearing following the event.

7.2 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. Gawcott is noted as a significant area of flooding. 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 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 a total of 161 incidents, most of which were flood related, during this period, with a number of these flooding incidents involving multiple rescues and multiple properties.

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 8-1 and described in the following sections.

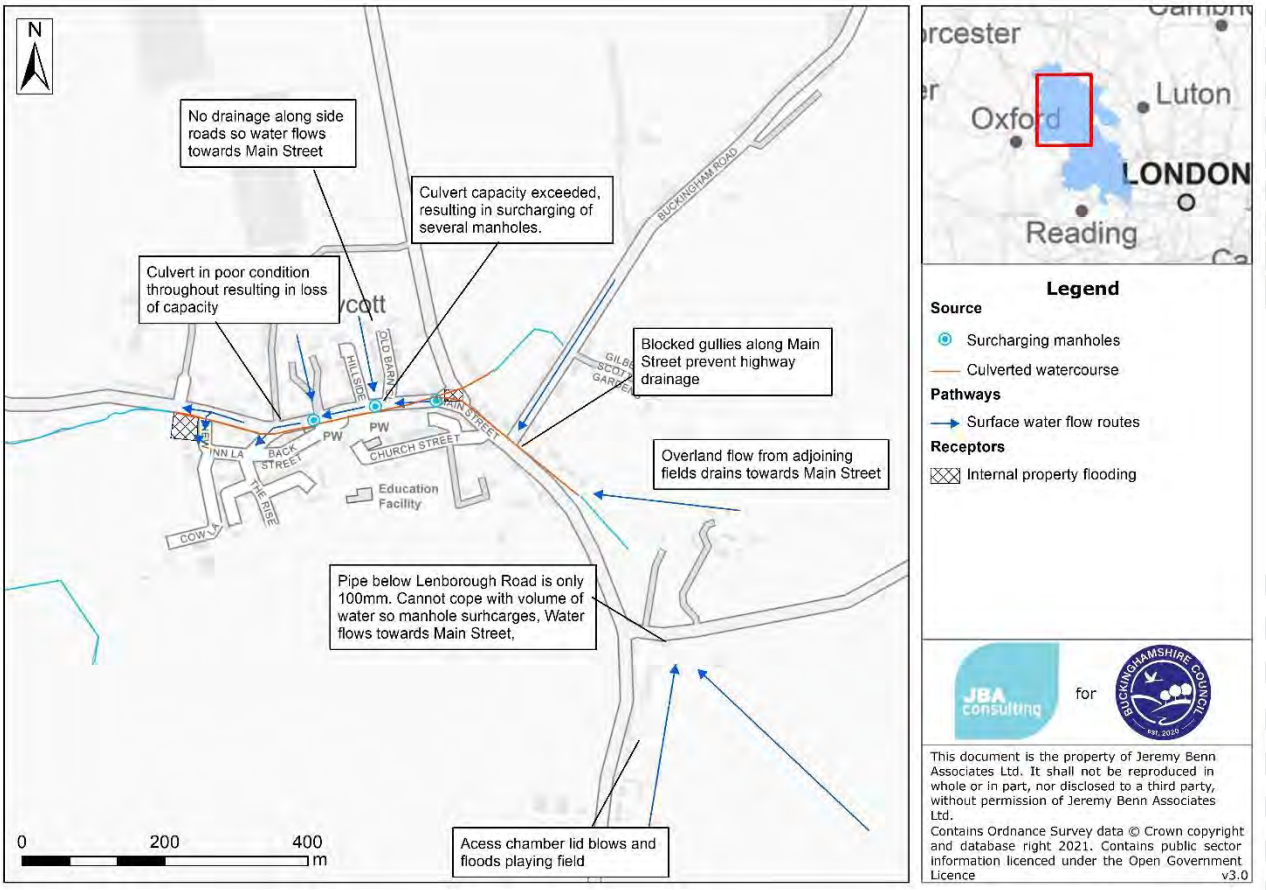

Figure 8-1: Map of sources, pathways and receptors

8.1 Source

8.1.1 Extreme rainfall

The intense rainfall experienced in Gawcott caused a large volume of water to fall directly onto the ground surface in the village. The total rainfall during the 23 December storm event had a 14% chance of occurring in any one year (return period of 7 years) (see Section 6). 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.

8.1.2 Ordinary watercourse

The ordinary watercourse (Section 3) which runs through the village rose rapidly in response to rainfall falling on the small but saturated catchment upstream, which has an area of 0.88km^2. The two upstream tributaries each become culverted as they enter the village, and then converge into one single culvert (largely of 600mm diameter) running below Main Street. The main culvert surcharged and its capacity was exceeded during the event providing a pathway for flooding (see Section 8.2.2).

With regard to the open channel to the west of the village, we do not believe this was a direct source of flooding during the event. Local accounts of the incident observed that the

culvert outlet into the open channel was not surcharged during the event, with the open channel being only one half to one third full. Given that the culvert was surcharging further upstream, this indicates that water was being throttled upstream by restrictions or blockages within the culvert barrel rather than backing up from high water levels in the open channel.

Figure 8-2: Open channel along Preston Road. Photo taken on site visit on 6 May 2021

Figure 8-3: Downstream end of culvert from site visit on 6 May 2021

8.2 Pathway

8.2.1 Surface water runoff and drainage

Surface water runoff started flowing towards the village from the eastern end before midday on the 23 December. Surface water likely accumulated from surrounding farmland, flowing into the playing fields. The drainage system in Lenborough Road has limited capacity and surface water runoff would have flowed as overland flow down Hillesden Road towards Main Street. Surface water also flowed down side roads such as Hillside and Old Barn Close towards Main Street.

On Main Street, the highway gullies are connected to the culverted watercourse. A number of the highway gullies were reported to be blocked at the time of the event. Blockages would have prevented water from draining into the culvert in locations or times during the event where the culvert had capacity to drain away the water. However, gullies are only effective when the culvert has capacity to convey more water. Given that the culverted watercourse was overwhelmed in this event (see Section 8.2.2), the highway gullies would not have been able to drain freely into the culvert even if they had all been clear, and so this would not have prevented flooding during the December 2020 event.

Water was also washed into homes by traffic driving through the water on Main Street.

8.2.2 Exceedance of capacity of the culverted watercourse

The capacity of the culverted watercourse was exceeded by the flows experienced during the event. The hydraulic modelling we have undertaken of the drainage system in Gawcott

(see Section 10 for further information) suggests that the culvert's capacity is exceeded in the 1 in 10 annual chance event. In comparison, we have estimated that flows during the December 2020 event had an annual chance in any given year of between 1 in 50 to 1 in 75, illustrating that the hydraulic capacity of the culvert was significantly exceeded. This led to surcharging from the culvert, with water lifting manholes along the line of the culvert under Main Street.

Water from surcharging manholes started flooding the highway at approximately 1:30pm, starting with manholes close to the chapel. Flood water flowed west along Main Street and towards New Inn Lane. Flood water pooled around the properties on the western side of New Inn Lane, which are situated in a low spot, leading to a significant flood extent along Main Street and New Inn Lane.

The CCTV survey of the culvert indicates that it is in poor condition with many defects, constrictions and blockages found (see Section 9 for more detail). Of particular note are a constriction to the culvert at the downstream end where pipe size is reduced, and a damaged section located close to the Methodist Chapel. This reduces the capacity and performance of the culvert to convey water and increases the flows and water levels spilling onto the surface via manholes.

Figure 8-4: Surcharged manhole in Main Street during the event

8.2.3 Combined sewer

There is at least one reported instance of internal flooding occurring due to toilets backing up.

8.3 Receptor

8.3.1 People

The flooding in Gawcott severely impacted affected residents and caused extensive flood damage. Residents reported having to claim on their insurance, which will likely increase their premiums in the future and adding an additional financial burden from the event. Concerns were also raised around the value of their properties if they were to try to move out or potential difficulties in trying to sell property. In at least one case, the residents of a property were forced to move out temporarily whilst damage was being repaired.

Mental health impacts were also reported, with a number of residents reporting feeling distressed by the damage to their homes and the loss of personal items. Feelings of stress at having to replace and repair flood damage to their homes were also reported, particularly as the flooding occurred so close to Christmas. Following the flooding, residents have reported feeling anxious whenever there is persistent rainfall, particularly considering the impacts of climate change in the future and how this could impact the severity of flooding in the village.

8.3.2 Property

Properties at the western end of the village are known to have been internally flooded, and it is noted that flood water entered these properties from both the front and rear. Information from Gawcott Parish Council and the questionnaire indicates that a total of 13 residential properties flooded internally, as well as Gawcott Methodist Chapel. At least a further 4 properties experienced flooding externally to gardens or outbuildings, with at least two experiencing a near miss, with water almost reaching the property threshold. A number of residents stated that it is likely they would have flooded internally if Buckinghamshire Fire and Rescue Service had not pumped water away.

In several cases, internal flooding resulted in significant property damage, with residents forced to temporarily move out of at least one property, and a number of others reporting significant damage. This includes structural damage to one property where damage to the walls led to crumbling brickwork. The flooding also caused damage where outbuildings such as garages were flooded. External flood depths around properties to the west of the village were noted to be significant at approximately 600 – 650mm.

8.3.3 Infrastructure

Highway flooding was significant along Main Street and New Inn Lane. As a result, Buckinghamshire Council in its role as Highway Authority ordered a road closure after 18:00 on the day of the event.

Figure 8-5: Flooding on Main Street, Gawcott during the event

8.3.4 Services

The Methodist chapel in Main Street flooded internally, with water seeping up through the floor in the storage room.

9 Condition assessment

9.1 Introduction

The survey collected in July 2021 by Buckinghamshire Council included CCTV of the culverted watercourses and tracing of connections with the highway drainage system through Gawcott.

The condition of the culverted watercourse running through Gawcott was reviewed based on information provided in the Flowline CCTV survey, with defect grades based on the Sewerage Rehabilitation Manual 4 grading system. The Buckinghamshire Council survey covered all that was in the Anglian Water survey, as well as additional sections, and is the most up to date available data.

Both 'structural defects' and 'service/operational condition' were taken into consideration. Structural scoring considers any physical defects in the wall of the pipe, whereas the service/operational scoring highlights the performance of the pipe and is often linked to the cross-sectional area of the pipe.

As a result of blockages and intrusions along the culverts, some sections were impassable (these are highlighted in Figure 9-5). Overall, the main culvert along Main Street was found to be in poor condition, with capacity reduced in several places as a result of blockages, intrusions (such as from utility service crossings), and pipe size changes.

9.2 Structural defect summary

Notably, the survey identified some short sections of the main culvert with significant structural defects, which require repairs in the short term to prevent collapse or failure.

The survey recorded one Grade 5 defect, associated with a hole in the culvert (shown in Figure 9-1), close to the Methodist Chapel between manholes SW01 and SW02 (Figure 9-5 for locations). Although not recorded as a graded defect, a further similar hole of similar severity in the wall of the culvert was identified from the CCTV footage, between the outfall and SW01. There are a small number of sections with less severe defects.

As of the date of this report, a scheme is being developed as a high priority by Transport for Buckinghamshire with the aim of making these defects safe. It is beyond the remit of this investigation to provide further information on this developing project – Transport for Buckinghamshire may be able to provide further information.

Table 9-1 summarises the number of structural defects, per grade, identified in the Buckinghamshire Council CCTV survey.

Table 9-1: Structural defects grading of the culverted watercourse

Defect grade	Number of defects	Defect Grade Description (from SRM4)
Grade 5	2 (Only 1 formally graded, but another appears of equivalent severity)	Best practice suggests that this pipe is at risk of collapse at any time. Urgent consideration should be given to repairs to avoid total failure.
Grade 4	0	Best practice suggests consideration should be given to repairs to avoid a potential collapse.
Grade 3	1	Best practice suggests consideration should be given to repairs in the medium term.

9.1 Service/operational defect summary

Table 9-2 summarises the number of service/operational defects, per grade, identified in the Buckinghamshire Council survey. All service/operational defects are highlighted in Figure 9-5.

A total of 12 Grade 5 defects were identified, which represent significant losses in the cross-sectional profile of the culvert. For example, Figure 9-2 shows a partial blockage by fallen masonry. Several pipes have been placed directly through the culvert which also result in a loss of cross-sectional area within the pipe – for example, as shown in Figure 9-3. In many cases, this also restricted the survey, as the camera was unable to pass the obstruction. Although not stated as a graded defect, there is also substantial decrease in pipe capacity between Outfall1 and SW01, shown in Figure 9-4.

Table 9-2: Service/operational defects grading of the culverted watercourse

Defect grade	Number of recorded defects	Description
Grade 3	11	Best practice suggests consideration should be given to maintenance activities in the medium term.
Grade 4	3	Best practice suggests consideration should be given to maintenance activity to avoid potential blockages.
Grade 5	12	Best practice suggests that this pipe is at a high risk of backing up or causing flooding.

9.2 Impact of condition on flood risk and water quality

The key defects identified during the survey are summarised in Figure 9-5. Those defects most likely to either cause water to back up and increase risk of flooding from surcharging and exceedance of the culvert via manholes, or increase the risk of a potential collapse are:

- Significant change in pipe size (600mm to 300mm and 150mm), downstream of SW01 close to the culvert outlet.
- Hole in pipe with missing bricks, potential for failure, downstream of SW01
- Hole in pipe with missing bricks, potential for failure, between SW02 and SW04
- 40% blockage, by masonry bricks, between SW04 and SW05
- Joint displaced, downstream of SW06
- 65% blockage, by pipe intrusions, between SW05 and SW06

There are also implications for water quality, with a 300mm foul misconnection identified by the survey between SW02 and SW01, which may be the source of the foul debris that has been observed by residents downstream.

Figure 9-1: CCTV survey - hole in wall of culvert

Figure 9-2: CCTV survey - masonry in base of culvert, 40% blockage.

Figure 9-3: CCTV survey - several pipe crossings through culvert

Figure 9-4: CCTV survey - change in culvert size from 600mm to 150mm and 300mm

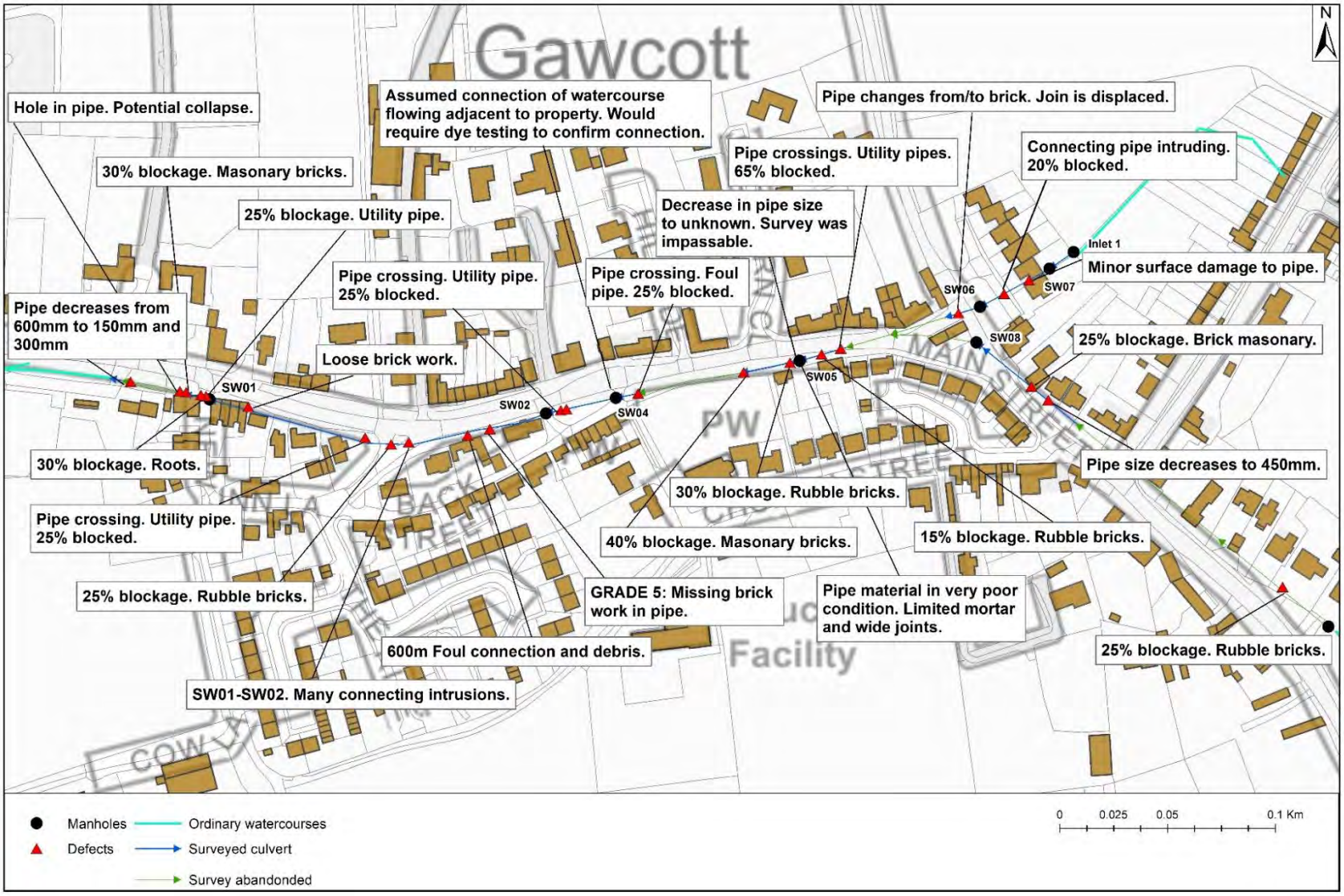

Figure 9-5: Defects identified during survey of surface water culvert

10 Hydraulic modelling

10.1 Modelling approach and justification

A surface water model was developed, in InfoWorks ICM, to better understand the flood risk at Gawcott. Full details on the model development and results can be found in the Modelling Technical Note (Appendix B).

10.2 Model development

10.2.1 Drainage network

In Gawcott, the sewer system mostly comprises a combined sewer system, with only small sections of separate public foul and surface water sewers in newer developments in the village (see Section 3.1). Notably, there is also the main culverted watercourse running the length of Main Street, itself fed by highway and surface water drainage plus the two upstream culverts conveying water from the open channels upstream of the village.

In the model, only the culverted watercourses and surface water drainage system has been included (excluding the combined and foul network) as this is the key source of flood risk.

Various sources of data were collected and used for the development of the model of the culverting/surface water system. Anglian Water provided GIS data of their sewer network system, plus some limited survey of the main culverted watercourse, collected in January 2021. Further survey was commissioned by Buckinghamshire Council as part of this Section 19 investigation to further understand the capacity, condition and extent of the culverted watercourse. This survey also included survey of the gullies along Main Street and dye tracing to confirm their connection into the surface water system. This survey was completed in July 2021 (see Section 9.1).

Using the data provided, the surface water system has been modelled to best represent its current condition, including any blockages and changes in condition.

10.3 Baseline model runs

The baseline model represents the existing situation (i.e. current condition of culverted watercourse) within Gawcott including the findings of the CCTV survey. The model was verified, using reported flood depths, to replicate the flooding that was experienced on 23 December 2020. The baseline model was also run for a series of 'design events' (events with different annual chances of occurring) to improve understanding on the capacity of the system in its current condition. The modelling found that the surface water system is overloaded in the 1 in 10 annual chance design event.

10.4 Scenario testing

Several scenarios were tested in the model to understand the impact on flood risk. A summary of the scenarios tested is provided below.

10.4.1 Culvert improvements

As discussed further in Section 9, the culvert below Main Street is in a very poor condition. One of the scenarios in the model tested the impact of improving the culvert condition. This involved removing all blockages, pipe size constrictions, sedimentation and providing a much smoother culvert material. The majority of the culvert, under Main Street, currently has a 600mm diameter. A scenario was considered where the culvert's cross-sectional area was doubled. In reality this could be achieved approximately either by increasing its diameter to 900mm, or adding another parallel culvert of 600mm diameter.

10.4.2 Increased number of gullies

The model was used to test the effect of increasing the number of highway gullies connecting to the culvert by adding additional gullies into the model along Main Street.

10.4.3 Upstream storage

A scenario was considered with storage areas upstream of the sections of open watercourse to capture runoff which flows towards Main Street. Storage areas were sized based on LiDAR ground data, with approximate volumes show in Figure 10-1.

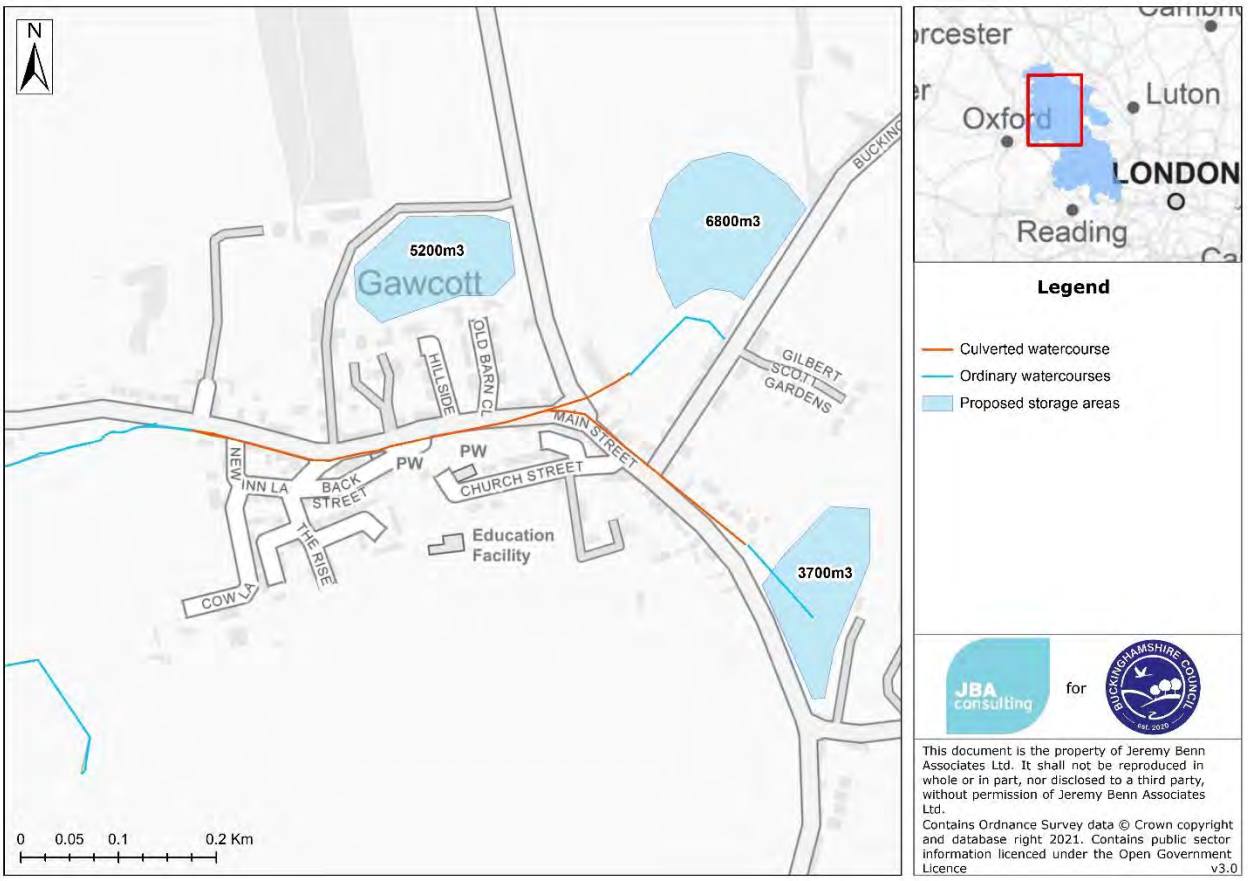

Figure 10-1: Modelled storage areas

Full discussion of the scenarios and results can be found in the Modelling Technical Note (Appendix B) and Section 11.

11 Discussion, appraisal and recommendations

11.1 Introduction

In this section, we consider potential options to mitigate flood risk and reduce damages, taking into account the identified causes and mechanisms of flooding in Gawcott.

This includes consideration of measures such as flood risk management capital scheme options such as culvert improvements or upstream flood attenuation, asset maintenance, Property Flood Resilience (PFR) (flood doors, barriers etc), community flood preparedness, and disconnection of impermeable areas.

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
- Approximate timescales
- Relative benefit-cost ratios

The scoring criteria and full results are described in more detail in Appendix C. Options were given a relative score and recommendations made for further work to be carried out, or quick-win actions. Indicative timescales are given. Doing nothing was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Gawcott.

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.

Where Buckinghamshire Council - whether as the Lead Local Flood Authority or Transport for Buckinghamshire - are noted as the responsible authority for taking forward recommendations to appraise engineering options (such as those within Section 11.2 through to 11.4), those that appear to have a realistic possibility of being financially viable will feed into either the pipeline for the LLFA's capital programme, or TfB's Capital Drainage programme.

Should any project ideas be taken forward by the LLFA, these will be added to the pipeline programme and prioritised against other existing projects. It must be emphasised that taking these forward will be subject to finance and staff time being available. Any new scheme is judged against other schemes in an equitable way on the risk and viability of the

schemes. For such projects to reach design and construction stage, the LLFA would need to make a successful business case into a national programme in order to secure grants from central government or a regional levy to fund the project[8].

The business case process is a rigorous exercise to appraise the different options available against criteria such as their technical deliverability, the cost of the scheme versus benefits provided, community and resident acceptability, environmental impacts, etc. Any scheme is assessed using these criteria against other schemes in the region and nationally, which determines how much funding is made available. The number of business cases and schemes that can be taken forward is also limited by staff resources and funding to develop the scheme, so there are no guarantees for taking forward new schemes for appraisal from the Flood Investigations.

If a successful business case can be made, the timescales between commencement of an initial options appraisal to construction on the ground are typically in the order of several years and can be a decade.

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

[8] 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

11.2 Improvements to Main Street culvert

The structural condition of the existing culvert under Main Street is in places classed as Grade 5 (pipe is at risk of collapse), particularly along Main Street close to the Methodist Chapel. The CCTV survey also shows that there are blockages and defects throughout, including services crossings and masonry rubble. This is limiting the capacity of the culvert to convey flood flows effectively. Modelling predicts that Gawcott would still have flooded in the December 2020 event, even if the culvert had been clear and in good condition, however flood depths would have been reduced. Aside from flood risk, the condition of the culvert is so poor that some action is required to make sure it is safe. There are a range of potential options for improving the culvert, which are outlined in detail in Section 11.2.1 through 11.2.5 below. These options are summarised in Table 11-1. Further appraisal and feasibility work would be required before taking any of these options forward.

11.2.1 Appraise the feasibility of replacing and enlarging of existing culvert

The culvert could be excavated and replaced along its 470m length with a larger diameter culvert.

The model showed that this would have prevented any flooding associated with capacity of the culvert during the event. Flooding was still expected from rainfall ponding, but surcharging does not occur. The modelling also showed that this option could be effective in a 1 in 100-year annual chance event. Replacing the culvert would also have water quality benefits as it would remove any connections between the ordinary watercourse and the combined sewer.

However, there would be a number of constraints to this approach, including significant, lengthy disruption to the road through the village, and the re-routing of the various services which cross the pipe. There are also short sections which go under private land. A full survey of below ground services would be required and the presence of services would influence the cost.

Replacing and enlarging the culvert are both very costly options, and initial high-level appraisal suggests that the costs would be much higher than the flood damages avoided by such a scheme. On this basis, this option is unlikely to be viable.

11.2.2 Appraise the feasibility of relining the existing culvert

Relining the culvert would be less intrusive than relaying the culvert and would structurally strengthen it. Blockages would be removed and the culvert would be much smoother. However, the diameter of the pipe would be reduced by around 150mm to allow for the liner and grout, and the loss of capacity may outweigh the benefit of smoothing the culvert.

Testing of this scenario found that it would not have prevented flooding during the 23 December event, but flood levels would have receded at a quicker rate due to the improved conveyance in the culvert. The modelling showed that this would provide some protection in lower-order events - for example in the 1 in 30 annual chance event, the culvert capacity is still exceeded along Main Street but impacts are reduced. Exceedance is prevented in the 1 in 20 annual chance event.

Similar constraints around moving services that cross the culvert would remain. Jetting out of the existing culvert prior to relining would increase the risk of instability. Relining the culvert is a costly option and initial high-level appraisal suggests that the costs would be much higher than the flood damages avoided by such a scheme. On this basis, this option is unlikely to be viable.

11.2.3 Appraise the feasibility of building a parallel culvert

Another option would be to leave the existing culvert and build a parallel relief culvert. This could potentially convey the highway drainage for instance, reducing the flows entering the

main culvert and potentially combined sewer and has the potential to reduce flooding. The model shows that this could have a similar impact to enlarging the culvert.

However, this would not improve the very poor condition of the existing culvert. Space within the highway may also be a constraint. Taking this forward would also involve significant, lengthy disruption to the road through the village. A full survey of below ground services would be required and the presence of services would influence the cost. Building a parallel culvert is a costly option and initial high-level appraisal suggests that the costs would be much higher than the flood damages avoided by such a scheme. On this basis, this option is unlikely to be viable.

11.2.4 Appraise the feasibility of enlarging short sections of the culvert

Generally, the Main Street culvert is 600mm in diameter but there are a number of sections where the pipe size is smaller. These have been identified by the CCTV survey, and are likely to be where the culvert has been replaced during repairs or building work. In particular there is a short section at the downstream end, close to the outlet, where the culvert enters parallel 300mm and 150mm pipes, which forms a constriction. There are further constrictions at the upstream end of the village.

Replacing short sections would be much more cost effective, and less disruptive, than replacing the whole culvert. It is unlikely that this would have prevented flooding during the 23 December event, but flood levels would have receded at a quicker rate due to the improved conveyance in the culvert, and impacts would have been reduced.

11.2.5 Targeted repairs to culvert

It should be possible to carry out targeted repairs, relining or clearing debris from the most problematic sections of the culvert.

At the time of writing, a high-priority scheme is already being developed by Transport for Buckinghamshire to address the immediate safety concerns relating to the poor structural integrity of sections of the main culvert. The scheme will also clear blockages comprising masonry bricks and roots, where possible. It is beyond the remit of this investigation to provide further information on this developing project – Transport for Buckinghamshire may be able to provide further information.

Table 11-1: Summary of options for culvert improvements

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Short-term targeted repairs to culvert to stabilise damaged sections and clear blockages of masonry and roots where possible	Buckinghamshire Council (TfB)	9	Recommended	In progress
Appraise the feasibility of enlarging short sections of the Main Street culvert	Buckinghamshire Council (TfB and LLFA)	8	Recommended for further investigation of feasibility	1 - 3 years
Appraise the feasibility of enlarging the Main Street culvert	Buckinghamshire Council	2	Unlikely to be cost-beneficial	3 – 5 years
Appraise the feasibility of building a parallel culvert in Main Street culvert	Buckinghamshire Council	1	Unlikely to be cost-beneficial	3 – 5 years
Appraise the feasibility of replacement of the Main Street culvert (same size)	Buckinghamshire Council	0	Unlikely to be cost-beneficial	3 – 5 years
Appraise the feasibility of relining the Main Street culvert	Buckinghamshire Council	1	Unlikely to be cost-beneficial	3 – 5 years

11.3 Appraise the feasibility of providing flood attenuation upstream

Incorporating flood attenuation upstream of Gawcott could slow down surface water flows and reduce the impacts of flooding in the village. This could include the use of distributed Sustainable Drainage Systems (SuDS) such as basins and ponds to temporarily store flows during extreme events and reduce the impact of these events on the existing drainage system, including the culvert.

There are several flow paths into the village, so in this case a single flood attenuation area is unlikely to capture enough water to make a significant improvement. A scenario with three small storage areas located on the main flow paths into the culvert was tested in the model for the 1 in 10 annual chance design event (the magnitude of event in which the culvert is predicted to be exceeded). In this scenario the additional storage did not prevent the culvert capacity from being exceeded, due to the volume of rainfall falling on the highways and other parts of the catchment. Optimum design for storage options could be investigated further as part of a feasibility study.

An attenuation option alone would not address the problem of the condition of the culvert under Main Street. It is likely to be a relatively costly option due to construction costs and the need to undertake surveys and feasibility studies. Land ownership and optimum location of storage features could also be a potential constraint.

Table 11-2: Recommendations for flood attenuation

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Appraise the feasibility of providing attenuation upstream	Buckinghamshire Council	7	Recommended for further investigation of feasibility	3 – 5 years

11.4 Appraise the feasibility of utilising Natural Flood Management techniques

Natural Flood Management (NFM) techniques could be used to retain water and attenuate flows that could otherwise contribute to flooding in Gawcott. Installation of features such as leaky dams and large woody debris in watercourses could mitigate flood risk and improve the capability of the culvert to manage more extreme events. Leaky dams are NFM measures in the form of wooden barriers that can be placed within a watercourse to restrict flows and filter silt and soil from flowing down the catchment watercourse. There may be the potential to install NFM measures upstream of the culverts, on flow paths to the east of the village.

NFM measures can be utilised in farming and general land management without large disruptions, as they can be delivered without significant land take and can be incorporated as an extension to existing land drainage. They also bring multiple benefits for biodiversity and water quality and have a lower carbon footprint than traditional 'engineered' flood risk management solutions.

A more detailed study to determine the opportunities for and benefit of NFM measures would need to be undertaken and the permission would need to be sought from the relevant landowners, in addition to ordinary watercourse consent from Buckinghamshire Council as LLFA. Engagement with landowners to develop and obtain approval for such measures, even where landowners are receptive, can be a lengthy process.

The Parish Council could seek technical support or grant funding from local charities and organisations (e.g. Catchment Based Approach) specifically created to help with catchment management and flood recovery, in order to deliver smaller-scale NFM interventions, such as storage bunds, ditches, and hedgerow planting.

However, it should be noted that the benefits of NFM tend to be greatest in smaller, more frequent events. NFM measures would have been unlikely to have had a significant impact on larger events, such as the flooding experienced during the December 2020 event. An NFM option alone would not address the problem of the condition of the culvert under Main Street.

Table 11-3: Recommendations for natural flood management

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Appraise the feasibility of providing natural flood management upstream	Buckinghamshire Council	8	Recommended for further investigation of feasibility	3 – 5 years

11.5 Community flood resilience

A community approach to resilience can significantly increase residents' ability to prepare, respond, and recover from floods in the future, and so reducing the impact of flooding on the community. Residents (with support from Gawcott with Lenborough Parish Council, the Environment Agency and Buckinghamshire Council) could form a local community Flood Action Group with the aim of increasing the community's resilience to flooding. Buckinghamshire Council[9] and the National Flood Forum[10] have resources to assist communities with planning and preparing for flooding,

It is recommended that a community Flood Plan[11] be developed to inform residents how to prepare for, respond to and recover from flooding.

The Flood Action Group could also create a 'flood preparedness' information pack for existing and future residents in the area. The pack may contain advice on taking out contents' insurance on belongings, property resistance and resilience measures and a checklist of what to do in the event of a flood. This may help to give reassurance to residents on what can be done in the event of another flood and minimise future loss of belongings and damage to properties.

The Flood Action Group can help share information and provide support during an event. Emergency flood packs may also be created to use during a flood and once established, the group could apply for community group funding to purchase communal flood protections measures (such as sandbags, inflatable barriers etc) that can be deployed to areas at risk during an event.

Table 11-4: Recommendations for community flood resilience

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Form a Flood Action Group	Community / Gawcott with Lenborough Parish Council	8	Recommended	<1 year
Create a community flood action plan and formalise any existing arrangements	Community / Gawcott with Lenborough Parish Council	8	Recommended	<1 year
Prepare a "flood preparedness" information pack for current and future residents	Community / Gawcott with Lenborough Parish Council	8	Recommended	<1 year

9 Working with your community: https://www.buckscc.gov.uk/services/environment/flooding/how-to-deal-with-a-flood/working-with-your-community/

10 National Flood Forum: https://nationalfloodforum.org.uk/working-together/communities/what-is-a-flood-action-group/

11 Community flood plan template - GOV.UK (www.gov.uk)

11.6 Property Flood Resilience

Responses and discussions with residents indicate that water entered many properties in Gawcott through multiple points including the front and rear doors of properties and in one case backing up through the toilets of a property.

Property Flood Resilience (PFR) can provide effective products and measures, at an individual property level to reduce the impact of future floods, by either aiming to limit water entry in the first place (resistance) or by adapting the internal fabric of the property to limit damage (resilience) if flooding does occur. Resistance measures can include flood doors, flood barriers, automatic airbricks and non-return valves. Resilience measures include raising electrics, using porous plaster, and fitting solid floors or tiled floor coverings instead of carpets.

Although resistance measures are not able to entirely prevent flood water ingress, they aim to limit damage and ensure properties are adapted to cope with the impacts of floods and recover quickly from these disruptive events.

PFR can either be taken forward as a community-wide scheme by a lead organisation such as Buckinghamshire Council, or privately by individual property owners. It should be noted that taking forward a community wide Property Flood Resilience scheme at Gawcott is likely to be reliant on securing grants from central government to fund the project (see Section 11.1). It would be considered as an option alongside any appraisal for a capital flood schemes. Further work will be required to assess the suitability of the properties for installation of Property Flood Resilience measures, costs/benefit of the proposals, and consideration will need to be given to the timing and availability of funding.

Individual property owners at risk of flooding may wish to consider installing PFR products and making their properties more resilient on a private basis[12]. Before any products are fitted, an independent PFR survey should be commissioned to identify the points of ingress and recommend appropriate measures[13]. Kitemarked PFR products should be supplied and installed by an approved supplier, to ensure the efficacy and reliability of the PFR measures.

Table 11-5: Recommendations for property flood resilience

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Investigate opportunities for installing PFR: a. Privately, by individual residents b. Community-wide scheme	a. Property owners b. Buckinghamshire Council	10	a. Recommended b. Further investigation of feasibility	1-5 years

12 The Homeowners' Guide to Flood Resilience' (https://www.knowyourfloodrisk.co.uk/sites/default/files/FloodGuide_ForHomeowners.pdf) aims to inform homeowners about how to reduce flood risk to their homes and the variety of PFR methods available. It also includes contact details for surveyors/providers of Kitemarked flood protection equipment.

The National Flood Forum provide a webpage and guidance leaflet for homeowners on the steps towards installing their own PFR measures, and a tool to provide indicative costs of measures at: https://nationalfloodforum.org.uk/about-flooding/reducing-your-risk/protecting-your-property/

13 The Blue Pages, a directory for flood risk reduction services provided by the National Flood Forum, list a number of companies who may be able to undertake such individual flood risk surveys: https://bluepages.org.uk/listing-category/surveys-building/.

11.7 Disconnecting roof water drainage

Disconnecting existing rainwater downpipes and redirecting surface water runoff into SuDS planters, rain gardens, above ground water butts or underground rainwater harvesting tanks, could relieve pressure on the existing Main Street culvert and provide sustainability benefits as a result of water re-use.

Rainwater can be reused for non-potable purposes such as gardening, toilet flushing and car washing with water butts, which can significantly vary in size. They can be provided in a variety of shapes and incorporated into a variety of settings. Rainwater harvesting tanks are typically larger and stored underground with a pumped supply for water re-use. As their capacity is dependent on the re-use of water, both systems should be designed with an overflow to discharge excess water through infiltration or discharge to a downstream drainage component.

In principle any disconnection of roof water drainage from entering the surface water culvert that can be done within the village by individual householders, should be encouraged as part of community resilience actions as a small-scale quick win. Opportunities can be taken as part of renovations for example. However, it is only likely to have an impact in small, frequent events.

Table 11-6: Recommendations for disconnecting roof water drainage

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Take opportunities to disconnect or slow down roof water drainage	Property owners	5	Recommended as opportunities arise	1-3 years

11.8 Channel maintenance

Some residents in Gawcott expressed concern that the condition of the channel of the ordinary watercourse and ponds downstream of the culvert outlet may have increased the impacts of flooding in December 2020.

However, observations by residents during the December 2020 event also suggest that the culvert outlet was running freely and not submerged (see also Section 8.1.2). Water levels in the open channel were observed to be only one-third to one-half full. The modelling carried out by this investigation has shown that the water levels in the culvert are controlled by the culvert capacity throttling flows rather than downstream water levels in the open channel. Therefore, we do not believe the condition of the channel was a factor in the flooding that occurred in December 2020.

It is therefore recommended that the current maintenance regime as agreed with riparian owners (see Section 5.3.2) is appropriate.

Table 11-7: Recommendations for channel maintenance

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Continue with agreed maintenance regime of downstream ordinary watercourse and ponds	Riparian owners	4	Recommended	<1 year

11.9 Highway maintenance and works

Blockage of highway gullies has been noted as a contributing factor to the severity of flooding in both this event and previous events. The gullies are currently cleaned on an annual basis by Transport for Buckinghamshire. Increasing the frequency of gully cleansing would reduce the risk of blockage. This is likely to have a positive impact in smaller magnitude events on access and egress and flooding from vehicle wash.

Modelling showed that increasing the number of highway gullies would also alleviate highway flooding in smaller magnitude events. However, this option would only be effective when the culvert has capacity to drain away the water. Therefore, it would not have prevented flooding during the December 2020 event. Based on the current condition of the culvert, it would have a positive impact in events smaller than the 1 in 10 annual chance event. Transport for Buckinghamshire could consider installing more gullies, or taking opportunities to incorporate this into future highway works to help with lower order, nuisance flooding.

Table 11-8: Recommendations for highway maintenance and works

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Consider increasing the frequency of gully cleansing	Buckinghamshire Council	8	Recommended	<1 year
Consider increasing / improving highway drainage	Buckinghamshire Council	4	Recommended	1-5 years

11.10 Investigating foul misconnections

Although sewage pollution is not within Buckinghamshire Council's remit as the Lead Local Flood Authority, the Council is aware that there have been local concerns about recurrent sewage contamination of the open watercourse alongside Preston Road, downstream of the culvert outlet, for a number of years. JBA and LLFA staff themselves noted detritus from foul sewage surrounding and within the watercourse during the site visit on 6 May 2021, which indicates foul flows have entered the watercourse. The LLFA is also aware that there have previously been some investigations by Anglian Water and the Environment Agency into the source of the contamination, without resolution to date.

In the interests of moving this forward, the Council's survey of the condition and capacity of the surface water culvert also sought to identify possible sources of contamination. The survey indicated potential direct foul misconnections[14] from domestic properties into the surface water culvert.

The Council has highlighted these findings to Anglian Water and the Environment Agency as it is within their remit to investigate such issues further and outline potential options to disconnect from the surface water culvert. As of the time of writing (February 2022), Anglian Water will be undertaking further onsite investigations in the coming weeks. Resolving these misconnections could improve water quality.

Table 11-9: Recommendations for investigating misconnections

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Investigate foul misconnections between domestic properties into surface water culvert	Anglian Water	7	Recommended	<1 year

[14] A "misconnection" is where wastewater is incorrectly released into watercourses or a surface water drainage system intended for rainwater, rather than into a foul/combined sewer that would take wastewater onwards to a sewage treatment system.

12 Conclusion

The flooding that occurred in Gawcott on 23 December 2020 led to the internal flooding of 13 residential properties, as well as Gawcott Methodist Chapel. A further 4 properties experienced external flooding to gardens or outbuildings. Buckinghamshire Council, as the Lead Local Flood Authority for Gawcott, has exercised their power to undertake a Section 19 investigation as this fulfilled its criteria of 'significant flooding'.

The total rainfall during the 23 December storm event had a 11% chance of occurring in any one year (return period of 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.

A surface water model was developed, in InfoWorks ICM, to better understand the flood risk of Gawcott. Full details on the model development and results are in the Modelling Technical Note.

The predominant source of the flooding was due to the exceptional combination of extreme rainfall falling on a saturated catchment. This resulted in rapid surface water runoff and increased flows into sewers, highway drainage systems and watercourses, including the culverted watercourses in Gawcott. The main culvert under Main Street surcharged, backing up through highway drainage and manholes. The highway gullies themselves were unable to discharge due to the culvert being overloaded.

Furthermore, it was noted on the site visit that drainage systems in Lenborough Road opposite the playing fields, have restricted outlets. During the event surface water runoff would back up leading to additional surface water flooding from manholes in the playing fields, this would have followed the topography, flowing down Hillesden Road and onto Main Street, contributing to the flooding experienced during the event. It was also noted that a large number of gullies were blocked which would have restricted the volume of water entering the drainage system.

Main Street, the main access road in Gawcott was impassable during the event and highway flooding was significant. Where there was internal property flooding, this resulted in significant property damage, with residents forced to temporarily move out of at least one property, and a number of others reporting significant damage. The flooding also caused damage where outbuildings such as garages were flooded. Mental health impacts were also reported and a number of residents were left concerned over the impacts of climate change and the possibility of flooding occurring in the future.

A high-level appraisal of possible flood risk management options has been undertaken (Section 11), which includes consideration of measures such as culvert improvements, flood storage, property flood resilience, community resilience and disconnecting roof drainage. A summary is given in Table 12-1.

Doing nothing was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Gawcott. The options which scored the highest were those that could ultimately result in a more resilient community.

- Form a community Flood Action Group and community flood resilience actions
- Investigate opportunities for installing Property Flood Resilience
- Targeted repairs to culvert to stabilise damaged sections and clear blockages, where possible

At the time of writing, a scheme is already being developed by Transport for Buckinghamshire to address the immediate safety concerns relating to the poor structural integrity of sections of the main culvert. The scheme will also clear blockages comprising masonry bricks and roots, where possible.

In the longer term it is recommended that Buckinghamshire Council should carry out a full options appraisal to examine, in detail, the feasibility and cost-benefit of capital works –

particularly those that scored relatively highly in this appraisal, such as an upstream flood storage scheme, Natural Flood Management, a community PFR scheme, and enlarging short sections of the culvert. Taking this appraisal forward will be subject to finance and staff time being available. It should be noted that the other, larger-scale culvert improvement options outlined in Sections 11.2.1 through 11.2.3 to enlarge or reline the entire culvert, or install a parallel relief culvert, are unlikely to be found to be feasible or financially viable.

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 Anglian Water or Buckinghamshire Council in its functions as either the Lead Local Flood Authority or Transport for Buckinghamshire. See Section 11.1 for further information on the LLFA's project development process. The outcomes of these investigations may result in a more beneficial solution being identified.

Small-scale, quick wins such as disconnecting roof water drainage are also recommended.

Table 12-1: Summary of recommended actions at Gawcott

Recommended actions	Risk Management Authority/Stakeholder
Short-term targeted repairs to culvert to stabilise damaged sections and clear blockages of masonry and roots where possible	Buckinghamshire Council (TfB)
Form a Flood Action Group	Community / Gawcott with Lenborough Parish Council
Create a community flood action plan and formalise any existing arrangements	Community / Gawcott with Lenborough Parish Council
Prepare a "flood preparedness" information pack for current and future residents	Community / Gawcott with Lenborough Parish Council
Investigate opportunities for installing PFR	Property owners or community-wide scheme led by Buckinghamshire Council
Appraise the feasibility of capital works such as: • culvert improvement options such as enlarging key sections of the culvert • upstream flood attenuation • Natural Flood Management • community-wide PFR scheme	Buckinghamshire Council
Consider increasing the frequency of gully cleansing	Buckinghamshire Council (TfB)
Continue with agreed maintenance regime of downstream ordinary watercourse and ponds	Riparian owners
Take opportunities to disconnect or slow down roof water drainage	Property owners
Investigate foul misconnections between domestic properties into surface water culvert	Anglian Water
Consider increasing / improving highway drainage	Buckinghamshire Council (TfB)

Appendices

A FEH calculation record

B Hydraulic modelling report

C Multi-criteria analysis

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

This includes consideration of measures culvert improvements, flood storage, property flood resilience, community resilience and disconnecting roof drainage.

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 benefit-cost ratios

Options were given a relative score and recommendations made for further work to be carried out, or quick-win actions. Indicative timescales are given.

Contribute towards reducing flood risk 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
Contribute towards reducing flood impacts on people/communities	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 criteria 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
	-1	
	0	Not known/not applicable
	1	
	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 compelted as part of existing maintenance routines
	2	No active maintenance required (passive maintenance designed)
Timescale (for info only)	High level assessment of timescales.	
	-2	Long term strategic aim (>10yrs to progress, funding route unclear)
	-1	
	0	Likely to be able to progress in next 1 - 5 yrs e.g. through FCERM partnership funding programme
	1	
	2	Quick win (<1yr), BC able to fund directly
Benefit cost	High level assessment of benefit to cost ratio	
	-2	Strong negative BCR
	-1	
	0	Equal BCR
	1	
	2	Strong positive BCR

			1	2	3	4	5	6	7	8	9	10	11	
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	Benefit cost ratio	**TOTAL**
1	Do nothing	N/A	-2	-2	0	0	-2	0	0	0	2	0	-2	-6
2	Business as usual	All	0	-1	0	0	-1	0	0	0	0	0	0	-2
3	Replacement of existing Main Street culvert (same size)	Buckinghamshire Council	1	3	0	-2	1	0	0	0	0	-2	-2	-1
4	Replacement of existing Main Street culvert (enlarging)	Buckinghamshire Council	2	4	0	-2	2	0	0	0	0	-2	-2	2
5	Building a parallel culvert to Main Street culvert	Buckinghamshire Council	2	4	0	-2	2	0	0	0	-1	-2	-2	1
6	Removing all blockages and relining of existing Main Street culvert	Buckinghamshire Council	1	3	0	-2	1	0	0	0	0	-2	-2	-1
7	Targeted repairs to Main Street culvert	Buckinghamshire Council	1	3	0	2	2	0	0	0	0	2	1	11
8	Enlarging small sections of Main Street culvert	Buckinghamshire Council	1	3	0	1	2	0	0	0	0	1	1	9
9	Property Flood Resilience (PFR)	Property owners	2	4	0	1	1	0	0	0	0	0	2	10
10	Community flood resilience	Gawcott Parish Council/ Community	0	4	0	1	2	0	0	0	0	2	1	10
11	Upstream flood storage scheme	Buckinghamshire Council	1	3	0	-1	2	2	0	0	0	-1	0	6
12	Natural Flood Management	Buckinghamshire Council	1	2	0	-1	2	2	0	1	0	0	1	8
13	Investigation of mis-connection between combined sewer and the culvert	Anglian Water	0	0	2	1	2	2	0	0	0	0	0	7
14	Disconnecting roof water drainage	Property owner with support from Anglian Water	0	1	0	1	1	1	1	0	0	0	0	5
15	Increasing/improving highway drainage	Buckinghamshire Council	0	2	0	0	2	0	0	0	0	1	0	5
16	Continue maintenance downstream of Main Street culvert	Riparian owners	0	0	0	2	2	0	0	0	0	2	0	6
17	Consider increasing the frequency of gully cleansing	Buckinghamshire Council	1	3	0	2	2	0	0	0	-1	2	1	10

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