COTSWOLD DISTRICT COUNCIL

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Review and Response to the Summer 2007 Floods in the Cotswold District

Second Phase Report

25 July 2008

Report no: 0002-NE02933-WXR-04

Hyder Consulting

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Second Phase Report

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Glossary

Attenuation storage – Temporary storage required to reduce the peak discharge of a flood wave. This is by an increase in duration of increased flow. Also known as **Flood storage**.

Catchment – A defined area, often determined by topographic features or land use, within which rain will contribute to runoff to a particular point.

Drainage – A collection of pipes, channels and other engineering works designed to convey storm water away from a built up environment.

Flood plain – An area of land over which river water is stored in times of flood.

Fluvial – Relates to rivers e.g. fluvial flooding- flooding from river water.

Extreme Event – Single occurrence of an event that is likely to occur infrequently (e.g. big storm of long drought).

Gully – A structure to permit the entry of surface runoff into the sewer system. It is usually fitted with a grating and grit trap.

Hydraulic Modelling – A series of mathematical equations in a computer, developed and used with the aim of replicating the behaviour of a system.

Impermeable surface – Surface which resists the infiltration of water.

Main River – Large streams and rivers but also include smaller watercourses of strategic drainage importance. The Environment Agency's powers to carry out flood works apply to main rivers only.

Mechanism – in the context of this report, mechanism relates to the action or process that contributes to the effect of flooding.

Outfall - The point, location or structure where wastewater, drainage discharges from a pipe, channel, sewer, drain or other conduit.

Riparian Owner – Any person who owns property (i.e. land) alongside a natural watercourse. Under common law they possess rights and responsibilities relating to the stretch of the watercourse which falls within the boundaries of the property.

Run off – Water from precipitation which flows off a surface to reach a drain sewer or receiving water.

Surcharging – Combined and rainwater sewers are designed to surcharge (i.e. the water level in the manhole rises above the top of the pipe) in heavy rainfall. Some foul sewers also receive rainwater and therefore surcharge.

Sustainable Urban Drainage Systems (SUDS) - Are designed to control the quantity and improve the runoff from a development. SUDS manage

runoff as close to the source as possible and include techniques such as permeable paving, swales, ponds and wetlands.

Swale – The term given to a grass channel for storm water collection with shallow side slopes and which is normally dry except during rainfall.

(Defra/Environment Agency, 2004)

List of Abbreviations

CDC - Cotswold District Council

EA - Environment Agency

GCC – Gloucester County Council

SUDS- Sustainable Urban Drainage Systems

1 Introduction

The devastating floods that hit Gloucestershire on 20 July 2007 affected many people and businesses across the Cotswold District. The District Council is still dealing with the aftermath of the flooding and has sought assistance to establish the extent and causes of the problems and to identify and prioritise remedial works as appropriate.

During the Phase one report published in February 2008 flood affected locations were identified and priority given to the locations where the estimated number of properties flooded in the Summer 2007 were the highest. From this a 'top 20' list of areas was identified for further investigation. This second phase documents the investigation and response for the 'top 20' sites in detail.

Phase two has been primarily informed by local residents and councillors through workshops and site inspections. Subsequent to this we have also met with key staff at CDC, GCC and the EA to incorporate their individual findings to form a comprehensive representation of the mechanisms and recommendation for each location.

The information provided by the local residents, site inspections and reports from EA and GCC has been used to assist in identifying remedial options to alleviate flooding in the future. The remedial options have been prioritised depending on the holistic importance of the option i.e. where hydraulic modelling of the watercourse is required this has been given high priority as subsequent recommendations will depend on the results of the modelling.

1.1 Project Scope

Subsequent to the completion of the first phase flood review, a detailed investigation has been undertaken for the second phase over the following scope of works:

- Site investigations at each of the top 20 sites
- Workshops with Ward Councillors, Parish Councillors and local residents at each of the top 20 sites
- Discussions with CDC staff
- Discussions with GCC and EA to coordinate a response
- Remedial options identified and prioritised
- Production of maps and a report summarising the findings at each site

1.2 Environment Agency Floods Review

The Environment Agency has investigated both the causes of the Summer 2007 floods in the Cotswold District and options for flood risk management.

Its findings are presented in four separate reports, each covering a different area of the District; these are summarised below (refer to Section 6 for full references to the reports). Findings common to all reports include the need to raise public awareness of both the Environment Agency's Flood Warning Service and riparian rights and responsibilities, as well as promote flood proofing of properties.

Upper Cotswolds

This report covers the settlements of Moreton-In-Marsh and Bledington, plus five other villages which lie outside the District. Although it concludes that there is no economic justification for any major flood alleviation works, the report does identify a number of small-scale works which the Environment Agency plans to carry out, including:

- Installation of a new flood warning gauge on the River Evenlode
- Replacement of the trash screen in Moreton-In-Marsh, with responsibility for future clearance to be taken up by Cotswold District Council
- Investigate the possibility of lowering the bed of the River Evenlode.

Lower Cotswolds

The Lower Cotswolds Floods Review focuses on Bourton-on-the-Water, Naunton and Lower Slaughter (plus Burford which lies outside the District). The report suggests seven options for improvement, including:

- In Bourton-on-the-Water, the Environment Agency will investigate the potential benefits and costs associated with creating flood storage areas
- In Naunton, the report recommends that Cotswold District Council, the Parish Council and landowners consider options for creating formal attenuation upstream of the Dovecote sluice.

Fairford, Whelford, Kempsford and Lechlade

This report provides detailed information on the characteristics of the River Coln catchment and considers a range of flood risk management options in each of the locations covered. In particular, the report appraises five options for Fairford (do nothing, do minimum, defences, upstream storage and dredging). It concludes that flood defences to the rear of Milton Street and along the left bank downstream of Town Bridge is the preferred option.

River Churn and Ampney Brook

The review includes the communities of Cirencester, and other villages on the River Churn and its associated tributaries. The area reviewed in Cirencester reviews several more areas than those covered in this report. It does also concentrate on an area Watermoor slightly north of the area

documented in this report. In addition to the existing strategy recommendations, further flood mitigation measures are recommended for Cirencester. It also documents issues associated with surface run off, ordinary watercourse drainage, the sewerage system, pumped sewerage systems, highway drainage and main rivers mitigation measures.

2 Methodology

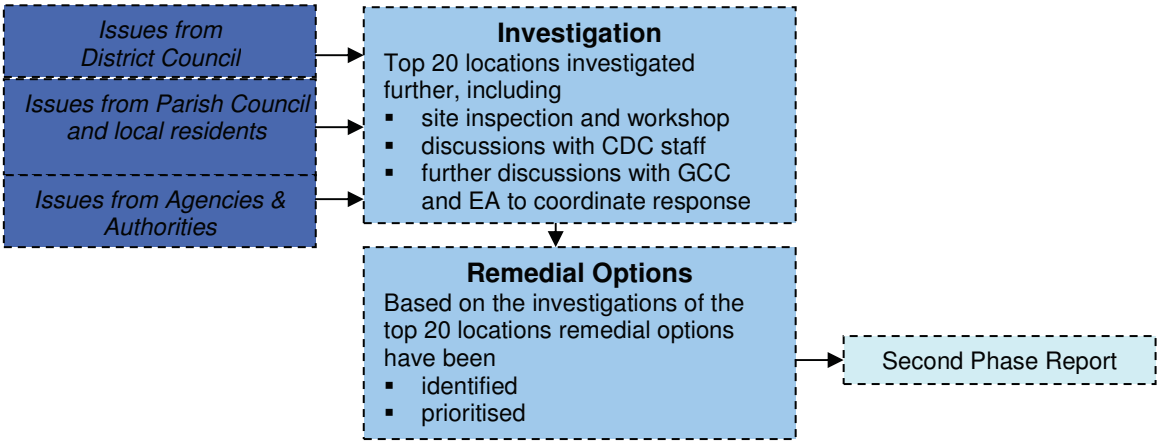
The 'top 20' sites identified in phase one required further investigation to identify both the causes of the flooding and the required mitigation. Site visits to each of the 'top 20' was undertaken to get a full appreciation of the potential sources of flooding and identify suitable mitigation measures, locations and any impediments.

A number of the local parishes have formed their own flood forums which have produced reports summarising the events and sequence of flooding in the summer. It is important that the community were involved in this second phase to not only capture this local knowledge but engage them in the work that CDC is undertaking. Therefore Ward Councillors and Parish Council Clerks were approached to offer local representatives the opportunity to attend workshops and inspections at each of the villages.

Subsequent to these site inspections and workshops Hyder met with CDC, GCC and EA staff to draw on their experience from the flooding of last summer together with historical references and works. The works program from GCC was incorporated and the three reports prepared by EA since the floods were reviewed and committed actions incorporated into the mitigation recommendations were appropriate.

These actions were then broadly prioritised within each site to inform each agency of their recommended responsibilities and action. This priority not only considered the number of sites flooded in an area but the frequency of flooding, ease and value that a mitigation measure can provide.

Figure 1 –Methodology Flow Diagram for Phase Two



3 Investigation Results

At all but one site there was at least one representative which attended the workshop and site inspection to inform our works, with the majority of areas represented by an enthusiastic and well informed team of local representatives who were generous with their time and knowledge. The remaining site we were able to review retrospectively in our office with one local resident. This information greatly assisted us in developing an accurate description of the flooding mechanisms at each of the villages.

In some villages flood response groups have formed to gather information and expertise from their local communities to assist in the development of emergency planning and mitigation works. Some of these groups are already progressing with various elements of a flood response strategy. For example the Fairford Flood Response group are developing an emergency response plan which will incorporate specific flood responses for a future emergency. Weston-sub-edge have formed the Riparian Owners Society to identify and assist riparian owners in improving the management of watercourses and ditches in the community. CDC is assisting both of these groups with time and resources so that each of these schemes can be used as a trial and rolled out across the district (where appropriate).

These local responses have been built into the mitigation recommendations together with our findings and those of other organisations such as GCC and the EA. GCC have two works programs, one program for more complex projects that require detailed investigation, the other program are more straightforward investigation and rectification projects. The EA have prepared four reports which cover the Cotswold District, each documenting what they understood to have occurred and their recommended responses. Both these organisations were enthusiastic about collaborative approaches and encouraged CDC's intention for inter-agency cooperation. GCC has a separate budget allocated to joint projects and EA have also identified where their modelling team may be able to assist with resources and/or funding in the development of 1 and 2-D models for the villages.

Our investigations are summarised below in Table 1. Comprehensive documentation and explanation of the flooding mechanisms and mitigation recommendations for each of the top 20 sites is presented in the Appendices.

Table 1 - Summary of Flooding Mechanisms and Recommendations.

No.	Location	Flooding Types Identified	Modelling Required?
1	Moreton-in-Marsh	Surface water (sewers and roads), river.	Y
2	Chipping Campden	Surface water (roads/drains), river.	Y

3	Bourton-on-the-Water	Surface water (foul sewer, fields and roads), river.	Y
4	Lechlade	Surface water (roads and fields), river.	
5	Fairford	Surface water (roads, sewers), river and groundwater.	Y
6	Willersey	Surface water (sewers), river.	
7	Whelford	Surface water (drains, roads), river.	
8	Cirencester - Watermoor	Surface water (roads/drains)	
9	Naunton	Surface water (roads/drains, foul sewer), river	Y
10	Poulton	Surface water (roads/drains, foul sewer, fields) river.	
11	Lower Slaughter	Surface water (fields, roads), river.	
12	Andoversford	Surface water (roads, foul sewer), river.	Y
13	Barnsley	Surface water (fields and drains)	
14	Northleach	Surface water (roads, fields), river.	
15	Southrop	Surface water (drains)	
16	Weston-sub-Edge	Surface water (drains), river.	Y
17	Eastleach	Surface water (fields and roads), river and groundwater.	
18	Aldsworth	Surface water and river.	
19	Cirencester - Chesterton	Surface water (roads, fields, foul sewer)	
20	Bledington	Surface water and river.	

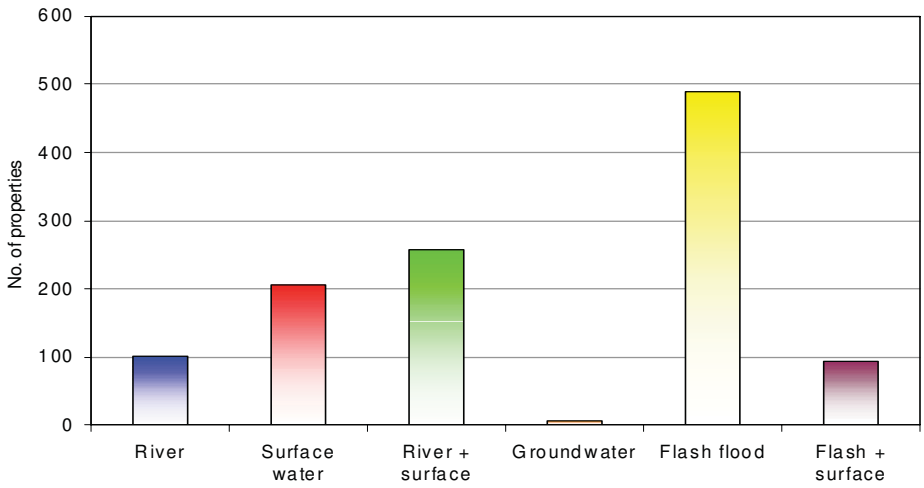
4 Flooding Responses

Detailed recommendations for reducing flood risk in each of the top 20 locations are given in the Appendices. More general information, applicable District-wide, is presented below.

4.1 Surface Water Runoff

Surface water runoff was a defining feature of the Summer 2007 floods. Two-thirds of the property flooding incidents in England and Wales as a whole were caused by surface water (Environment Agency, 2007). In the Cotswold District, 40 per cent of respondents to the Council's flood assessment questionnaire reported that their property had been flooded by this source (Figure 2). However, it is likely that a number of the reports of flash flooding also relate to surface water.

Figure 2 - Type of flooding reported by respondents to Cotswold District Council's flood assessment questionnaire



Surface water runoff occurs when the rainfall rate exceeds the infiltration rate of the ground. The infiltration rate is influenced by a number of factors, including soil type and wetness, topography and land use. Both the Environment Agency (2007) and Pitt (2007) highlight increased urbanisation as a key cause of the surface water flooding in Summer 2007. The impermeable surfaces of buildings, roads and pavements limit infiltration and, hence, increase the volume and rate of surface water runoff. Indeed, the Government's Foresight Project (OST, 2004) on flood and coastal defence reports an approximate linear relationship between the increase in the area of impermeable surfaces and the increase in the rate and volume of surface water runoff.

This relationship between impervious area and runoff is well recognised in the UK and overseas with the more progressive authorities instating

measures and conditions on new developments to combat this. Such measures include the provision of on-site detention conditions or maximum percentage imperviousness. SUDS is one measure being promoted within the UK to assist in managing surface water runoff. SUDS should be promoted within the Cotswold District as part of an appropriate development response.

4.2 Rural Land Management

In the Cotswold District, agricultural land was also a major source of runoff in the Summer 2007 floods, leading to surface water flooding in 13 of the top 20 locations. The impact of changing agricultural practices on flood generation was a common concern expressed by the Parish Councillors and local residents at the workshops. Since the Second World War, the agricultural landscape of the United Kingdom has changed dramatically, with the removal of hedgerows and the creation of larger fields, the use of heavier machinery and overstocking. These changes all have the potential to increase surface water runoff. Central Government recognises this problem and, as part of its Making Space for Water Programme[1], is undertaking research into the role of land use and land management in delivering flood risk management.

Field evidence suggests that rural land management can impact significantly on the generation of surface water runoff, at least at a local scale. For example, research at Pontbren in Mid Wales has shown that infiltration rates are up to 60 times higher under young native woodland compared to grazed pasture (Bird *et al*, 2003); further information on this case study is given in Box 1 below. However, agricultural land in the Cotswold District is also transitioning from farms of extensive areas and fields to much smaller farming parcels often managed by less experienced owners. Knowledge of farming practices is unfortunately not transferred and traditional practices such as ditching and fencing, and soil and riparian management are not being employed.

Research into the impacts of rural land management on flood risk at a catchment scale is in its infancy and further work is needed to improve scientific understanding (Halcrow, 2008). Therefore, it is suggested that CDC consider, with the support of local farmers, opportunities for a research study to be conducted on land within the District. This would provide the potential for flood risk reduction, whilst placing the District at the forefront of research into sustainable flood risk management. It is also recommended that the Council promotes the Government's Environmental Stewardship scheme, which provides funding to farmers and other land managers who deliver effective environmental management on their land,

[1] The Making Space for Water Programme was launched in 2004 to develop a new strategy for flood and coastal erosion risk management in England (Defra, 2008[i]). Developing sustainable approaches to flood risk management is central to this Programme

including flood management (Defra, 2008[ii]). Further information on this scheme is available at

http://www.defra.gov.uk/erdp/schemes/es/default.htm.

Box 1 – The Pontbren group

The Pontbren group comprises 10 families who farm 1000 ha in the upper reaches of the River Severn. The farmers have come together to develop a more sustainable approach to farming. They are planting more trees, reducing stocking rates, protecting stream banks and restoring wetlands. Of particular interest is the establishment of small strips of trees, known as 'shelter belts', which provide shelter for sheep. The farmers noticed that these shelter belts seem to reduce the amount of rainwater flowing over the land. They asked the Centre for Ecology and Hydrology (CEH) and the University of Wales Bangor to investigate this phenomenon.

CEH took soil measurements in the sheep-grazing pastures and in the enclosed tree shelter belts. Preliminary results suggest that rainwater enters the soil at a greater rate in the areas planted with trees compared to the grazed areas. This implies that small areas of woodland, strategically placed within the catchment, could, in conjunction with other sustainable farming practices, slow down the flow of water into local streams and, hence, reduce flood risk. Research is currently taking place to investigate this further and to establish its impacts at catchment level.

(Source – Environment Agency, 2005)

4.3 River Maintenance

There is a wide held belief among the general public that a lack of river maintenance played a major role in the extent of the Summer 2007 floods. In the Cotswold District, poor maintenance has been reported in 35 of the 79 towns and villages flooded in July 2007, and strong concerns about the impact of river maintenance on flood generation were expressed at all 20 workshops. In recent years, the EA has reduced the scale of its river maintenance works in rural areas, in part due to a lack of funding, but also because channel desilting and dredging were found to make little improvement to channel conveyance in the long term (EA, 2007). Indeed, computer modelling undertaken by the EA has shown that maintenance of rivers in Cheltenham would not have reduced the level of flooding experienced in the town in Summer 2007. This is because the volume occupied by weed growth, silt and other debris was insignificant compared to the volume of floodwater.

However, river maintenance can reduce the risk of flooding during events less extreme than Summer 2007. Therefore, Hyder recommend that CDC undertakes a campaign to raise awareness among riparian owners of their duties to maintain watercourses flowing through their land. Specific recommendations for improved maintenance in the top 20 locations are included in the Appendices. It is also suggested that computer modelling is undertaken to quantify the impact of river maintenance on flood risk for a range of return periods. This work could be undertaken as part of the

modelling required for individual villages (see Table 1 for a summary of these locations and the Appendices for further details) at little additional cost, and used to manage the general public's expectations of the flood risk management benefits of river maintenance as well as help target resources. Sections 4.3.1 and 4.3.2 are included below to assist with further information and references which could be utilised in CDC's awareness campaign.

4.3.1 Roles and Responsibilities

The workshops highlighted confusion among the general public over who is responsible for maintaining watercourses, roadside ditches and road gullies. Therefore, a summary of maintenance responsibilities is provided in Box 2 below.

Box 2 – Maintenance responsibilities

Main rivers

Definition - these are watercourses that have been designated by Defra on the basis of their strategic drainage importance

Operating authority – Environment Agency

Riparian owners (i.e. the owner of land bounding upon a river or other body of water) are responsible for maintaining watercourses that flow through their land. However, under the Water Resources Act 1991, the Environment Agency has permissive powers to maintain and improve main rivers, to ensure the efficient conveyance of flood flows and to manage water levels. It is important to note that the Environment Agency does not have a statutory duty to carry out these works, which are subject to funding

Ordinary watercourses

Definition - these are all watercourses (river, stream, ditch, drain, cut, dyke, sluice, sewer, except public sewer) that have not been designated as main river

Operating authority – Cotswold District Council

Riparian owners are responsible for maintaining watercourses that flow through their land. However, under the Land Drainage Acts 1991 and 1994, Cotswold District Council has permissive powers to undertake works on ordinary watercourses for flood alleviation

Road gullies

Definition – road gullies allow water to drain away from roads and pavements, and comprise a gully grating with gully pot underneath

Operating authority – Gloucestershire Highways

Gloucestershire Highways operates a programme to ensure that all gullies are cleared of leaves, litter, silt and debris at least once a year

Roadside ditches

The owner of the land adjoining the road is usually responsible for the maintenance of roadside ditches

(Sources – Environment Agency (2008)[i, ii]; Gloucestershire Highways (2008))

4.3.2 Riparian Guidance

A number of people at the workshops expressed an eagerness to undertake works relating to ditch clearing and bank maintenance but cited a lack of information or direction to assist them in doing appropriately. The EA have recently released a revised version of "Living on the edge". This document is now in its 3rd Edition and covers the following:

- Riparian owners rights and responsibilities. It also explains EA's role and that of other organisations with which riparian owners may need to work.
- Who is responsible for flood defences and what that means in practice.
- Shows how The EA can work together with other riparian owners to protect and enhance the natural environment of our rivers and streams.

(Source: http://www.environment-agency.gov.uk/subjects/flood/362926/)

This information should be tailored to suit specific villages in line with the detailed recommendations presented in the Appendices.

Box 3 – Responsibilities of Riparian Owners

- Development in the Flood Plain You have the responsibility to pass on flow without obstruction, pollution or diversion affecting the rights of others. Others also have the right to receive water in its natural quantity and quality.
- You must accept flood flows through your land, even if caused by inadequate capacity downstream. There is no duty in common law for a landowner to improve the drainage capacity of a watercourse.
- You must maintain the bed and banks of the watercourse, and also the trees and shrubs growing on the banks. You must also clear any debris, even if it did not originate from your land. This debris may be natural or man-made, and includes litter and animal carcasses. See 'Flood defence consents' link below for information on consent for these works. Your local authority can give you advice on the removal of animal carcasses.
- You must not cause any obstructions - either temporary or permanent - that would prevent the free passage of fish.
- You must keep the bed and banks clear of any matter that could cause an obstruction, either on your land or downstream if it is washed away. Please help us to protect water quality - do not use riverbanks for the disposal of any form of garden or other waste where there is any danger that it will be washed into the river. This includes grass clippings, which are highly polluting.
- You must keep any structures that you own clear of debris. These structures include culverts, trash screens, weirs and mill gates.
- You are responsible for protecting your property from water that seeps through natural or man-made banks. Where such seepage threatens the

structural integrity of a flood defence, we may wish to see that it is repaired.

- You must control any invasive alien species such as japanese knotweed. If you suspect such a species is present, please get in touch. We can advise you on how to manage and control these species.
- If you do not carry out your responsibilities, you could face a legal action.

(Source: Environment Agency website)

4.4 Fostering Self Help

A number of local communities in Cotswold District have adopted a practice of self-help as a response to the July 2007 floods. These communities are self motivated, keen and able to undertake some flood management works themselves and should be supported where ever possible by CDC, GCC and the EA. Key areas such as the development of Emergency Flood Response, ditch clearing and riparian management could be managed more affectively through the guidance and support of the local groups.

4.4.1 Emergency Flood Response

As mentioned earlier in the report. Fairford is initiating the Emergency Response Plan (ERP) as a trial for the Cotswold District area. At present it is intended to be a general plan to cover any type of emergency - terrorism and flooding. However, flooding emergencies require a very specific response with direction for structure operation (for weirs, sluices, penstocks etc) and locations for protection measures such as sand bags detailed. It is recommended that this ERP address flooding specifically before it is rolled out as a model to the rest of the Cotswold District where appropriate.

Other villages have begun to develop plans independently. Weston-sub-Edge Parish Council has undertaken a comprehensive review of the Summer 2007 floods and proposed that a flood warden scheme is set up to help the community work together to prepare for a flood event (see Smith, 2008). In Moreton-In-Marsh, a local resident has carried out an appraisal of ditch maintenance in the town, including visual inspections of 30 drains (see Dutton, 2008). Several flood committees have also been formed, for example, in Chipping Campden, Bourton-on-the-Water, Fairford, Lechlade, Naunton, Lower Slaughter and Whelford. Similar local action and self-help should be promoted across the District to ensure that communities are as prepared as they can be for any future flooding. In particular, they should be encouraged to produce community flood action plans, containing the following information (Environment Agency, 2008[iii]):

- Flood response procedures, including lines of communication
- A list of useful telephone numbers (e.g. Cotswold District Council, Environment Agency)
- Flood maps identifying vulnerable properties and residents

- Key community skills and equipment
- Emergency accommodation.

The Environment Agency has already sent a template for these plans to the Parish Councils of Bledington and Moreton-In-Marsh.

In addition, people who live and/or work in the District should be encouraged to register for the Environment Agency's Floodline Warnings Direct Service, where available. This is a free service that provides flood warnings direct to people at risk of flooding, as well as local authorities, the Emergency Services and the media, by telephone, mobile, fax or pager.

4.4.2 Flood Resilience

A range of flood resilient construction techniques can be employed to reduce the consequences of floodwater entering a building. These are summarised in Box 4 below. Flood resistant techniques, which prevent water from entering a building, are also available. However, these techniques are not recommended where the flood depth exceeds 600 mm, due to the risk of structural damage from the differential water pressure (Bowker *et al*, 2007). Detailed guidance on flood proofing new and existing buildings has been published by DTLR (available at http://www.environment-agency.gov.uk/commondata/acrobat/dtlr_guide.pdf) and CLG (available at www.floodforum.org.uk/improvingfloodresilienceofnewbuildings.pdf).

Box 4 – A list of some of the flood proofing techniques available

Flood resilient techniques

- Use water-resistant materials for floors, walls and fixtures (avoid the use of chipboard and MDF)
- Raise electrical wiring, electricity meters and consumer units, sockets, gas meters, boilers and ventilation equipment above the flood level

Flood resistant techniques

- Moveable flood protection barriers for doorways, low level windows and other openings
- Airbrick covers
- Anti-backflow valves on drains and sewers
- Flexible skirting systems (plastic skirting that encloses the bottom 600 mm of buildings)

5 Recommendations and Conclusions

Specific recommendations for each of the 20 sites investigated in the phase two works is included in the Appendices. Section 4 of this report also details general flooding responses and makes a number of recommendations, including:

- Incorporation of SUDS within new developments to offset the impacts of increased impervious areas;
- Investigation into the effects of rural land management practices and how the changes to farming practices since the Second World War has impacted runoff and erosion;
- Inclusion of the effects of river maintenance within the any model development to establish the impact of overgrown waterways on various storm events specifically targeting known pinch points;
- Improve awareness of owner responsibilities for maintaining watercourses, roadside ditches and roadside gullies;
- Support riparian management through the development of specific guidance;
- Support and foster self-help schemes across the villages to develop Flood Response Plans, flood resilience and community management of ditches;
- Continue to work with other agencies to support collaborative approaches where ever possible to develop whole solutions that address various issues to provide better value to the community

With climate change likely to increase the intensity of rainfall in the future it is imperative that CDC be both a support and guide to the local community as well as enabling mitigation works to improve the districts resilience to flooding. This future minimisation should also be done in conjunction with other authorities in a collaborative way with all agencies working toward the same end goal. This report identifies opportunities where CDC can both holistically manage flooding and provide a response within the district.

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Note: Further references are included in the Apendices.

Appendix 1

Moreton-in-Marsh – Site Response

Location 1 – Moreton-in-Marsh

Date of visit	23 April 2008
Attendees of the workshop	Councillor Ben Jeffrey, Robert Dutton, Jenny Harris and Colin Burford

1 Mechanisms

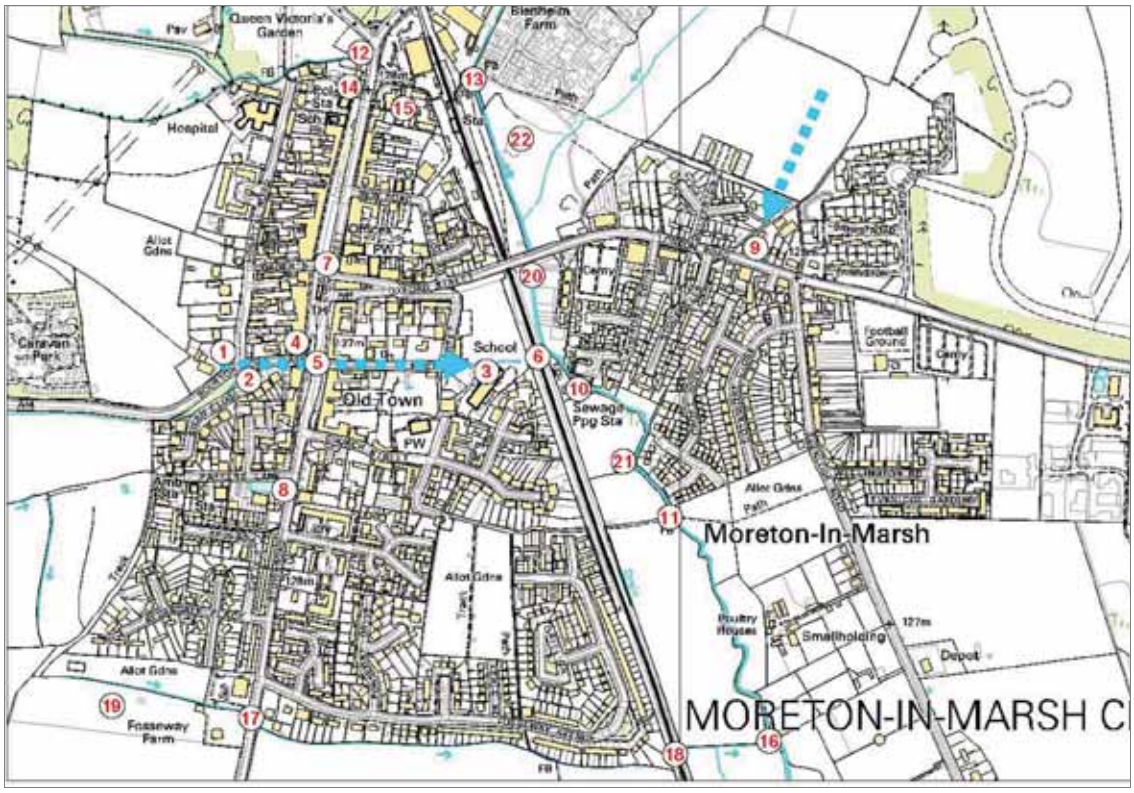
Summary

Moreton-In-Marsh suffered unprecedented flooding on 20 July 2007, with a reported 265 homes and businesses affected. The flooding occurred in three main stages:

1 Surface water run-off from Bourton-on-the-Hill caused flooding in the High Street and East Street;

2 The River Evenlode backed-up in Queen Victoria's Garden, before spilling out onto the High Street;

3 Backwater from a culvert, which carries a flood relief ditch under the railway line, flooded properties on Fosseway Avenue.



Description of Mechanisms
Surface water run-off
Photograph – View of Bourton Road, across the High Street, from East Street      Surface water run-off from Bourton-on-the-Hill is reported to have caused flooding problems in Moreton-In-Marsh for a number of decades. Ditches run along both the north and south side of Bourton Road (A44), before entering culverts near the junctions with Hospital Road and Swan Close (at **1** and **2**). The capacity of this drainage system has been overwhelmed on at least three occasions in the past ten years, with surface water flowing
from Bourton Road into the High Street and along East Street; residents of East Street have had door flood guards fitted for a number of years. On 20 July 2007, the flooding here was exacerbated by blockages in the culverts (the Parish Council received confirmation of this from GCC); the water exceeded a depth of 1 m, causing over £1 million worth of damage to St. David's Community Centre and Primary School (**3**; BBC, 2007). Particular concern has been expressed, by both CDC and attendees of the flood surgery, regarding the condition of the northern culvert, since the road above it has collapsed repeatedly (in the vicinity of the HSBC bank; **4**), suggesting that the culvert may be damaged. Gloucestershire Highways has agreed to undertake a survey of both culverts.
It is unclear whether these culverts continue separately under the High Street and East Street (GCC has reported that this is the case; Dutton, 2008) or merge into a single culvert at the cross-roads (**5**; as suggested by Parish Councillors and CDC, 2008). In either case, the culvert(s) continues eastwards, with a short open length through the school grounds, before discharging into the River Evenlode (**6**). Road drainage along the High Street from Corder's Lane (**7**), and the overflow system from the Parkers Lane pond (**8**) are connected to this culvert (CDC, 2008). Surface water run-off also flowed into the town from the fields to the north of the Matcon factory (**9**). This water, which flooded part of London Road, continued southwards along Croft Holm, affecting over 40 properties. Flooding here was exacerbated by failure of the sewage pumping station (**10**; this failure occurred on 19 July 2007 and was not related to the flooding).
River Evenlode
A local resident is also concerned that a bridge (**11**) over the River Evenlode presents an obstruction to the flow, elevating the upstream water level and exacerbating the flooding problem along Croft Holm.

Photograph – View of the River Evenlode in Queen Victoria's Garden, looking upstream

The River Evenlode flows eastwards through Queen Victoria's Garden, before entering a culvert at **12**. This culvert carries the watercourse under the High Street and the Cotswold railway line; a trash screen is installed on the culvert inlet. Immediately downstream of the culvert outlet (**13**), the river turns southwards, flowing roughly parallel to the railway. During the Summer 2007 floods, the culvert was unable to convey all of the flow and water backed-up behind it, flooding Queen Victoria's Garden. Water spilled out of the Garden (in the vicinity of **14**) onto the High Street and continued eastwards, via a residential care home (The Grange; **15**), to the railway line. The residential care home had to be evacuated and the water reached the level of the station platforms.

Photograph - Existing trash screen on the inlet to the culvert in Queen Victoria's Garden (**12**)

Indeed, the Environment Agency has highlighted the culvert as a significant cause of the flooding in the town on 20 July 2007, noting in particular that the trash screen is inadequate and difficult to keep clear (van Beesten, 2008). A CCTV survey of the culvert, commissioned by the Environment Agency, was carried out (in part[1]) in December 2007. This showed that, after 40 m, the culvert splits into twin barrels and that tree branches and silt had collected at this split, restricting the capacity of the culvert. The Environment Agency has since cleared the culvert, and it is currently designing a new trash screen (van Beesten, 2008).

[1] The survey could not be completed because the outlet was completely submerged

Photograph – Downstream view of the flood relief ditch, from Stow Road

A flood relief ditch was constructed in the 1960s to route water from the Bourton Road area to the south of the town, before discharging into the River Evenlode at point **16**. Twin culverts carry this ditch under the Stow Road (**17**) and the railway line (**18**). The culvert under the railway comprises a brick barrel cell, which is the responsibility of Network Rail, and a concrete cell, maintained by CDC. The backwater of this culvert flooded properties along Fosseway Avenue. Both Parish Councillors and local residents have reported that this culvert was partially blocked at the time of the flood. CDC has written to Network Rail regarding this; Network Rail's reply noted that the culvert was not blocked, but that work was required to the outfall. It is unclear whether this work has been undertaken.

The culvert under the Stow Road was also partially blocked, causing flooding of the field on the right bank (**19**). Again, CDC has written to the riparian owners, requesting remedial action to be taken.

Maintenance of watercourses and drains

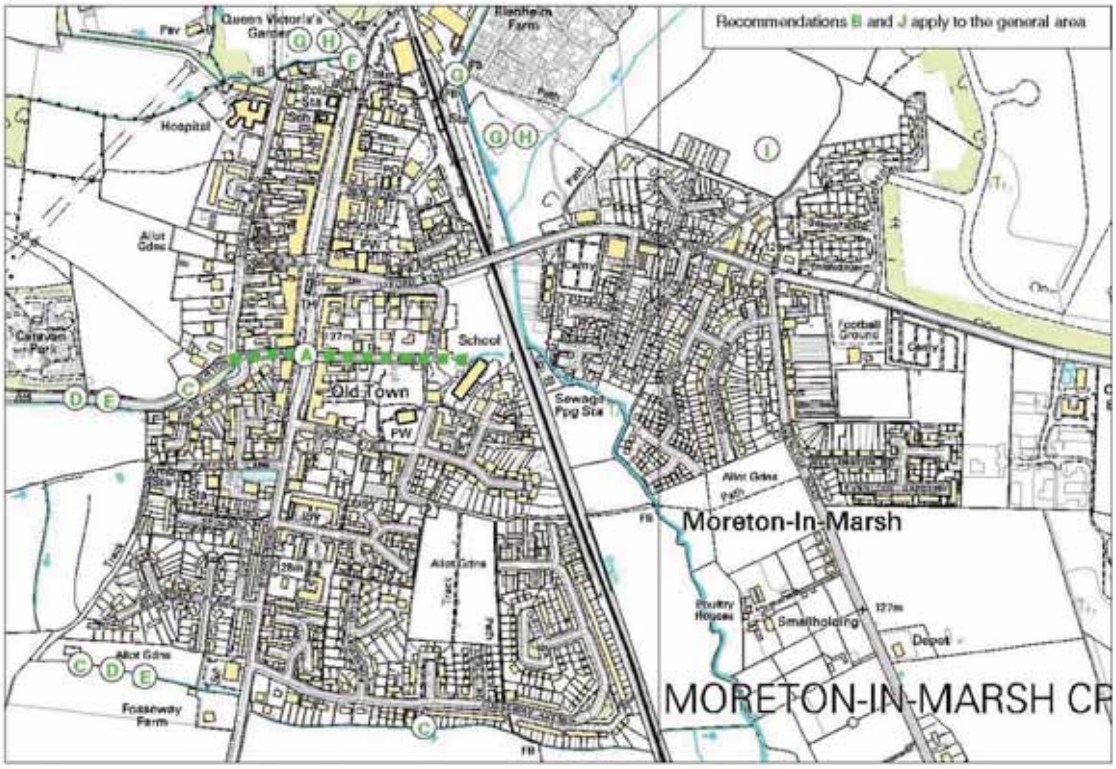
Photograph – The right bank of the River Evenlode, downstream of the culvert from Queen Victoria's Garden (**13**). *Soil has built up (or been placed) against the bank, narrowing the channel width*

Parish Councillors and local residents have expressed strong concerns regarding the lack of maintenance of watercourses and drains in the town. Indeed, a number of obstructions were observed on our walking survey of the River Evenlode; in particular, the reach immediately downstream of the Oxford Street road bridge is heavily vegetated (**20**). In addition, the right bank at the outlet of the culvert from Queen Victoria's Garden (**13**) appears to have encroached upon the channel (see photograph above). A resident of Croft Holm has also noted that a fence, erected along the right bank of the Evenlode (**21**) by Thames Water, prevents maintenance access to the channel and bank. The Environment Agency has reported that, prior to the Summer 2007 floods, the River Evenlode was not included in its maintenance programme. However, it has re-assessed the situation and the river will now be cleared of blockages and trees as required. In particular, annual clearance of the river through Moreton-In-Marsh is programmed for late summer. However, it is important to note that maintenance is unlikely to have prevented the extreme flooding of Summer 2007 (refer to the main report).

On 3 May 2008, Robert Dutton, a local resident, conducted a visual inspection of 30 drains in the town and found many of them to be blocked. He has also reported that the ditches along both the north and south of Bourton Road are overgrown and blocked by debris. In addition, CDC (2008) has suggested that a potential blockage in a drain on the High Street may have exacerbated the flooding in the vicinity of The Grange.

2 Mitigation Recommendations

As mentioned above, the Environment Agency intends to carry out maintenance work on the River Evenlode through Moreton-In-Marsh annually (in late summer) and it is currently designing a new trash screen for the culvert inlet in Queen Victoria's Garden. To reduce the risk of flooding in the town further, it is recommended that the following actions are also taken.



Mitigation Recommendations	
A	Carry out a CCTV survey of the culverts that run from Bourton Road into East Street. Remove any blockages and make necessary repairs
B	Clear all road drains in the town. Refer to Robert Dutton's (2008) report for problem areas
C	Clear and maintain all land drainage ditches, including trash screens and culverts. Particular attention should be paid to Bourton Road and the flood relief ditch
D	Calculate the peak flow rate and volume of surface water run-off from Bourton-on-the-Hill, for a range of return periods. Use these calculations to assess the adequacy of the drainage of Bourton Road, including the flood relief ditch
E	Depending on the findings of recommendation D, investigate options for improving drainage of the Bourton Road area. In particular, assess the feasibility of increasing the capacity of the flood relief ditch, including establishing an attenuation pond (e.g. in the fields to the south of Bourton Road and/or Fosseway Avenue)
F	Undertake hydrological and hydraulic assessment of the River Evenlode for a range of return periods, taking account of climate change impacts. The model will confirm the pinch points along the river. Blockage analysis of the culvert, that runs from Queen Victoria's Garden under the High Street and railway line, should be included

G	Use the hydraulic model to quantify the flood risk management benefits of the following measures: • River maintenance, including removal of the soil bank at **13** • Creation of a formal attenuation pond upstream of Queen Victoria's Garden and improve overbank storage along the river within Queen Victoria's Garden; • Increasing the storage volume of Blenheim Park (**22**) by land re-profiling.
H	Depending on the findings of recommendation G, carry out any necessary river maintenance works (if not covered by the Environment Agency's annual programme) and investigate the feasibility of establishing formal attenuation upstream of Queen Victoria's Garden and/or Blenheim Park
I	Investigate options for improving the natural and formal drainage of fields to the north of the Matcon factory (refer to the main report)
J	Promote self-help and non-structural approaches to flood risk management (refer to the main report). (The Environment Agency has already sent a Community Flood Action Plan template to the Parish Council, and it is working to improve its Flood Warning Service in the town; van Beesten, 2008)

References

BBC (2007) *Flood schools to re-open on time*. http://news.bbc.co.uk/1/hi/education/6928156.stm

Cotswold District Council (2008) Meeting with Rob Bull, Engineer. 8 May 2008

Dutton, R.W. (2008) *Memorandum*. Prepared for Councillor Colin Hancox, Chairman of Moreton-In-Marsh Town Council to demonstrate that the main drainage system in the town is still not fit for purpose and cannot properly drain the town. 3 May 2008

Dutton, R. W. (2007) *Moreton-In-Marsh Flood Map*

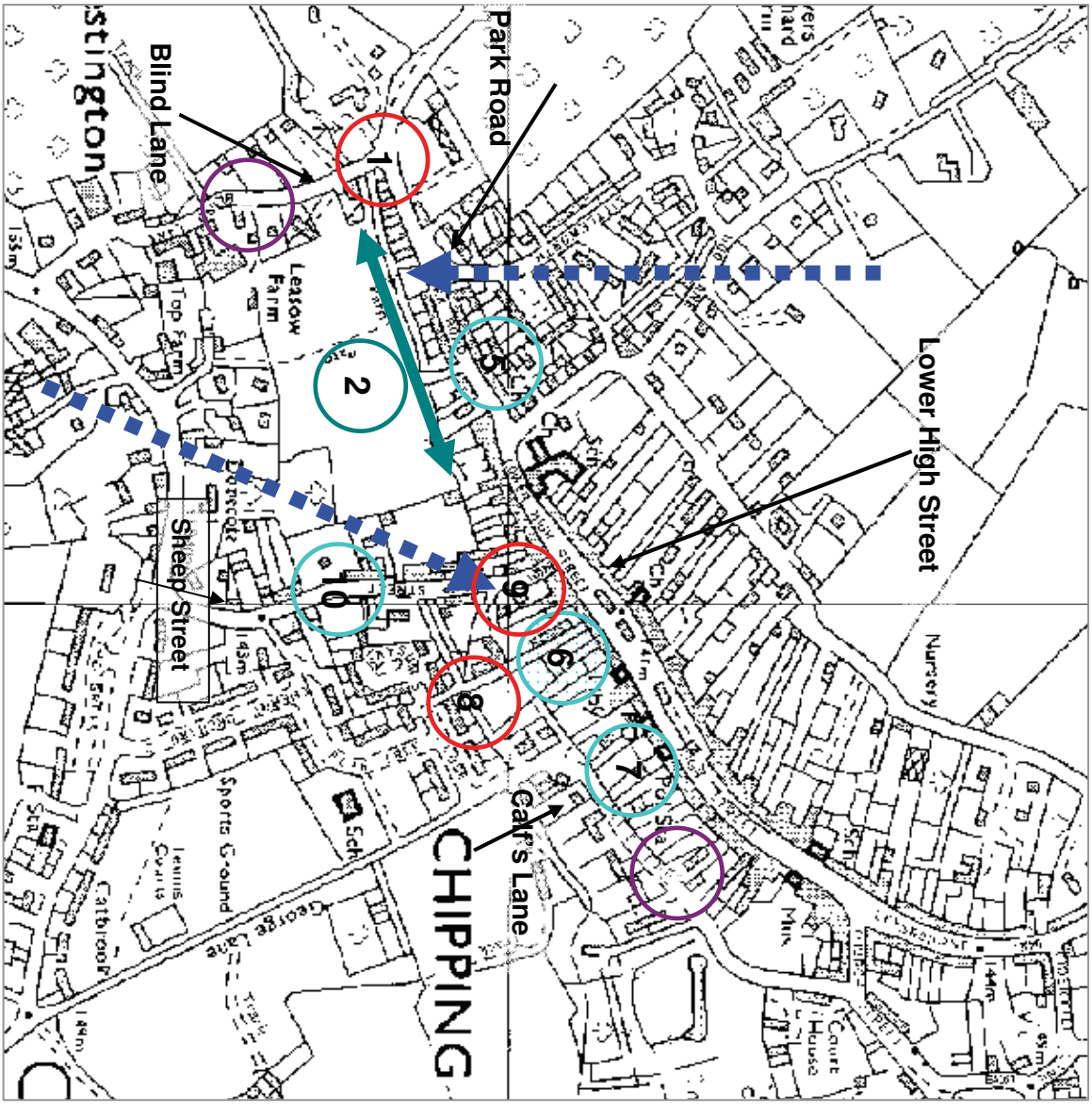
Appendix 2

Chipping Campden - Site Response

Location 2 – Chipping Campden

Date of visit	03/04/2008
Attendees of the workshop	Ken Wilkins, David Atkinson and Mayor Chris Jones

1 Mechanisms



Summary

The town flooded from surface water runoff, fluvial flooding and there were two reports of surcharging sewers. Chipping Campden has a well organised flood response group, coordinated by the Parish Council. The flood group described the mechanisms of the flooding and flood extents maps.

Mechanisms of the flooding have been detailed by the Chipping Campden flood group.

Surface water runoff from a large catchment resulted in surface water flooding, fluvial flooding and there were two reports of flooding from surcharging sewers.

The maintenance of the River Cam throughout the town has been poor, resulting in the channel through the town being silted up, with obstructions, overhanging vegetation and banks which vary in height and material.

The culvert under Blind Lane **(1)** is of insufficient capacity to convey high flows and results in the flow backing up through the channel.

The Cam flows very slowly between Westington Mills and Sheep St, due to channel constrictions. There are channel irregularities which impede the flow and obstructions in sections cause water to back up and increase river levels, especially on the left bank bordering the gardens of houses on Park Road/Lower High Street **(2)**.

The infrastructure throughout the town is generally poor and drains on Calf Lane **(3)** and Blind Lane **(4)** are inadequate and are frequently blocked. Surface water flooding caused the flooding on Park Road and Calf Lane before the River Cam has burst its banks.

There are low points on Park Road **(5)**, Lower High St **(6)** and Calfs Lane **(7)** which result in flood water (surface or fluvial) to pond, with no route back to Cam Brook.

The flow through the town is limited by structures, including the twin culverts **(8)** under the old mill and the bridge over Sheep Street **(9).**

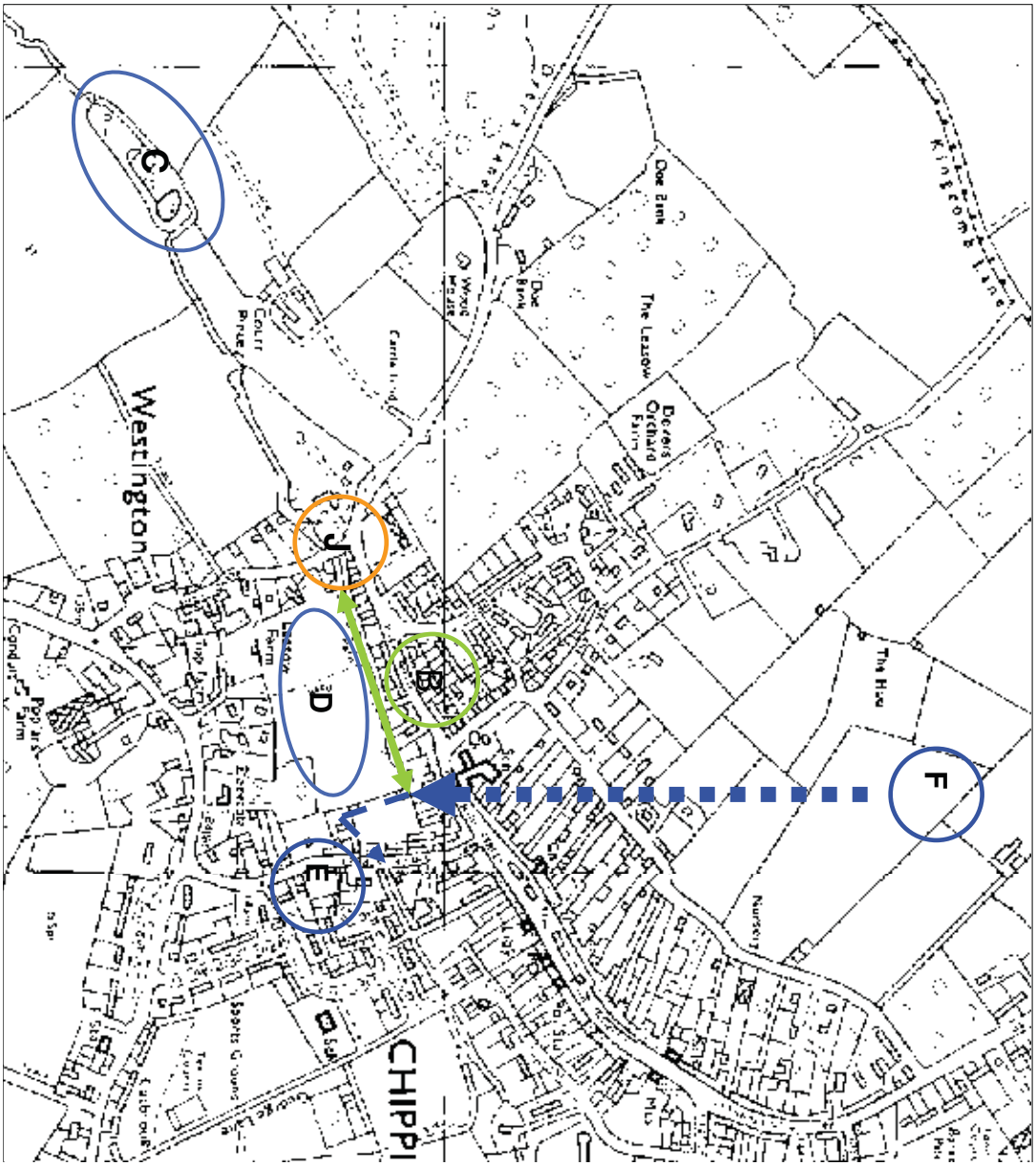
The length of the channel from Sheep Street to Juliana's Gate is narrow and overgrown, resulting in flow being obstructed in this section. If flood waters overtop the channel the water which builds up in Sheep Street **(10)** has no route to flow out of the street, resulting in water ponding in the area.

The land drains which flow through the town are not of sufficient capacity to convey flows during periods of high rainfall. The two town drains, which drain surface water from The Hoo and Wessington Hill issue into a relatively short reach of the Cam. During high flows this results in a build up water in this reach and the manhole blew on the Park Road/Littleworth Road junction

Description of Mechanism	**Photograph**
Looking upstream at the culvert under Blind Lane The culvert Blind Lane is of insufficient capacity to convey high flows and results in the flow backing up through the channel. The long high stone wall over the culvert then diverts the flow away from the river.	

Looking at the River Cam and the backs of gardens of the houses on Lower High Street from the Craves field. The banks of the River Cam vary throughout the town, especially along the bank which forms the back of the garden of the houses on High Street. The irregularities in the bank height and material impede the flow through town and obstructions in sections caused water to back up and the river level to rise. Sections of the banks at the back of the gardens are low, when the river overtops during high flows river water flows through these points.	
Looking upstream at the town drain which takes runoff from Wessington Hill and issues next to the elf garage adjacent to the care home. The two land drains which flow through the town are not of sufficient capacity to convey flows during periods of high rainfall. A large proportion of the catchment to the north of the town drains into the Cam upstream of the new care home. The two town drains, which drain surface water from The Hoo and Westington Hill issue into a relatively short reach of the Cam. During high flows this results in a build up water in this section as the flows from the Cam and the two land drains converge. The level at which town drains enter the Cam is below the level of the river during high flow. Subsequently the water backs up through the town drains, exacerbating flooding.	

2 Mitigation Recommendations



Recommended Mitigation	
A	Undertake hydrological and hydraulic assessment of The Cam and its key tributaries (Landgate Drain) for a range of return periods, taking account of climate change impacts. The model will confirm the pinch points along the river verify mitigation measures below.
B	To improve the conveyance of flow through the reach of the channel from Westington Mill to Sheep Street (behind the gardens of the houses on Park Road/Lower High Street), it is recommended the left hand bank of the channel should be made a consistent material and height. This recommendation could be complemented with the widening of the channel or benching of the right bank of channel in the Craves

	field, to increase the capacity of the channel at this location. Contact landowners to raise awareness of their responsibility for riparian maintenance. Once the modelling in A is completed specific advice on River bank heights can be delivered to the riparian owners GCC have surveyed a long section of the channel through this reach which should be utilised.
C	Attenuation occurs upstream naturally during high flows. There is an option to formalise the attenuation upstream in the area around the old swimming lakes of Campden House. Attenuation would allow flood water to be stored and flow at a controlled rate into the town. This would reduce the river level and flow through the town and subsequently alleviate the pressure on the structures present along the watercourse. The upstream attenuation would hold the peak flow back from the upstream catchment, allowing the flood peak from the land drains discharging surface water from The Hoo and Westington catchment to flow though the town before the peak of the Cam arrives. The Parish Flood Committee reported that the land owner would support such a scheme on the land.
D	There is the potential to use the Craves field as a flood storage area during periods of high flow. This would require the field levels to be adjusted to provide a low attenuation area and the construction a flood bund to provide protection to the properties surrounding the field. This scheme would require consent from the land owner.
E	The flow limiting structures present on the watercourse, such as the twin culverts under the old mill and the bridge over Sheep Street, are likely to be of historical importance and the removal or replacement of the obstructions may not be possible. The solution could be to reduce the flow in the channel through attenuation upstream of the town and formalise a diversion or overland flow path route to safely convey water from this area.
F	As a considerable amount of development has taken place since the installation of the town drains it is believed that the drains are now under capacity. To alleviate the pressure of the town drain which takes water from The Hoo, the installation of a second land drain to split the runoff should be investigated. GCC have investigated the drain which takes water from The Hoo and have planned maintenance.
G	For properties in the low areas of the town (Park Road, Lower High St and Calf's Lane and Sheep Street) where ponding occurs from surface water or flood water, the installation of an emergency pumping system, to pump the water from the low areas back to the river during lower magnitude flood events could be installed. During large flood events, such as the July 2007, pumping water back to the river would not be possible. It is advised that properties located in the low areas should consider flood resilience measures, such as the installation of flood boards to reduce the impact of flooding in these areas. GCC have identified an engineering solution is required to increase the watercourses capacity.

H	The maintenance of the river channel throughout the village has been poor over the years. To ensure a consistent approach throughout the town it is recommended the riparian owners through the town are mapped. Once all of the riparian owners have been identified a riparian owners group could be formed. The group can be made aware of their responsibilities as riparian owners and maintenance at regular intervals can proceed accordingly.
I	The risk of surface water flooding could be reduced by the regular inspection and maintenance of the drains in the town, especially on Calf's Lane and Blind Lane. As the current surface water drainage network has been in place before extensive development took place in the village GCC may want to consider an engineering solution.
J	The feasibility of enlarging the Blind Lane culvert to prevent water backing up through the channel during high flows should be investigated. This recommendation would require support from a hydraulic model to ensure increasing the culverts would not increase flood risk downstream.
K	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Issues
Chipping Campden has flooded a number of times in the last 30 years. CDC should investigate the reclassification of the River Cam as a main river .

Appendix 3

Bourton-on-the-Water - Site Response

Location 3 – Bourton-on-the-Water

Date of visit	10/04/2008
Attendees of the workshop	Bryan Sumner, Alan Rogers, Tim Faulkner, Mike Hopkins (Storm Geomatics)

1 Mechanisms

Summary

81 properties flooded throughout Bourton-on-the-Water as a result of the flooding in July 2007. Flooding occurred from fluvial, surface water runoff and surcharging of the sewer system. A flood group, coordinated by the Parish Council, has been formed which has provided extensive information relating to the flooding mechanisms. The town flooded from surface water runoff from the surrounding fields, fluvial flooding from the River Windrush and the River Dickler and surcharging of sewers.

1 There was surface water runoff from the hills surrounding the town.

2 The banks of the ditch which take surface water runoff from the school playing fields are very low. The ditch overtopped during the flooding.

3 A redundant sluice gate at the rear of the old mill, was inoperable in the open position. The sluice gate restricted flow, causing river levels to back up, which then flooded the area.

4 CDC ditch (at Clapton Hill) runs from Clapton Hill Road, there is a restriction of the flow under the road in the form of a short culvert.

5 During high flow the water is not conveyed effectively into the drain which runs along Pockhill Lane.

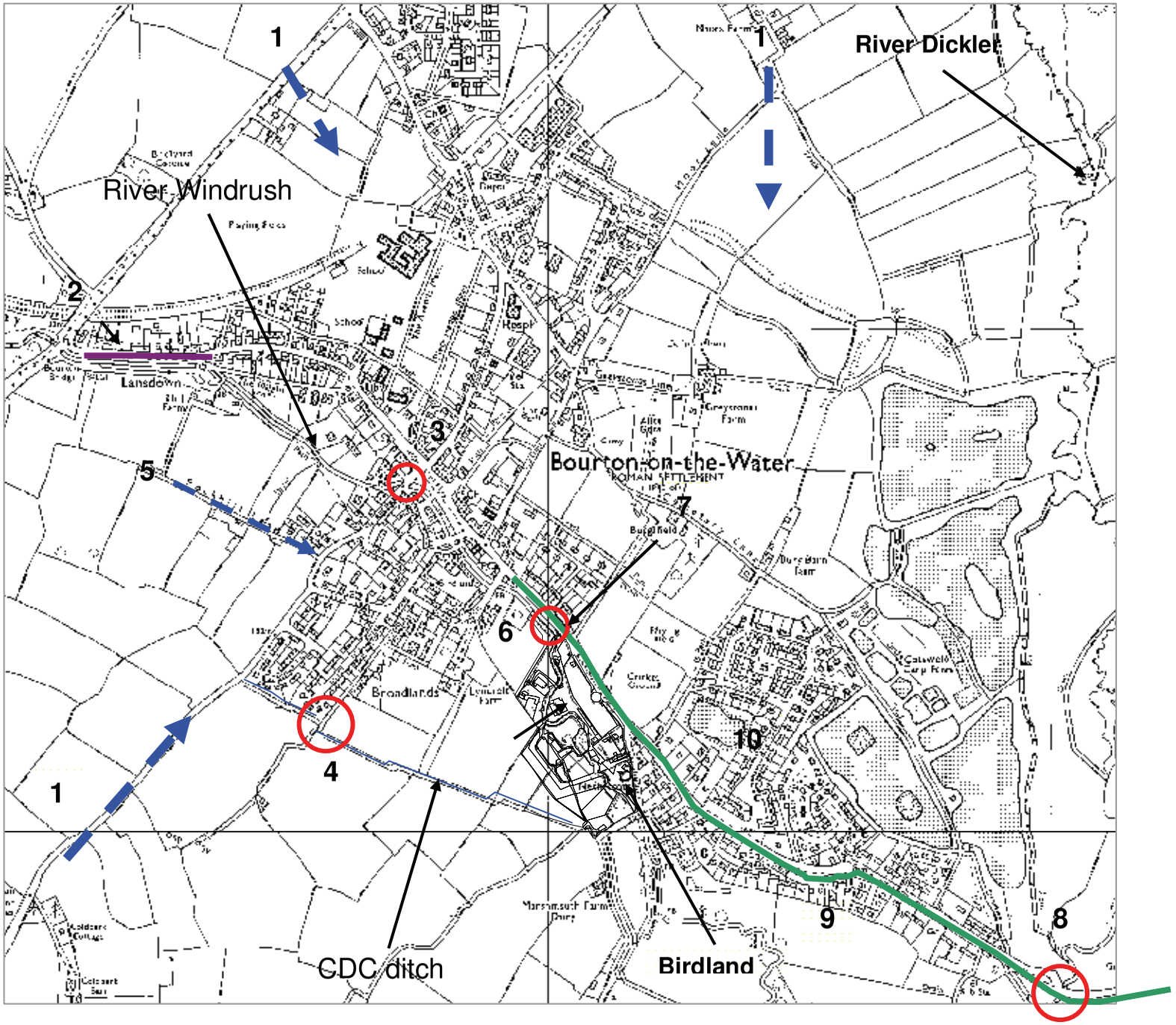
6 The right wall alongside the river (just downstream of Birdland) has been bricked up. This prevents water from flowing onto the water meadows on the Lyncott Farm fields. This exacerbated the flooding in the town.

7 The River Windrush overtopped the low left bank before Birdland, resulting in flooding of Rissington Road.

8 The Dickler peaks before the Windrush and has a history of flooding. There is a pinch point where the water flows under the old road bridge- the bridge restricts the flow then the water backs up into the lakes (into Lake No1 then Lake No2).

9 A considerable amount of the ditches which take surface water runoff from the surrounding catchment were blocked during the flooding.

10 The sewage pumping station was also flooded in the event which in turn flooded surrounded properties.


River Windrush
River Dicklet
Bourton-on-the-Water
Lansdown
Broadlands
CDC ditch
Birdland
1
2
3
4
5
6
7
8
9
10

Description of Mechanism	Photograph
Looking downstream at the CDC ditch culvert. CDC ditch (at Clapton Hill) runs from Clapton Hill Road, there is a restriction of the flow under the road in the form of a short culvert. The constriction results in water backing up through the ditch during high flow.	
Looking upstream at the redundant sluice from the Duke of Wellington car park. A redundant sluice gate at the rear of the old mill (presently the motor museum) was inoperable in the open position. The sluice gate restricted flow, causing river levels to back up, resulting in the flooding of the museum and properties upstream. Flood water flowed through the Manor House and onto High Street. The water then combined with water flowing down Sherbourne Street.	
Looking at the ditch which runs alongside the High Street through town. The ditch takes surface water drainage from the hills to the north of the village, the school fields and Moore Road. Surface water runs into the school playing fields, goes down the ditch onto the road and issues near the war memorial. The banks of the ditch are very low providing minimal freeboard above the water level and the top of bank. The ditch overtopped during the flooding resulting in water flowing onto the High Street.	
Looking at the right bank of the River Windrush from High Street. The bricked up hole in the wall just downstream of Birdland prevented water from flowing through the field into the water meadows. This resulted in the loss of possible flood storage in the meadows and exacerbating the flooding on Rissington Road.	

Looking at a ditch in Bourton. During the flooding there were poorly maintained ditches throughout the town which were blocked by debris or obstructions which exacerbated the flooding. Overflowing drains were reported during the flooding.	
Looking downstream of the River Dicker at the old road bridge. There is a pinch point where the water flows under the old road bridge. The bridge restricts the flow resulting in water backing up into the lakes (into Lake No1 then Lake No2).	

2 Mitigation Recommendations

Recommended Mitigation	
A	Undertake hydrological and hydraulic assessment of the River Windrush for a range of return periods, taking account of climate change impacts. The model will confirm the pinch points along the river and verify the mitigation measures detailed below
B	It is recommended the redundant sluice gate behind the old mill is removed to take out the obstruction to flow in the section of the river. An application for the removal of the sluice gate was submitted in January 2008. The gate was present during the site visit on the 10/04/08. In conjunction with the sluice gate removal the EA have recommended raising the wall along the edge of the pub (right bank downstream of sluice), to reduce the flood risk to the pub.
C	The extension of the CDC ditch across to the fields to the west of the Clapton Hill to form a new network which will assist in draining surface water from the catchment above the village level should be investigated. This would help to protect Sherborne Street, an area which suffered severe flooding as a result of runoff from the hills. The pinch point in the CDC culvert will need to be improved with conjunction with the proposed extension to the ditch. The EA have surveyed the ditch from Broadlands to Nethercote, the information may help to inform the design of the proposed extension.
D	The land to the west of Sherborne Street and North of Pockhill Lane could be used an area to attenuate flood water. The scheme would require a flood wall or the raising of the land to prevent flood waters flowing through properties on Sherborne Street. The EA is investigating this recommendation as part of the options for improvement in their flood review report (March 2008). The EA has completed initial surveys of the ground levels and are investigating the cost and benefit of the scheme.
E	The floodplain to the west of the Mill at Lansdowne could provide additional formal flood storage or some attenuation if ground work is carried out. The EA is investigating this recommendation as part of the options for improvement in their flood review report (March 2008).
F	The ditch which runs alongside the road takes the water from the school field and Moore Road. It is recommended that the authorities build up banks of ditch which runs through town (takes water from school fields) to increase the capacity within the ditch and allow higher level of protection against overtopping. Increasing the height of the banks along the ditch would also have safety benefits and reduce the possibility of someone accidentally falling into the ditch.
G	There is an option during high river flows to allow water to flow from the River Windrush into the water meadows by opening the bricked up hole in the wall upstream of Birdland. Flood water could be stored in the water meadows and reduce the likelihood of water overtopping the bank and flowing onto Rissington Road. This recommendation will need to be supported by hydraulic modelling to ensure the scheme is not increasing the flood risk elsewhere.

H	The left bank requires raising near the pinch point on the road to stop Rissington Road flooding. There is an option to raise the left bank of the wall between the Painted House and the Birdland entrance. This is one place where water flowed out of bank onto Rissington Road. The stone wall could be raised to give a constant top level to the wall to allow more flow capacity in the river. The EA is investigating this recommendation as part of the options for improvement in their flood review report (March 2008). The EA have completed a survey of the wall.
I	The EA have recommended clearing the CDC drainage ditch between Broadlands and Nethercote to divert some field drainage to from the fields to the south west of Bourton to rejoin the River Windrush beyond Nethercote. The ditch has been cleared prior to the site visit on the 10/04/08. It was noted that additional clearance was required to the ditch to the west of Broadlands. The ditch should be cleared on a regular basis to ensure it has the maximum available capacity to convey flows.
J	Inspect and maintain the ditches throughout the town on an annual basis, to prevent the long term build up of debris and silt, which restrict flows through the ditch and reduce the capacity. Bourton have a well prepared flood group who are keen and able to undertake immediate alleviation measures such as ditch clearing. This group could be mobilised very quickly to carry out work in the area with assistance and technical advice from CDC.
J	The old road bridge over the River Dickler may be structurally instable and it is recommended the bridge be investigated for its structural integrity. Reconstruction of the bridge would allow for appropriately sized culverts to be installed to reduce the obstruction to flow, the backing up of water into the Lakes and reduce the risk of flooding during lower flood flows.
K	Contact landowners to raise awareness of their responsibility for maintaining roadside ditches (refer to the main report)
L	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Other Issues	
Looking downstream of the River Dicker at the old road bridge. The old road bridge collapsed during the flooding. Some of the debris has been removed from the watercourse but there are still remnants of the bridge in the channel. It is recommended the channel is cleared of debris to ensure the channel is efficient as possible by limiting the obstructions to flow.	
Looking at the left bank of the river from the Duke of Wellington car park. The wall on the left bank of the river appears to be structurally unstable. There is visible undermining of the wall at the upstream end of the wall. The tree growing from the wall may also be contributing to the deterioration of the wall. It is recommended that the tree is removed and the wall is shored to prevent collapse of the structure and subsequent obstruction to flow.	
Birdland needs to ensure the trash screens are free of vegetation to allow the flow to get through the area. During the flooding grass from the catchment blocked the trash screen. The EA have recommended the channels within Birdland can be improved by removal of obstructions and localised raising of the banks to ensure the river stays in its banks for longer. There is an option for the security screens to be replaced with screens which would minimise flow impediment without compromising security for the birds.	
Concerns regarding the capacity of the Dickler Close sewage station should be noted. The existing station was established over 50 years ago, since then significant development has occurred in Bourton. Consideration should be given to increasing the capacity of the pumping station to meet modern day requirements. Thames Water has management responsibility for the sewage system in Bourton.	

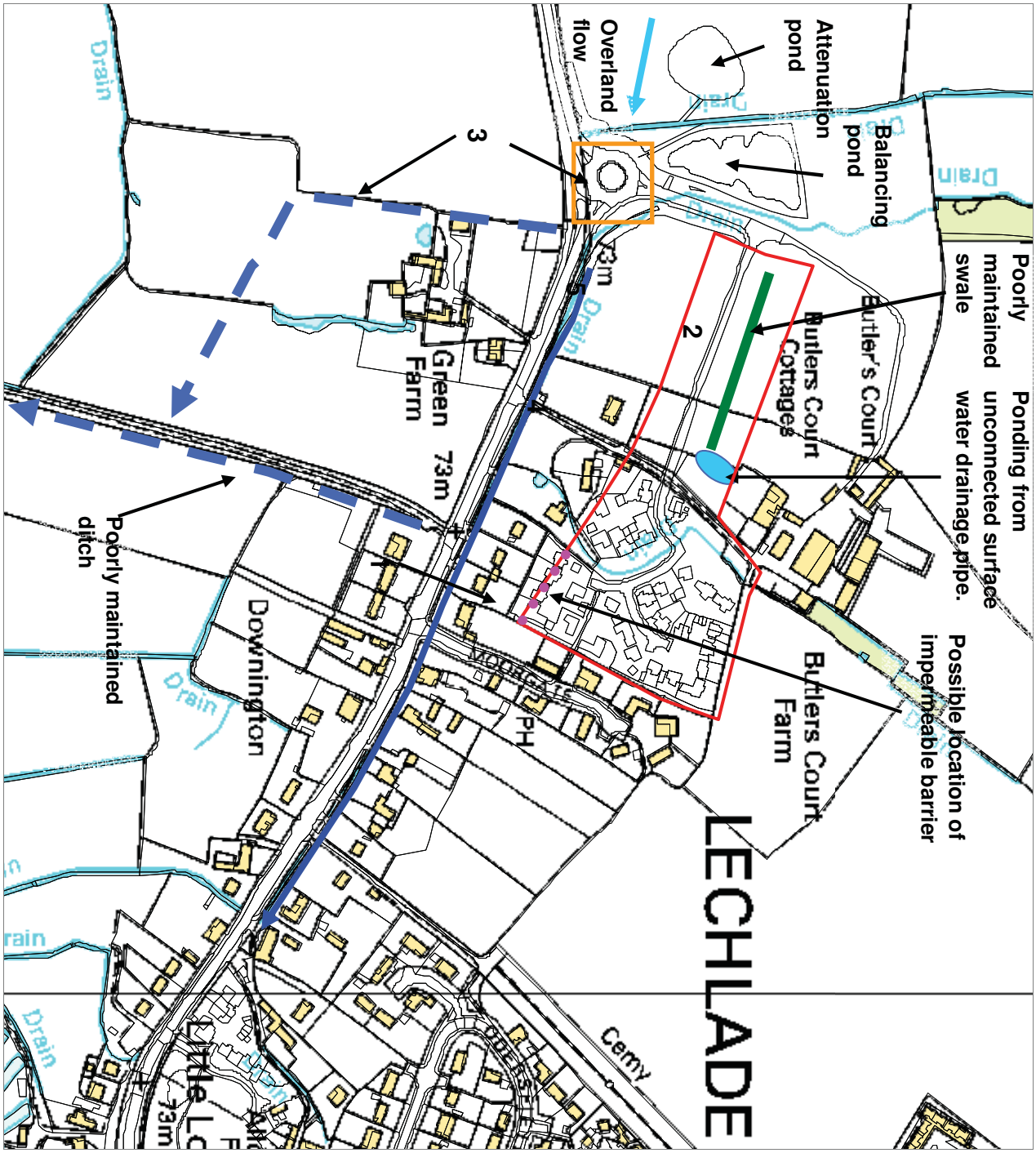
Appendix 4

Lechlade - Site Response

Location 4 – Lechlade

Date of visit	09/04/2008
Attendees of the workshop	Michael Cawsley, Nigel Jones, Richard Lambert and Peter Godfrey

1 Mechanisms

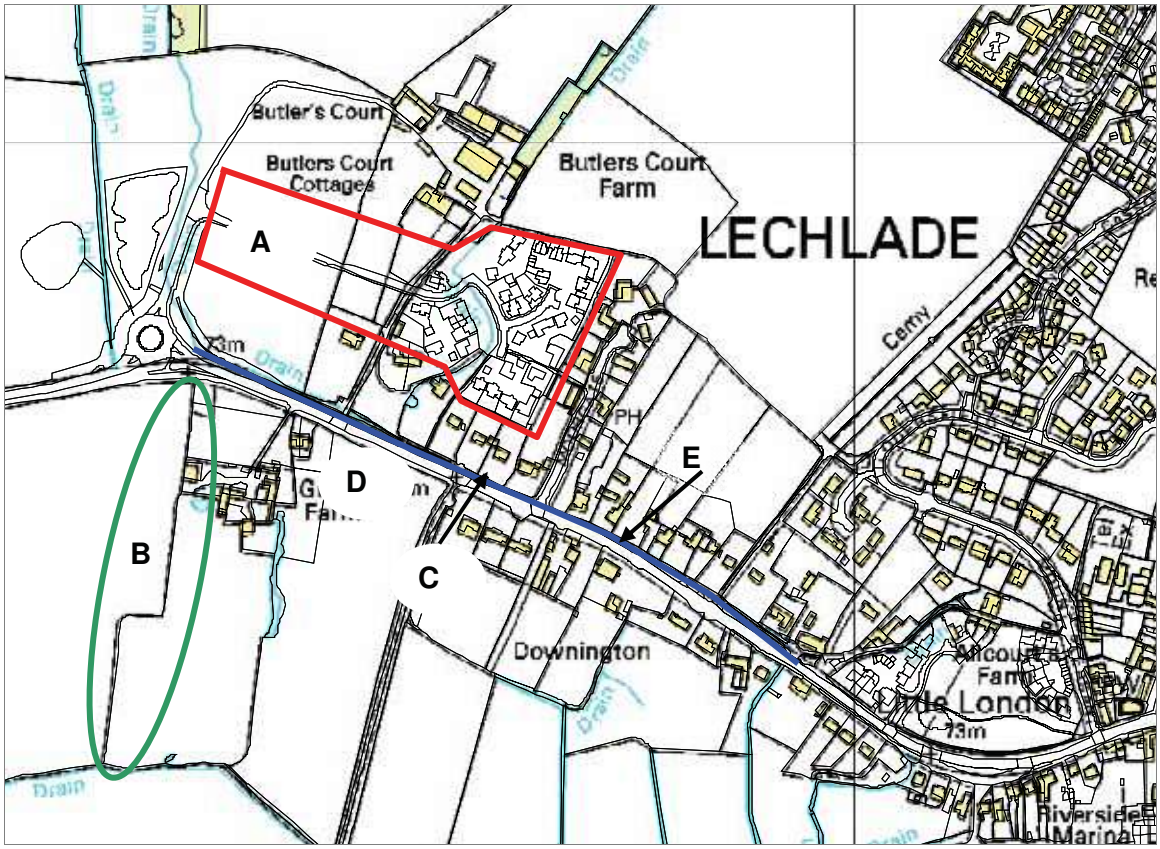


Summary
Subsequent to the flooding in July 2007 130 properties were reported as having flooded. Flooding was the result of surface water and river flooding. The key mechanisms are: **1** Flooding occurred from surface water runoff from the surrounding fields. It is believed significant runoff was generated from arable farming within the catchment. Over topping of the Downington ditch which runs alongside the main road (A417) through the town resulted in flooding. **2** The impact of the drainage design and poorly maintained SUDs in the Butlers Court development exacerbated the flooding. GCC has reported that surface water drainage from the development has not been connected into the main drainage system in locations, resulting in surface water issuing directly onto the land. An impermeable barrier was meant to be places within the development, it is unknown if there is a barrier in place. Properties located in the vicinity of the development have reported groundwater since the development. **3** A new culvert was installed under the roundabout. The flood relief ditch to the west of Green Farm was constructed to convey the flow from the culvert around the village, into the River Leach during high flows. There were reports the ditch was obstructed during the flooding, resulting in the water flowing down the main road through the town. **4** There is a low point near Green Farm where the flooding regularly occurs first during high flows. The water backs up and spreads out in all directions from the low area. **5** The drainage ditch which runs along the southern side of the main road (A417) through the village was poorly maintained, resulting in overgrown vegetation and a reduced capacity through silt deposition. **6** The Priory Lane caravan park flooded directly from the River Leach. **7** An area of properties flooded on the Claydon Pike Road.

Description of Mechanism	Photograph
Looking downstream of the Downington Ditch from the A417. Flows overtopping the ditch caused flooding in the July 2007 floods.	
A drainage ditch in the Butlers Close development. The development has a SUDS system which has not been maintained. The drainage ditches within the development are overgrown with vegetation and local residents reported infrequent inspection and maintenance of the ditches. The new development has gravel soakaways. Residents reported that during the flooding the soakaways caused water to drain onto the main road (A417).	

Overgrown swale next to the access road from the A417 to the Butlers Close development. The swale is very overgrown and had permanent stagnant water. There is a concern that the poor condition of the surface water drainage systems in the new development is increasing runoff and the development exacerbated the flooding in July 2007.	
Standing water from an unconnected pipe in the Butlers Court development. GCC have confirmed the surface water system in the development was not connected to the main surface water drainage in locations. This is resulting in uncontrolled discharge issuing onto the land.	
Looking upstream of the ditch leading to culvert under the roundabout. When the new roundabout was constructed new culverts were installed under the roundabout. There were reports the flood relief ditch constructed by GCC to convey flows from the roundabout around the town during high flows was blocked during the flooding. Flood water flowed down the ditch alongside the main road and exacerbated flooding downstream.	
The ditch which runs alongside the A417. The A417 road was flooded, past the garden centre to the veterinary surgery, as the drainage on the road was not functioning. The ditches were silted up, overgrown and as a result not functioning properly.	
A sharp bend in the course of the drainage ditch on the A417. The bend is a critical low point along the main road. The bank of the ditch is very low and is likely to breach at this point. The main A417 road floods regularly (annually) due to poor highway drainage.	

2 Mitigation Recommendations



Mitigation Recommendations	
A	The surface water runoff from the Butlers Court development requires investigation. GCC has contacted the development manager at Persimmon and is investigating the surface water runoff and the drainage system within the development. GCC plans to complete an assets survey for the development to check if the development was built in accordance with the plans submitted for planning.
B	The flood relief ditch requires regular inspection and maintenance to ensure the ditch can convey flows around the village during high flows. GCC manages the area around Green Farm and the maintenance of the flood relief ditch is on their regular works programme.
C	The highway drainage needs improving to reduce the flood risk on the main road (A417). GCC is going to investigate the problems with the highway drainage and maintain the drainage ditch. The ditches and gullies have been cleared since the flooding and the maintenance should be a regular item on GCC works.
D	Build up bank at low point to reduce the likelihood of the bank overtopping and causing flooding to the main road.

E	The Downington Ditch requires regular clearing, especially in the reach along the main road, to ensure the ditch is at maximum capacity to convey flows. Review the disposal method for debris removed from land drainage ditches. The EA maintains the Downington Ditch on an annual basis.
F	The Priory Lane caravan park requires a flood resilience and flood emergency plan, to reduce the impact of future flooding.
G	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Other Issues	
The new roundabout on the A417 has a system of ponds to attenuate surface water drainage. There are two new ponds, one attenuation pond and one balancing pond. The ponds are designed to take the surface water drainage from the new roundabout. GCC has reported the attenuation pond has not been connected to the main surface water drainage system, as there is no outfall from the pond. To reduce the risk of the pond overtopping during high rainfall GCC has constructed an overflow channel to reduce the likelihood of uncontrolled overtopping occurring.	

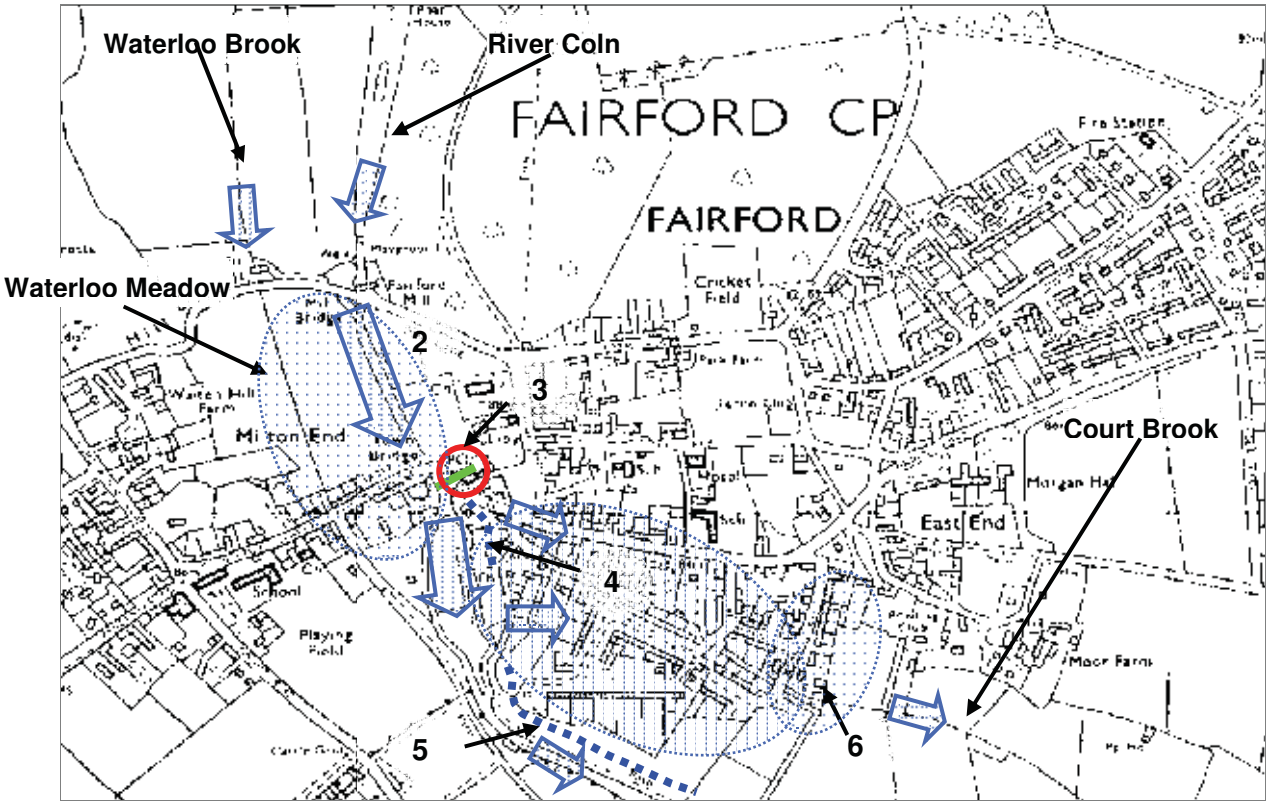
Appendix 5

Fairford - Site Response

Location 5 – Fairford

Date of visit	09/04/2008
Attendees of the workshop	Chris Roberts, Suzanne Jones and Trevor Hing

1 Mechanisms



Summary

92 properties throughout Fairford reported having flooded as a result of the July 2007 floods. Flooding sources included surface water, and river flooding. The EA have prepared a comprehensive flood extents within the report. Following are the main flooding mechanisms detailed by residents of Fairford during the workshop:

1 Flooding occurred from surface water runoff, surcharging sewers and fluvial flooding from the Waterloo Brook, Court Brook and the River Coln.

2 River levels rose quickly in the River Coln and flowed into the Waterloo Water Meadows. The flood water flowed through the permeable dry stone wall to the back of the properties on Milton Street.

3 The gap in the wall on the High Street just before the Bull Inn caused water to flow from the River Coln onto the High Street.

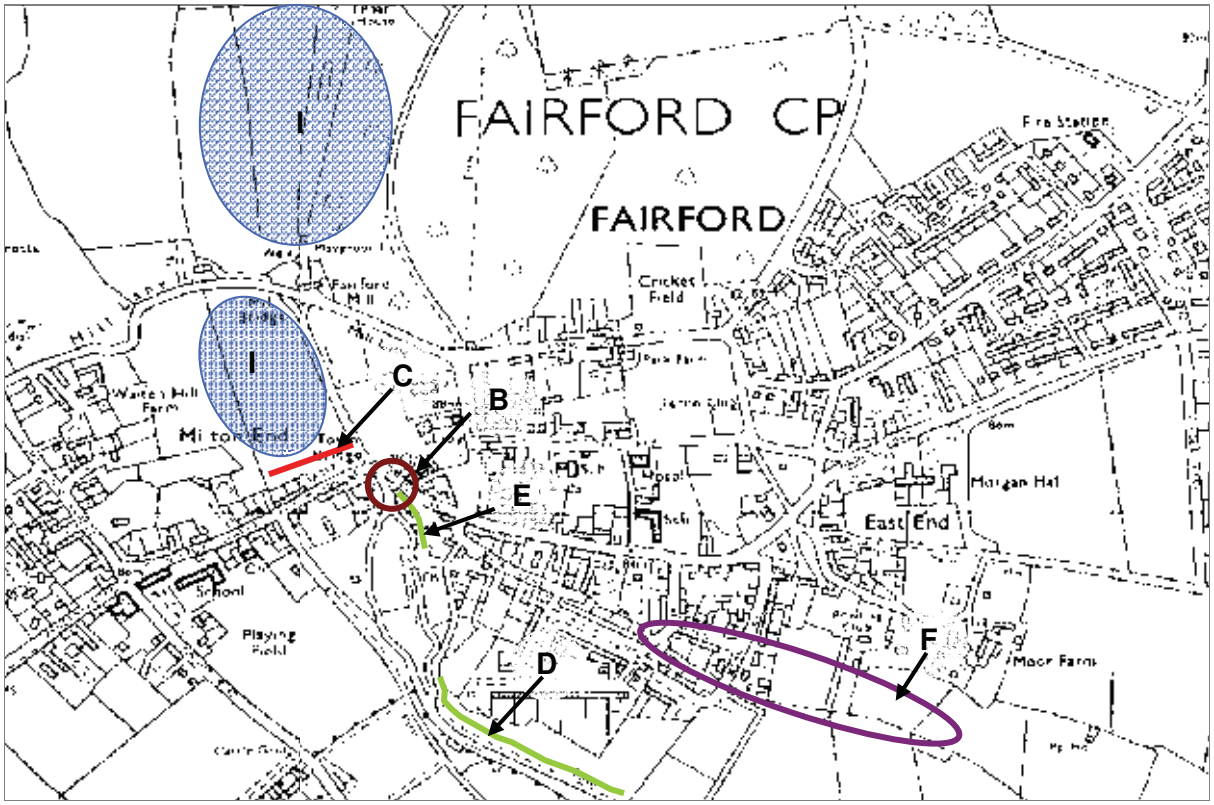
4 The left bank of the River Coln is very low, this resulted in the river flowing out of bank at the location of White Hart Court and causing flooding of the properties in the close.

5 The river side walkway and river bank along the left hand bank of the River Coln is low, resulting in the overtopping of the bank during the flooding.

6 The capacity of Court Brook was insufficient during the flood event and caused extensive flooding on Moor Lane.

Description of mechanisms	Photograph
Looking downstream at the Waterloo Brook- the houses in the background are the back of the houses on Milton Street. The Waterloo Water Meadows flooded as water spilled from the River Coln into the meadows. The flood waters flowed through the permeable dry stone wall to the back of the properties and flooded the properties on Milton Street.	
Looking downstream at the River Coln from Milton Street Bridge The gap in the wall before the Bull Inn, allowed water to flow onto High Street during the flooding.	
Looking upstream at the River Coln and the left bank of the river from White Hart Court. The banks of the river are very low on each side, especially the left hand bank. White Hart Court flooded from fluvial flooding during the 2007 floods. White Hart Court flooded previously during the floods of 2000.	
Looking upstream at the River Coln from the river side walkway. The riverside walkway and the left bank of the river is very low, allowing water to overtop the bank during a relatively minor increase in river levels. Water overtopped the bank during the flooding and flooded properties adjacent to the river. During the flood water flowed across the Fairford Beech farm and flowed down Snake Lane.	
Looking downstream at Court Brook. Moor Lane is low lying and at risk of flooding from Court Brook (channelled water course). The channel has insufficient capacity during high rainfall and during the July 2007 floods the brook caused extensive flooding on Moor Lane.	

2 Mitigation Recommendations



Mitigation Recommendations	
A	Undertake hydrological and hydraulic assessment of the River Coln for a range of return periods, taking account of climate change impacts. The model will confirm the pinch points along the river and verify the mitigation recommendations. A model of the River Coln catchment is currently being undertaken by the EA to inform the flood alleviation scheme in Fairford.
B	Fill in the gap in the wall east of the road bridge and raise the river bank in this area. This recommendation will require hydraulic modelling of the watercourse to ensure this measure does not increase flooding or flood properties on the opposite bank. The EA is reviewing this option in as part of their flood alleviation scheme.
C	A flood defence structure or bund to be constructed around the back of the properties on Milton Street to protect the properties. This will help to prevent flood water seeping through the wall at the rear of the properties where flood water accumulates in Waterloo Meadows. The EA is reviewing this option in as part of their flood alleviation scheme.
D	Raised footpath and river bank alongside the river walk is required to allow flows to stay in bank during flood flows in this reach of the river. The EA is reviewing this option in as part of their flood alleviation scheme.

E	Investigate raising of the bank behind properties in White Hart Court to provide a higher level of protection to the area. Any wall height will need to be carefully considered to ensure properties on the opposite bank are not adversely affected. The EA should review this option in as part of their flood alleviation scheme.
F	Regular maintenance of the Court Brook is required to ensure the brook has the maximum capacity to convey high flows to reduce the risk of overtopping. The Court Brook has been cleared since the flooding.
H	Regularly inspect and maintain drains throughout the village, as blocked drains can cause surface water flooding during relatively minor rainfall events. Some drains throughout the town have been cleared since the flooding. GCC should have regular inspection and maintenance of the drains on its ongoing works program.
I	The potential for formal attenuation upstream of Fairford Mill and in Waterloo Meadows should be investigated, to store flood water during high flows. The EA is reviewing this option in as part of their flood alleviation scheme.
J	Remove all overgrown vegetation and obstructions from the River Coln to improve the flow through the town. The EA maintain the River Coln annually.
K	Investigate runoff from surrounding fields, the outcome of which may suggest improving or maintaining the drainage system in the fields.
L	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Appendix 6

Willersey - Site Response

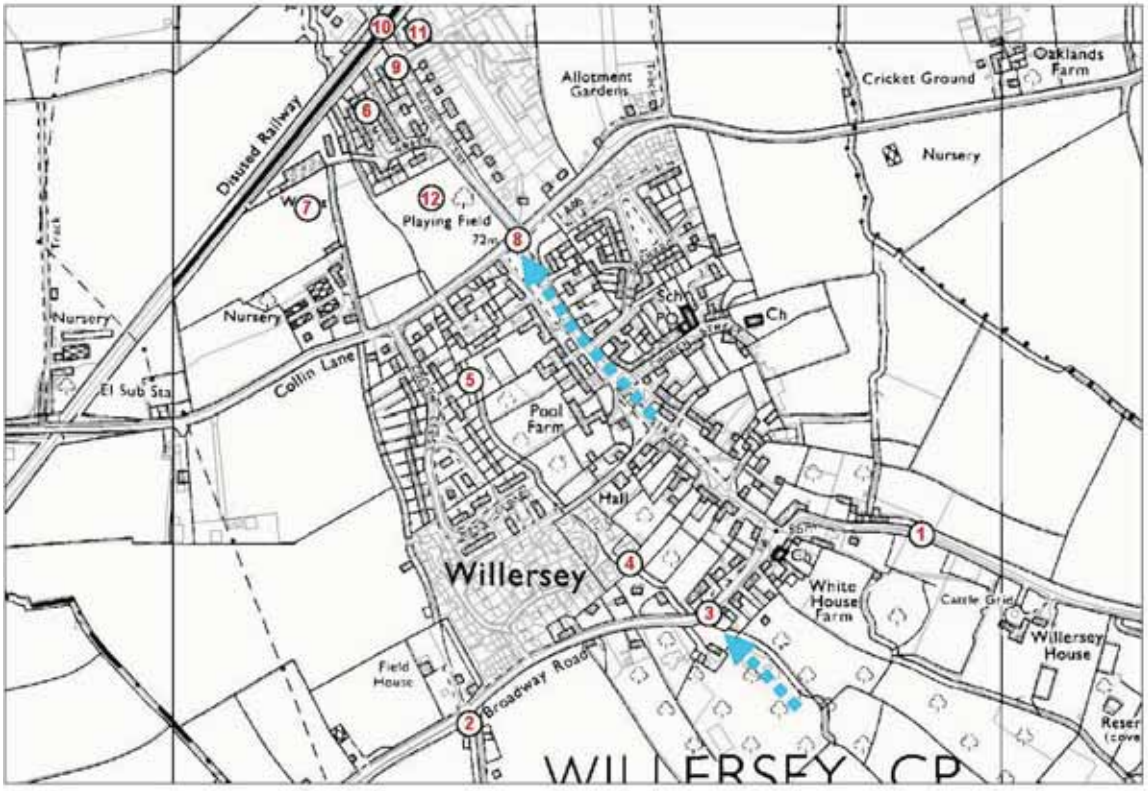
Location 6 – Willersey

Date of flood surgery	11 April 2008
Attendees	Maurice Andrews, Parish Council Chairman

1 Mechanisms

Summary

On 20 July 2007, 36 properties in the village of Willersey were flooded. The properties affected were spread out across the village, with a number of different flooding mechanisms in operation.



Description of Mechanisms	
Drainage ditches	
Photographs – (top) Upstream view of ditch along the northern side of Campden Lane (**1**)*; (bottom) View of land drainage ditch from Broadway Road, looking south* (**2**)*. This ditch is culverted beneath the road* Flooding in Campden Lane is a regular occurrence, affecting up to five properties. An open ditch runs along the northern side of the road, before entering a pipe at **1** (on private land) and, then, crossing under the road. The pipe, which was laid by the private landowner, is reported to have exacerbated the flooding problem. Gloucestershire County Council is currently working to secure the support of this landowner for replacing the pipe; Cotswold District Council has agreed to make a financial contribution to the scheme. The Parish Council has also suggested that there may be a blockage in the culvert under the road. *Broadway Road* A number of properties along Broadway Road were flooded by overflow from a land drainage ditch (**2**). This ditch, which flows northwards, is culverted under the road. The Parish Council has suggested that a blockage in the culvert (possibly due to structural damage from the heavy vehicles that use the road) caused water to back-up. Gloucestershire Highways has agreed with the Parish Council that the culvert should be cleared out. The open ditches in this area are maintained but it has been reported that any debris removed from the channel is left on the banks, to be washed straight back into the channel on the next high flow event. Further along Broadway Road to the east (**3**), some properties were flooded by surface water run-off from the fields to the south of the road. Cotswold District Council has noted that a privately-owned culvert also exacerbated the flooding problem here.	 
River flooding	

An un-named watercourse, which flows north-westwards through Willersey, flooded three areas of the village on 20 July 2007.

Willow Road

The watercourse enters a culvert, with a diameter of more than 1 m, at **4**. The trash screen on the culvert inlet has a narrow bar spacing (approximately 200 mm) and was blocked at the time of the Summer 2007 floods, causing water to back-up and flood properties in Willow Road. Gloucestershire County Council is currently looking into replacing this trash screen.

Frampton Drive

A blockage in the watercourse at **5** also caused water to back-up and flow overland into the gardens and houses of Frampton Drive. Two houses are reported to flood regularly here.

Timms Green

Overland flow from the watercourse also flooded three bungalows in Timms Green (**6**).

Five new houses are currently being constructed on land (occupied formerly by a motor caravan manufacturer) to the west of Timms Green (**7**). The Parish Council is concerned that this development will exacerbate the flooding problem. It is unclear whether the Planning Application for the development was supported by a Flood Risk Assessment, although the proposal submitted at the planning stage did include the opening up of an existing culvert.

Photographs – The watercourses in the vicinity of the new development (**7**)

Surface water run-off and sewage pumping station

Collin Lane

Surface water run-off flowed down the Main Street and collected at the roundabout junction with Collin Lane (**8**), as well as entered the sewers.

Badsey lane

Manhole covers on Badsey Lane were lifted due to surcharging (**9**). The overland flow collected in a low spot in the road, under the disused railway bridge (**10**). The Parish Council has reported that the water reaches a depth here of around 1 m, even following only moderate rainfall. Severn Trent Water has admitted that the capacity of the sewage pumping station (**11**) is inadequate and has promised to take action in Summer 2008.

Disused railway

The railway line is now disused and has been transformed into a cycle route by Sustrans. The Parish Council has reported that, since the railway was abandoned, the drainage openings through the embankment have not been maintained. This may have exacerbated the build up of surface water in the village.

Photograph – Railway bridge over Badsey Lane. Surface water run-off collects in this low spot (**10**)

2 Mitigation Recommendations

In addition to the work already being carried out by Gloucestershire County Council and Cotswold District Council, it is recommended that the following actions are taken to reduce the risk of flooding in Willersey.

Recommendation	
A	Ensure that the construction of the new development (**7**) includes appropriate mitigation measures to reduce the risk of flooding both to and from the site
B	Ensure that the un-named watercourse, which flows north-westwards through the village, is maintained and that the trash screens are inspected and cleared regularly
C	Examine the cause of the blockage that occurred to the south of Frampton Drive (**5**), and take any necessary remedial action
D	Undertake a condition survey of the culverts under Campden Lane and Broadway Road. Remove any blockages and make necessary repairs
E	Review the disposal method for debris removed from land drainage ditches
F	To reduce the risk of flooding to Timms Green, investigate the feasibility of creating a temporary flood storage area in the playing field (**12**) adjacent to the watercourse (this may require hydrological and hydraulic assessment of the watercourse)
G	Calculate the peak flow rate and volume of surface water run-off that is generated on the fields to the south of Willersey and within the village itself
H	Use the calculations from recommendation G to assess the adequacy of the village's drainage system. If the drainage is found to be inadequate, investigate options for improving the system, including establishing formal attenuation ponds
I	Irrespective of the findings of recommendations G and H, investigate options for improving the natural and formal drainage of the fields to the south of the village, in order to reduce the risk of surface water flooding to properties along the south side of Broadway Road

J	Provide advice to the owner of the private culvert on Broadway Road (**3**), for addressing the flooding problem associated with the culvert.
K	Promote self-help and non-structural approaches to flood risk management (refer to the main report)

References

Cotswold District Council (2008) Meeting with Rob Bull, Engineer. 8 May 2008

Appendix 7

Whelford - Site Response

Location 7 – Whelford

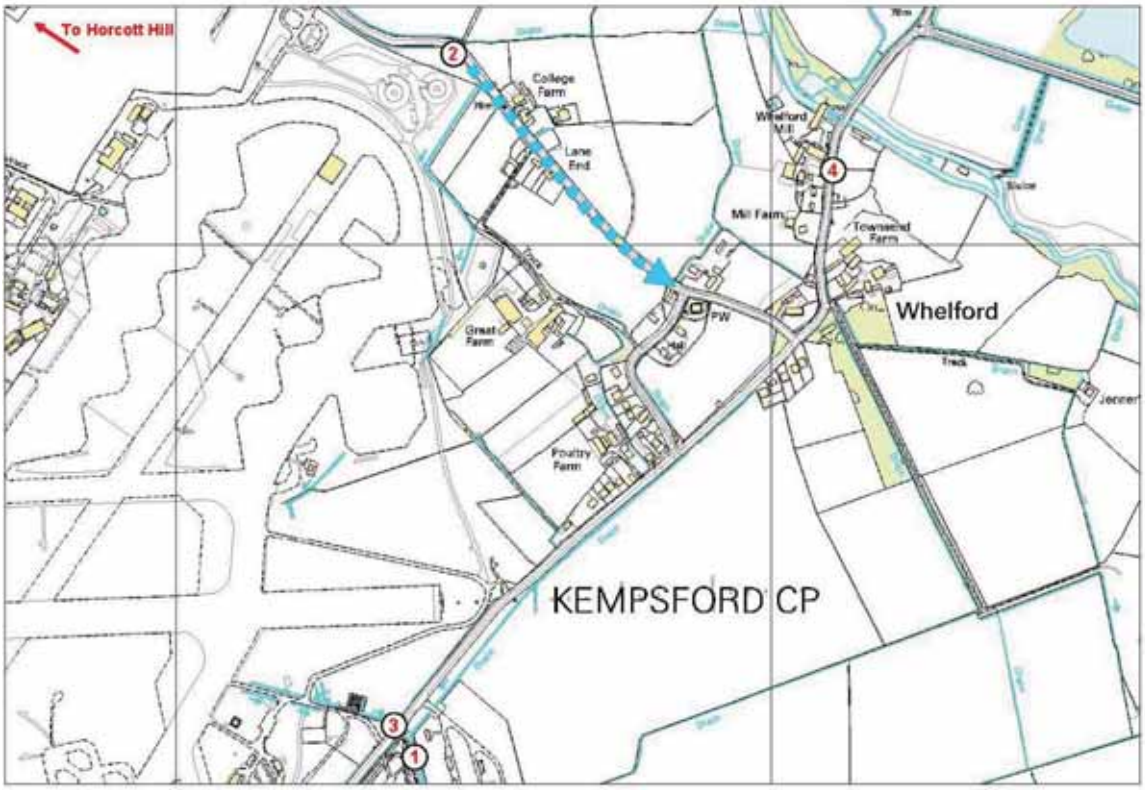
Date of visit	22 April 2008
Attendees of the workshop	Eric Hiscock, Leonie Mcintosh and Alistair Kennedy

1 Mechanisms

Summary

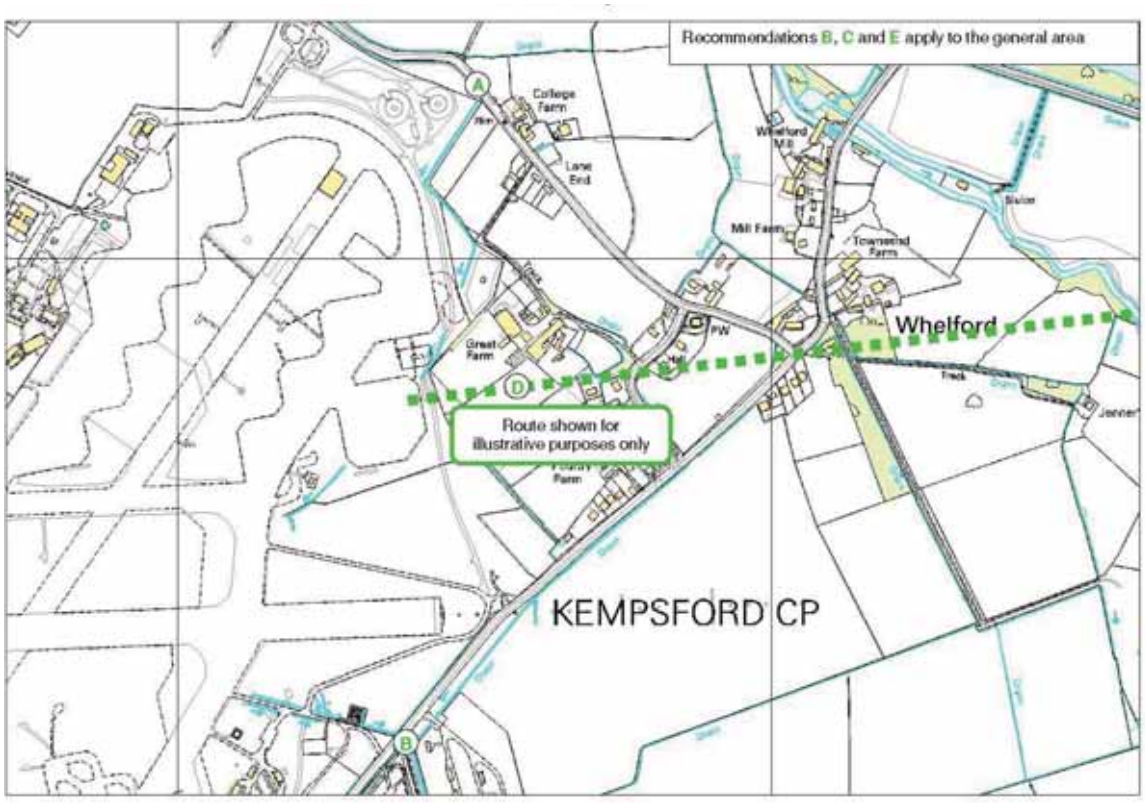
Flooding is a regular occurrence in the village of Whelford, with some properties having been affected three times in the last five years. On 20 July 2007, 36 homes were flooded by surface water run-off. A further 3 properties are reported to have flooded the following day from the River Coln.

Nearly a quarter of the Whelford residents who responded to Cotswold District Council's flood assessment questionnaire, reported that surface water run-off from RAF Fairford played a major role in the Summer 2007 floods. Since the floods, personnel from the RAF base have taken a number of measures to reduce flood risk, including clearing all storm drainage ditches on the base and conducting a flood emergency exercise.



Description of Mechanisms
Surface water run-off
The Horcott A land drainage ditch, which runs in a general southerly direction from the foot of Horcott Hill to Washpool Drain (**1**), enters a culvert on Peace Camp Bend (**2**). On 20 July 2007, backwater from this culvert flowed south-eastwards along The Horcott and into the village. Following the flood, RAF Fairford replaced the culvert with a larger box culvert (1 m diameter) and installed a new trash screen, the design of which was approved by Gloucestershire Highways. Attendees of the workshop expressed concern that road gullies on The Horcott are still not functioning properly. However, Gloucestershire Highways plans to improve the drainage in this area. *Whelford Road* Surface water run-off from approximately 70 per cent of the RAF base is reported to discharge into the Washpool Drain (**1**; designated Main River). This drain flows southwards off of the base, before turning east towards the River Coln. At the time of the Summer 2007 floods, a cycle path was being constructed along the Whelford Road (**3**), and the culvert which carries the Washpool Drain under the road had been replaced temporarily by two small pipes. These pipes are reported to have restricted the flow and exacerbated flooding in the village. The original culvert has now been restored. A flow control device is installed on the Washpool Drain and this is reported to have also caused water to back-up on the RAF base. Local residents are concerned the recently re-layered airfield will shed water down to Whelford. The Parish Council have expressed concerns that recently culverted ditches have exacerbated flooding
River flooding
Following surface water flooding in the village centre on Friday 20 July 2007, the River Coln flooded the area of Whelford Mill, Townsend Farm and Mill Farm the following day (Saturday 21 July; **4**). Concerns have also been expressed about the lack of maintenance to the Dudgrove Brook (at gate 7 of the RAF base).

2 Mitigation Recommendations



Mitigation Recommendations	
A	Improve the road drainage of The Horcott (Gloucestershire Highways has already committed to this). Investigate if the recently culverted ditches have exacerbated flooding.
B	Check with RAF Fairford whether a quantitative assessment of the air base drainage systems has been undertaken. If not, calculate the peak flow rate and volume of surface water run-off that drains to both the Washpool Drain and Dudgrove Brook, for a range of return periods. Use these calculations to assess the adequacy of the drainage systems, including the appropriateness of the flow control device on the Washpool Drain (taking account of the Environment Agency's requirements for controlling surface water run-off)
C	Investigate options for retrofitting Sustainable Drainage Systems on the RAF base
D	Investigate the feasibility of creating a flood relief ditch that runs from the RAF base to the River Coln. The owner of Great Farm is prepared to offer his land free of charge for this purpose
E	Promote self-help and non-structural approaches to flood risk management (refer to the main report)

Reevey
As part of the workshop for Whelford, we were also shown the village of Reevey. This village is located approximately 2.5 km to the south-west of Whelford, and 5-10 properties are reported to have flooded here in Summer 2007. As in Whelford, the flooding was caused by surface water on Friday 20 July 2007, followed by the River Thames on Saturday 21 July 2007. Although this village is not one of the top 20 locations, it is recommended that, in order to reduce the risk of surface water flooding here, residents are given advice on retrofitting Sustainable Drainage Systems.

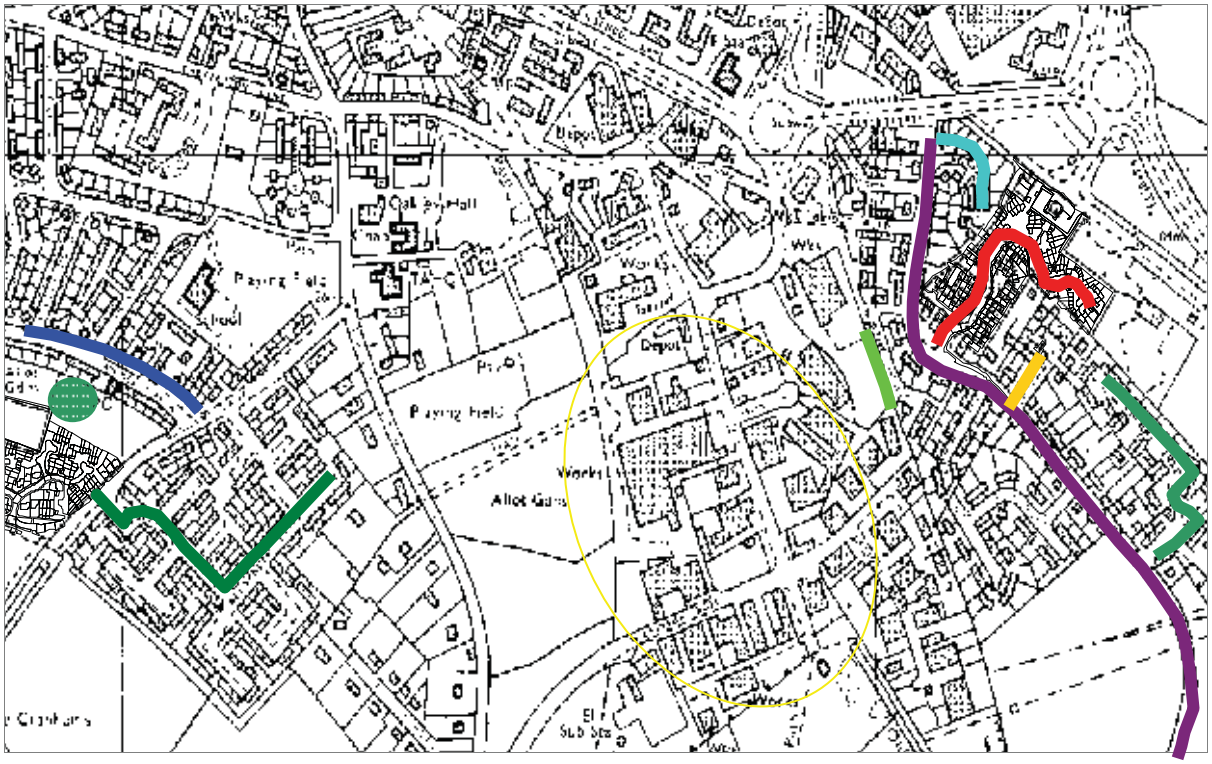
Appendix 8

Cirencester (Watermoor & Chesterton areas) - Site Response

Location 8 & 19 - Cirencester (Watermoor & Chesterton)

Date of visit	10/04/2008
Attendees of the workshop	Clifford Hilditch and Deryck Nash

1 Mechanisms



Summary

55 properties across the areas of Watermoor and Chesterton were reported as flooded as a result of July 2007 flooding. The mechanisms in each area were different.

Watermoor (south of the ring road)

1- **Melmore Gardens**- The road has a long history of surface water drainage problems and flooding. The road and drainage is in very poor condition and some manholes have been sealed to prevent them bursting open during highly pressurised flows.

2- **Rose Way**- Flooding is a regular occurrence as the water comes from Love Lane and the drainage system is overwhelmed. The drainage is in very poor condition and could be under capacity as flooding occurs every time there is high rainfall.

3- **Southmead Close**- In 2007 flooding occurred due to overwhelmed drains, the drains surcharged and flooded properties up to 10 cm (4 inches) in water. The manholes surcharge frequently if there is high rainfall, resulting in flooding from both foul and surface water.

4- Love Lane Industrial Estate (O) - The area generates a high level of surface water runoff due to the high amounts of impermeable area**.** **Siddington Road** is located down gradient from the estate and receives the runoff from the area.

The EA report for the area also suggests that properties north of the ring road flooded although these were not reported to CDC.

Chesterton

5- Drains are regularly overwhelmed. The area has a long history of surcharging resulting in flooding from surface and foul water. The soakaway (O) in the field behind **Countess Lilias Road** could be under capacity and may need extending. Due to recent development around the area there is uncertainty regarding the connections into the soakaway.

6- **Countess Lilias Road**- All drains from the road go to the soakaway located in the field behind the road. The area has a foul water flooding problem.

7- Love Lane Industrial Estate (O) - The area generates a high level of surface water runoff due to the high amounts of impermeable area**.** **Nursery Close** is located down gradient from the estate and receives the runoff from the area.

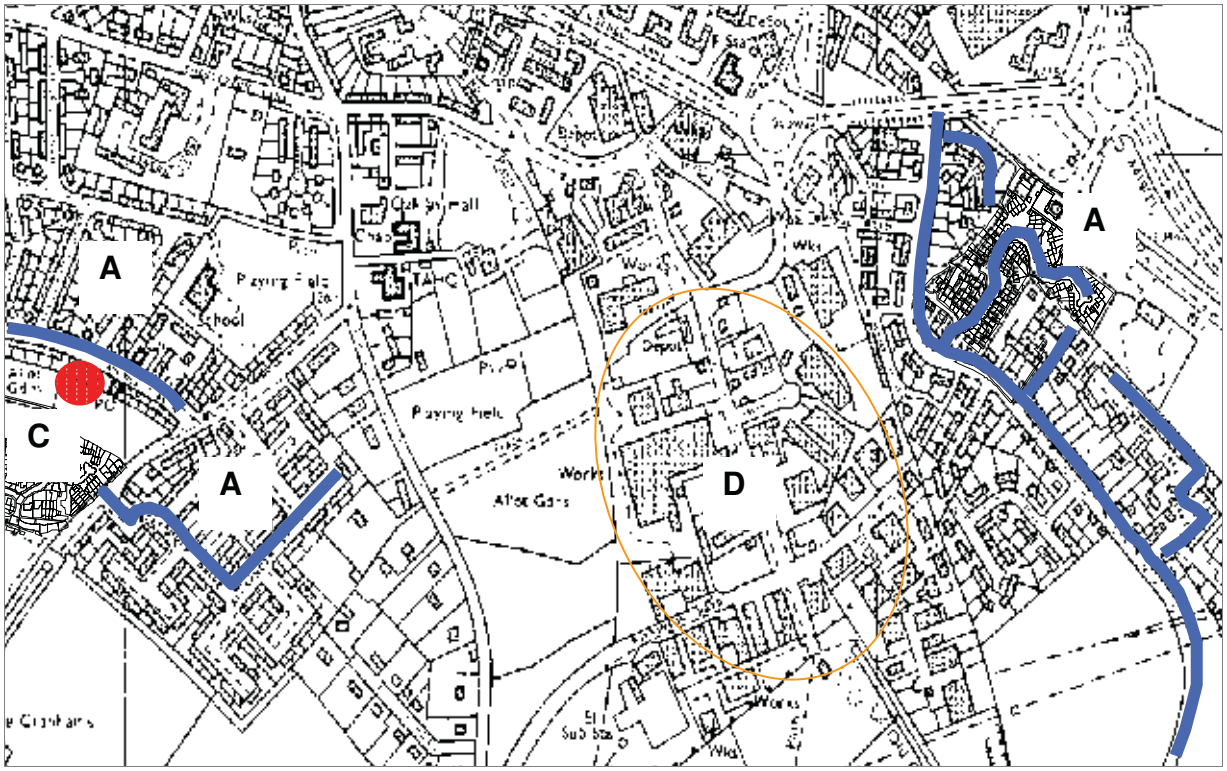
8- **Nursery Close**- The surface water flows from the industrial estate and runs into the close

9- **Alexander Drive**- Floods regularly from surcharging drains.

Description of Mechanism	**Photograph**
The Rose Way area has a long history of flooding. The water surcharges from the drains during high rainfall and the water ponds in the cul-de-sac. A local resident reported that once the water has surcharged it takes on average around 8 hours to drain away. During the 2007 flooding the water level in the houses was at a depth of around 0.3 m (1ft). The highway drainage is in very poor condition and is possibly under capacity as the area floods every time there is high rainfall. The belief is that the flooding is a regular occurrence as surface water comes from the Love Lane Estate and the drainage can not cope with the volume of water in the system.	
Nursery close flooded from surface water during the 2007 floods. Local residents view that the Love Lane Industrial Estate is the source of the majority of the surface water runoff. The industrial estate generates a high level of surface water runoff due to the high amounts of impermeable surfacing in the area. Nursery Close and Siddington Road are located down gradient from the industrial estate and the surface water flows from the industrial estate and into the Nursery Close and Siddington Road.	

Drains are regularly overwhelmed on Countess Lilias Road. The area has a long history of surcharging resulting in flooding from surface and foul water. The soakaway in the field behind the road could be under capacity and need extending. The area has a very high water table and recently built developments have flooded from ground water flooding. All drains on the road go to the soakaway located in the field behind the road. The area has a foul water flooding problem and flooded from foul and surface water during the 2007 floods. Due to the recent development in the area there are uncertainties regarding the connections into the soakaway.	

2 Mitigation Recommendations



Mitigation Recommendations	
A	Melmore Gardens, Rose Way, Southmead Close, Countess Lilias Road and Alexander Drive require a drainage survey to be completed to assess the capacity of the drains. If the drainage is found to be inadequate, improvements should be made to the drainage network to reduce the risk of flooding. GCC has reported that a drainage pipe under Siddington Road has collapsed in sections and is of insufficient capacity. The poor condition of the pipe is contributing to flooding to the east and west of the road. This requires investigation by Thames Water.
B	As a short term measure all of the drains in the areas affected by flooding should be regularly inspected and maintained on a regular basis.
C	The soakaway located in the field behind Countess Lilias Road should be investigated to check the connections into the soakaway and to determine if the capacity of the soakaway needs increasing.
D	The runoff generated by the Love Lane Industrial Estate should be investigated. If the development is found to generate significant runoff, measures could be taken to reduce the runoff from the estate by attenuation.
F	The EA have investigated the Watermoor area north of the ring road and a strategy has been developed which has been approved. CDC should work with the EA project team to ensure all areas are covered as part of this strategy and collaborate where possible. The EA have investigated the cost/benefit ratio the scheme and funding may not be able to be obtained for the scheme to progress.

Appendix 9

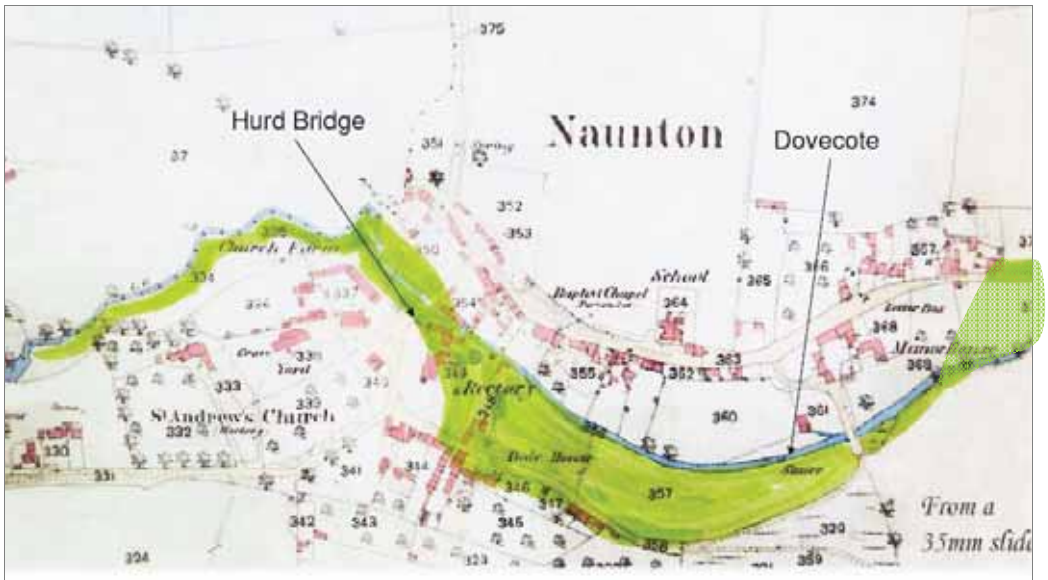
Naunton - Site Response

Location 9 – Naunton

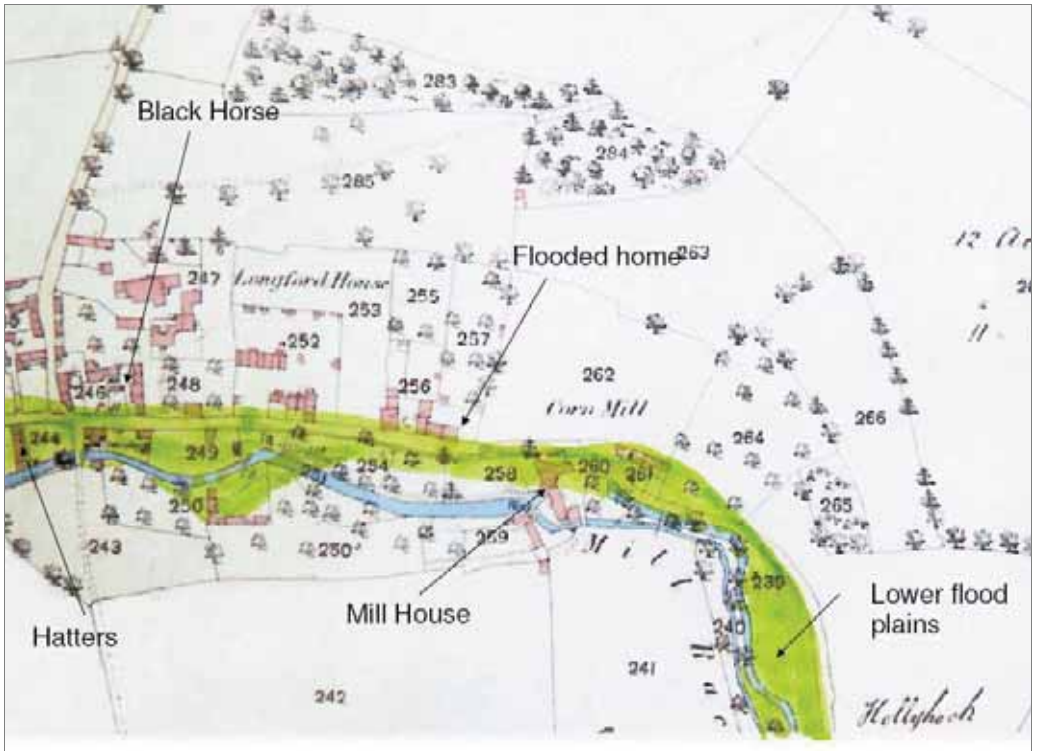
Date of visit	03/04/2008
Attendees of the workshop	Graham Hunter, Ian Banks, Jonathon and Cathy.

1 Mechanisms

Map 1 & 2

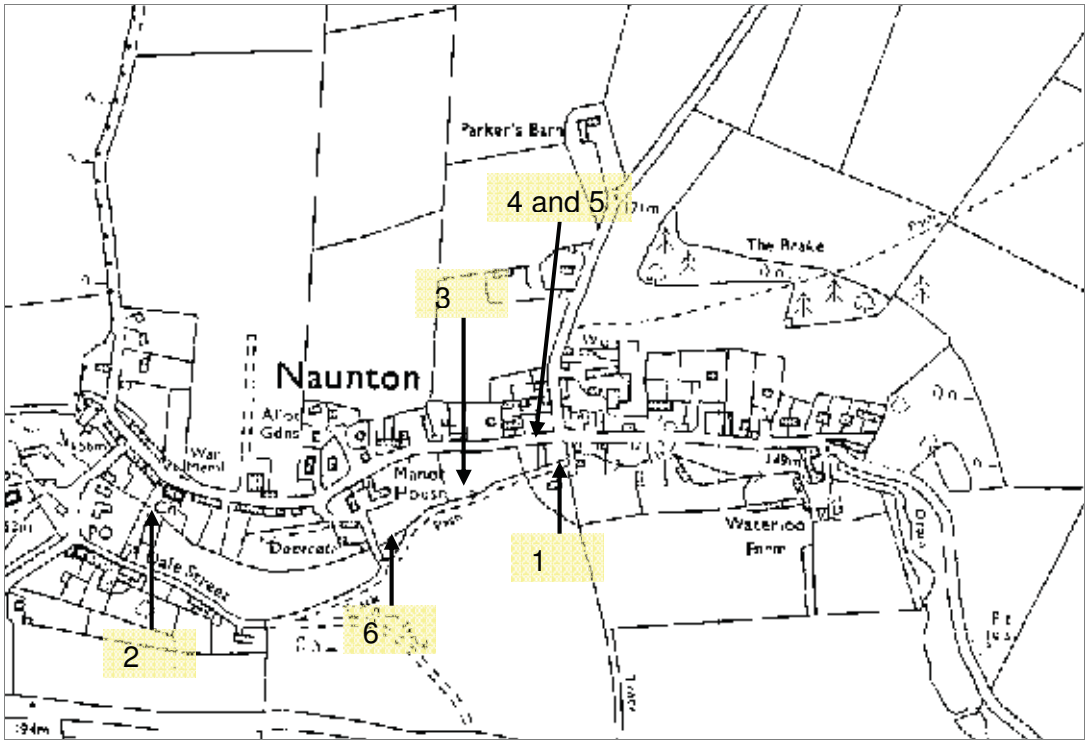


Extent of the flood waters (in green) – west end of village, 20th July, 2007



Extent of flood waters (in green), east end of village - 20th July 2007

Map 3



Summary

Naunton experienced flooding from fluvial flooding and sewerage discharge. 22 properties were reported as having flooded as a result of the July 2007 flooding. The village is at risk of fluvial flooding from the River Windrush. Residents of Naunton have formed a village flood group committee who have provided flood extents maps and information regarding the flooding mechanisms. The flood extents maps are an extract from a presentation produced by the flood group.

Mechanisms relate to Map 3.

1 There is a pinch point in the river channel at Hatters.

2 There is an opening in a wall on the right bank of the river downstream of Hurd Bridge, which resulted in flood flowing through the Old Rectory's garden and into Dale Street.

3 The river channel is poorly maintained in reaches, with overhanging vegetation and obstructions.

4 The main road which runs through the village has poor drainage. There used to be an open land drain which ran alongside the length of the main road. Sections of the drain have been covered over, resulting in deterioration of the drainage on the main road.

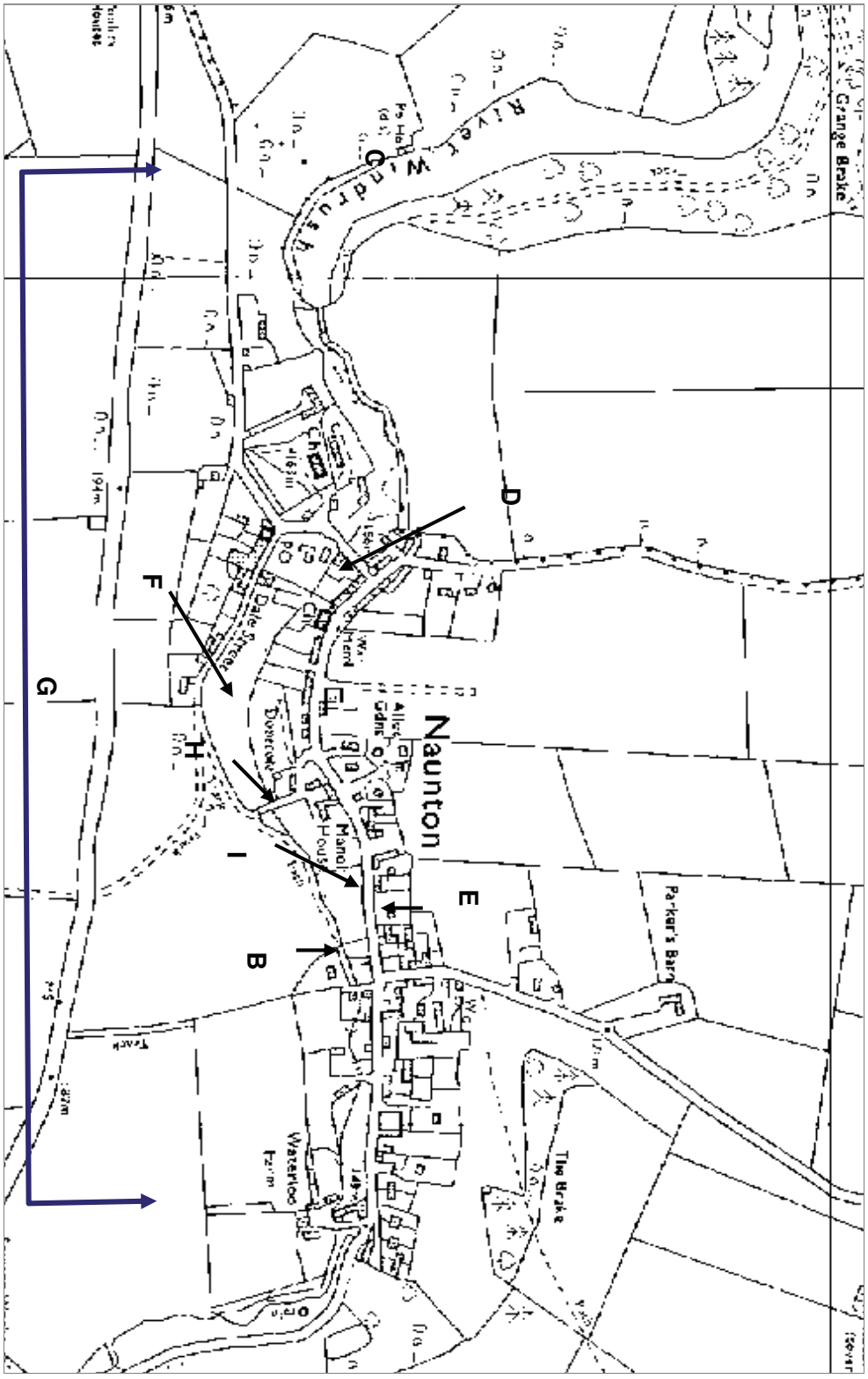
5 The road used to have a slope, with an increase in gradient from the river up to the houses, which provided protection to the houses as the river would flood the road. Over the years road resurfacing has removed this gradient and the protection provided to the houses from the increase in gradient.

6 The gate which usually allows flood water to flow from the Dovecote floodplain and rejoin the river downstream of the bridge was blocked during the flooding, resulting in flood water flowing onto the road.

Description of Mechanism	Photograph
Looking downstream from the Hurd Bridge. There is an opening in wall on right bank which allows water to break out of bank during high flows and to flow through the garden of the Old Rectory. There is minimal freeboard between the water level in the river and the top of the opening in the wall. During the flooding the opening in the wall caused water the flood water to flow from the river, through the property and resulted in flooding on Dale Street.	
Photo taken looking upstream from houses located after the Dovecote floodplain. Reaches of the river have overgrown vegetation obstructing the channel. During flood events the vegetation will restrict the flow of water through the channel and reduce the rate at which water can move though the village.	
The drain which runs on left hand side of the main road. The open drain which used to run across the length of the main road has been covered in sections, this has worsened the drainage of the road and as a result water collects on the road rather than in the ditch. The short culverts under the access strips to the houses vary is size along the remaining open areas of the drain. This constricts the flow in sections and causes water to back up.	
Looking upstream at the Dovecote and the floodplain from the Dovecote Bridge. The Dovecote floodplain acts as a flood storage area during flood events. The small orifices under the Dovecote bridge restrict the flow and water backs up and is stored on the floodplain. There is a concern that planting of the Dovecote floodplain could reduce the capacity of the floodplain and that vegetation from the planting could block the orifices under the bridge.	

Looking at the Dovecote Bridge from the road. The bridge has 3 small orifices which hold back water during high flows on the Dovecote floodplain. If the capacity of the floodplain is exceed, in previous events, water has flowed through a gate by the bridge and joined the river downstream of the bridge. During the flooding the gate was blocked by grass which had recently been cut and water could not rejoin the river downstream. Subsequently the river flowed over the left bank onto the main road and flooded properties.	

2 Mitigation Recommendations



Mitigation Recommendation	
A	Undertake hydrological and hydraulic assessment of the River Windrush for a range of return periods, taking account of climate change impacts. The model will confirm the pinch points along the river and verify the proposed mitigation measures.
B	To improve the pinch point at Hatters it is recommended all obstructions in the watercourse are removed in the vicinity of Hatters, to increase channel efficiency at the point of constriction. There is an option for river widening at this point.
C	The bridges along the river restrict the flow, due to the small orifices under the bridges, resulting in the attenuation of flood water in the fields behind. There is potential to formally attenuate flood water upstream in the water meadows and in the fields behind the bridges and control the flow into the village. This recommendation would require cooperation from landowners.
D	It is recommended the opening in the river wall of the Old Rectory on the right bank downstream of Hurd Bridge is closed off. A flood board it not recommended as this relies upon someone having assess to the property to put the board in place during high flows. This opening is considered to pose a major risk to the Old Rectory and to the surrounding houses due to the minimal freeboard between the river level and the step to the garden.
E	During flood events ensure the gate is left open to the right of the bridge, to ensure there is no obstruction to flow. There is an option to install an overflow drain over the road at the Dovecote bridge to reduce water build up on bridge, to allow the flow to rejoin the river downstream and to avoid water flowing onto the main street over the left bank.
F	The Dovecote floodplain acts as a flood storage area during high flows. To ensure the capacity of the area is maximised it is essential riparian owners maintain the river bed and banks to ensure they are free of overhanging vegetation, debris and obstructions. Planting of the floodplain is not advised, as in the long-term effect will be to reduce the capacity of the floodplain. Debris from planting in the floodplain could result in the small orifices on the bridge becoming blocked, resulting in water building up in the floodplain during low flow conditions.
G	To ensure flood water can flow through the Naunton without restrictions it is essential the banks of the river are maintained on a regular basis and are free of overhanging vegetation, debris and obstructions. Regular maintenance of the river is required, particularly between Dovecote and public house downstream.
H	Reinstate the old gradient on the main road, which would provide a higher level of protection during lower flood flows for properties on the main street, as water would flow along the lower roadside adjacent to the river and into the land drain. The mitigation measure has been recommended to GCC and they are going to investigate the option.
I	Improve the drainage on the main road. Consideration should be given to replacing the open and covered drain with a channel drain with a metal grate. This would convey the water on the main road out of the village, and prevent vehicles from driving into the drain. GCC have replaced a 9” clay pipe under the main road with a 300mm pipe to improve the road drainage.
J	Contact landowners to raise awareness of their responsibility for riparian maintenance (refer to the main report)

K	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Issues
After the flooding in July 2007 many people in Cheltenham who were without water used the facilities at the golf club south of Naunton. This resulted in the sewer system being overloaded further with a reported 10 properties experiencing sewerage back ups. A number of properties also identified sewerage emanating from the gullies draining gardens and patios which suggests illegal connections to the sewage system. It is also known that there are blockages in the system which may have contributed to the reduction in capacity. It is therefore recommended that there be a thorough investigation of the sewage system in Naunton which will identify manholes which can be sealed and a suitable maintenance schedule to clear blockages. We also suggest that an emergency management plan be developed which involves the golf course to identify how best to manage the facility in an emergency which will minimise the impact on Naunton residents.

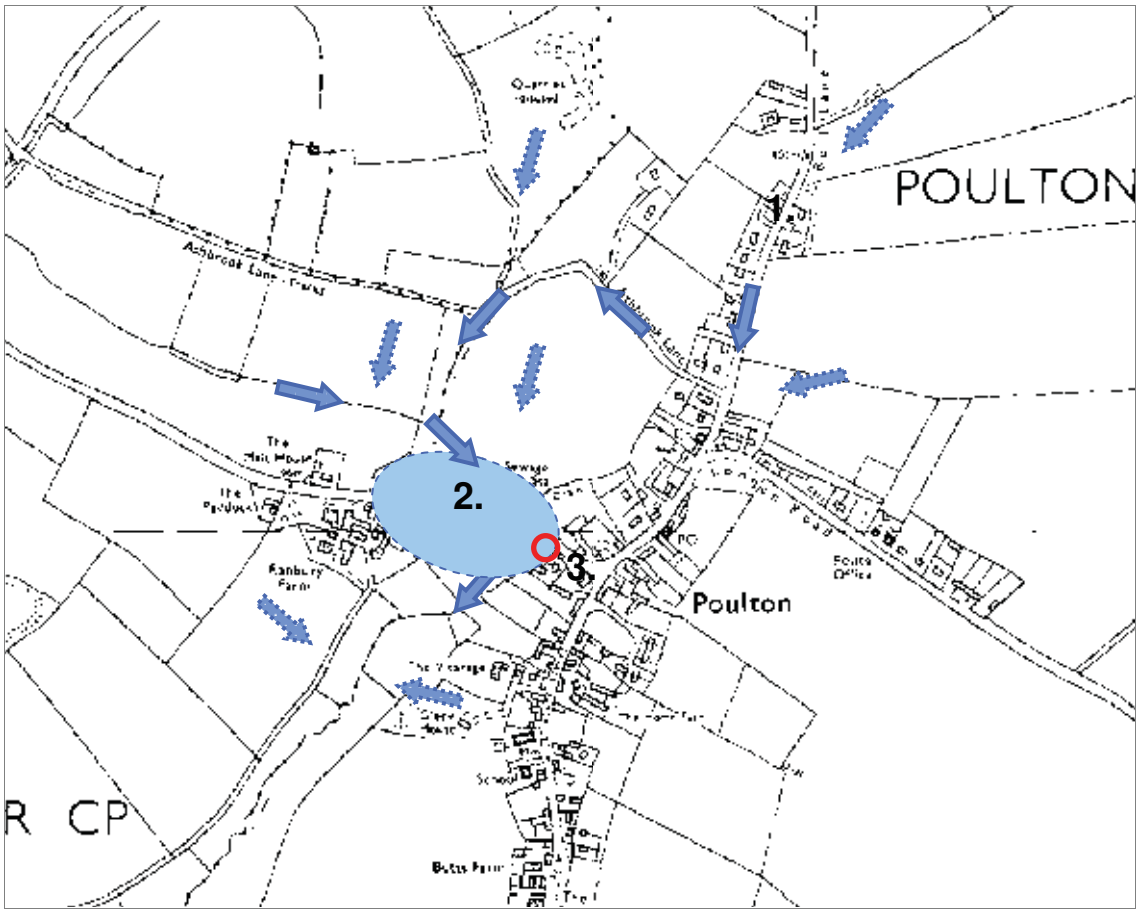
Appendix 10

Poulton - Site Response

Location 10 – Poulton

Date of visit	25/04/2008
Attendees of the workshop	Geoff Chapman, Councillor David Fowles, Chris Davies.

1 Mechanisms



Summary

In July 2007 up to 20 properties flooded in the village of Poulton from fluvial, surface, groundwater and sewer sources. Runoff from the fields surrounding Bell Lane and Ashbrook Lane combined upstream of the road culvert to overwhelm the ditch and flood adjacent properties upstream of the road bridge. Properties in Bell Lane **(1.)** were flooded from both surface water runoff from the fields behind the properties and surface water runoff from the road. Properties surrounding the A417 road bridge **(2.)** were flooded from a combination of fluvial, surface and groundwater. High groundwater levels in the area resulting from the prolonged rainfall over May to July are believed to have contributed to water flowing up through basements in some properties. Properties in Stoney Pool **(3.)** were also affected by sewer flooding in the event. It is understood that the Sewage Treatment Plant did not flood however.

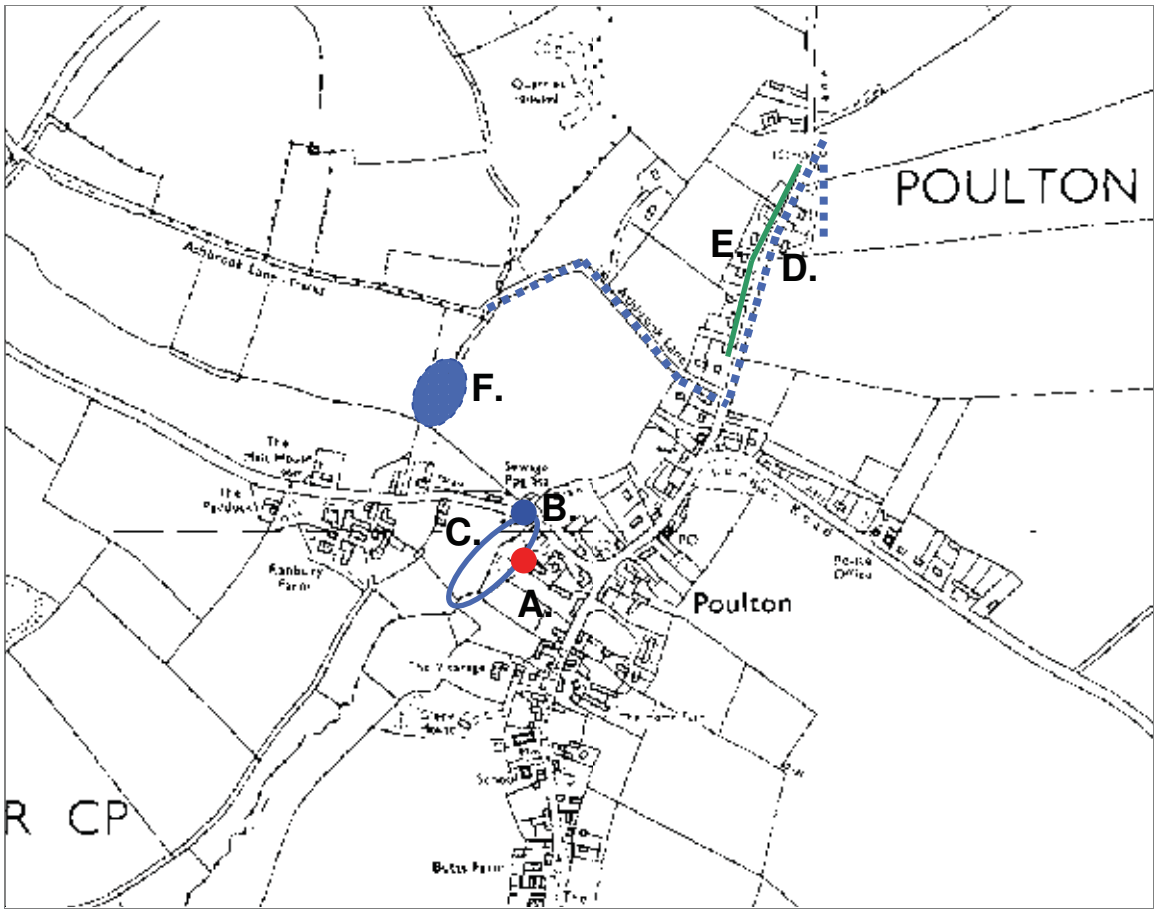
The Old Manor Farm House is regularly affected by flooding which has been reported as occurring since 1992. Properties in Stoney Pool are also regularly affected by sewer flooding however it is understood that the sewer has not previously flooded the properties internally.

Some works have already been undertaken around the village. Ditches have been cleared and houses along Bell Lane have had sleeping policemen installed. Some individuals have also formalised and improved banks on ditches adjacent to their properties.

Description of Mechanism	Photograph
Photo looking west and upstream from upstream of the road culvert. This ditch overtopped the banks and flooded seven surrounding properties. Ditch upstream is generally clear.	
Looking downstream at the culvert underneath the A417 road bridge (opposite the sewage treatment works). The banks either side are overgrown and show signs of scour and undercutting in places. It was also reported that debris regularly accumulates at the entrance to impede flow[1].	
Looking downstream from the road bridge. Ditch is generally clear downstream, however banks tend to be overgrown and difficult to access in some locations. The ditch makes several right angle turns before being allowed to meander towards Ampney Brook. Fences that cross the ditch are also thought to catch debris and impede flows during storm events[1].	

[1] Reference: Discussions and letter (undated) from Chris Davies.

2 Mitigation Recommendations



Mitigation Recommendations	
A	Contact Thames Water to confirm status of its investigations into sewer flooding in Stoney Pool. It is understood that there have been meetings relating to this issue but the status and schedule is unknown.
B	Clear and regrade banks upstream of culvert to improve conveyance. Investigate, design and construct appropriate works at upstream end of culvert to protect banks from scour. Gabion baskets, or equivalent, benched from the base of the ditch is recommended.
C	Obtain survey undertaken by GCC to determine whether bed slope alterations will improve conveyance. Undertake ditch clearing: remove obstructions, thin bank vegetation and formalise banks. Investigate benching and scour protection on right angle bends.
D	Reinstate appropriately sized ditches/pipes along Bell Street and Ashbrook Lane to formally convey surface water runoff to the ditch south of Ashbrook Lane.
E	Protect properties on the low side of Bell Lane with “sleeping policeman” to prevent washover.

F	Investigate whether the installation of an attenuation basin upstream of the confluence of the two ditches is likely to benefit conveyance and assist in flood prevention downstream. There may be an opportunity to jointly fund the investigation and construction of the basin subject to permission from the land owner.
G	Contact landowners to raise awareness of their responsibility for maintaining roadside ditches and riparian maintenance (refer to the main report)
H	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

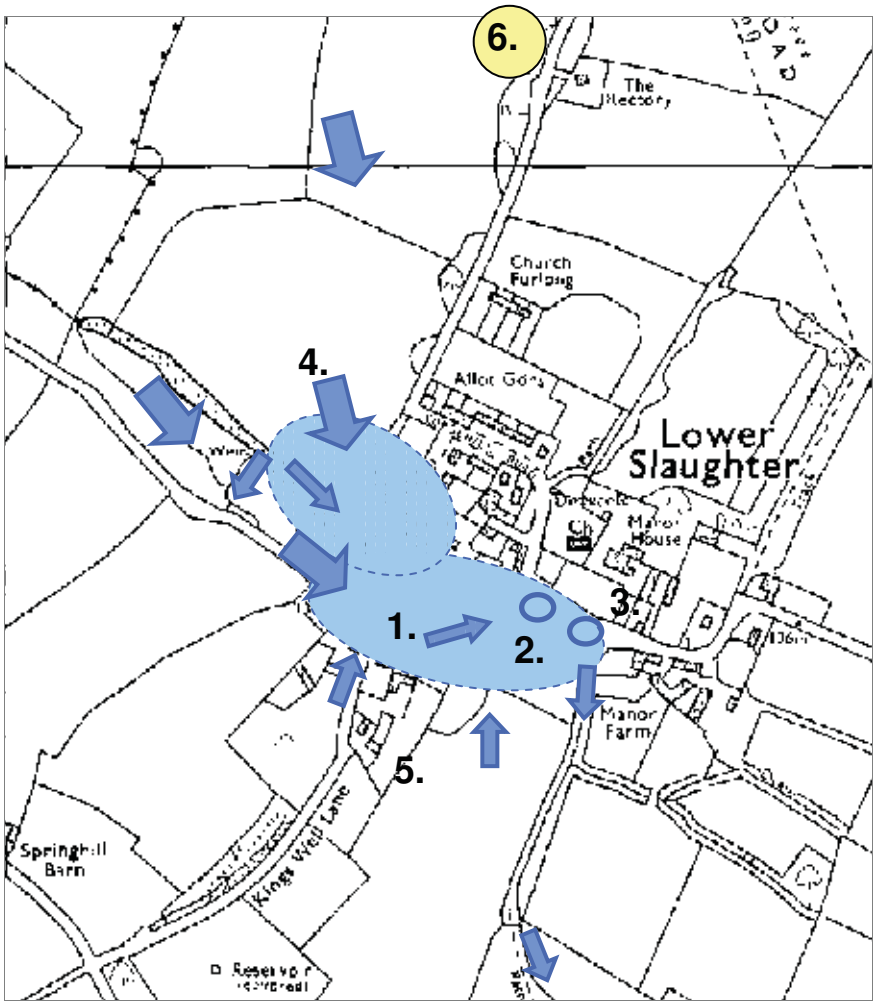
Appendix 11

Lower Slaughter - Site Response

Location 11 – Lower Slaughter

Date of visit	24/04/2008
Attendees of the workshop	Bob Williams, Steve Randles, Tony Long

1 Mechanisms



Summary

22 properties in Lower Slaughter were reported as having flooded in July 2007 due to:

1 the River Eye through the centre of town overtopping its banks,

2 the road bridge constrained the flow of the River Eye before it was overtopped,

3 the penstock downstream from the Hotel was also thought to contribute to backing up the River Eye,

4 surface water runoff from fields behind Mill Lane flooded properties as it couldn't discharge from the mill pond to the River Eye.

5 surface water runoff from fields behind Becky Hill and Copsehill Road, and

6 pumping station at Upper Slaughter contributed to sewer flooding within properties in Lower Slaughter

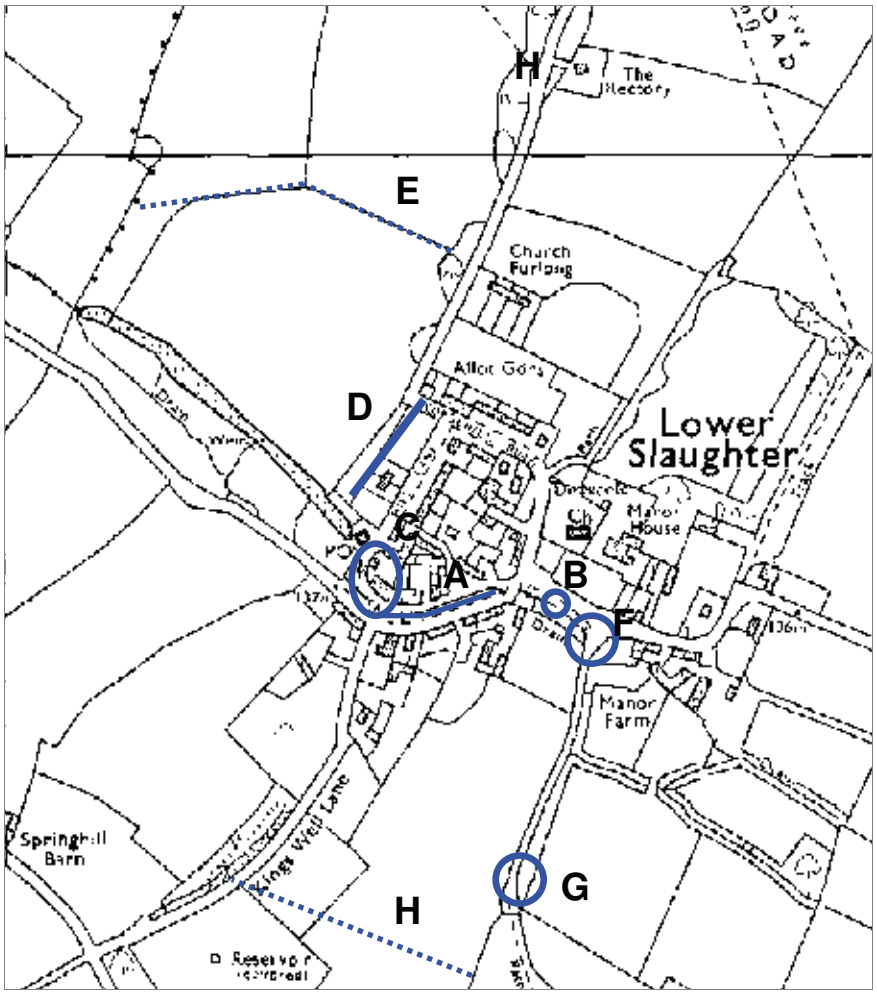
Unlike a number of other villages, a local flood response group was already established and

was therefore active in managing the flooding during July 2007. The group assisted with the opening of penstocks and distribution of sand bags in the village and were able to provide good information on the flooding extents and mechanisms.

Description of Mechanism	Photograph
Photo looking downstream along River Eye toward road bridge. The main drain overtopped the banks on both sides flooding properties on both sides. The culverts under the road bridge were able to convey sufficient flows during the July 2007 event and contributed to the backing up of flows in the river.	
Photo looking downstream along River Eye at minor obstructions. Properties (shown) on either side of the river were flooded.	
Photo looking upstream at penstock (located downstream from Hotel). Members of the local flood response group operated this penstock (at great risk to their safety) during the flooding in July 2007. Boards from either side of the penstock were also removed and it was noted that there was almost an immediate drop in water level. The local flood response group have also spent considerable time investigating the ownership of this device. They have recently been advised that the Hotel does not make any claim of ownership and has allowed the parish to obtain full ownership of the penstock device. The local flood response group are proposing to rebuild this device to create four openings (with two penstocks) to make it easier to operate in high flows.	
Photo looking upstream River Eye as it leaves the village. There are concerns from the local flood response group that the culverts are not of sufficient capacity and may have contributed to flooding further upstream. The river has silted up at this location.	

Looking downstream at fields behind the properties on Mill Lane. This area was reported as being completely underwater. Surface water from upstream of this field collected here and was unable to discharge to the mill pond.	
Looking south at the weir between the mill pond and the River Eye. The penstock (to the right of the weir) was operated by the tenant farmer during the flooding in July 2007. The capacity of this system to convey surface water from the fields upstream and the mill pond was constrained by the flows already in the River Eye.	
Looking upstream at the confluence of the mill pond and the River Eye (mill at centre of photo). The water discharging from the mill pond enters the River Eye at this point. During high flows, water from the pond hits the outside wall of the cottage (shown to the right) and in July contributed to flooding not only this cottage but adjacent properties.	

2 Mitigation Recommendations



Mitigation	
A	Increase bank heights along the River Eye through the village to improve bank full flows and protect adjacent properties.
B	Remove penstock and weir if possible. Or, alter the penstock to improve operation.
C	Investigate increasing the river wall height to provide protection from high flows from the mill pond.
D	Some residents are constructing flood walls at the end of their properties. It is recommended that this wall be extended across all properties backing onto this field.
E	Work has begun on the construction of a ditch in the fields upstream from the field behind Mill Lane. This will assist in diverting a significant amount of flow away from the properties in Mill Lane and it is recommended that ditch be continued to connect to the River Eye (upstream of the mill pond).

F	Some bank protection (gabion baskets) has been installed at the bend of the river to protect from scour. This treatment needs to be extended further downstream and on the opposite bank.
G	Investigate improvements to ditch, culvert and river to improve flow rates through this area and minimise erosion.
H	Continue construction of the ditch to Kings Well Lane to divert surface water runoff away from the rear of the properties fronting Copsehill Road.
I	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

Issues
Investigate Thames Water procedure for pumping shutdowns during major storm events.

Appendix 12

Andoversford - Site Response

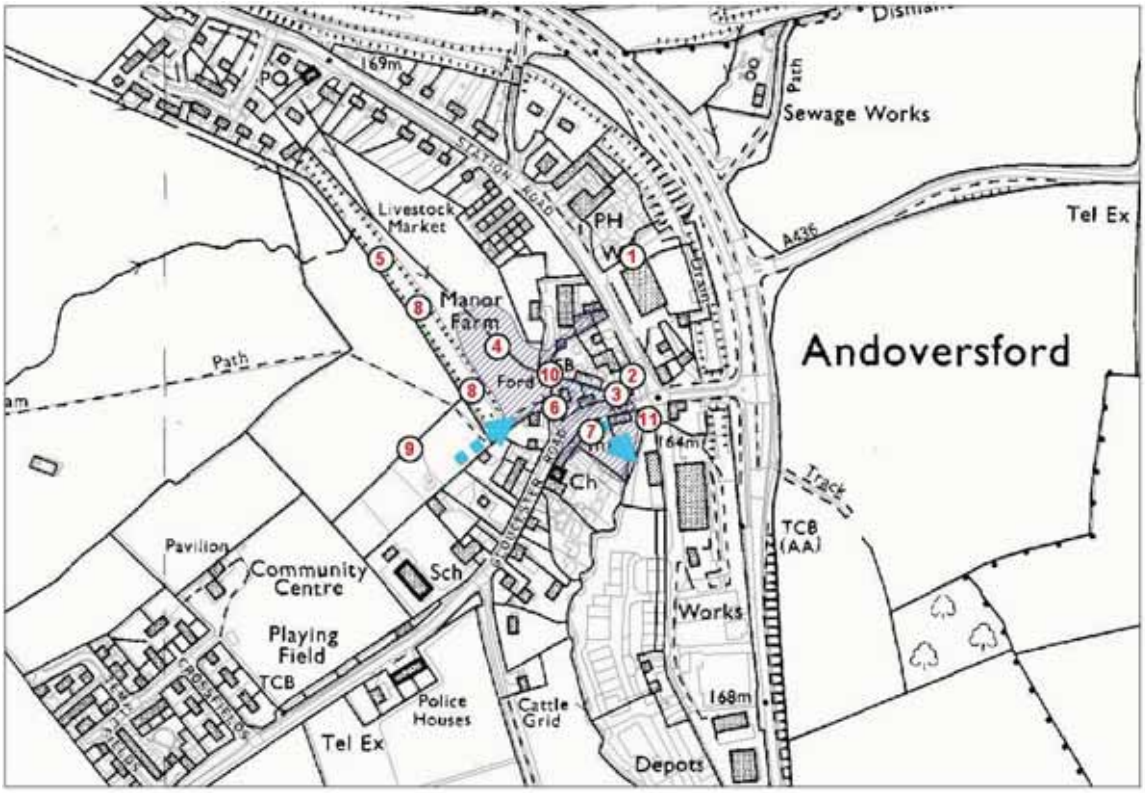
Location 12 – Andoversford

Date of visit	1 May 2008 (site visit made on 17 April 2008)
Attendee of the workshop	Simon Redmond

1 Mechanisms

Summary

On 20 July 2007, 24 properties were flooded in the village of Andoversford. It was the first time some properties had flooded since they were built in 1961. The flooding was caused by a combination of river and surface water.



Description of Mechanism	
River Coln and an un-named tributary	
Photograph – River Coln: downstream face of Station Road bridge (**2**) The River Coln flows in a general southerly direction through Andoversford. It is culverted beneath the premises of the agricultural machinery business (**1**) and Station Road. Surface water discharging from a side road onto the northern section of station road almost flooded properties on Station Road (**2**); the capacity of the Station Road culvert appears relatively small. Limited	

However, the main source of flooding was an un-named tributary of the Coln, which joins it on its right bank immediately upstream of Gloucester Road bridge (**3**). This tributary, which has a catchment area of 10 km^2 (CEH, 2006), drains predominantly agricultural land to the west and north of the village.

On 20 July 2007, the capacity of this tributary was exceeded and water spilled out onto the field (**4**), adjacent to the embankment and to the west of the embankment (**5**). Surface water run-off from agricultural land further west, also flowed into this field via the south of the embankment. As the water in the field built up, it began spilling out of the gate along the southern boundary (**6**), flowing both eastwards and southwards; some of the water flowed across the car park of the Royal Oak pub (**7**) and into the River Coln. The extent of the flooding, observed and mapped by Simon Redmond, is shown on the accompanying map.

Mr. Redmond has noted that openings in the embankment have become blocked over time (**8**), preventing drainage of water through it; this may have exacerbated the build-up of water in the field. A land drainage ditch on the west side of the embankment (**9**) is reported to be poorly maintained and may have contributed to the surface water flowing around the south of the embankment. Concerns have also been expressed regarding the impact of a footbridge and stone structure (both located at **10**), together with obstructions in the River Coln, on upstream water levels.

Development is likely to increase over the next few years and local residents are concerned future development will increase the flood risk.

Photograph –View of right bank tributary, looking north-west towards the embankment. Water built up in this field before spilling into the village centre	*Photograph – Stone structure across the watercourse* (**10**)*. This structure is reported to be boarded up at times to prevent livestock escaping*
	
Photograph –20 July 2007: water flowing towards the field gate (**6**) *(Courtesy of Simon Redmond)*	*Photograph – 20 July 2007: Flooding along Gloucester Road* (**7**) *(Courtesy of Simon Redmond)*

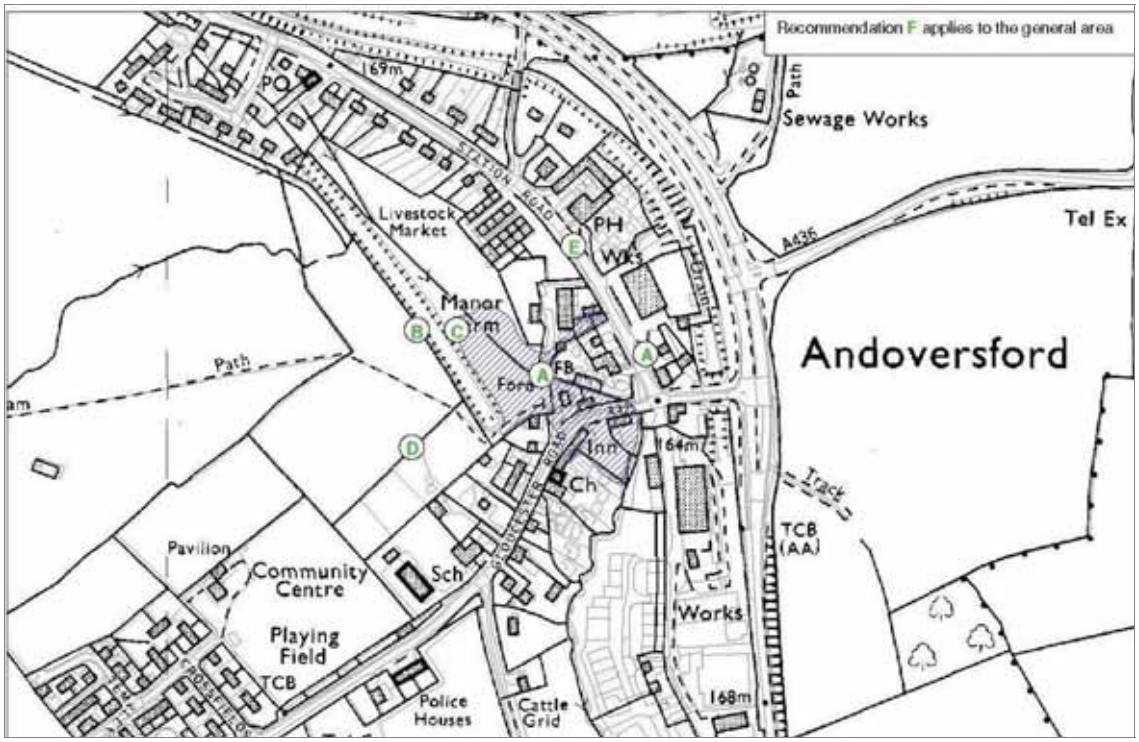
Sewage pumping station

A sewage pumping station, located immediately to the south of Gloucester Road bridge (**11**), is undersized, causing some foul water flooding problems in the village. Thames Water plans to increase the capacity of this pumping station by 25 per cent, in Summer 2008, in order to address this problem.

Road drains

Local residents have also expressed concerns regarding the condition of road drains along Station Road; it has been reported that these drains are not cleared on a regular basis.

2 Mitigation Recommendations



Mitigation Recommendations	
A	Undertake hydrological and hydraulic assessment of the un-named watercourse and the River Coln, for a range of return periods, taking account of climate change impacts. Use the model to identify the locations of pinch points, and assess the impact of the footbridge and stone structure on upstream water levels. (A channel and floodplain survey of the watercourses will be required to build the model)
B	Use the hydraulic model to quantify the flood risk management benefits of the following measures: • removing the embankment (**5**); • creating a formal attenuation pond in the fields either side of the embankment.
C	Depending on the results of the hydraulic model, investigate the feasibility of removing the embankment and/or creating a formal attenuation pond. This recommendation could be undertaken without completing A and B above, if uncertainties in the design criteria and flood risk management benefits are deemed acceptable. However, topographic information on the fields either side of the embankment will still be required
D	Clear and maintain the drainage ditch on the field to the west of the embankment
E	Review the maintenance programme for the road drains along Station Road
F	Promote self-help and non-structural approaches to flood risk management (refer to the main report)

References

[CEH] Centre for Ecology and Hydrology (2006) *FEH CD-ROM*. Version 2.0. NERC (CEH)

Appendix 13

Barnsley - Site Response

Location 13 – Barnsley

Date of visit	18 April 2008
Attendees of workshop	Sir Edward Horsfall, Stephanie Cushing, Lynn Barrack and Brian Skarda

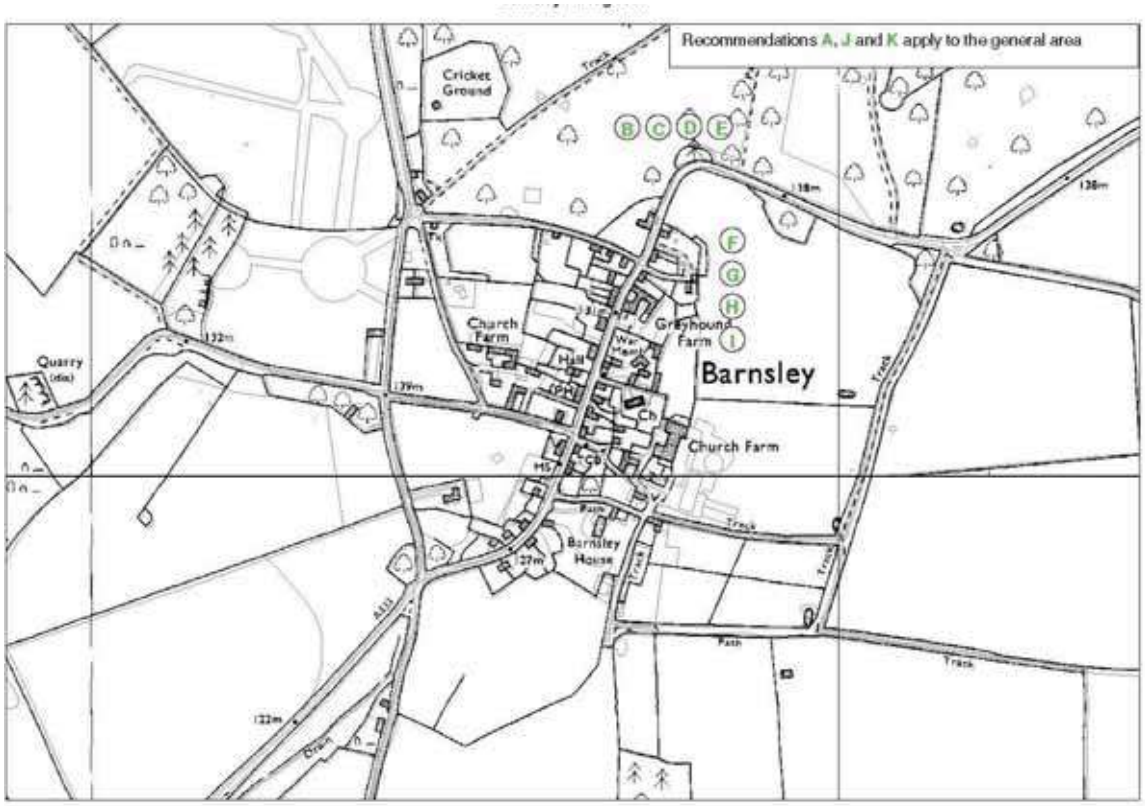
1 Mechanisms

Summary

On 20 July 2007, 16 properties are reported to have flooded in the village of Barnsley. Two phases of flooding occurred:

1 Mid-afternoon, surface water run-off from the fields to the east of the village, in particular the Furlongs field (1), flowed into several properties. In some cases, the water also entered septic tanks, causing them to overflow and exacerbate property flooding

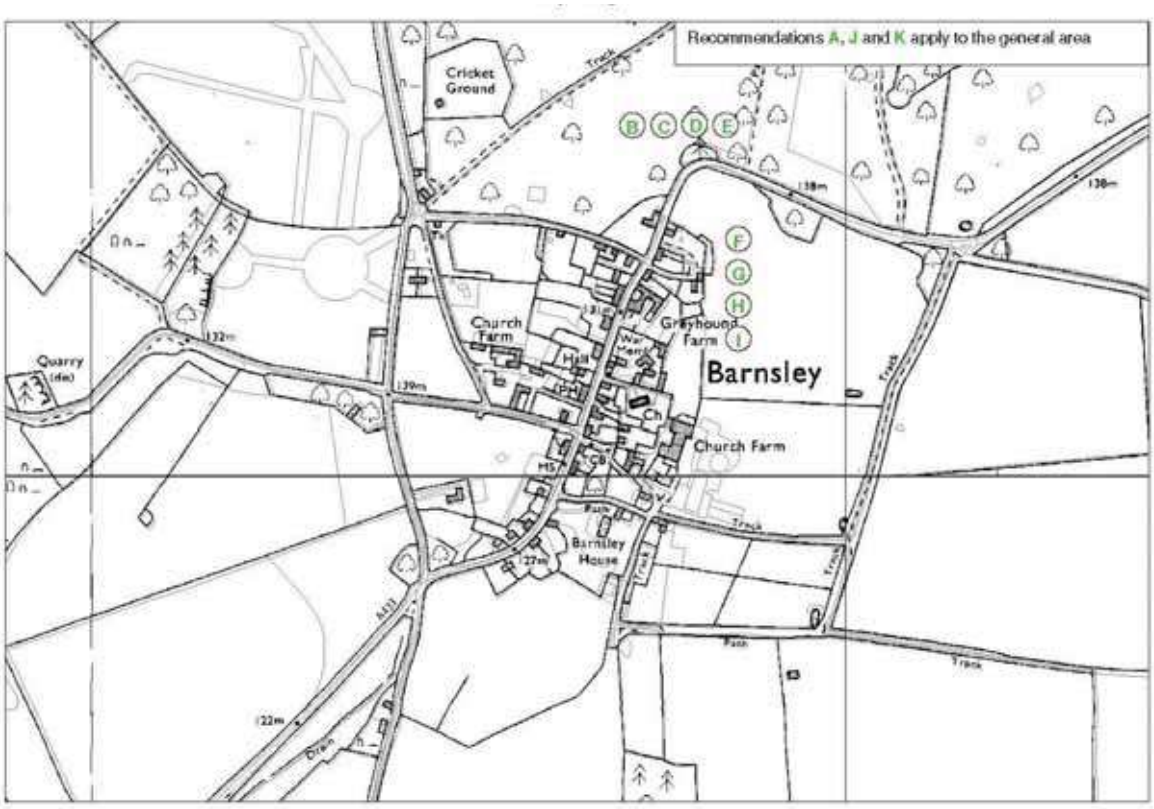
2 In the evening, a second wave of floodwater, this time from Barnsley Park (2), caused renewed and more extensive flooding. The water is reported to have risen and receded very quickly.



Description of Mechanism	
Surface water run-off	
Photograph – View of the Furlongs field, looking east Surface water runs off of the Furlongs field regularly (**1**). The landowner (The Ernest Cook Trust) installed a French drain and soakaway along the western edge of the field around 15 years ago. However, this drainage system was ineffective on 20 July 2007. The villagers reported that the Furlongs field has not been ploughed for many years. This is likely to have increased surface water run-off.	
Photograph – View of Barnsley Park, looking north from the B4425 Barnsley Park is an eighteenth century landscaped estate, covering an area of 160 ha (UKPG, 2002). The topography of the Park slopes downwards to the south and the B4425; the land is lowest adjacent to the road bend and surface water run-off collects here frequently (**2**). A 150 mm diameter drainage pipe runs in a north-south direction under the Park and the B4425, and into Furlongs field (Skarda, 2008). A sump/soakaway in the Park is reported to drain surface water into this pipe as well as an ancient culvert, known locally as the 'Barnsley Drain'.	
On 20 July 2007, surface water spilled out from Barnsley Park (either by overtopping the Park's boundary wall or via a hole in the wall caused by a previous car accident) and onto the B4425. The road is reported to have flooded to a depth of 0.3-0.45 m (le Bars, 2007). The water then flowed south along the B4425 into the village, as well as into the Furlongs field, augmenting the run-off from the field itself. Reports indicate that flow passed through the dry stone wall and filled the Furlong field within 40 minutes. Villagers suggest that the build up of water in Barnsley Park on 20 July 2007 was the result of a blockage, since water usually drains away without causing any flooding problems in the village (as occurred on 13 January 2008 following heavy rainfall). The villagers have also reported that surface water collects on the road bend itself and has caused accidents. Gloucestershire County Council note that a letter has been sent to Barnsley Park and The Ernest Cook Trust requesting a meeting with their representatives, to discuss whether routine maintenance or other further measures on their estate land can be taken to prevent future flooding problems in the village (Galland, 2008).	
Barnsley Drain	

The Barnsley Drain runs south from Barnsley Park, under the properties along the eastern side of the B4425, before discharging into an open watercourse at the southern end of the village (**3**; le Baars, 2007). The exact route, condition and capacity of the Drain are unknown, although villagers have reported that it has a cross-sectional area of around 1 m^2. The Drain has not been adopted by any flood defence operating authority. One property in the village is reported to have flooded on 20 July 2007 as a result of surcharging of the Barnsley Drain (via a drain cover located in the front garden of the property).
Springs
There are several springs on land to the west of the B4425, which become active after heavy rainfall. Water flows from these springs onto the main road and into the road drains (le Bars, 2007).

2 Mitigation Recommendations



Mitigation Recommendations	
A	Undertake a CCTV survey of the Barnsley Drain to establish the exact route, condition and capacity of the drain. Gloucestershire County Council has proposed that the survey is carried out in partnership by the local authorities (Galland, 2008). However, this work had not been completed at the time of the workshop (18 April 2008)
B	Clarify how the drainage system in Barnsley Park operates, including: • soakaway design • connection between the soakaway, and the 150 mm pipe and Barnsley Drain
C	Determine the capacity and condition of the 150 mm diameter pipe under the Park and B4425
D	Calculate the peak flow rate and volume of surface water run-off from the Park, for a range of return periods, to determine whether the capacity of the drainage system is adequate
E	Investigate the feasibility of creating an attenuation pond in Barnsley Park. A pond provides opportunities for biodiversity enhancement, as well as flood risk management
F	Clarify the design of the drainage system in Furlongs field, including capacity, condition and discharge point
G	Calculate the peak flow rate and volume of surface water run-off from the Furlongs field, for a range of return periods. This will inform recommendation I.
H	Investigate the feasibility of improving the formal drainage of the Furlongs field. Consideration should be given to the discharge point; in particular, assess whether the drain(s) could discharge to the Barnsley Drain.

I	Investigate ways of improving the natural drainage of the Furlongs field (refer to the main report)
J	Agree who is responsible for the Barnsley Drain
K	Promote self-help and non-structural approaches to flood risk management (refer to the main report)

References

Galland, P. (2008) *Flooding on B4425 at Barnsley, Cirencester*. Letter sent to Mr. Brian Skarda, dated 7 February 2008

Le Bars, P. (2007) *The Great Storm at Barnsley, Gloucestershire: 20 July 2007*

Skarda, B. (2008) [annotated map]

UKPG (2002) *Barnsley Park*. UK database of historic parks and gardens http://www.york.ac.uk/depts/arch/landscapes/ukpg/sites/barnsley.htm

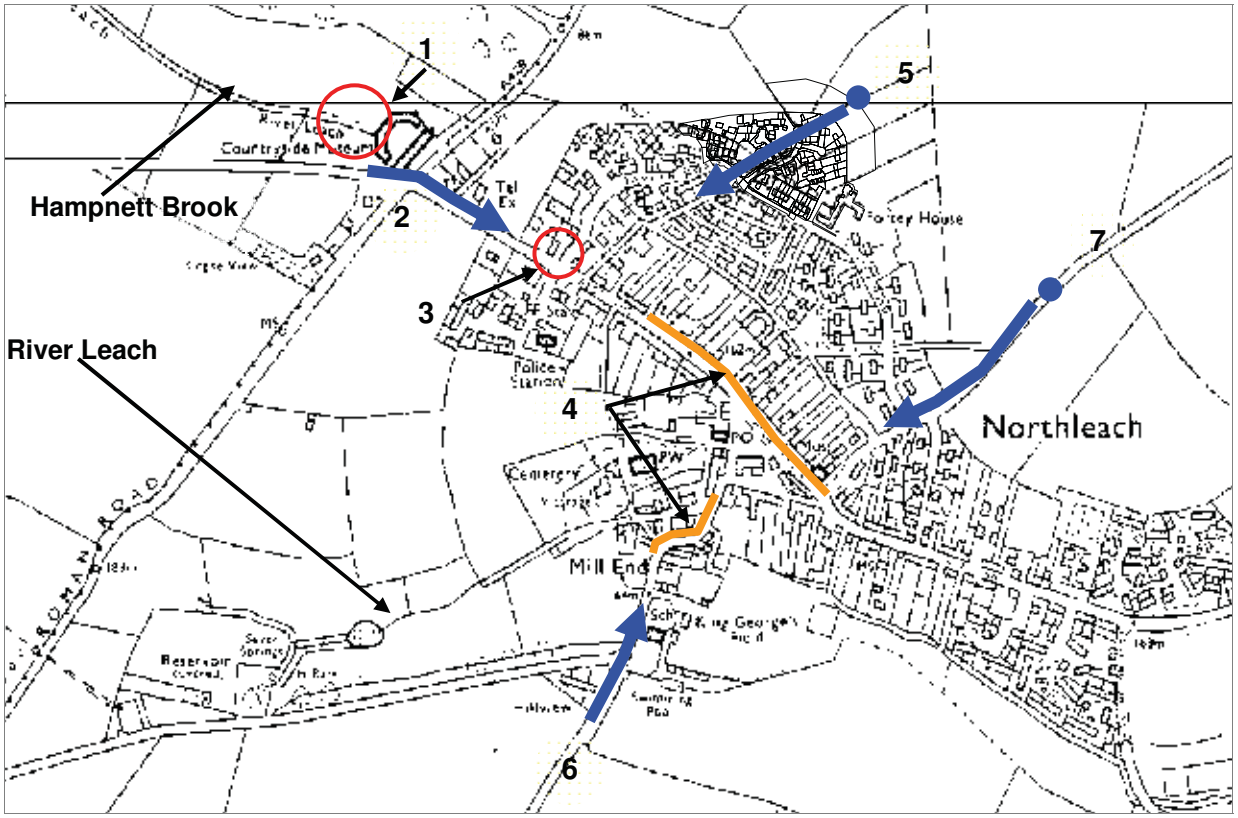
Appendix 14

Northleach - Site Response

Location 14 – Northleach

Date of visit	23/04/2008
Attendees of the workshop	Chris Hancock, John Mustoe, Judith White, Gerald Green

1 Mechanisms



Summary

10 properties reported as having flooded as a result of the July 2007 flooding. Flooding mechanisms have been detailed by the members of the flood response group. The town flooded directly from surface water, ground water flooding and fluvial flooding from an unnamed watercourse (know as the River Leach by the residents) and the River Leach (known as Hampnett Brook by residents). For the purpose of this report the watercourses will be referred to as they are labelled on the map above.

1 The Hampnett Brook is culverted under the old prison, the flood waters built up to approximately 2m against the prison building during the 2007 floods.

2 The Cirencester Road floods regularly, as the road has very poor drainage and the water flowed into the town along the road.

3 The intersection between the main road/Midwinter Road - large metal cover, covering a drain which takes the water from the surrounding hills. During the flooding the pressure in the drain causes the cover to blow.

4 Resurfacing of the roads at High Street and Mill End has resulted in the road level being close to or at the kerb level. This resulted in flood water flowing directly from the road into

properties. Kerbs have been dropped along West End and the High Street, routing water into houses

5 There are several springs throughout the town, which caused flooding, the worst affected area was Ward Road.

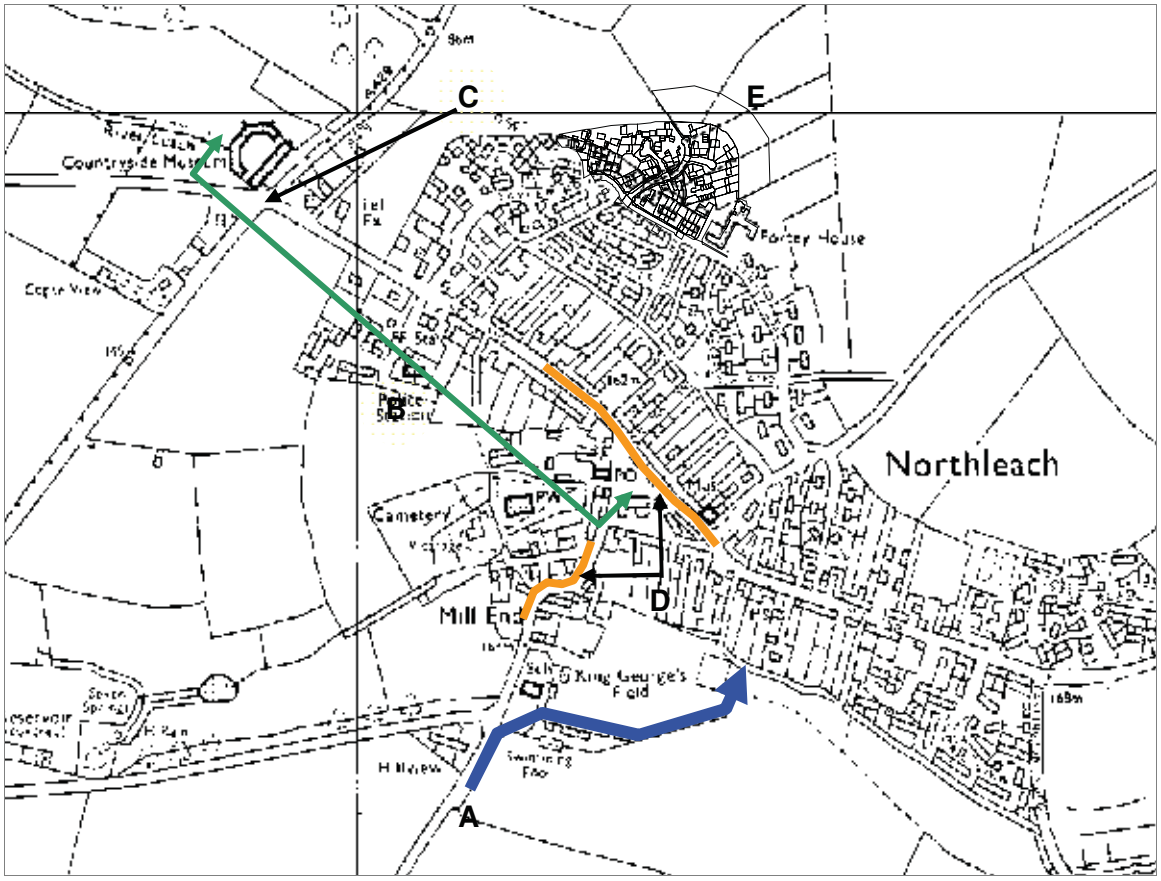
6 Runoff from the fields surrounding School Hill caused flooding in Mill End.

Farmington Road has natural springs which originate in the fields at the top of the road- which cause flooding and on a regular basis.

Description of Mechanisms	**Photograph**
Looking down stream of the Hampnett Brook as it is culverted under the prison. The Hampnett Brook is culverted under the old prison and is culverted under Northleach. During high rainfall water regularly backs up behind the prison upstream of the culvert. There are concerns there maybe blockages in the culvert from the inlet to the market square. Hampnett Brook culvert crosses under West End near Guggle Lane; the manhole at the junction of West End and Guggle Lane surcharged to a height of around 1 m, with water from Hampnett Brook running down West End/High Street for 2-3 days 1.5 m (5 ft) culvert starts in Market Place; upstream of here, the culvert is 0.6 m (2 ft) diameter. Residents have questioned whether the 0.6 m diameter pipe is adequate.	
The Cirencester Road (A429). The Cirencester Road floods regularly, as the road has very poor drainage, as a result the water flows directly into the town along the High Street. During the flooding surface water from the surrounding fields flowed down the road and into the town. There used to be open drains along the main road which ran through the town. Local opinion is since the drains have been filled flooding in the town has got worse.	
The road level is the same height as the kerb on College Row. Road resurfacing has caused the road level to be raised to the height of the kerb along many roads throughout the town. The road drainage is poor and this results in the roads flooding on a regular basis. The height of the road in relation to the kerb resulted in water flowing directly into properties from the roads. The areas worst affected by this are Mill End, College Row and the High Street.	

Dropped kerb and heightened road level on the High Street. The road level has been raised due to the resurfacing of the road. On the High Street this raising of the road level has been combined with the dropping of the kerb along areas of the path. The road drainage is poor and this results in regular flooding, with surface water flowing from the road directly into properties. As there is no barrier between the road and the properties water flowed in through the front door.	
The waterlogged area to the back of Ward Road. The water from the field located at the back of Ward Road drains into the low spot to the back of the gardens of the properties. During the flooding water from the area flowed into the gardens of properties and down Ward Road. Flooding here has been a recurrent problem since the houses were built. Directly behind the gardens what appears to be a French drain or soakaway.	
Looking up School Hill Surface water flow occurs frequently from School Hill due to the gradient of the road and the inadequate drainage on the road. The surface water flowed into the town and caused flooding in Mill End. Surface water flooding in Mill End from runoff from School Hill is a frequent occurrence. There used to be an overflow channel for the surface water from School Hill. The channel has been covered by a house extension. It is reported the flooding in Mill End has become more frequent since the channel has been covered.	
Blocked drain at the bottom of School Hill. School Hill has very poor surface water drainage, resulting in surface water from the surrounding fields flowing down the road itself. The one drain at the base of the hill is reported as being constantly blocked with debris and material having been deposited by water flowing directly over the drain. During the flooding surface water was running down School Hill.	

2 Mitigation Recommendations



Mitigation Recommendations	
A	The flooding from runoff from School Hill in Mill End is a frequent event during high rainfall and needs addressing urgently. The option of constructing a flood alleviation channel to convey water from the road, through King Georges field and to the watercourse needs to be investigated. This scheme should be complemented with works to improve the drainage on School Road and regular inspection and clearing of the drains should be on GCCs works list. GCC are aware of the need for such a scheme and will require cooperation from GCC as the landowner.
B	It is recommended the section of the culvert between the prison and the market place is inspected and cleared. The option to enlarge the culvert in this reach will need to be validated by a hydraulic model, to ensure enlarging the pipe is not allowing an increased flow through the town and exacerbating flooding downstream. The culvert has been cleared by GCC from the market place to the outlet in King Georges field and the need for clearance upstream has been highlighted to CDC and GCC.

	The EA is conducting a survey of the manholes between West End and High Street.
C	Investigate improving the drainage on the Cirencester road by installing drainage ditches alongside the road and the improvement of the drainage system.
D	The roads need lowering to a level which will provide a higher level of protection to properties. It is recommended the dropped kerbs be removed along the High Street, unless they are essential for access by the individual resident. These works should be incorporated with a general improvement of the road drainage throughout the town.
E	The springs which occur behind Ward Road and Farmingdon Road are natural and flow will occur during high rainfall. It is recommended that properties which regularly flood from springs should consider making the property flood resilient.
F	Due to the magnitude of the event in 2007 there is no specific recommendation for the blown drain on Midwinter Road. Attenuation upstream of the prison should be investigated as part of the overall surface water management solution. The survey work being conducted by the EA may raise issues which may require works to be undertaken.

Appendix 15

Southrop - Site Response

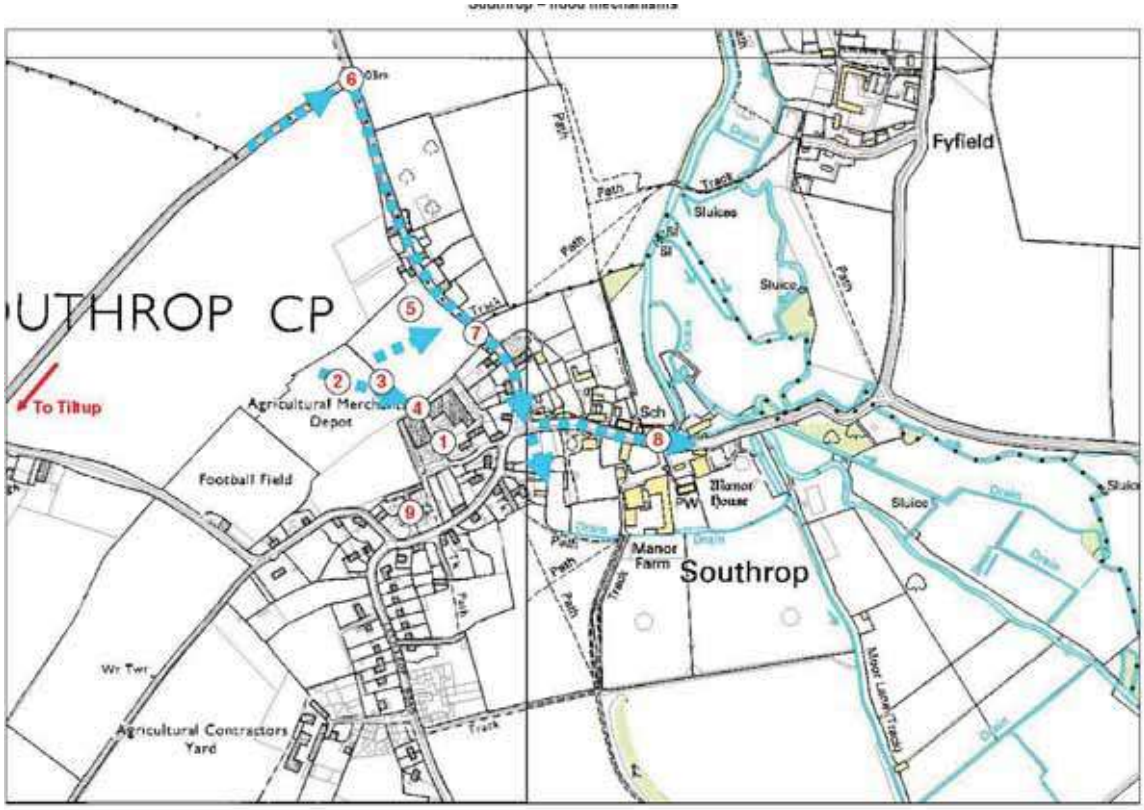
Location 15 – Southrop

Date of visit	17 April 2008
Attendees of workshop	Dr. Brookes; Telephone conversation held subsequently with Chris Moughton

1 Mechanisms

Summary

Flooding in the village of Southrop was caused by surface water run-off from the surrounding fields. Ten properties are reported to have been affected

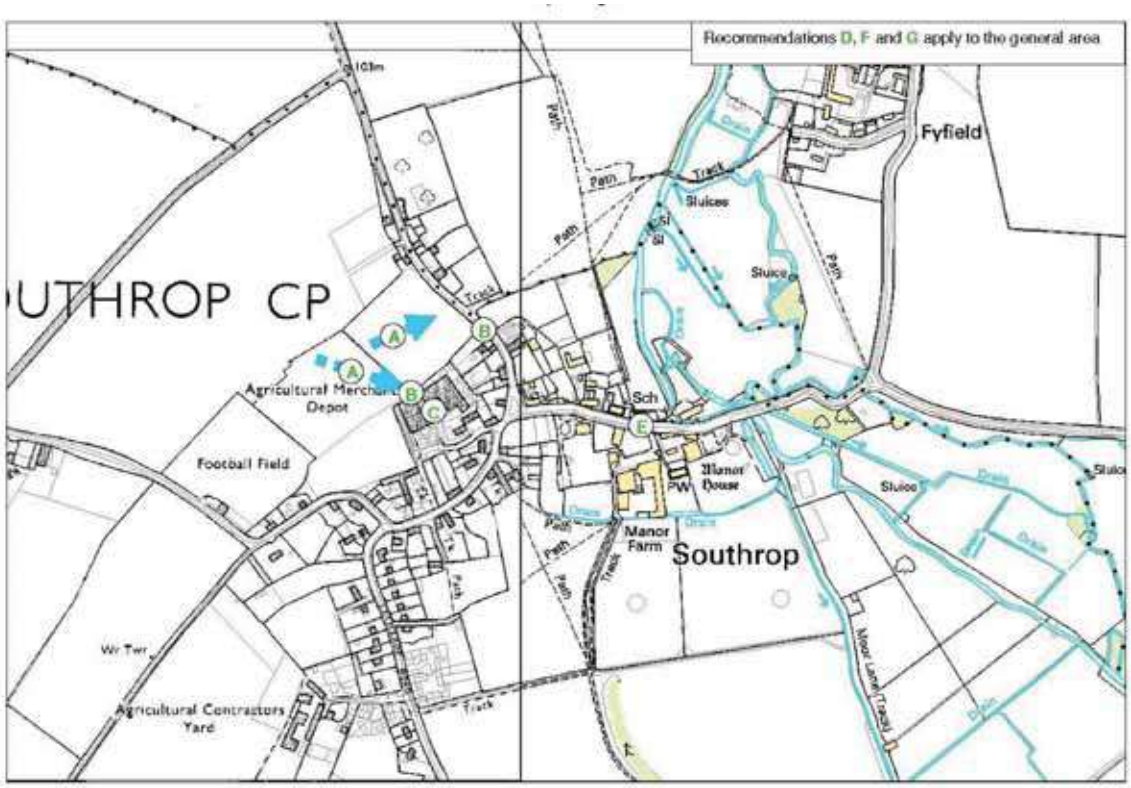


Description of Mechanism	
Surface water run-off	
Photograph – Inlet to the culvert that carries a land drainage ditch under The Farriers (**4**) The Farriers estate (**1**) was flooded by surface water run-off from fields immediately to the north of the village (**2**). A land drainage ditch runs south-eastwards along a field boundary (**3**); this ditch is heavily vegetated. It enters a culvert at **4**, which runs under the estate. The estate is reported to have been flooded once a year on average since it was built nine years ago, indicating that the capacity of the culvert is inadequate. Following heavy rainfall, the culvert is overtopped and manhole covers on the estate are lifted due to surcharging. Overland flow is reported to enter the foul sewer system.	
Photograph – Field to the north of The Forge (**5**) Surface water run-off from the fields also flowed eastwards onto the Eastleach road (**6** and **7**) and then followed this road southwards, into the village centre. Run-off from the field immediately to the north of The Forge was a particular problem (**5**). This field has no formal drainage system and a resident had to dig a ditch to try and direct the water away from his property; the water is reported to have reached a depth of approximately 0.5 m. The flooding here was exacerbated by a blocked road ditch; this ditch enters a culvert at **7**, which runs under The Forge.	
Blocked ditches were also a problem at the Standing Cross Lane Junction (**6**), where surface water run-off from Tiltup joined the Eastleach road. Following the Summer 2007 floods, villagers paid to have the road ditches cleared out. A trash screen at the Standing Cross Lane junction remains in a poor condition. On reaching the village centre, the surface water from the Eastleach road continued southwards and also flowed eastwards along Lechlade Road, past the school (**8**).	
Hydro-Brake	
Around ten years ago, a developer, under the guidance of Cotswold District Council, installed a surface drain which runs from the Wadham Close area (**9**), east along Lechlade Road, to the River Leach. The highway drainage of Lechlade Road is connected to this drain. Discharge from it into the river is controlled by a Hydro-Brake. The Parish Council is concerned that this structure exacerbated the flooding in the village, by preventing the release of surface water into the river. Indeed, Cotswold District Council has, in the past, observed surcharging of the highways drains, indicating a possible blockage in the Hydro-Brake; it reported this to Gloucestershire Highways.	
Photograph – Side of property at The Forge. Surface water reached the level of the vent (**7**)	*Photograph – Partially blocked entrance to a culvert at the Standing Cross Lane junction*

Photograph – The roadside ditch immediately north of The Forge (**7**)*. This ditch has been cleared since the Summer 2007 floods*

Photograph – A roadside ditch at the Standing Cross Lane junction (**6**)*. This ditch has been cleared since the Summer 2007 floods*

2 Mitigation Recommendations



Mitigation Recommendations	
A	Calculate the peak flow rate and volume of surface water run-off from the fields to the north of The Farriers and The Forge, for a range of return periods
B	Use these calculations to assess the adequacy of the existing culverts under The Farriers and The Forge
C	Investigate the feasibility of resizing the culvert under The Farriers
D	Assess the adequacy of land drainage in the catchment as a whole, and investigate opportunities for improving both the natural and formal drainage (refer to the main report)
E	Assess whether the design and operation of the Hydro-Brake is appropriate, taking account of the Environment Agency's requirements for controlling surface water run-off. If the installation is deemed appropriate, clarify maintenance responsibilities for the Hydro-Brake and formulate a maintenance programme (if this has not been done already)
F	Contact landowners to raise awareness of their responsibility for maintaining roadside ditches (refer to the main report)
G	Promote self-help and non-structural approaches to flood risk management (refer to the main report)

Appendix 16

Weston-Sub-Edge - Site Response

Location 16 – Weston-sub-Edge

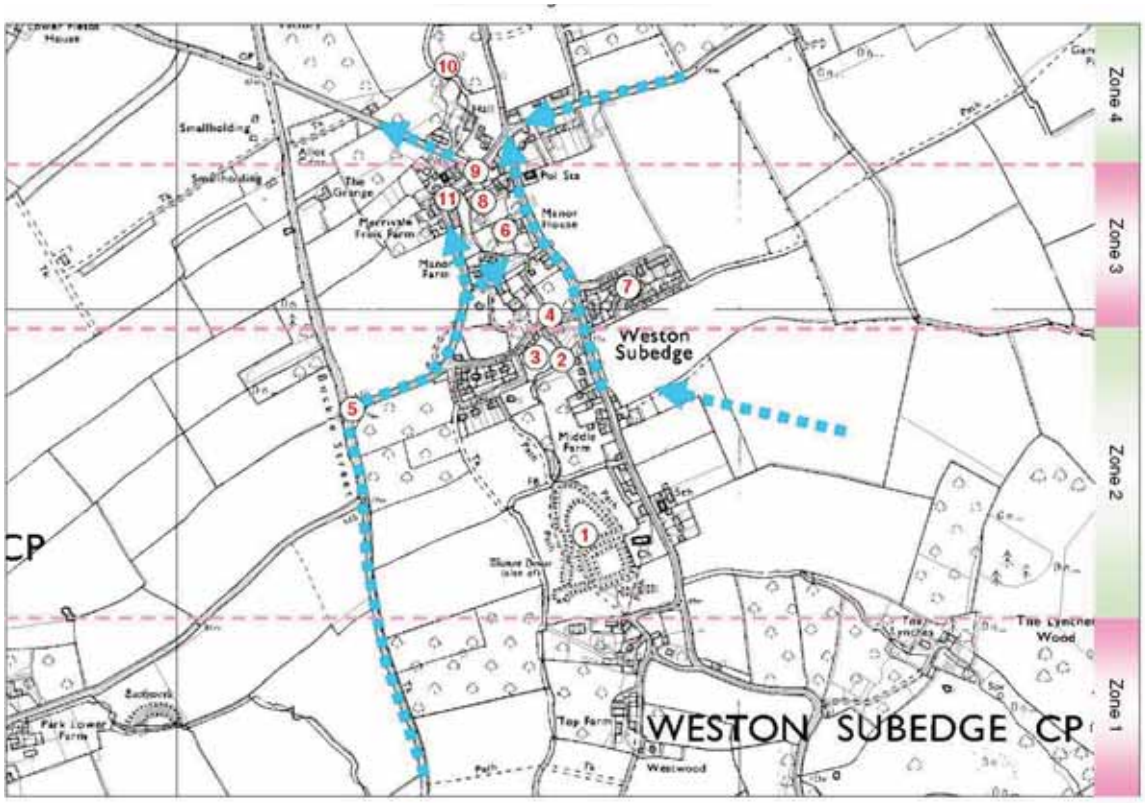
Date of visit	11 April 2008
Attendees of workshop	David Smith, Chris Tombs and Alan Edmonds

1 Mechanisms

Summary

The village of Weston-sub-Edge has flooded three times in the last nine years. As a result, residents have experienced difficulties in securing home insurance. On 20 July 2007, 16 properties were affected by a combination of surface water run-off from surrounding agricultural land and flooding from the Coombe Brook. The drainage basin is steeply sloping and, consequently, its response to rainfall is rapid: flooding of Friday Street has been observed within two hours of a thunderstorm over Dover's Hill (Smith, 2008).

Weston-sub-Edge Parish Council has split the village into four zones, for the purpose of reviewing the Summer 2007 floods (refer to accompanying map). These zones are used in the following account of flood mechanisms. Further details of the flooding are available in a comprehensive report prepared by the Parish Council (see Smith, 2008).



Description of Mechanism
Zone 1 – Weston Park to Giddy Bridge
The Coombe Brook rises in Weston Park, 1 km to the south of the village centre. The watercourse, which has a catchment area of approximately 3 km^2 at Friday Street (CEH, 2006), flows northwards through the village. Heavy rainfall began filling the moat[1], located immediately to the west of the parish church (**1**), on Thursday 19 July 2007. By 12:30 pm the following day, water was spilling out along its western margin and flowing into the Coombe Brook.
Zone 2 - Giddy Bridge to Parsons Lane
Surface water run-off from the fields to the east of the village (known as The Lynches) flowed onto Church Street and along Parsons Lane. A pipe also drains these fields and is meant to discharge into the Coombe Brook at **2**. However, water is reported to flow out of this pipe under high pressure, overshooting the brook and, on 20 July 2007, caused flooding in the private garden on the left bank (**3**).
Water also spilled out of the Coombe Brook in this zone and flowed northwards onto Parsons Lane, combining with the surface water run-off from The Lynches. Bricks have been removed from the northern face of Parsons Lane road bridge (**4**) in an attempt to encourage overland flow to enter the brook downstream. The Working Group has expressed concerns regarding the capacity of the culvert under Parsons Lane, as well as the shallow gradient of the streambed in this area.
Zone 3 - Parsons Lane to the south side of Friday Street
On 20 July 2007, surface water run-off from fields to the south-west of the village flowed onto the un-made stretch of Buckle Street (known locally as Dirty Lane), before joining the B4632 and continuing north-eastwards into the village. A road gully at the T–junction (**5**), which discharges to a roadside ditch running north along Buckle Street, was ineffective at draining the volume of water. The culvert carrying the ditch under the road is reported to have been 75 per cent blocked with silt and debris at the time of the Summer 2007 floods. It is important to note that surface water also collected at the T-junction, to a depth of around 250 mm, following heavy rainfall in January 2008. The surface water run-off from the B4632 flowed onto Manor Farm and into the grounds of Manor House (**6**). Surface water from the Dover's View residential development in the east of the village (**7**) also flowed towards this area, plus the capacity of the Coombe Brook was exceeded here; the channel is particularly narrow. The combined waters flowed northwards into Cidermill Orchard (**8**), flooding properties. An hour or so later, water also spilled out of the brook along the western margin of Cidermill Orchard, exacerbating property flooding here. A gardener, who worked in the grounds of the Manor House in the 1990s, has reported an 'underground' river in the area of the swimming pool. Further investigation of this is required to help understand the flow processes operating in this area. Two properties in this zone were also flooded by water rising through their floors.
Zone 4 – South side of Friday Street to the northern boundary of the Parish

[1] a relict of a residential manor used by the medieval bishops of Worcester (http://www.ecastles.co.uk/westonsubedge.html)

The capacity of the Coombe Brook culvert under Friday Street (**9**) was exceeded. The backwater spilled onto the road and flowed along the Evesham road and Stratford road, before turning north onto Featherbed Lane. It then rejoined the Coombe Brook to the north of the bowling club (**10**). Surface water also flowed onto Friday Street from Brook Bend (**11**), Church Street and the Stratford road (from the direction of Aston-sub-Edge). Approximately 90 per cent of the Weston Industrial Park, located to the north of the village, was flooded by surface water up to a depth of 300 mm.
Community self-help
Following the Summer 2007 floods, Weston-sub-Edge Parish Council appointed a Working Group "to assist in the determination of a long-term solution to the flooding problem and to look at ways in which residents could be more self-reliant in terms of maintenance and monitoring of the main watercourses, and the implementation of improved flood defences" (Smith, 2008, p.1). This Group has already carried out the following: 1) identified flood mechanisms, and proposed options for alleviating the flooding problems in the village (see below) 2) set up a Flood Warden Scheme to help the community work together to prepare for a flood event 3) produced a riparian owners register 4) held a flood forum to organise the clean up of local ditches.

Zone 1 – The Moat (**1**)	*Zone 2 – Water flows out of this pipe under high pressure, overshooting the brook* (**2**)
	
Zone 2 – Footbridge, located a few metres downstream of the pipe (above right), collecting debris	*Zone 2 – Downstream (northern) face of Parsons Lane road bridge, with some bricks removed* (**4**)

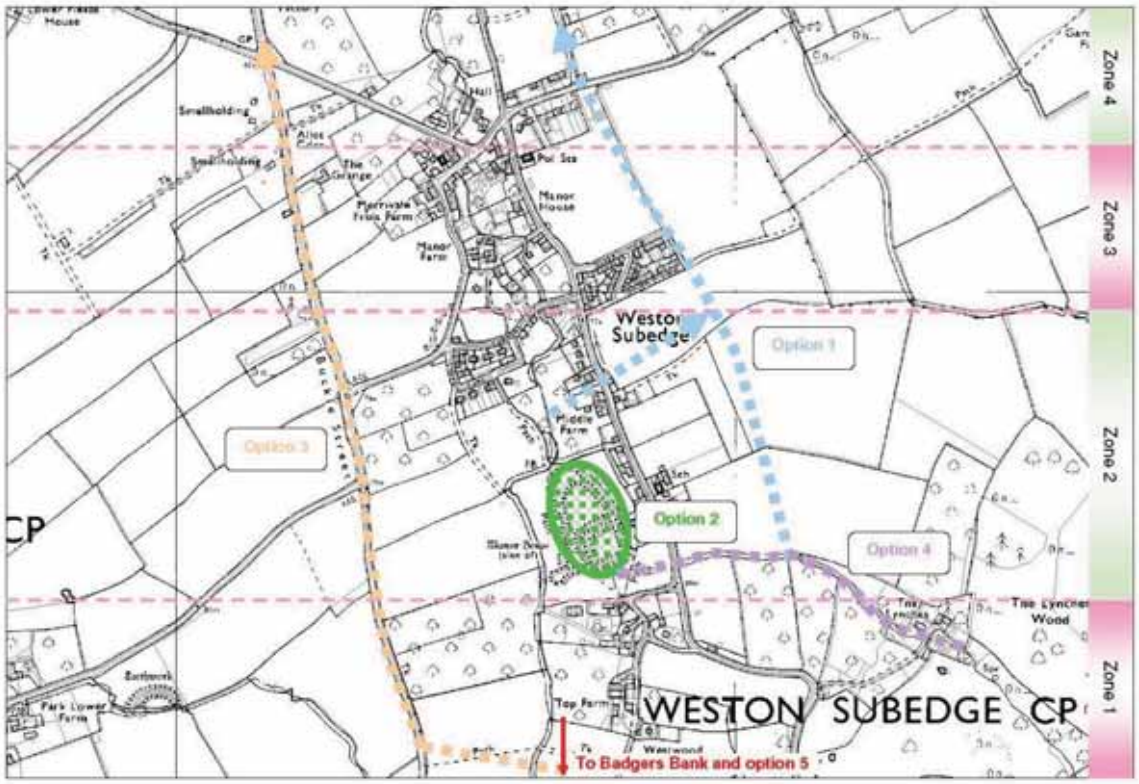
	
Zone 3 – The restricted course of the Coombe Brook between Parsons Lane and Friday Street	*Zone 4 – Upstream face of the Coombe Brook culvert under Friday Street* (**9**)
	

2 Mitigation Recommendations

The Working Group has proposed the following options for alleviating the flooding problems in the village:

Option 1 – Eastern bypass
Divert surface water run-off from The Lynches, plus a proportion of the flow in the Coombe Brook, to the east of the village, along Featherbed Lane, and into the brook to the north of the bowling club
Option 2 – Floodwater retention at Church Orchard
Use the moat for flood storage. Raise the banks of the moat to increase its storage capacity and install automatic sluice gates to control the release of water into the Coombe Brook. Gloucestershire County Council has studied this option in the past. The Working Group has calculated that the total capacity of the moat is greater than the surface water recorded in the village centre in the Summer 2007 floods. However, it is important to note that, on 20 July 2007, the moat had already been filled by rainfall by the time flooding begun in the village
Option 3 – Western bypass
Divert water from the Coombe Brook on Badgers Bank (located on the edge of Weston Park) into the drainage ditches along Buckle Street (Dirty Lane)
Option 4 – Restoration of the watercourse from The Lynches to the moat
Restore the original watercourse that ran from the Lynches Wood to the moat. Raise the banks of the moat to increase its storage capacity and install automatic sluice gates to control the release of water into the Coombe Brook
Option 5 – Balancing pond at Badgers Bank
Construct an attenuation pond on Badgers Bank, to collect and attenuate surface water run-off. Install sluice gates on the pond outlet to control the release of water into the Coombe Brook
Other suggestions by local residents
Lower the surface of Parsons Lane and remove the culvert to create a ford (**4**) Install a gate on the northern face of Parsons Lane road bridge (**4**) that can be opened to release floodwater from the road into the Coombe Brook Remove the boulders located near the outlet of the pipe at **2** The Working Group notes that previous suggestions of increasing the capacity of the Coombe Brook and culverts in the village centre have been unsuccessful due to logistical and financial constraints

It is recommended that the following actions are taken in order to progress the work of the local residents, and help alleviate the flooding problems in the village:



Mitigation Recommendations	
A	Undertake hydrological and hydraulic assessment of the Coombe Brook for a range of return periods, taking account of climate change impacts. This assessment is essential for critical evaluation of the Working Group's proposals and for the appropriate design of any structural measures. A channel and floodplain survey of the brook will be required to build the hydraulic model. Further information should be sought on the 'underground' river in the area of the Manor House, to ensure that all flood mechanisms are accounted for
B	Undertake a pre-feasibility study of the options proposed by the Working Group. Use the hydraulic model to determine the flood risk management benefits afforded by each option. Gloucestershire County Council is currently investigating the proposals for flow diversion
C	Provide advice and guidance to the Riparian Owners Society on the maintenance of the Coombe Brook and land drainage ditches

References

[CEH] Centre for Ecology and Hydrology (2006) *FEH CD-ROM*. Version 2.0. NERC (CEH)

Smith (2008) *Review of flooding July 2007: Weston-sub-Edge*. Draft Report. Contributions from Rupert Brice, Alan Edmonds, Paul Elvin, Jenny King and Christine Rossington

Appendix 17

Eastleach - Site Response

Location 17 – Eastleach

Date of visit	22 April 2008
Attendees of the workshop	Preston Jones, Raymond Coleby and Carole Topple

1 Mechanisms

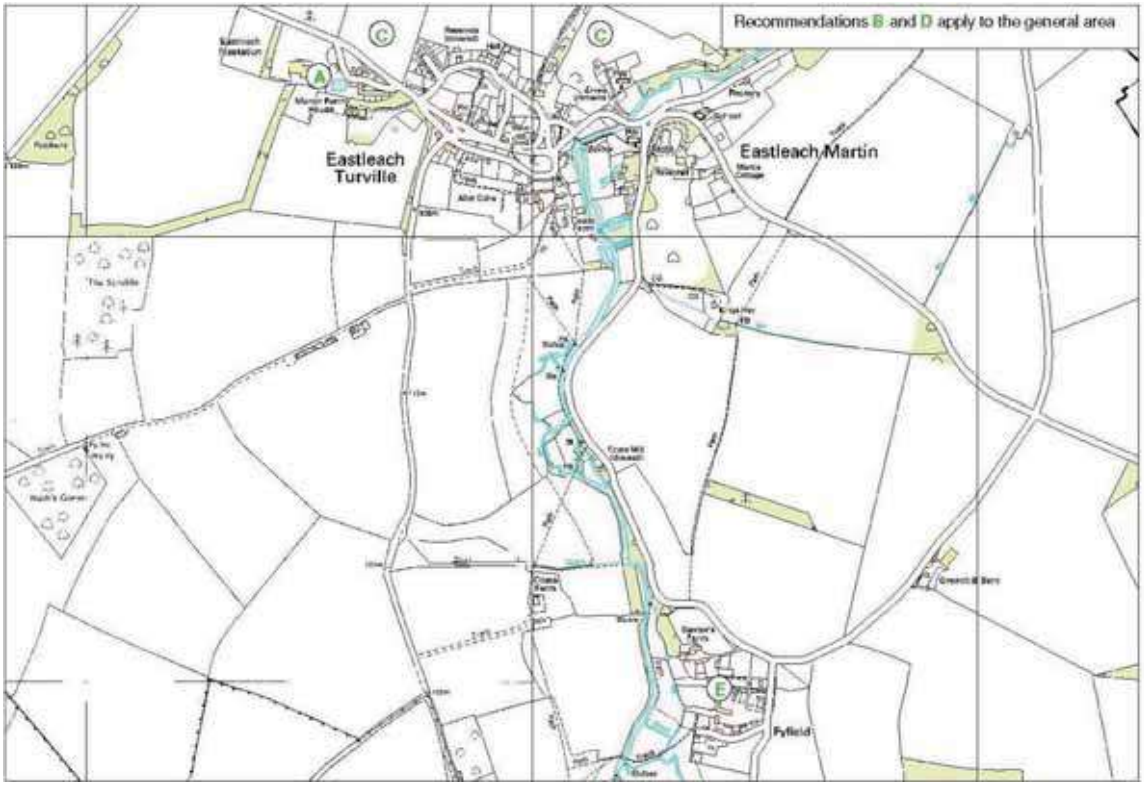
Summary

Village residents report that approximately 125mm of rainfall fell during the event. On 20 July 2007, 21 properties are reported to have flooded in the village of Eastleach. Two phases of flooding occurred:

1 surface water run-off from the fields surrounding the village. This was the source of flooding in 76 per cent of the properties affected;

2 flooding from the River Leach. Only one property was affected by this source.

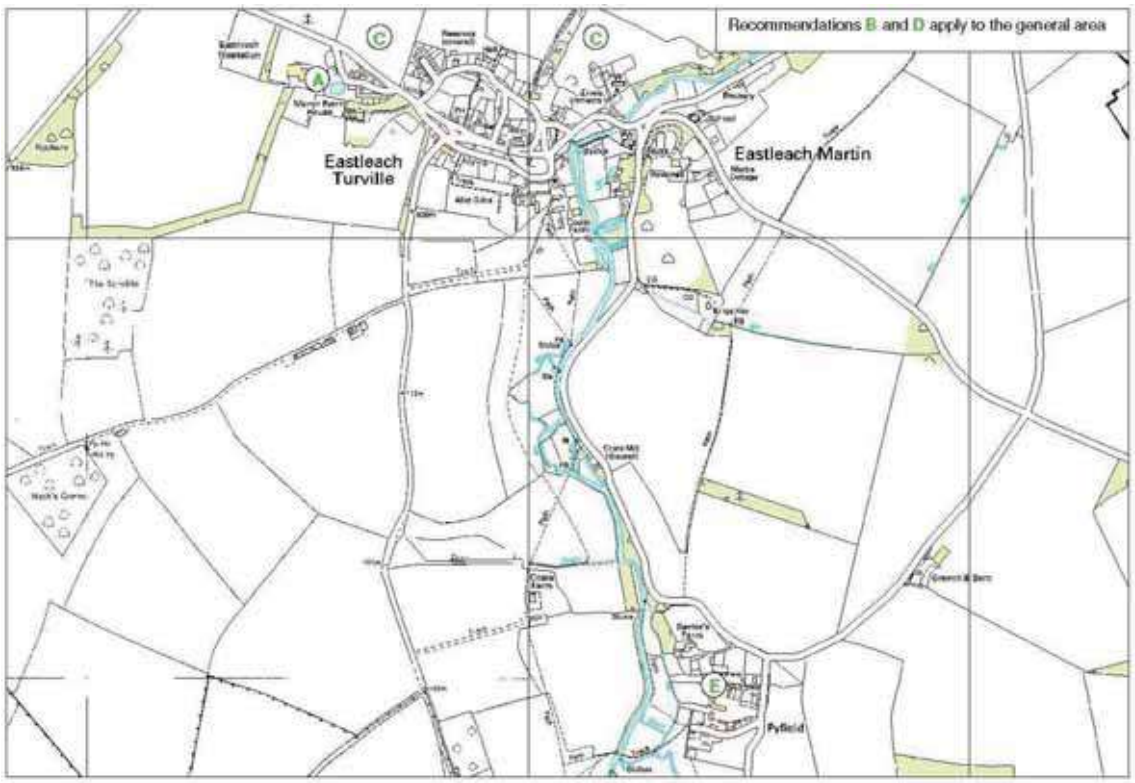
Some properties were also flooded by water rising through their floors.



Description of Mechanism	
Surface water run-off	
Photograph – Heavily vegetated ditch along the Southwark road (**3**) Surface water run-off from the fields to the west of the village flowed onto the Hatherop Road (**1**), where the water reached a depth of approximately 350 mm. This run-off also flooded properties in Blunts Hay (**2**). The attendees of the flood surgery expressed strong concerns regarding the lack of maintenance of land drainage ditches and the impact of changing agricultural practices on flood generation in the village. The Parish Council has met with the land owner and Gloucestershire Highways to discuss the state of the ditch along the Fyfield road (**3**; photograph). Many of the ditches in the village are reported to be in a similar condition. The Ernest Cook Trust has cleared the ditch in the vicinity of **4**, but there is believed to be a blockage in the culvert under the road.	
Photograph – Duck pond (**5**) The fields to the west discharge into a pond at 5 through one pipe. On 20 July 2007, the capacity of this pond was exceeded and water spilled out, flowing east along Turville Barns and flooding properties. A further two pipes discharge into the pond and drain the Manor Barn development.	
Photograph (Gravepix © 2008) - St. Andrew's Church (**6**) Surface water run-off from fields to the north of the village flooded the church (**6**), rendering it unusable for four months. In an attempt to reduce the risk of internal flooding in the future, the church body has had a topographic survey carried out to assess the feasibility of re-instating trenches that used to run around the outside of the church.	

Photograph courtesy of Raymond Coleby – Gravel transported by the surface-water run-off (**7**) Run-off also transported gravel from a private driveway, adjacent to the church (**7**).	
River Leach	
Photograph – Upstream face of the road bridge connecting Eastleach Turville and Eastleach Martin The River Leach, which flows in a general southerly direction through the village, is designated main river downstream of the road bridge (**8**). The topography of the village rises steeply from the river and, as a result, only two properties were flooded by it. A resident who has lived in the village for 25 years, reported that the normal summer level of the river is now higher than in the past. He also expressed concern regarding the impact of sluice gate operation in the wider area on the river level in the village.	

2 Mitigation Recommendations



Mitigation Recommendations	
A	Review the drainage of the fields to the west of Manor Farm into the pond: Calculate the peak flow rate and volume of surface water run-off that drains into the pond, for a range of return periods and compare with the capacity of the pond; Determine the volume of water that spills out of the pond in a 1 in 100 year event and investigate alternative options for the drainage of this water (e.g. an attenuation pond on Manor Farm)
B	Arrange a meeting with The Ernest Cook Trust to discuss maintenance of ditches
C	Investigate options for improving the natural and formal drainage of land surrounding the village (refer to main report)
D	Promote self-help and non-structural approaches to flood risk management (refer to the main report)
E	Fyfield, where 5 properties are reported to have flooded in the Summer 2007 floods, is also located within the Parish of Eastleach. This village should be included in the implementation of recommendations B to D

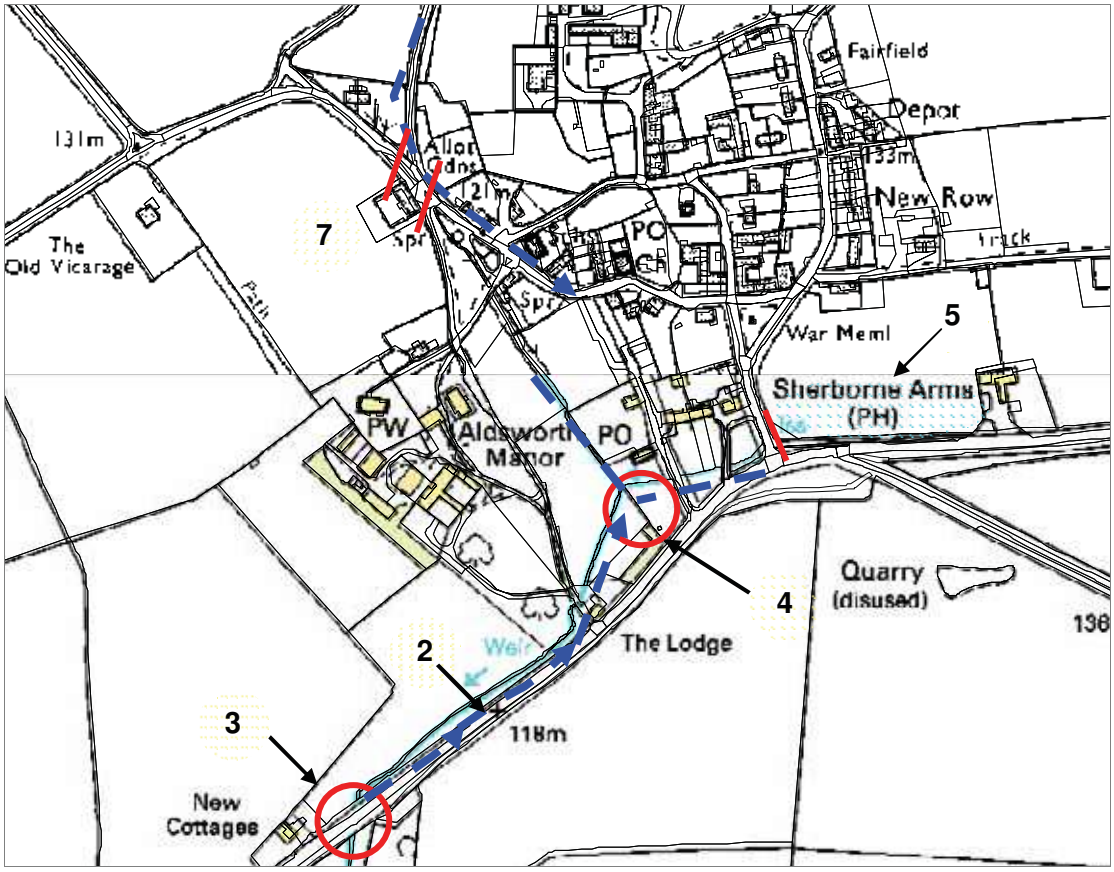
Appendix 18

Aldsworth - Site Response

Location 18 – Aldsworth

Date of visit	18/04/2008
Attendees of the workshop	Christopher Grose, David Pegrum, Dominic Kay, Carole Topple, Shelia Stewart, Saline Lykke-Dahn

1 Mechanisms



Summary

As a result of the flooding on the 20th July 2007 16 properties were reported as having flooded in the village of Aldsworth. Local residents described the flooding mechanisms during the workshop:

1 The village flooded from surface water overland flow from the surrounding fields in the catchment and was conveyed into the village via a drainage ditch. Flooding occurred from direct runoff from the fields and from the drainage ditch overtopping.

2 The drainage ditch which runs through the village was overwhelmed and water backed up through the village. The ditch is overgrown and silted up and the lack of maintenance of the ditch has reduced the ditches capacity.

3 The triple culverts under the B4425 are blocked and do not appear to be functioning. During the flooding this is resulted in water backing up through the drainage ditch, resulting in flooding to the properties in close proximity to the ditch.

4 The point at which two drainage ditches meet the water begins to back up as

conveyance through the ditch is obstructed by overgrown vegetation.

5 Surface water runoff from the field to the west of the Sherborne Arms ponded in the field as the wall acted as a dam and held back water.

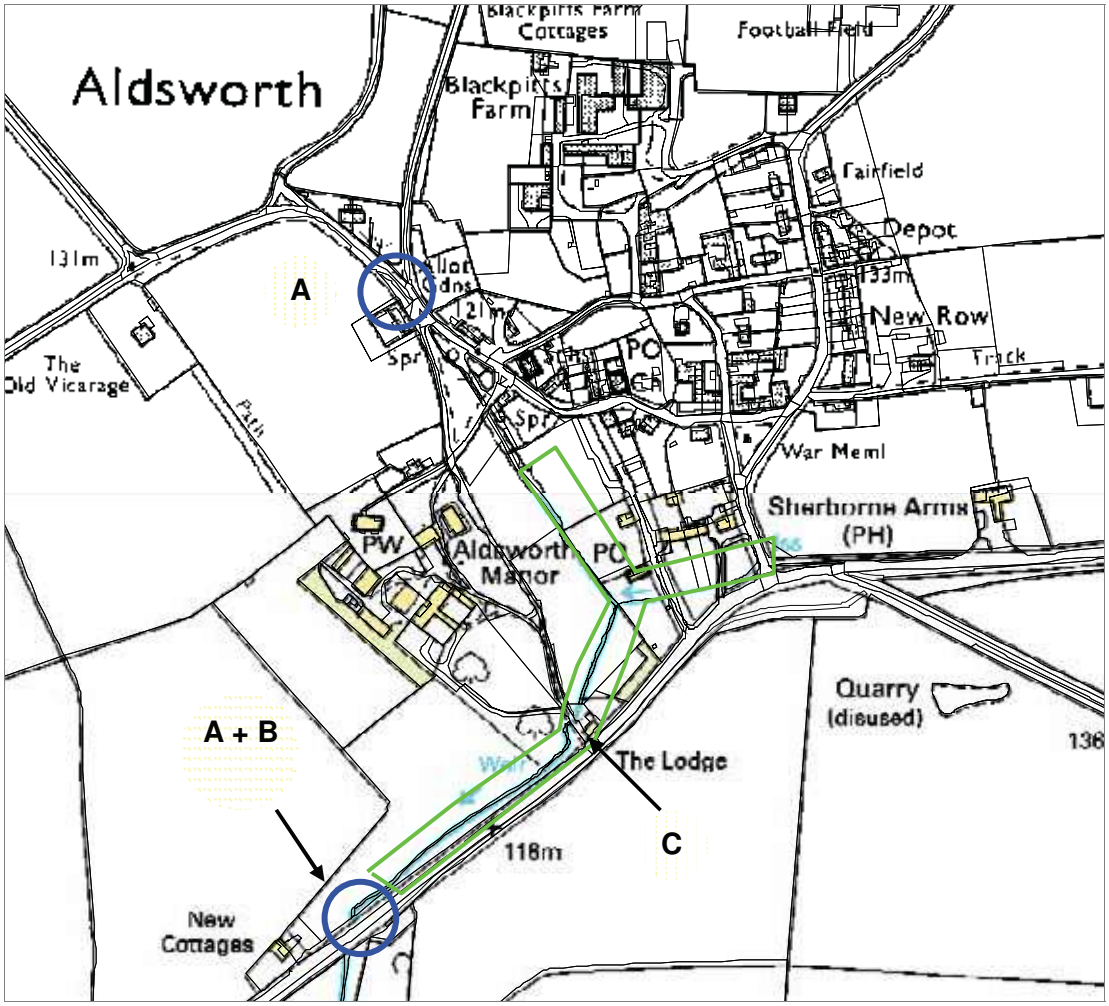
6 Surface water flooding from the north from runoff from the A40 was exacerbated by under capacity culverts.

7 Flooding occurred from springs coming through the floors of properties.

Description of Mechanism	**Photograph**
Looking at the drainage ditch near the Post Office. The ditch is overgrown with vegetation and there are obstructions to flow in the ditch throughout the village. During the flooding this caused water to back up in the ditch through the village, resulting in flooding to properties in proximity to the ditch.	
Looking down at the drainage ditch from a field near the Post Office. Deposition of debris and silt has caused the ditches capacity to be reduced. Local residents report the drainage ditches were larger in the past to a depth of approximately 5 feet. There were reports that the maintenance of the ditch has been poor over the years and this has resulted in the gradual deposition of material. The drain was overwhelmed during the flooding.	
Looking at the drainage ditch as it runs behind the wall alongside the B4425. The drainage ditch is barely visible due to the overgrown vegetation within and around the channel.	
Looking downstream at the culverts under the B4425 at the drainage ditch. Water in the ditch is not flowing through the culverts, which indicates a blockage. There are reports that the culverts were blocked during the flooding, resulting in flooding of properties upstream as water could flow out of the village through the culverts.	

Looking upstream at the culverts as they issue into the field by the B4425. The water level is higher at the downstream end of the culverts, indicating a possible design fault in the culverts. The ponding of the water in front of the culverts may indicate the ditch requires re-profiling through the field.	

2 Mitigation Recommendations



Mitigation	
A	Clear the culverts of any blockages to remove the impediment to flow and inspect and maintain culverts on a regular basis to ensure the culverts are free of debris. The blocked culverts have been highlighted to GCC and they are going to inspect and clear the culverts. Regular inspection of the structure should be added to GCC's works list.
B	Assess the capacity of culverts under the road and consider the need for new culverts if the existing proves to be of insufficient capacity or not functional.
C	The drainage ditch needs depending and clearing to allow water to flow out of the village through the culverts and into the field downstream of the B4425. Re-profiling of the ditch downstream of the culverts should be investigated, to avoid drowning of the culvert outfall. The sequencing of the clearance needs to be carefully coordinated and clearance of the ditch is not recommended until the issue with the culverts has been resolved.
D	Promote self-help and non-structural approaches to flood risk management (refer to the main report).

E	Review the disposal method for debris removed from land drainage ditches

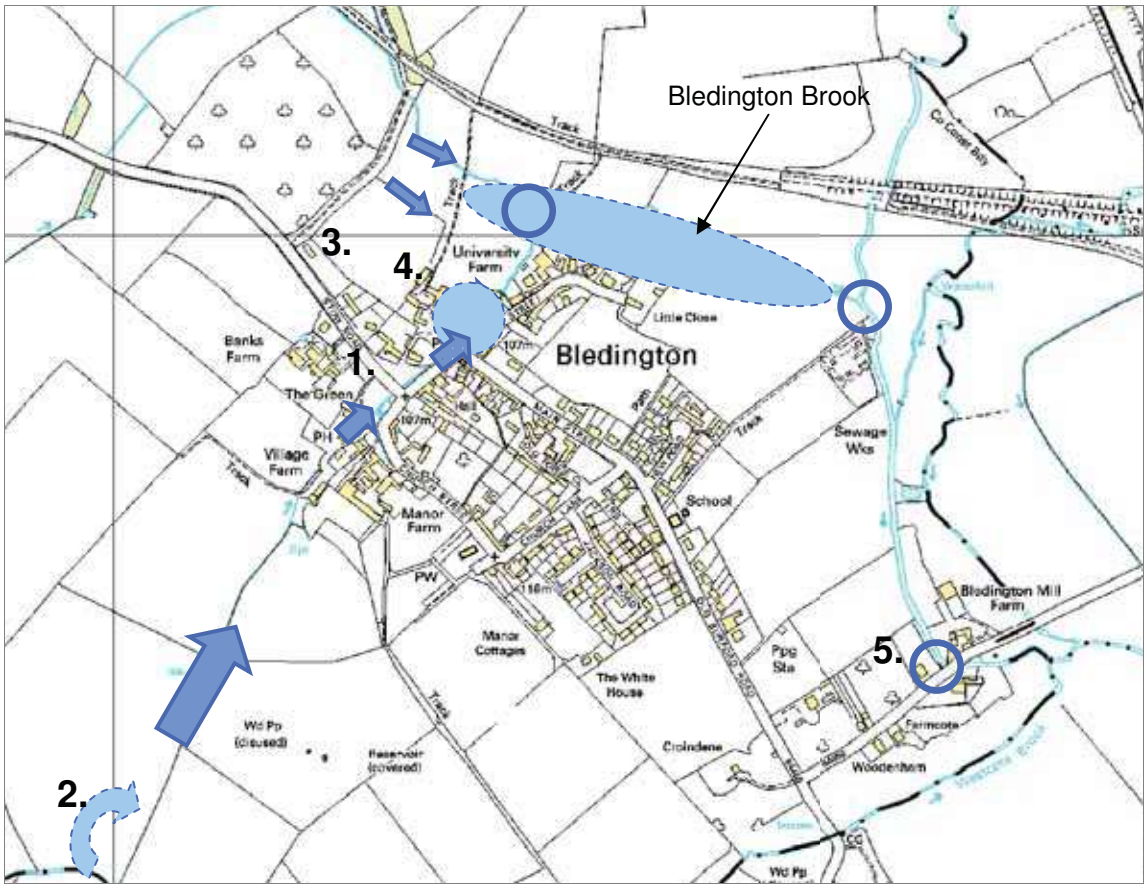
Appendix 19

Bledington - Site Response

Location 20 – Bledington

Date of visit	24/04/2008
Attendees of the workshop	Merryl Phillips, Ken & Mary Plant, Pauline & William Hunter

1 Mechanisms



Summary

11 properties adjacent to Chapel Street were reported to have flooded during July 2007. The pipes in Chapel Street were rodded and cleared prior to the flood so it is not believed that there were any obstructions in the pipe system. The key mechanisms which contributed to the flooding in Bledington are:

1 Main river running parallel to Chapel Street over capacity.

2 Westcote Brook broke its banks upstream.

3 Ditch behind properties fronting Chapel Street over capacity.

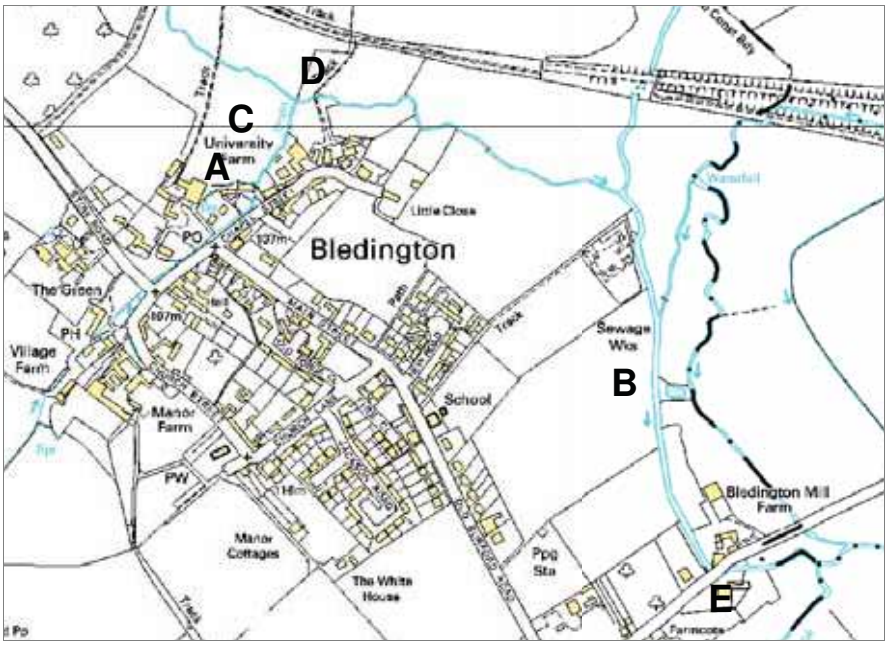
4 Chapel Street main river and ditch unable to discharge effectively due to restricted capacity downstream in Bledington Brook and the River Evenlode.

5 Mill weir and sluice gate downstream contributing to backflow effects in the River Evenlode and Unnamed River.

Description of Mechanism	Photograph
Looking downstream from the intersection of Stow Road and Chapel Street. Surface water runoff from 1) fields upstream and 2) the village itself is collected and directed through a ditch running parallel to Chapel Street. This ditch is considered and maintained as a main river by EA. This system flooded properties on either side of Chapel Street.	
Looking upstream from the intersection of Stow Road and Chapel Street towards Westcote Brook. Westcote Brook upstream of the village broke its banks and travelled overland until hitting the main river parallel to Chapel Street. This exacerbated the flooding through Chapel Street. The depth of flooding at its worst resulted in house being inundated by approximately 0.5m.	
Ditch behind properties in Chapel Street looking downstream towards Bledington Brook. Runoff from the university farm and fields upstream (left of photo) is collected in a ditch which runs behind properties fronting Chapel Street. The ditch is overgrown in sections and accessible to stock from adjacent farming fields leading to bank collapse in some areas. During the storms of July 2007 this ditch overtopped and spread floodwater into the properties adjacent (to the right of the photo).	
Looking downstream at confluence of ditch and main river from Chapel Street Residents felt that although this area is clear and appropriately sized to convey the flows from the ditch and main river from Chapel Street, it is unable to do so because the ditch backs up from water in the Bledington Brook downstream. Properties in this area have flooded previously with back and front gardens more typically inundated rather than the houses themselves.	

Confluence of the Bledington Brook and the River Evenlode (looking upstream of the River Evenlode). Adjacent fields (left, right and photo location) were inundated subsequent to the river overtopping its banks. The area is very flat with shallow river bed gradients. Once this area reaches capacity backwater effects are conveyed upstream which prevents the main river from the village from discharging. The sewer treatment plant is located approximately 50m downstream from this location however it was not reported as having flooded.	
At the Mill downstream from the confluence of the Bledington Brook and the Evenlode. Looking north-east towards the grated culverts under the road (B4450). Typically of Mill systems, two culverts flow underneath the mill building while one culvert diverts the flow away from the mill when not in operation. Residents in the village believe that the mill constrains the flow and prevents the Evenlode from draining adequately therefore contributing to the backwater effects in the village. The penstocks look to be operational however it is unknown whether it is controlled during storm events. During July 2007hay and straw was washed from the catchment and was caught against the grates.	

2 Mitigation Recommendations



Recommended Mitigation	
A	Clear and repair the ditch behind the properties in Chapel Street. Remove vegetation, formalise banks on both sides of ditch and install fence to prevent stock from accessing ditch.
B	Investigate opportunities for diverting overflows from the Bledington Brook directly to the River Evenlode upstream of the Mill. It is understood that EA have considered this previously but have been unable to implement the scheme due to funding. EA advised that this may now be able to be reactivated.
C	Investigate whether bed slopes in the Chapel Street river (downstream from ditch) can be altered to improve conveyance.
D	Improve confluence of Chapel Street main river with the Unnamed River to improve conveyance.
E	Drop mill weir level to improve conveyance and prevent water backing up the system from here.
F	Promote self-help and non-structural approaches to flood risk management (refer to the main report).