Bourton-on-the-Water Drainage Strategy

Stage 1 - Initialise/Prepare

Thames Water

At the heart of daily life

Introduction

Why sewer flooding

Britain's first sewerage systems were constructed 150 years ago in the Victorian era, and have served us well for generations. The sewer network Thames Water operates today has been much improved and vastly extended over the years; yet it remains under increasing pressure.

Everyday our network manages the demands of one of the world's busiest and most densely populated capital cities, and its urbanised surrounding areas; together with the equally complex challenges arising in our predominantly rural catchments in the Thames Valley, Surrey and Kent.

A number of factors including population growth, less frequent but heavier rainfall, the urbanisation of green spaces and changes in agricultural land practices, and utilised machinery, occasionally overwhelm our sewer network. The result can be unwanted sewer flooding for customers and our neighbouring natural environments.

This document contains:

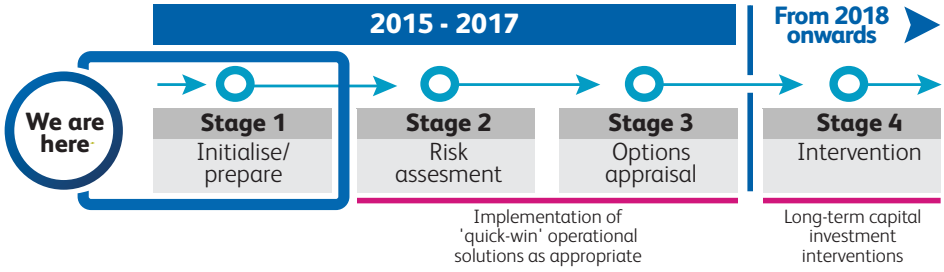
- an Introduction to the work we are undertaking to alleviate sewer flooding in our region
- a Feedback: Q&A section addressing key questions from customers and stakeholders
- the Bourton-on-the-Water Drainage Strategy technical document.

What can be done and when?

Sewer flooding is unacceptable. We have undertaken extensive customer research and initiated a programme of work to improve drainage and alleviate sewer flooding issues across our region.

We are adopting the good practice Drainage Strategy framework* developed by the Environment Agency and Ofwat, the water industry economic regulator, to produce a drainage strategy for our affected catchments with a primary focus on our sewerage network. As outlined in Figure 1, the strategies will develop throughout the 4-stage framework to define how we intend to alleviate sewer flooding or to address growth related issues in each area sustainably, and economically, over the next few years.

Figure 1 High-level Drainage Strategy framework* and estimated delivery and intervention timeline**



* The detailed 4-stage Drainage Strategy framework can be found in the following Drainage Strategy document. ** The estimated delivery timeline is dependent on factors including weather conditions and is, therefore, open to change. The intervention timeline includes the implementation of 'quick-win' operational solutions throughout Stage 2 & 3, and long-term capital investment interventions in Stage 4.

Who will resolve the sewer flooding?

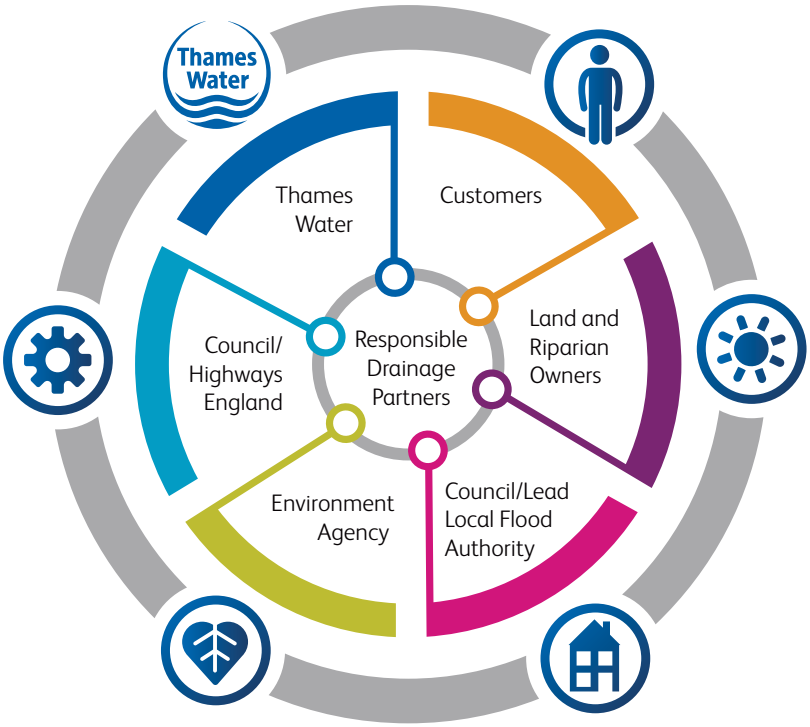
There are a number of stakeholders who, like us, have important drainage responsibilities and therefore, play an essential role in resolving sewer flooding in our region. These stakeholders include customers, private land owners and the Environment Agency; to name but a few. We are seeking to work in partnership with all stakeholders to ensure that together, we implement and maintain the most effective and sustainable drainage strategies.

Just as our responsibilities to improve drainage and alleviate sewer flooding focus on removing and treating wastewater; other stakeholders' responsibilities include managing local flood risk on riverbanks, ground water, land and highways, utilising appropriate agricultural practices and maintaining private drains.

We take full responsibility for resolving all drainage and sewer flooding issues that fall within our remit. If the causes of sewer flooding sit outside of this, we will support the responsible stakeholder to resolve the issue and to reduce the impact on customers.

Figure 2 provides a high-level view of the stakeholders responsible for drainage in each catchment area, more detail regarding responsibilities can be found in Section 1 of the following Drainage Strategy document.

Figure 2 Partners with Drainage Responsibilities



Next steps

Over the coming months we will undertake the following activities as this drainage strategy develops:

2015 - 2017

Customer Focus Actions

- Continue to consult with customers during this stage and every stage, through meetings, communications and surveys. We have gained important customer feedback during this first stage, which we are using to shape our activities
- Publish strategy documents for comment and contribution, throughout this framework process.

Partnership Actions

- Continue to establish partnership working with the regional drainage stakeholders, and agree ongoing consultation processes.

Other Key Actions

- Define catchment flooding uncertainties
- Prepare flooding risk data
- Undertake ongoing repair work to our sewer network, as the strategy develops and our investigations identify reparation work linked to drainage and flooding issues.

We will **regularly consult with customers and stakeholders, update and republish** this document throughout this 4-stage framework process.

Feedback: Q&A

Your questions answered

We are committed to listening to, consulting and collaborating with customers and stakeholders on our sewerage network activities and plans. We have addressed key feedback and questions raised by customers and stakeholders in the Bourton-on-the-Water catchment, and customers affected by flooding throughout the region, in this Feedback Q&A section. As far as possible, and as is relevant to Stage 1 in the framework process, we have incorporated feedback from customers and stakeholders into our network strategy development. More detail can be found throughout the following Drainage Strategy document.

Q1 Will undertaking this Drainage Strategy framework process defer essential work in our area?

Answer

It is essential for us to complete this drainage strategy process, which has been developed and recommended by the water industry economic regulator Ofwat, and the Environment Agency. This will enable us to better understand the root cause of the sewer flooding issues affecting the catchment, before any major investment can be considered. However, we may carry out some repair works as this strategy develops, in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have caused flooding, as outlined in Section 7 of the Drainage Strategy document. Our previous investigations have identified some sources of inflow, such as the misconnection of surface water to foul sewers. However, as stated in the following strategy, we are not yet able to say how much this impacts on flooding and will update this as our plan develops through Stage 2 to Stage 3 –Option Appraisal. Therefore, this more detailed approach is required to ensure that the most effective and sustainable drainage strategies are implemented in the Bourton-on-the-Water catchment.

We are committed to **listening to, consulting and collaborating** with customers and stakeholders on our sewerage network activities and plans.

Q2 What drainage actions are you undertaking in our area, and when will they be happening?

Answer

As stated above, we are developing our plan for this area and will provide further details as our plan develops through Stage 2 to Stage 3 – Option Appraisal. The following drainage actions have recently been undertaken, or are underway, in the Bourton-on-the-Water catchment:

Actions completed include: (For more information please see Table 2)

1. Pump replacement
2. Maintenance of flows using tankering
3. Sewer cleaning, descales and blockage clearing
4. Manhole sealing
5. CCTV investigations
6. Sewer repairs
7. Sewer flooding clean-up
8. Manhole 'Lift and Look' surveys
9. Depth monitor installation
10. Repairs to rising main.

Actions underway or planned include:
(For more information please see Table 4)

1. Permanent monitoring of sewer levels
2. Permanent flow monitoring of pumping station
3. Customer surveys
4. Misconnection surveys
5. Consider innovative solutions.

Q3 Are you renovating the sewers in our area?

Answer

We will renovate sewers which have been damaged, either as they have aged or through other streetworks activities. Our CCTV investigations and manhole 'Lift and Look' surveys sought to identify possible defects and assess the structural and service grade of the sewer network. As per Question 2 above, Table 4 in the drainage strategy sets out the proposed improvements to the sewerage network in the Bourton-on-the-Water catchment. As our strategy work continues, we will target and repair localised sewer defects identified through our investigations as contributing to, or causing, drainage and flooding issues in the catchment over the coming months.

Q4 What are the improvement plans for Bourton-on-the-Water's sewage treatment works to manage capacity?

Answer

The Bourton-on-the-Water sewage treatment works operates a fully-compliant permanent storm overflow which permits us to discharge into local watercourses during storm events. . To meet changing performance requirements and regulatory measures the works has undergone upgrades over the years.

The capacities of the sewage treatment works has been assessed to be more than adequate under normal design flow conditions. Therefore, we do not plan to enhance the treatment capability of the sewage treatment works at this time.

Q5 How are you planning for future development in the catchment?

Answer

As per Section 5.3 in the following Drainage Strategy document, we will continue to closely monitor development applications in the catchment and assess the impact that they may have on the capacity of our operations in the future. Our existing sewage treatment works currently has the capacity to manage all of the development applications submitted and projected for the catchment, as outlined in the latest Cotswold District Council Development Plan.

We will continue to work with all involved stakeholders through our stakeholder engagement activities, to monitor local plans and planning applications and to incorporate current and projected developments into our business planning cycle, to ensure that our service is maintained for customers throughout the catchment's development.

Q6 Are you working with the Highway Authority to resolve blocked gullies, sewers and ditches, and with landowners to reduce field run-off, as both affect drainage and our sewers?

Answer

We have undertaken work to clean, descale and remove blockages from sections of the Bourton-on-the-Water sewerage network as the needs were identified. However, the customer feedback we have received specifically regarding sewer maintenance by the "Highways" and to agricultural practices by landowners, relates to highway drainage and to land drainage issues rather than to foul sewers maintenance.

In Section 1 of the following Drainage Strategy document, we outline the other stakeholders who, like us, have important drainage responsibilities and therefore, play an essential role in resolving sewer flooding issues in this catchment area.

As Highways maintenance activities and agricultural land maintenance practices sit outside of our remit we will work with the responsible stakeholders, to highlight these issues where this is found to have a major influence and impact on our sewerage network.

We will continue to work closely with the Council and Highways England to understand the extent to which flood waters may be escaping from highway or land drainage systems; and impacting the foul sewer network. An update on this issue will be shared with customers and featured in the later stages of this Drainage Strategy document.

Q7 Is an Infiltration Reduction Plan (IRP), required for this catchment?

Answer

Ensuring that our drainage strategies fully meet the requirements of an Infiltration Reduction Plan, as set out in the Environment Agency's Regulatory Position Statement, is a fundamental consideration in their development. Therefore, to maintain our service to customers during future wet weather events, if we need to discharge to watercourses through temporary overflows, a dedicated section will be included in each affected strategy, providing details of their location and intended use. This section will be included and /or revised when each strategy is updated.

Following extreme weather conditions during the winters of 2012/13 and 2013/14 tankering was utilised in the Bourton-on- the-Water catchment, however temporary pumps were not used. In the event that temporary overflows are required, as stated above, we will describe their location and the circumstances under which we would use them. Together with plans to reduce infiltration, this drainage strategy would then fully meet the requirements of an Infiltration Reduction Plan.

Q8 Why are costs a consideration within your Wastewater outcomes?

Answer

The service we provide is the most fundamental of all – at the heart of daily life for the 15 million customers we serve. Getting it right is our focus every day, and we never forget it is paid for by customers.

As a regulated company we have to carefully balance service and cost in order to keep customer bills affordable, whilst delivering our outcomes and customer service commitments.

Q9 How are you ensuring that our local pumping stations are operating effectively?

Answer

The pumping stations in the catchment are supported by 24 hour diagnostic monitoring so that we can tightly control its operation through a flow of real-time information. Based on this performance data we can respond quickly through site visits by our engineers, and both project and rectify potential issues before they occur. The pumps at the principal Bourton-on-the-Water pumping station were replaced with more modern pumps in 2012.

As we move through this 4-stage framework process and further develop our drainage strategy for this catchment, we will review the operational control options of this station, particularly during wet weather, carefully avoiding increasing the risk of sewer flooding in doing so.

Q10 Are growth and urban creep minor factors in these rural catchments?

Answer

When compared against the rest of the Thames Water Operational Area, the urban creep rate for Bourton-on-the-Water is just above average, but not as high as suburban areas around central London and major towns.

Relatively small population increases in these smaller rural catchments can be influential on sewer flows, hence the need for us to closely monitor planning applications. Similarly urban creep, and in particular misconnection of surface water and change of land use, can have a significant impact on sewer flooding; particularly when permeable areas such as grass are replaced with hard-standings and driveways.

More growth and urban creep information can be found in Section 5.1 of the following Drainage Strategy document.

Q11 Are best practice techniques already used by other water companies being considered?

Answer

We are constantly reviewing and improving our business to meet and exceed industry standards, to implement best practice and to drive innovation. We lead and participate in a large number of industry forums both in the UK and worldwide, to share and expand our learning; with the ultimate aim of improving services for customers.

We are deploying industry best practice techniques throughout our Drainage Strategy work, and also trialling new technology that is innovative within our industry, to achieve the best possible drainage outcomes for customers and their local environment.

Q12 Why are you collecting climate change data rather than 'climate proofing' assets?

Answer

We are committed to responding to climate change and to reducing our contribution to it by reducing emissions in accordance with government policy. Our voluntary target is to achieve a challenging 20 per cent reduction in emissions (compared to 1990 levels), for our Scope 1 and 2 emissions*. We continue to assess and collect climate change data and its impact on assets across our region, to ensure that we are fully informed and can prioritise our plans, targeted actions and investments. For more information please see the Climate Change section on the Homepage of our website.

*Scope 1 emissions refer to greenhouse gas emissions associated with the operation of our assets. Scope 2 emissions are emissions associated with the use of grid electricity.

Q13 What is the impact on local rivers of overflow points?

Answer

During extreme weather conditions foul sewers may become overwhelmed through a combination of surface water or ground water, resulting in a much diluted sewage. The impact on local rivers is dependent on the nature and size of the river, and on the overflow.

To reduce the environmental impact on local watercourses we will only use overflow points when groundwater and river levels are high, and therefore sewage dilution rates are also high. Additionally, we are also investigating deploying mobile biological filters and screening to prevent litter and other matter from entering local rivers. If during the development of our drainage strategy we consider that temporary overflow points are necessary in the local network, we will update the Drainage Strategy document to reflect this position.

Bourton-on-the-Water Drainage Strategy

Technical Document

Thames Water

At the heart of daily life

Stage 1: Initialise / Prepare

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About this document

Based on customer research

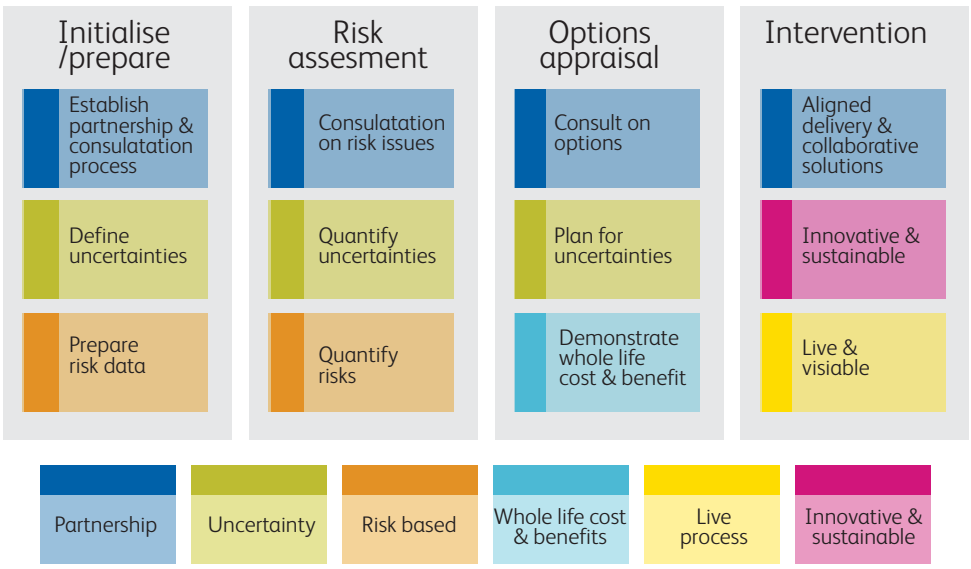
Undertaking extensive customer research has been a fundamental step in our business plan preparation for 2015-20. Our research findings have informed our business planning activities, and contributed to the development of a set of long-term customer 'outcomes'.

The water industry economic regulator, Ofwat, defines 'outcomes' as "High-level objectives that company actions, activities and achievements are intended to help deliver..[they] represent what customers and society value". As a company, we are committed to achieving our customer outcomes, a number of which are focussed on alleviating sewer flooding issues within our region, through effective, economic and sustainable drainage. This document describes the strategy that we will follow in delivering our long-term customer outcomes for drainage, specifically in the Bourton-on-the-Water catchment, in a sustainable and economic manner.

Approved approach

We have adopted the Drainage Strategy Framework[1] outlined in Figure 1 below, developed by the Environment Agency and Ofwat. It identifies 4 key stages to producing a good-practice drainage strategy. Drainage strategies typically focus on the sewerage network, and not the performance of sewage treatment works. The Bourton-on-the-Water drainage strategy is currently at the first stage of this framework - the Initialise/Prepare stage. In this document, we describe the activities that we plan to undertake to address current issues and future challenges facing the catchment, and the data that we need to gather to complete the risk assessment and options appraisal stages.

Figure 1 The Drainage Strategy Framework



[1] http://www.ofwat.gov.uk/future/sustainable/drainage/rpt_com201305drainagestrategy.pdf

Consultation and publication

We will update and republish this document to provide the results of our risk assessment, options appraisal and our selected strategy for intervention, once data from instrumentation and other fieldwork has been collected and analysed.

Throughout this process we will attend local flood forums for ongoing communication and consultation with customers and stakeholders. We will also make the Drainage Strategy documents available on the Drainage Strategies webpage of our website.

Meeting the Infiltration Reduction Plan (IRP)

To ensure that this Drainage Strategy meets the requirements of an Infiltration Reduction Plan, as set out in the Environment Agency's Regulatory Position Statement on discharges made from groundwater surcharged sewers, we have included a section in this document which defines if, how and when we propose to operate temporary overflows. This is in addition to our plans to reduce infiltration over time, where it has been identified as a root cause of sewer flooding. Please see Section 8 in the Drainage Strategy document below.

Executive summary

In recent years the foul sewerage system in the Bourton-on-the-Water catchment has become overwhelmed in some locations, following prolonged and heavy rainfall and raised groundwater levels. This has resulted in certain properties suffering from sewer flooding and restricted toilet use. The sewerage system is identified on the public sewer records as being a separate foul system, rather than a combined system, and should therefore only be accepting foul drainage rather than the combination of foul and surface water, however, there are a limited number of public surface water sewers in the area.

We believe that the foul system has surcharged because of a combination of groundwater infiltration, surface water run-off from saturated fields, surface water inundation from highways and public spaces, surface water misconnections and flooding from the River Windrush.

The root causes of sewer surcharges are therefore numerous and the resolution of the issues complex, requiring all stakeholders responsible for drainage in the catchment to work together to resolve them. The Floods and Water Management Act 2010 places a responsibility on lead local flood authorities (LLFAs), to manage flood risk from surface and groundwater, plus a duty on all risk management authorities (RMAs), to cooperate regarding flood risk. In our role as a RMA, Thames Water will work with Gloucestershire County Council as lead local flood authority, Cotswold District Council as Planning Authority and the Environment Agency to ensure that a collaborative approach can be developed to address the problems.

In response, this Drainage Strategy follows the Environment Agency and Ofwat's 4-stage framework. The Bourton-on-the-Water strategy is currently at Stage 1 (Initialise/Prepare). We describe in this document the actions that we plan to carry out to complete the risk assessment and options appraisal stages. We will update and republish this document once this work has been completed.

In preparing our company business plan for the 5 year period 2015 to 2020 we have listened very carefully to the views of customers. Beyond being able to maintain the current service that we provide, customers have told us that they would like to see a reduction in instances of sewer flooding and odour nuisance and an improvement in river water quality. Our research indicates that customers are willing to pay for these improvements to service ; a summary of our related customer research can be found on our website via the hyperlink below.

We have therefore developed a set of company outcomes that we are committed to working towards over the next 5 years and beyond. The outcomes relevant to the Bourton-on-the-Water drainage strategy are:

- Asset health - a composite range of measures against which we will manage the health of our sewerage network
- Properties and public areas protected from sewer flooding
- River water quality meets customers' expectations and regulatory requirements.

This drainage strategy must also address future challenges to the Bourton-on-the-Water catchment. We assess these to be:

- Climate change – analysis of the latest data suggests that rainfall could become 15% more intensive by 2080 increasing the likelihood of flooding. Longer wetter winters may also mean groundwater levels are high more often; this could also exacerbate fluvial flooding from local watercourses
- Urban creep – paving over of front gardens and loss of green space results in more strain on the sewerage network when it rains heavily. Modelling we have undertaken suggests urban creep

[2] http://www.thameswater.co.uk/cr/Howwedobusiness/Engagingwithourstakeholders/Publicconsultationresearch/index.html

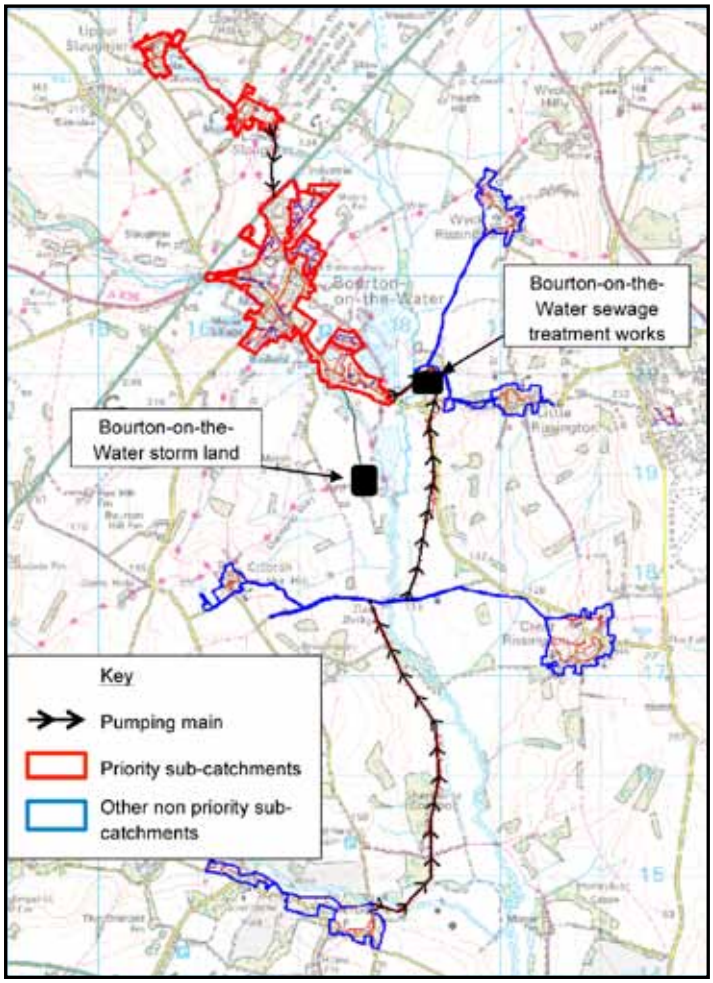
rates in Bourton-on-the-Water are just above average for the Thames Operational Area

- Population growth – the population in the South East is set to grow rapidly. A number of possible developments are identified in Bourton-on-the-Water and we will continue to track these and any other emerging applications for this catchment arising in the future.

Our strategy is to understand the relative impact on this catchment of overland flow from saturated fields, groundwater infiltration and surface water misconnections and how this effects the performance that our network has in respect of flooding. We will then try to identify cost beneficial solutions to reduce the risk of sewer flooding using customer willingness to pay research. We may carry out sewer rehabilitation works as the strategy develops in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have contributed to flooding.

Our next steps are to continue to collect real-time flow information from the permanent depth monitors we installed at the end of last year, and to collect sewer flooding information from customers. The depth monitors will remain in place as we move through this 4-stage framework and develop our plans. The priority sub-catchments we are monitoring are outlined in Figure 2.

Figure 2 Bourton-on-the-Water priority sub-catchments



The extent of the catchment is outline in red.

1 Thames Water and drainage

1.1 Our statutory responsibilities

Thames Water is a regulated Water and Sewerage Company. We supply water to 9 million customers in London and the Thames Valley and provide wastewater services to 15 million customers across an area that stretches from Gloucestershire to Essex. We operate 108,000km of sewer through which an average of more than 4.4bn litres of wastewater is collected and treated every day at our 350 sewage treatment works.

The primary legislation that sets out our role and responsibilities is the Water Industry Act (1991), which describes the duties and services that we are responsible for and the powers that we have to connect, operate, maintain and extend the sewerage network. We are regulated by the Water Services Regulation Authority (Ofwat). The original 1991 Act has been amended by further legislation in recent years, transferring some drains and sewers that were hitherto in private ownership to Thames Water's responsibility[3].

Other recent pieces of legislation relevant to this Drainage Strategy are the Flood & Water Management Act (2010) and the Water Act (2014). These set out new responsibilities for Thames Water to manage flood risk in partnership with local councils and the Environment Agency, with more emphasis on Sustainable Drainage Systems (SuDS), such as swales and permeable paving to mimic natural drainage.

Thames Water also has a statutory obligation to comply with environmental legislation, including European Directives. The Water Framework Directive establishes a strategic approach to managing the water environment, which the Environment Agency achieves through River Basin Management Plans and setting environmental objectives for groundwater and surface water. The environment is also protected from adverse effects of discharges of urban wastewater through the Urban Wastewater Treatment Directive, which requires us to improve and extend the sewerage system according to section 94 of the Water Industry Act (1991).

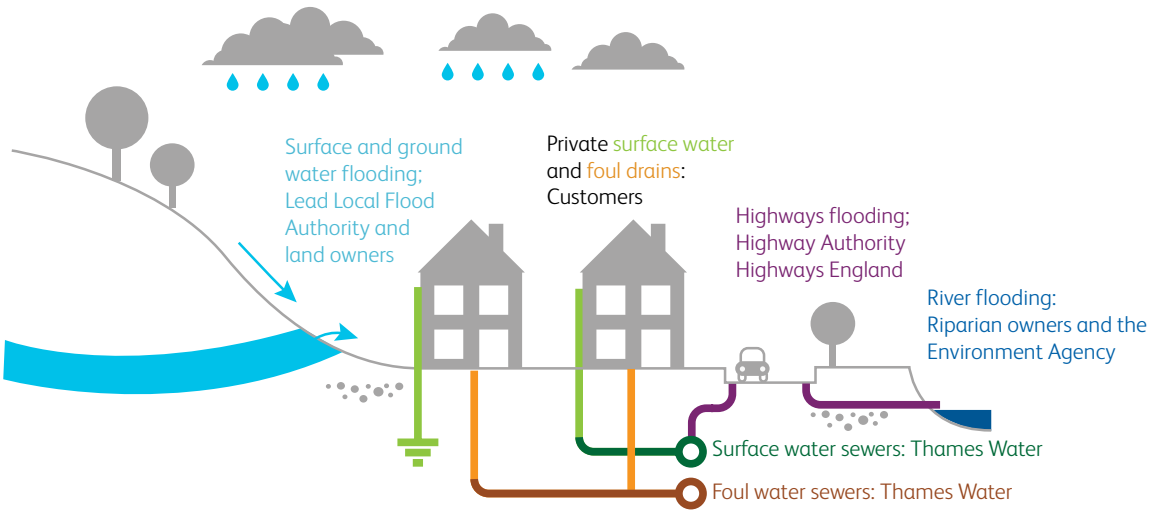
A comprehensive and detailed list of all legislation relevant to Thames Water can be found in the 'statement of obligations' published by Defra[4].

[3] See http://www.thameswater.co.uk/help-and-advice/8654.htm for more information.
[4] See https://www.gov.uk/government/publications/statement-of-obligations.

1.2 Working in partnership with other stakeholders

Other stakeholders responsible for managing various forms of drainage need to work together with us to reduce the risk of flooding. Each has specific responsibilities as summarised in Figure 3 below.

Figure 3 Stakeholder responsibilities for drainage



Thames Water

We are responsible for removing and treating wastewater which includes the foul sewers, and in some areas the combined sewers that are in some of the older large urbanised areas such as London[5]. We also manage and maintain surface water sewers where they exist, these will typically discharge to a watercourse or river. In some cases, the cause of sewer flooding may not fall under our responsibility. In these circumstances, we will explain what we can do to help and continue supporting the relevant authorities or third parties to reduce the impact for our customers.

Environment Agency

The Environment Agency is responsible for main rivers and part of its remit includes monitoring and informing the levels of ground and river water. The Environment Agency also investigates pollution incidents and monitors the quality of the water in rivers.

Lead Local Flood Authority and District Council

Gloucestershire County Council is the Lead Local Flood Authority and has the responsibility under the Flood & Water Management Act for managing the local flood risk from groundwater and surface water runoff e.g. local watercourses and culverts[6]. They work with landowners to maintain privately owned ditches, drainage and watercourses, keeping them clear of blockages. They are also responsible for managing the risk of groundwater flooding, both inside and outside of properties. Water from these local authority gullies and drains and privately owned ditches can also impact Thames Water's sewers, therefore, we work with all responsible stakeholders to resolve the excess flow. Cotswold District Council is the Planning Authority responsible for approving new development, but equally may have responsibility for ensuring maintenance of watercourses; particularly on council-owned land.

Highway Authority

Gloucestershire County Council is the Highway Authority and is responsible for highway maintenance and highway drainage and for clearing roadside gullies. Highways England is responsible for the drainage of motorways and certain trunk roads.

Customers

Customers own, and are responsible for, the maintenance of private drains within the curtilage of their property, which did not transfer to Thames Water ownership in October 2011[7].

Riparian Owners

Riparian Owners are landowners who own land with watercourses or land adjacent to watercourse (ie road side ditches). The responsibility for the operation and maintenance of ditches, local watercourses and general land drainage lies mostly with riparian owners.

Land Owners

Land owners include farmers and both residential and commercial customers, but includes trusts etc. They are responsible for ensuring the adequate drainage of their land, such that it is not a nuisance to others.

[5] Thames Water is responsible for the collection and treatment of commercial and domestic sewage. Typically this will be the foul sewerage. Domestic or commercial roof and paved drainage will often go to a soakaway or directly to a water course/river, which if so is not the responsibility of Thames Water.

[6] Some local watercourses and/or culverts are termed as 'Riparian' meaning that a land owner, possibly adjoining or owning the land containing the watercourse/culvert is responsible for the maintenance and free-flowing of the watercourse/culvert.

[7] See http://www.thameswater.co.uk/help-and-advice/8654.htm for more information.

2 Catchment description

2.1 Geology and topography

The Bourton-on-the-Water sewerage catchment is located approximately 20km west of Cheltenham and serves Bourton-on-the-Water along with the villages of Clapton-on-the-Hill, Great Rissington, Little Rissington, Wyck Rissington, Sherborne, Upper Slaughter and Lower Slaughter as outlined in Figure 2.

The geology of the catchment is generally made up of limestone, sandstone, siltstone and mudstone. There is a small area of sand and gravel to the south of Bourton-on-the-Water and a band of clay, silt and sand that runs up to the north east. The geological make-up of this area shows mostly highly permeable soils within the catchment areas, and following the River Windrush, River Eye and River Dikler. The surrounding area is composed of clayey soils with an impermeable layer at shallow depth. This impermeable layer is likely to create localised high groundwater levels within the catchment and increase the risk of induced infiltration. According to the Environment Agency, the current ecological status of the River Dickler, the River Eye and the River Windrush is 'Good'[8].

Appendix B includes maps showing the geology and fluvial, pluvial and groundwater flood risk areas in the catchment.

2.2 Sewage treatment works

The Bourton-on-the-Water sewage treatment works serves the town of Bourton-on-the-Water and the villages of Lower Slaughter, Upper Slaughter and Sherbourne via a number of sewage pumping stations and gravity-fed sewers. The works serves a population equivalent of circa 6,430 with a dry weather flow consent of 3,366 m3/day, but typically treating a daily flow of up to 7,808m3/day during wet weather periods. The treated effluent discharges to the River Dikler and then on to the River Windrush. It includes a storm tank to handle excess flows above the flow to full treatment during storms, which returns the flows to the filter distribution chamber for treatment.
The foul sewerage system dates back to the 1920s and would have been constructed by the local authority incumbent at the time. Foul sewage was originally treated at a sewage treatment works at the south of the town, near Lower Marsh Farm, but the flows were diverted in the 1950s to the current sewage treatment works at the east of the town, via the Bourton-on-the-Water sewage pumping station. The sewerage system has grown further in the intervening period necessitating enhancements to the sewage treatment works to treat the increased flows. The most recent major improvement was carried out at the works in 2001 due to changes in performance criteria.

The capacity of the sewage works has been assessed to be adequate under normal design flow conditions for the current population. However, given the likely growth for the catchment area, we will be carrying out a study over the course of this current Business Plan period (2015 to 2020), to determine how the growth may impact on the performance of the sewage works. An implementation programme will be undertaken based on the resulting recommendations from the study, should this be required.

[8] Environment Agency website, interactive map, Basin Management Plans.

2.3 Foul sewers

The catchment is served by a foul water gravity sewerage system, which includes a number of sewage pumping stations that pump flows from the outlying villages. The sewerage system is identified on the public sewer records as being a separate foul system, rather than a combined system designed to cater for both foul and surface water, however, there are a limited number of public surface water sewers in the area.

The earliest foul sewers in the catchment are believed to date from the 1920s. Flows were diverted in the 1950s to the current sewage treatment works to the east of the town, via the Bourton-on-the-Water sewage pumping station, but land at the former sewage treatment works is used as a storm irrigation area. The sewerage system in the intervening period has grown to serve additional areas and new developments, including first time sewerage schemes in outlying villages such as Upper and Lower Slaughter and Wyke Rissington constructed by the North Cotswold Rural District Council in the 1970's. A schematic diagram of the catchment is shown in Figure 4 below.

Sewer design criteria ensures the appropriate sizing and laying of pipes at an appropriate gradient to maintain a satisfactory self-cleansing characteristic. The capacity of the sewers is typically set to cater for a maximum of six times Dry Weather Flow and a 10% allowance is included for infiltration[8]. In terms of capacity a 225mm diameter sewer laid at a gradient of 1 in 225 will have sufficient capacity to cater for the foul sewage from 1,000 to 1,500 houses or 3,000 to 4,500 people. Problems in sewers smaller than 300mm diameter tend to be a result of blockages in the pipes. However, occasionally surface water can be misconnected into the foul sewerage network – problems then arise when it rains heavily.

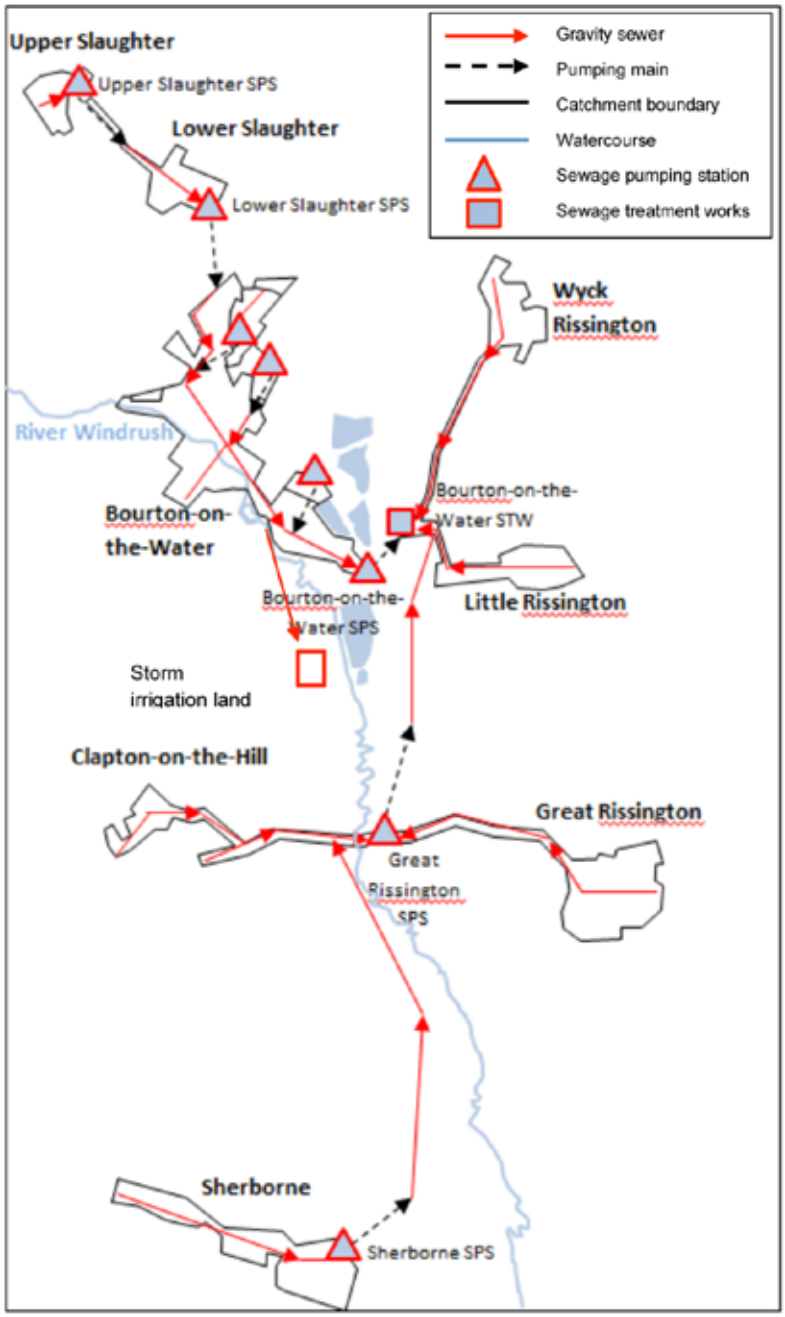
In Bourton-on-the-Water, the foul sewers typically range from 150mm to 525mm in diameter, and include a 900mm diameter offline storm attenuation tank sewer to the south of Risington Road upstream of the Bourton-on-the-Water sewage pumping station.

Materials used in the construction of the sewerage system are typical of the time, with vitrified clay pipework for smaller diameters, concrete pipes for larger diameters and brick and concrete manholes. However, surveys indicate that a number of the sewers in the area are cast iron, which is typically used in areas with high water tables, as the jointing techniques significantly reduces the risk of infiltration. Clay pipework has a very long service life, but sometimes the joint seals deteriorate over time.

The earlier pipes were laid on bedding material such as pea shingle with the trenches likely to have been backfilled with 'as dug' material. More recent drains and sewers, i.e. since the 1980s, are typically surrounded with pea shingle. This protects the pipe but also acts as a good conduit for groundwater. The layout of the village suggests that most properties are likely to have their own foul drains that connect directly into the public sewer. The private foul water drains within the property boundaries in Bourton-on-the-Water are the responsibility of the property owners, where they are not shared.

[8] Dry Weather Flow is the term given to the average flow rate observed over a 24 hour period and based on Sewers for Adoption, the industry standard, includes an allowance for infiltration of 10% of the calculated flow rate.

Figure 4 Bourton-on-the Water foul sewerage catchment schematic



2.4 Surface water sewers

There are a few public surface water sewers within Bourton-on-the-Water itself. The surface water from the majority of properties is likely to drain to soakaways or to the River Windrush. Soakaways can only function satisfactorily when ground conditions allow soakage and may be completely ineffective at times when groundwater levels are high. In some areas, we have seen examples of customers draining surface water through their foul drains when their soakaways do not work. This exacerbates capacity problems for other customers connected further downstream in the sewerage network.

The rest of the catchment is mostly rural and incorporates a network of roadside ditches and minor watercourses that are intended to take surface water from roads and public spaces in the area. As per Section 1.2 the responsibility for the operation and maintenance of these ditches, local watercourses and general land drainage is mostly with riparian owners. Gloucestershire County Council as lead local flood authority has overall responsibility for managing groundwater. The responsibility for the maintenance lies with the riparian owners.

The Environment Agency has the duty and the authority to ensure that the River Windrush, River Dickler, and the River Eye are maintained appropriately. The responsibility for maintenance lies with the riparian owners.

Highway drainage typically discharges to the roadside ditches. Owing to the high local beauty of the area the ditches tend to be well maintained with clearance of vegetation and debris occurring. However, the area does have an active groundwater table and as a result groundwater springs do occur from time to time, which can lead to localised land drainage issues. The extent of highway drainage is uncertain, but it is likely that highway surface water run-off discharges directly to roadside ditches, some of which will act as soakaways. Gloucestershire County Council is responsible for highway drainage and culverts crossing the highway.

3 Long-term outcomes

We have listened very carefully to the views of customers before developing our plan for the Asset Management Period 6 (AMP6) regulatory period. Between 2009 and 2013 we carried out over 50 separate customer research and engagement activities.

Beyond being able to maintain the current service that we provide, customers have told us that they would like to see a reduction in instances of sewer flooding and odour nuisance and an improvement in river water quality. These are areas where some customers are prepared to see, and pay for, an improvement in the current level of service.

In response to this, we have developed 4 company outcomes and 11 service outcomes for our wastewater service that we are committed to working towards over the next 5 years and beyond, further details can be found in Table 1 below and on our website[9].

Table 1 Wastewater outcomes

Company outcome	Wastewater service outcome	Why is this service outcome chosen
We will provide a safe and reliable wastewater service that complies with all necessary standards and is available when our customers require it.	Asset health: maintaining our assets to ensure we can provide a safe and reliable service in the long-term.	We must ensure an appropriate balance between reducing costs today and not compromising our future service.
	Properties and public areas protected from flooding.	Flooding is one of the worst service failures for customers.
	Resilient sewage treatment service that minimises the impact of extreme events on river water quality.	We need to be able to provide service against a variety of pressures such as climate change and population growth.
Our customers and stakeholders can trust us, we are easy to do business with and we care.	Do the basics excellently by getting things right first time.	This service outcome ensures our wholesale activity is completely aligned to our objective to improve our Service Incentive Mechanism (SIM) scoring.
We will provide the level of customer service our customers require, in the most economic and efficient manner, to ensure that bills are no more than necessary.	Reduced dependence on energy from the grid.	Reducing dependence on energy from the grid is one of a range of measures across our entire plan to keep costs down to an affordable level for customers.
We will limit our impact on the environment and achieve a socially responsible, sustainable business for future generations, including reducing levels of leakage.	Minimising our carbon footprint.	There is an expectation from society that we will play our part in reducing carbon emissions.

[9] See http://www.thameswater.co.uk/tw/common/downloads/about%20us%20-%20corporate%20responsibility/AMP6_-_Outcomes_Reporting_Policy.pdf for more information.

Company outcome	Wastewater service outcome	Why is this service outcome chosen
	River water quality meets customers' expectations and regulatory requirements.	We must meet environmental regulations, and river quality is a visible indicator to citizens of our environmental stewardship.
	Satisfactory sludge disposal.	Sludge is a resource that we should manage effectively to keep bills down.
	Corporate responsibility.	We will act as a responsible company, meeting expectations from wider society.
	Reduced odour from wastewater operations.	Odour is a problem for some of our customers.
	Compliance with new environmental regulations.	We must meet environmental regulations, and river quality is a visible indicator to citizens of our environmental stewardship.

Below we provide more information about our asset health, properties and public areas protected from flooding and river water quality outcomes, as these are relevant to the Bourton-on-the-Water drainage strategy.

3.1 Asset health

Our Asset health performance commitment encompasses a composite range of measures against which we will manage the health of our sewerage network. This commitment underpins our outcome of a safe and reliable wastewater service. It includes sewer collapses, blockages, unconsented category 1 to 3 pollution incidents and properties internally flooded due to operational problems (such as blockages, collapses or equipment failures).

3.2 Properties and public areas protected from flooding

There are two performance commitments that underpin the delivery of this service outcome:

1. We commit to protecting properties from flooding due to rainfall. We estimate that our plan for 2015-20 will result in over 2,100 properties being alleviated from internal flooding, external flooding and also from restricted toilet use. (for example when groundwater levels are high following prolonged periods of wet weather). Our customer research indicates that our sewer flooding programme will deliver £20m of benefit to customers every year by 2020.
2. We commit to reducing the risk of sewer flooding and pollution from combined sewers (i.e. those that convey both foul and surface water) by slowing down surface water run-off and re-routing the flow through sustainable drainage measures such as water butts, permeable paving, rain gardens and green roofs. We aim to retrofit over 20 hectares of sustainable drainage measures by 2020. We may also apply this commitment to areas where the network was designed to take foul flow only, but investigation shows that a substantial amount of surface water is in the foul sewer.

3.3 River water quality meets customers' expectations and regulatory requirements

We have a performance commitment to reduce the number of pollution incidents as a result of discharges from our sewerage network and treatment works. Pollution can occur as a result of blockages, collapses or failure of our equipment and also following heavy rainfall when our sewers have insufficient capacity to cope with the flow. All pollution incidents are reported to the Environment Agency's National Incident Recording System (NIRS).

4 Current issues

4.1 Recent wet weather events

The foul sewerage system in Bourton-on-the-Water has become overwhelmed for weeks and even months at a time in recent years following prolonged heavy rainfall. This has been associated with significant sewer flooding. Based on site reconnaissance that we have carried out we believe that the system has surcharged due to a combination of groundwater infiltration, surface water run-off from saturated fields, surface water inundation from highways and public spaces, surface water misconnections and flooding from the River Windrush.

We are confident that this is a comprehensive list of factors that have caused flooding.
The following incidents have been observed with respect to the sewerage network (see Figure 5 below):

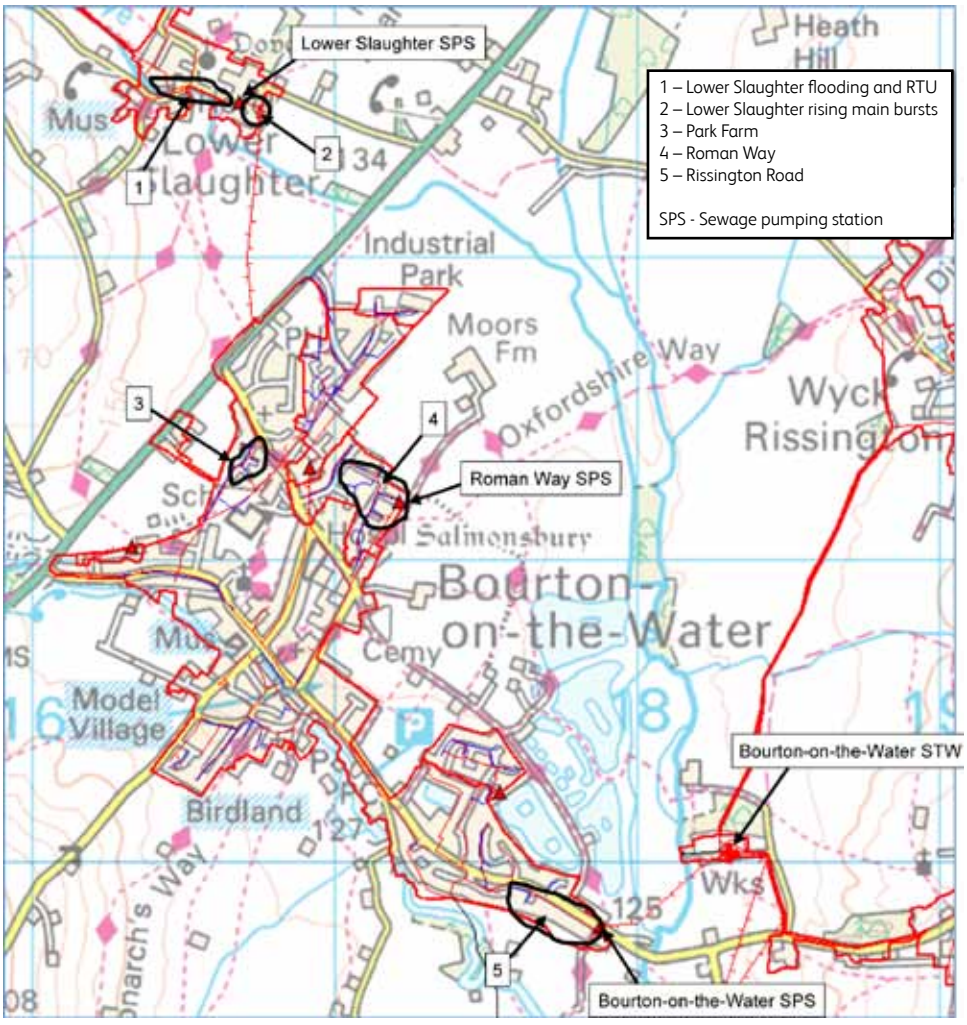
- surcharging sewers causing spills out of many public manholes and restricted toilet use, including:
  - Rissington Road near the Bourton–on-the-Water sewage pumping station
  - Roman Way upstream of the Roman Way sewage pumping station
  - Lower Slaughter upstream of the Lower Slaughter sewage pumping station
  - Park Farm.
- pollution caused by surcharging sewers
- burst rising main – Lower Slaughter sewage pumping station.

During these events, other sources of flooding have also been observed:

- highway drainage overwhelmed causing highway flooding
- the River Windrush overwhelmed causing fluvial flooding of properties
- land drainage issues with water running off fields and onto highways.

To reduce the risk of flooding, we understand that some customers have had to pump floodwaters onto the highway or protect their properties with sandbags.

Figure 5 Bourton-on-the-Water key performance issues



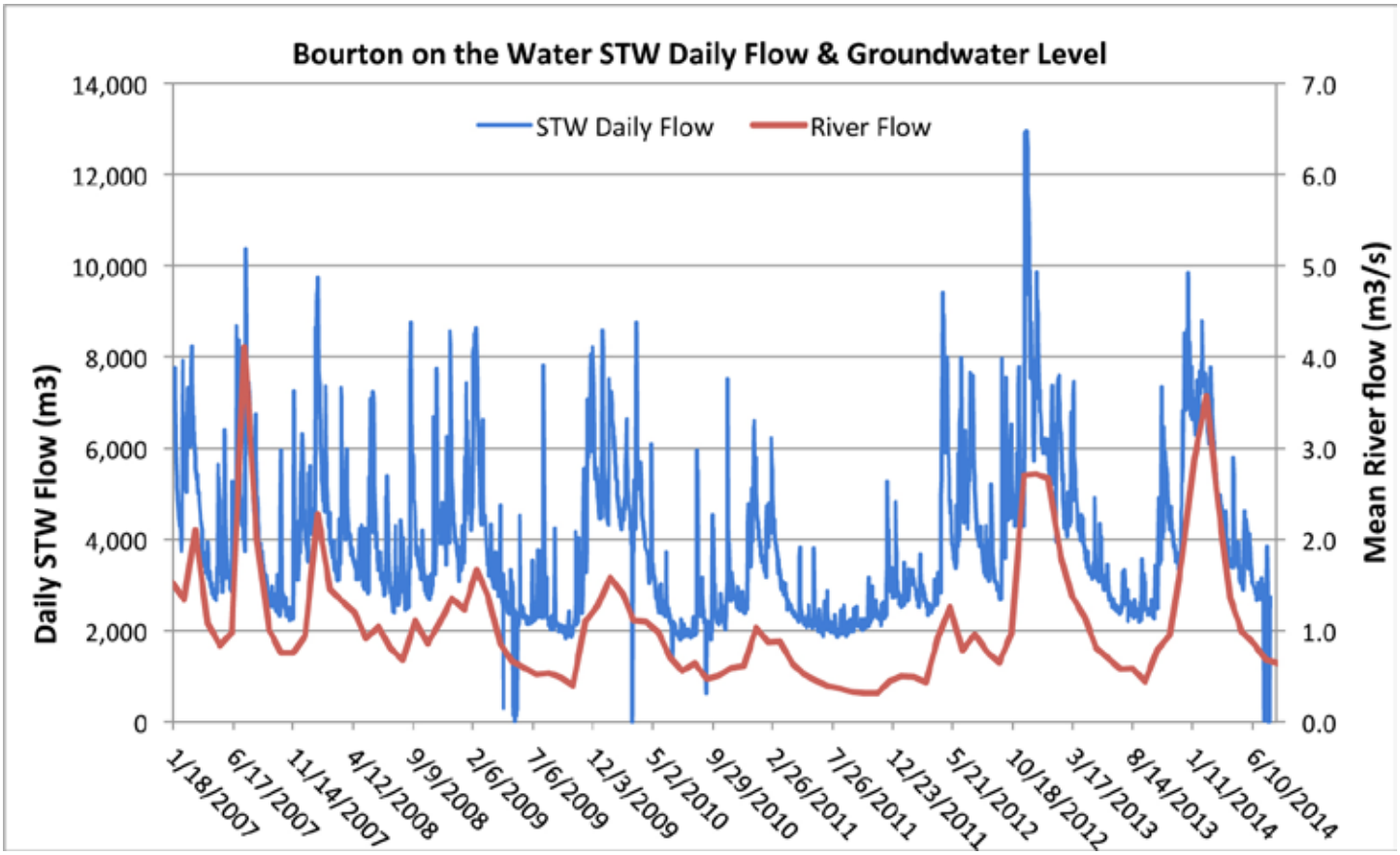
4.2 Our operational response

We have deployed tankers to Bourton-on-the-Water and Lower Slaughter sewage pumping stations during the winters of 2012/13 and 2013/14 to manage excess flows and maintain service to our customers. We acknowledge that customers find tankering noisy and disruptive. To date we have not installed temporary pumps to discharge excess flows to neighbouring watercourses during prolonged wet weather, but we will investigate the benefits of doing so as this drainage strategy develops. There may be circumstances that might necessitate this practice.

Even if flows can be contained within the sewer network, excessive flows arriving at the treatment works may not always be given full treatment prior to discharge to the River Windrush. The use of such storm sewage overflows, including the storm treatment land, is accepted by our regulators, subject to conditions.

Figure 6 compares the treated flows at Bourton-on-the-Water sewage treatment works with river flows recorded at the Environment Agency gauging station in the area. It can be seen from this graph that periods of high flow to the sewage treatment works correlate well with high flow in the river. However, high river flows do not necessarily mean that infiltration levels will be high, because pluvial and fluvial flooding will also correlate with high river flows.

Figure 6 Bourton-on-the-Water sewage treatment works treated flows and River Windrush flows



4.3 Investigations and activities completed to date

Table 2, below, details the investigations and actions that we have completed in recent years within the Bourton-on-the-Water catchment. These form the extent of our current understanding of issues within the catchment.

Table 2 Investigations and activities completed

Activity	Purpose	Date complete	Outcome
Pump Replacement	Bourton-on-the-Water sewage pumping station, both pumps replaced.	February 2012	Maintain 'asset health'.
Maintenance of flows	Tankering has been used to maintain levels of service during autumn 2012.	October 2012	Service maintained during wet weather.
Sewer Descale	3 sewer descales carried out at Greenlea between May 2012 and March 2013.	March 2013	Improve flow through pipework.
Repairs to rising main	Restore pumping capability of the Lower Slaughter sewage pumping station.	2013/2014	Main repaired on 3 occasions.
Manhole Sealing	2 manholes investigated and sealed at Greenlea on 08/10/2013 and 15/01/2014.	January 2014	Stop infiltration into the manholes.
CCTV investigations	Assess structural and service grade of the sewerage network and if possible detect sources of infiltration.	February 2014	9 CCTV investigations carried out between June 2012 and February 2014 including two cases in Station Road of 240m and 430m to aid planned maintenance.
		July 2014	240m of main sewer in Rissington Road, near sewage pumping station.
		September 2014	640m of main sewer in fields to south of Rissington Road.
Sewer Flooding clean-up	Clean-ups carried out after sewer flooding events to ensure public health and safety.	March 2014	7 clean-up activities undertaken between November 2012 and March 2014 including one large event on Rissington Road, completed 19/03/2014.
Sewer Blockages cleared	107 blockages cleared between 04/04/2012 and 22/03/2014 – clearing of blockages as they are reported.	March 2014	Improve flow through pipework and reducing flooding problems.
Sewer Cleaning	3 sewers cleaned: 100m on Lansdown, 85m on Station Road and 144m on Moore Road – all 150mm pipes.	March 2014	Maintain 'asset health'.
Sewer and manhole surveys	Ascertain sewer and manhole condition and evidence of infiltration.	March 2014	Survey included 5km of sewer in Bourton-on-the-Water and Lower Slaughter.

Activity	Purpose	Date complete	Outcome
Manhole 'Lift and Look' surveys	Undertaken on all accessible public manholes in the village to identify any obvious points of inflow.	June 2014	No obvious defects identified – one length of sewer with higher than expected flows identified for further investigation in wet weather, when infiltration will be observable.
Permanent monitoring of sewer levels	Installation of permanent depth monitors into the foul sewers at strategic locations in Bourton-on-the-Water and Lower Slaughter. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels.	Installed Nov 2014	Use the information to identify additional actions for inclusion in the drainage strategy for Bourton-on-the-Water. Share information with other agencies.
Sewer repairs	Sewer lining of 165m of 150mm diameter pipework to prevent ingress of groundwater.	April 2015	Stop infiltration into the public sewers (private sewers and drains were not included in the scope of the project).

In summary, following previous concerns that the sewerage network suffered excessive infiltration, considerable action has been taken over a number of years to identify the potential sources. It is clear that small scale rehabilitation and existing surveys may have been locally successful in identifying and preventing some sources of inflow, but they have not significantly impacted on the extent of the surcharging and flooding subsequently experienced. This may be due to our earlier work focussing only on public sewers within our ownership, and not private sewers and drains, or inundation from surface water ponding or misconnected properties.

Survey works have been carried out in the catchment over recent years and further survey and investigation is required to identify sources of inflow and their resolution. Permanent depth monitors were installed in the catchment in 2014, we will continue to monitor this data as our strategy develops through this 4-stage framework process.

4.4 Activities carried out by drainage partners

Table 3 below, details the activities carried out by other stakeholders with drainage responsibilities within the Bourton-on-the-Water catchment, to reduce the risk of flooding in the area. For more detail on the other organisations responsible for managing various forms of drainage within the catchment, please see Section 1 of this drainage strategy document.

Table 3 Actions by other stakeholders to prevent flooding

Activity	Purpose	Impact on sewerage
Routine maintenance of River Windrush, watercourses and local ditches.	Ensure free flow of river and ditches.	Less risk of surface water flooding and inundation into the foul sewers and hence less risk of sewer flooding and pollution incidents.
Routine maintenance of private surface water drainage and soakaways.	Ensure adequate surface water drainage from properties.	Less risk of surface water flooding and inundation into the foul sewers and hence less risk of sewer flooding and pollution incidents.
Routine maintenance of highway drainage.	Ensure adequate highway drainage.	Less risk of surface water flooding and inundation into the foul sewers and hence less risk of sewer flooding and pollution incidents.
Routine maintenance of land drainage.	Ensure effective land drainage.	Less risk of surface water flooding and inundation into the foul sewers and hence less risk of sewer flooding and pollution incidents.
Strategy for infiltration through private drains*.	Consider a strategy for reducing infiltration into the sewer network via private drains if the permanent monitoring identifies this as a significant cause for concern.	Less risk of groundwater flooding and infiltration into private drains and hence less risk of sewer flooding and pollution incidents.
Monitoring and control of construction standards for private drains.	Local Authority Building Control to ensure private drainage is fit for purpose.	Less risk of groundwater flooding and infiltration into private drains and hence less risk of sewer flooding and pollution incidents.
Sharing of information.	Agencies to share information to ensure collaborative approach to groundwater infiltration, surface water inundation, pluvial and fluvial flooding. Use forums as appropriate, i.e. Cotswold Flood Action Group.	Identification of most cost beneficial solutions and quicker resolution of issues.

*Thames Water does not have powers to compel customers to repair defective private drains at their cost. At this stage, we do not have the data to show how significant infiltration from private drains is within the Bourton-on-the-Water catchment, but we will develop an appropriate strategy when this information becomes available. We note that local authorities are only able to instigate action under Section 59 of the Building Act where evidence is provided of a defective private drain.

5 Future challenges

In 2011, Ofwat commissioned Mott MacDonald to look at factors likely to affect sewerage networks in the future. The report 'Future impacts on sewer systems in England and Wales' (June 2011)[10] looked at the likely relative impact of climate change, population growth and impermeable areas up to around 2040. In preparing our plan for 2015-2020, we have also carried out research into these factors across the Thames Water region. We summarise our findings for the Bourton-on-the-Water catchment in this section.

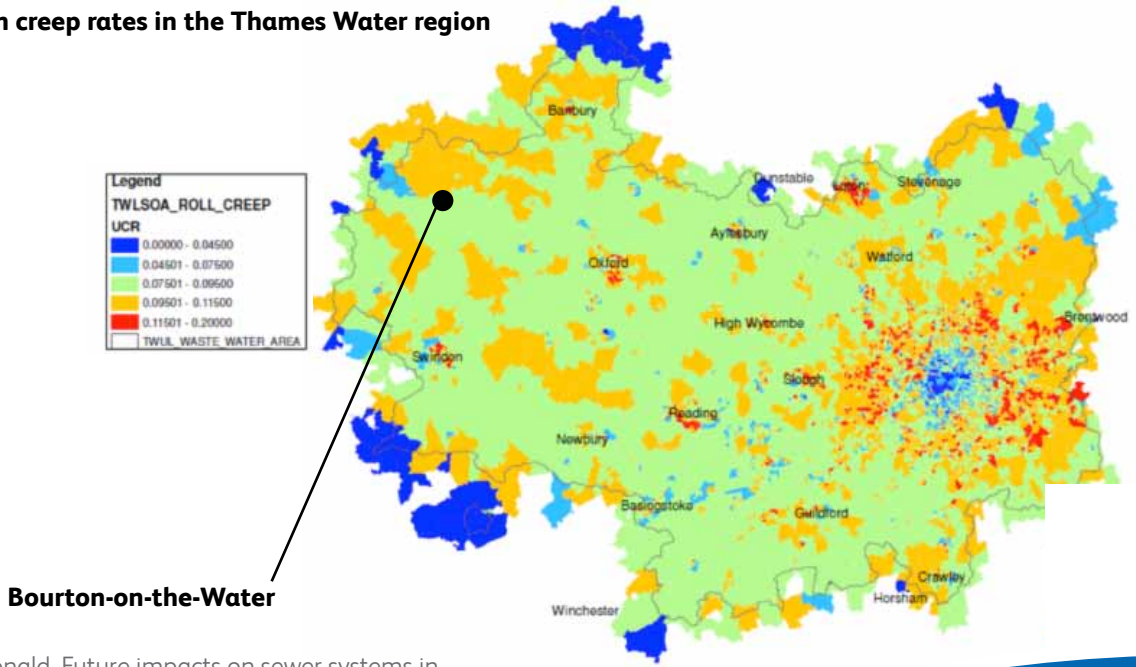
5.1 Urban creep

Urban creep is defined as the transformation of a catchment by the paving over of previously permeable areas, and includes extensions to existing properties and other land use changes. Rather than surface water soaking into the ground when it rains heavily, more water runs off into the sewerage network and can cause the sewers to surcharge and flood. It is therefore important to understand the rate at which urban creep is occurring.

We have studied aerial photography and satellite imagery across 11 catchments across the Thames Water region using data from two periods in the late 1990s and mid-2000s to determine the rate at which urban creep is occurring. We then carried out a statistical analysis and built a model to predict the rate of urban creep for the entire Thames Water region, taking account of factors such as property age, land use, demographics such as family sizes and financial income, need and available space. We found that affluent suburban areas with detached and semi-detached properties, where families have young children, are most likely to have high urban creep rates.

The results for the Thames Region are presented in Figure 7 below. The urban creep rate for Bourton-on-the-Water is 0.097%. In other words, this is the increase in impermeable area per year as a percentage of the total area connected to the sewerage network. When compared against the rest of the Thames Water region, Bourton-on-the-Water is just above average, but not as high as suburban areas around central London and major towns. Whilst the immediate issues in Bourton-on-the-Water appear to be strongly related to groundwater and pluvial/fluvial inundation, we will continue to monitor change in impermeable area as the strategy continues to develop. If we observe an increase in urban creep, we will raise the issue with Gloucester County Council who is responsible for managing surface water. We may then also look to retrofit sustainable drainage measures (such as permeable paving and water butts), in the area to counter the increased run-off following rainfall, to reduce the risk of flooding.

Figure 7 Urban creep rates in the Thames Water region



[10] Mott MacDonald, Future impacts on sewer systems in England and Wales, June 2011.

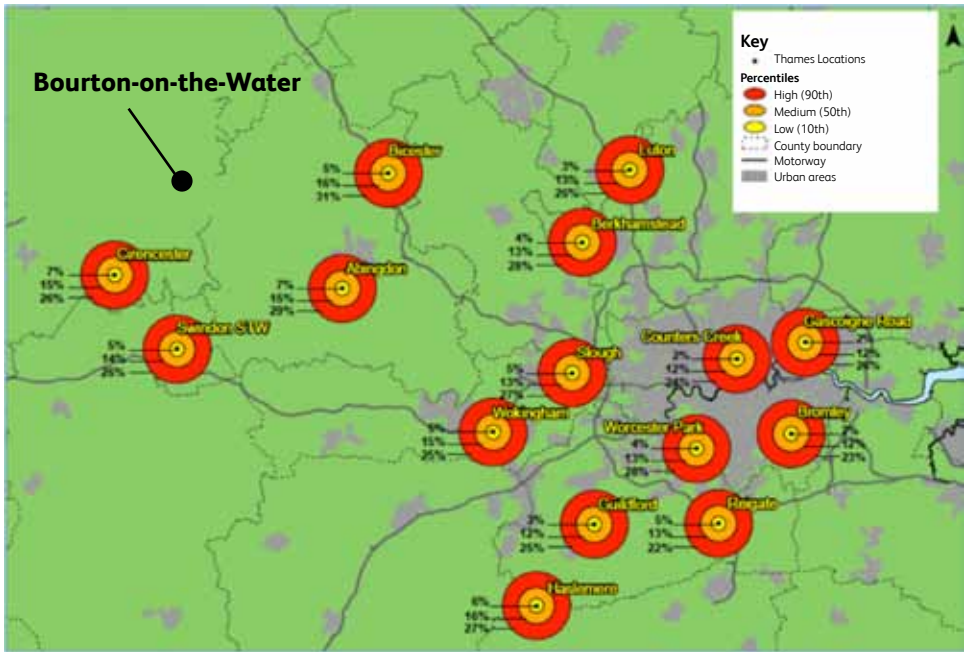
5.2 Climate change

We have analysed the 2009 UK Climate Projections (UKCP09) to determine the likely increase in rainfall intensity due to climate change in 15 catchments across our region. More intensive rainfall in the future will increase the peak flow in sewerage networks and with it the likelihood of sewer flooding.

Fifteen catchments across our region[11] were selected to give a representative sample of inner London, outer London and more rural areas in the Thames Valley. A number of these catchments are also areas which experience sewerage related issues like pollution, flooding and urban creep.

We assessed different combinations of emission scenarios and climate change percentiles for each of the 15 catchments. The nearest catchment to Bourton-on-the-Water that was analysed for climate change was Cirencester. The results show a central estimate of an increase of 15% in rainfall by 2080, but in some scenarios this could be as high as 26% or as low as 7% as per Figure 8 below. We will ensure that our strategy takes account of these potential increased peak flows as it develops.

Figure 8 Locations assessed for increased rainfall intensity by 2080



Increased rainfall intensity may not be the only consequence of climate change. UKCP09 data also suggests that the UK is likely to experience longer wetter winters in future. Further research is needed to understand whether high groundwater levels, such as those observed in the winters of 2012/13 and 2013/14 are likely to become more frequent in future. As the recent experience of prolonged rainfall and high groundwater levels have been shown to be the principal factors, this research will be very significant in informing any risk assessment and appraisal of costs and benefits of solutions.

[11] Atkins Thames UKCP09 Rainfall Intensity Assessment Revised Report, October 2012.

5.3 Population growth and new development

We use a combination of top-down and bottom-up information to ensure that our forecast of population and new development is as robust as possible to keep costs down, in order to minimise the bill impact of any investment that may be necessary.

Our forecast of the number of new households is taken directly from Experian data. We have used the 'Plan-Based' projection which uses information provided by local authorities about planned numbers of new dwellings in their respective areas. During the period 2015 to 2020 we expect to see an increase in new development across that Thames Water region and are forecasting a total of 263,000 new connections to the sewerage network during this time.

Our Development Tracker System is used to track developer enquiries through the planning process to construction. When we are contacted by a developer, we typically carry out preliminary modelling to determine whether our network or treatment works has the capacity to accommodate the increase in flow. Where it does not, we propose planning conditions for consideration by the Planning Authority, although we encourage developers to contact us as early as possible in the planning process to avoid this.

The independent review into the causes of the 2007 floods (The Pitt Review), concluded Sustainable Drainage Systems (commonly known as SuDS), are an effective way to reduce the risk of 'flash-flooding' which occurs when rainwater rapidly flows into the public sewerage and drainage systems, causing overloading and back-up of water. Typically, SuDS slow the rate of surface water run-off entry into the drainage system and improve the percolating feature, ie rainfall recharging the groundwater system, thus mimicking natural drainage processes. In April 2015, the Government made changes to the planning process effecting planning policies and decisions on planning applications of 10 dwellings or more (or equivalent non-residential or mixed development), to ensure that sustainable drainage systems are put in place, unless demonstrated to be inappropriate. This requires that when considering planning applications, local planning authorities should consult the relevant Lead Local Flood Authority (County Council or Unitary Authority), on the management of surface water, to satisfy themselves that the proposed standards of operation are appropriate and ensure, through the use of planning conditions or planning obligations, that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

In the case of Bourton-on-the -Water, whilst SuDS might help to reduce the risk of flooding following rainfall when groundwater levels are low (i.e. typically during summer months), they may not be as effective in reducing the flood risk when groundwater levels are high (typically during the winter months). We will therefore take account of the potential influence of groundwater when we come to assess any options as part of this drainage strategy framework process.

Cotswold District Council is currently developing its Local Plan for the period to 2031. Using sources of data that include the Cotswold District Council Preferred Development Strategy (PDS May 2013), the Strategic Land Housing Availability Assessment, and third party planning enquiries, potential development sites we are currently tracking include:

- 100 dwellings, Station Road, Bourton-on-the-Water
- 20 dwellings, Pulhams Coaches, Station Road, Bourton-on-the-Water
- 148 dwelling, Land to north of Roman Way, Bourton-on-the-Water
- 63 Units, land parcel north of Bourton Industrial Park Bourton Industrial Park
- 26 dwellings, land between Sandy Lane Court and Southgate Court, Sandy Lane Court, Upper Rissington.

Other applications exist but relate to developments in which detailed numbers have not been confirmed, or are single properties. We will continue to monitor future plans for the catchment through our stakeholder engagement work.

A key element of our assessments will be to establish the extent to which these developments may be significant in the context of challenges currently experienced in the catchment. This assessment work will be undertaken and findings shared in an update to this Strategy document.

6 Strategy development

The Drainage Strategy for the Bourton-on-the-Water catchment is currently at Stage 1 (Initialise/prepare), of the 4-stage framework process. The following activities are planned and ongoing, in order to carry out our risk assessment and development of strategy options.

Table 4 Activities planned and ongoing to enable strategy development

Activity	Purpose	Date planned	Outcome
Permanent monitoring of sewer levels	Continue monitoring sewer depth monitors installed last year. Plan is for monitors to remain in situ for at least 5 years and to capture the next wet weather event as a minimum. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels.	Ongoing	Use information to identify additional actions for inclusion in the drainage strategy for Bourton-on-the-Water. Share information with other agencies.
Permanent flow monitoring of pumping station	Enhance existing monitoring with the installation of permanent flow monitors on rising mains. Bourton-on-the-Water, Roman Way and Lower Slaughter sewage pumping stations	From winter 2015	Use information to identify additional actions for inclusion in the drainage strategy for Bourton-on-the-Water. And monitor performance of pumping station through future events
Customer surveys	Validate the historical records of flooding and restricted toilet use in the catchment to enable a detailed benefits assessment of potential further intervention options that could be implemented by Thames Water	From winter 2015	Use information to help test the cost benefit of options to improve drainage and reduce the risk of sewer flooding in Bourton-on-the-Water.
Pilot trials of mobile treatment plant	As part of our wider approach to managing high groundwater levels, we have trialled the use of biological filters within other catchments. Our findings will inform and may influence our strategy plans for Bourton-on-the-Water. If successful, these could be used to abstract dilute sewage from surcharged sewers and discharge it safely to a watercourse.	Ongoing	Service may be restored for customers without the need for tankering.
Misconnection surveys	Carry out visual inspection of properties to determine the extent of roof drainage and other surface water drainage that discharges into the foul sewer network.	From winter 2015	A better understanding of the contribution that misconnections make to sewer flooding in the area.
Update drainage strategy	Improve the drainage strategy based on the initial results from the permanent monitoring, customer surveys, misconnection surveys and feedback from stakeholders.	2017	Risk assessment, options appraisal and preferred strategy to be completed, subject to capturing weather events through monitoring and surveys.
Consider innovative solutions	Identify quicker / cheaper / collaborative options that improve the benefit to cost ratio in order to keep customers' bills down to prioritise investment to ensure greatest benefit to customers.	Ongoing	Enhanced toolkit available to reduce the risk of sewer flooding and then apply this once data becomes available.

7 Preferred strategy and plan

We believe that the foul sewerage system in Bourton-on-the-Water has surcharged and flooded predominantly due to a combination of groundwater infiltration, surface water run-off from saturated fields, surface water inundation from highways, public spaces and properties, surface water misconnections, and river water overflowing from the River Windrush. Our network strategy is to understand the relative impact that each of these factors has on the risk of sewer flooding, and then to develop a plan comprising cost beneficial solutions using customer willingness to pay research. In parallel, we will assess the extent to which new developments may be significant in the context of challenges currently experienced and where necessary we will develop solutions to accommodate the proposed development in the catchment.

We may carry out some repair works as this strategy develops, in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have caused flooding. Table 5 below, details the repair activities that we have identified to date.

Table 5 Activities identified in preferred plan to date

Activity	Purpose	Date planned	Outcome
Replace manhole covers	Covers in areas identified to be at risk of fluvial or pluvial inundation to be replaced with low leak covers.	When identified	Reduced inflow of surface water to the foul sewerage system.
Sewer repairs	Repair / reline identified defective lengths of public sewer.	When identified	Reduce inflow of groundwater to the foul sewerage system.
Permanent monitoring of sewer levels	Continued monitoring of depth monitors for at least 5 years and to capture the next wet weather event as a minimum. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels.	Ongoing	To identify additional actions for inclusion in the Drainage Strategy for Bourton-on-the-Water.

Our plan will be updated once the Risk Assessment and Options Appraisal sections have been completed in accordance with the Drainage Strategy framework.

8 Temporary overflows

We have not installed temporary pipework and pumps in the sewerage network during wet weather events in Bourton-on-the-Water to maintain service, but we would consider doing so to prevent the backup of sewerage into customers' properties and uncontrolled spilling from the sewer system into the environment.

As part of the stage 2 risk assessment and stage 3 options appraisal, we will be investigating the circumstances under which emergency discharges would be required in future, such as the use of temporary overflows, to pump out from the sewerage network through biological filters to maintain service to customers and prevent homes from flooding. As this Drainage Strategy develops, in this section we will describe the location of any proposed temporary overflows and the circumstances under which we would use them, in order that this Drainage Strategy, together with our plans to reduce infiltration, fully meets the requirements of an Infiltration Reduction Plan as set out in the Environment Agency's Regulatory Position Statement. We will continue to identify sewer rehabilitation and other permanent works to reduce groundwater infiltration alongside refining the use of temporary overflows.

Appendix A
Glossary of terms

Term	Definition
Blockages	Obstacles or the build-up of fat and grease, block or obstruct our sewerage pipes. This is normally caused by things which should not be flushed, or poured, into drains and sewers.
Combined sewer	A pipe conveying the combined rainwater and contaminated wastewater from two or more properties. A combined sewer is designed to carry wastewater to a sewage works for treatment but during periods of heavy rainfall or snowmelt, the volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water courses.
Dry weather flow	The average flow rate observed over a 24 hour period in dry weather and based on Sewers for Adoption, the industry standard, includes an allowance for infiltration of 10% of the calculated flow rate.
Foul drain	A pipe conveying the contaminated wastewater from a single property. If the pipe extends beyond the property boundary, the portion of the pipe outside of the boundary is termed a lateral drain. The portion of the pipe inside the boundary is a private drain. On 1 October 2011 water and sewerage companies in England and Wales became responsible for lateral drains, which were previously the responsibility of property owners. Private drains remain the responsibility of property owners.
Foul sewer	A pipe conveying the sewage from two or more properties. On 1 October 2011, water and sewerage companies in England and Wales also became responsible for private sewers, which were previously the responsibility of property owners. A foul sewer is designed to carry contaminated wastewater to a sewage works for treatment. It disposes of wastewater from sources including toilets, baths, showers, kitchen sinks, washing machines and dishwashers.
Infiltration	Groundwater finds its way into the sewerage system (including private drains), via defective pipes or pipe joints and through the brickwork or defects in manhole structures.
Inundation	Accumulated surface water from rain and/or river floodwater that has resulted in localised flooding, finds its way into the sewerage system through manhole covers and drains.
Lateral drain	These may be public or private. See definition for Foul drain.
Misconnections (surface water to foul water)	Property owners have connected rainwater and/or land drainage to our sewers (e.g. roof drainage, paved driveways drains, soakaway overflows), and can cause major issues for the performance of the sewerage system.
Misconnections (foul water to surface water)	A plumbing mistake resulting in wastewater appliances being misconnected to the surface water system.
Private sewers	See definition for Foul sewer.
Rainfall induced infiltration	Sewer infiltration that occurs as a result of rainfall percolating into the ground impacting the sewer on route to recharging the groundwater table.
Riparian owner	If you own land adjoining, above or with a watercourse running through it, you have certain rights and responsibilities. In legal terms you are a 'riparian owner'. If you rent the land, you should agree with the owner who will manage these rights and responsibilities.
Soakaway	Surface water from a roof and driveway of a property is piped to an underground pit, usually filled with gravel or similar material. Some soakaways are situated within the boundary of the property.
Surface water drain	A pipe conveying uncontaminated rainwater from a single property.
Surface water sewer	A pipe containing uncontaminated rainwater from two or more properties. A surface water sewer is designed to dispose of rainwater from roofs, driveways, patios, roads, etc to a local watercourse.
Sustainable Drainage Systems (SuDS)	Measures designed to attenuate and slow down surface water before it enters sewers to reduce the risk of flooding following heavy rainfall. Includes green infrastructure such as raingardens, green roofs as well as other measures, such as permeable paving and water butts.

Appendix B
Supporting figures and photographs

Figure B1 Bourton-on-the-Water Watercourses

This watercourse map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

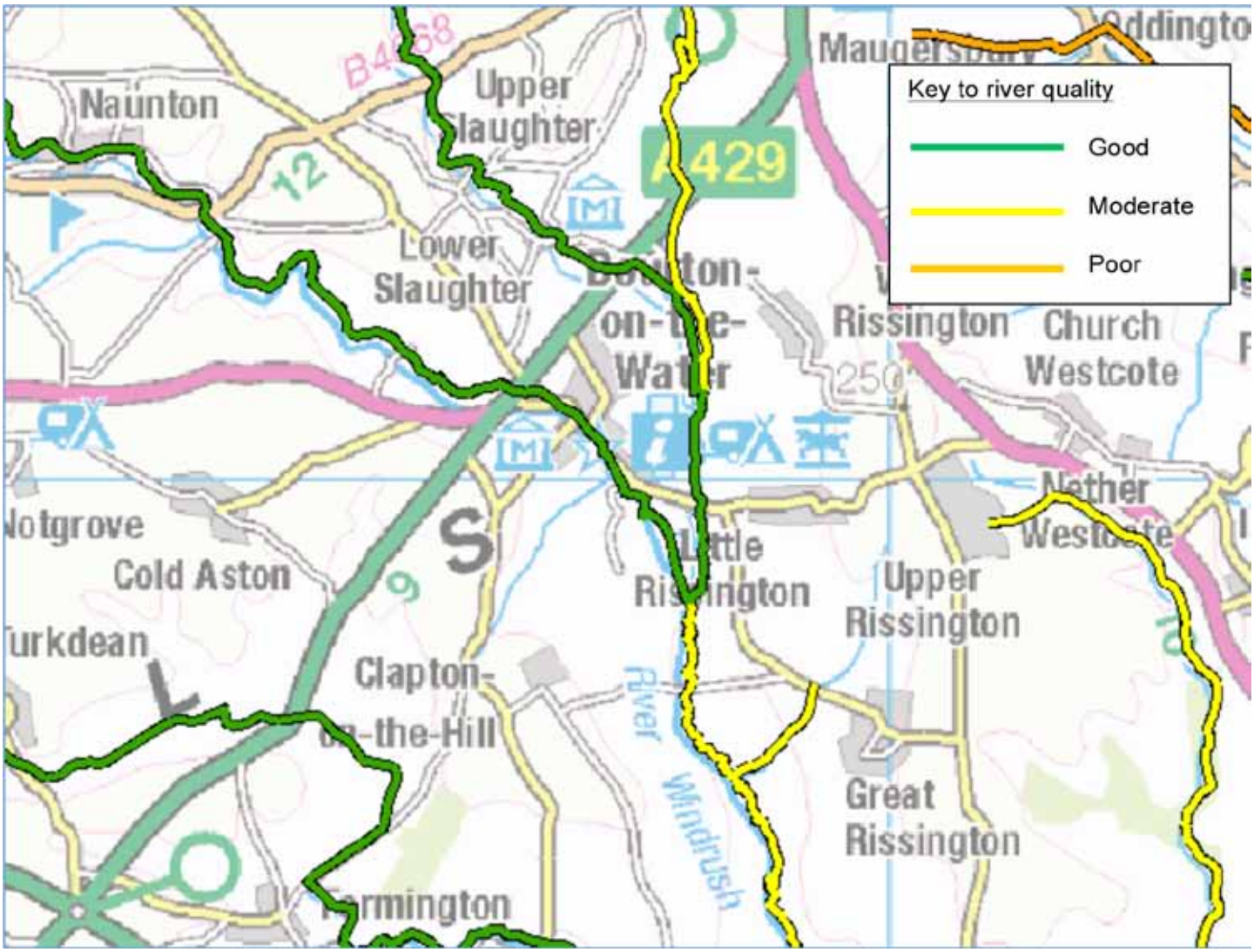


Figure B2 Bourton-on-the-Water bedrock and drift geology

This geological map information has been sourced from the British Geological Survey website. For more detailed geological information for this catchment, please access the British Geological Survey website.

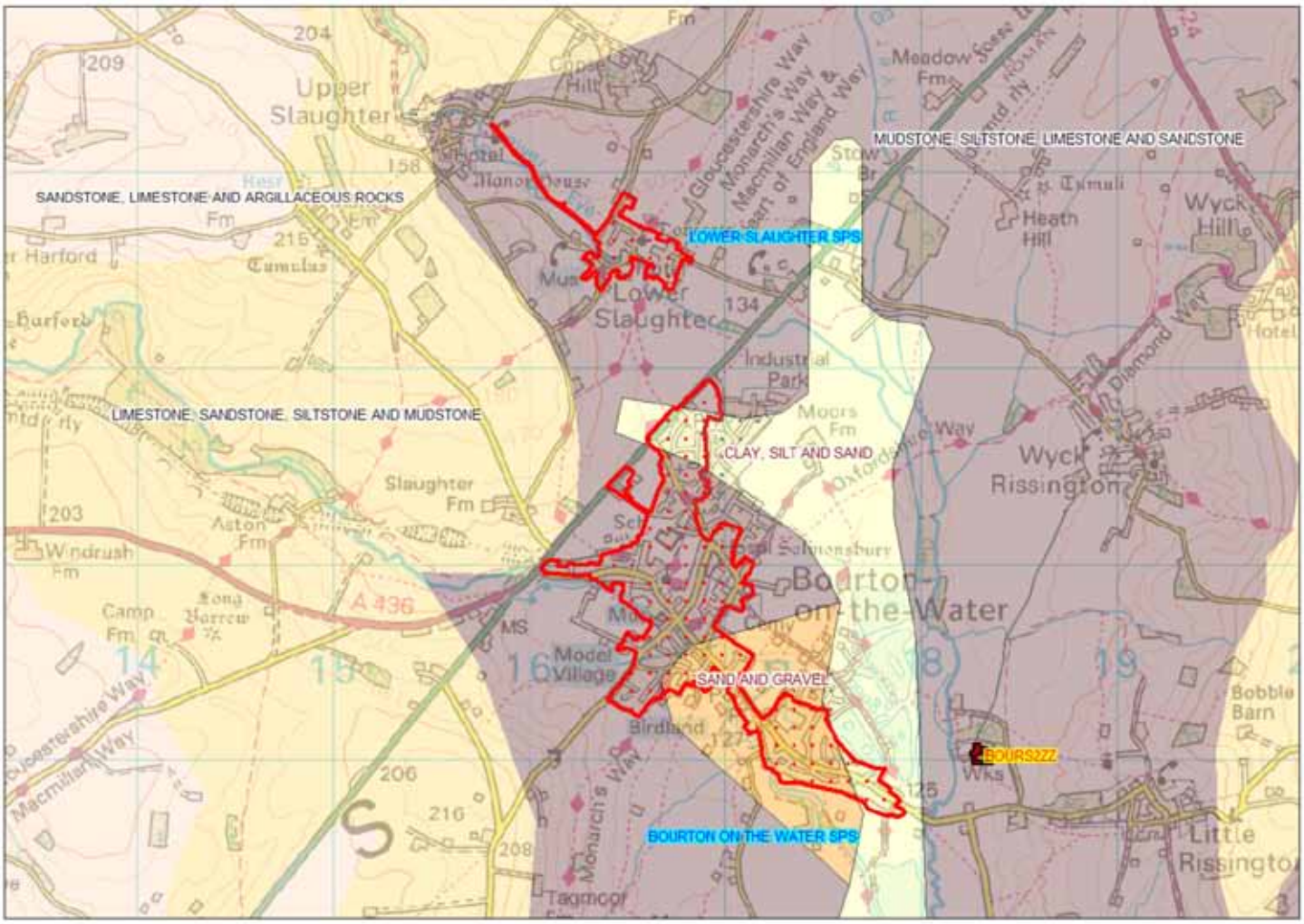


Figure B3 Bourton-on-the-Water fluvial flood risk based on Environment Agency plans

This flood risk map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

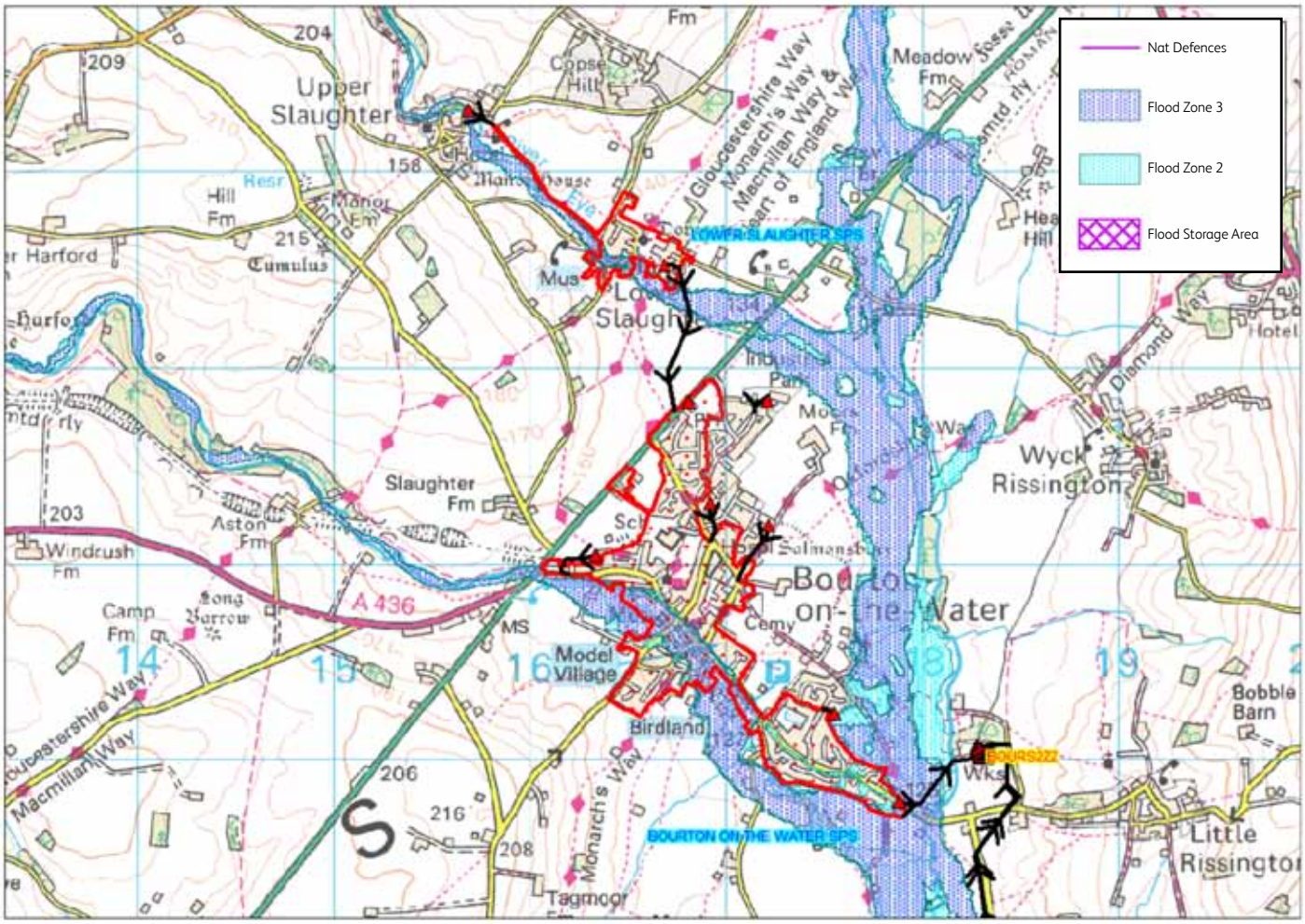


Figure B4 Bourton-on-the-Water surface water flood risk from Environment Agency plans

This flood risk map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

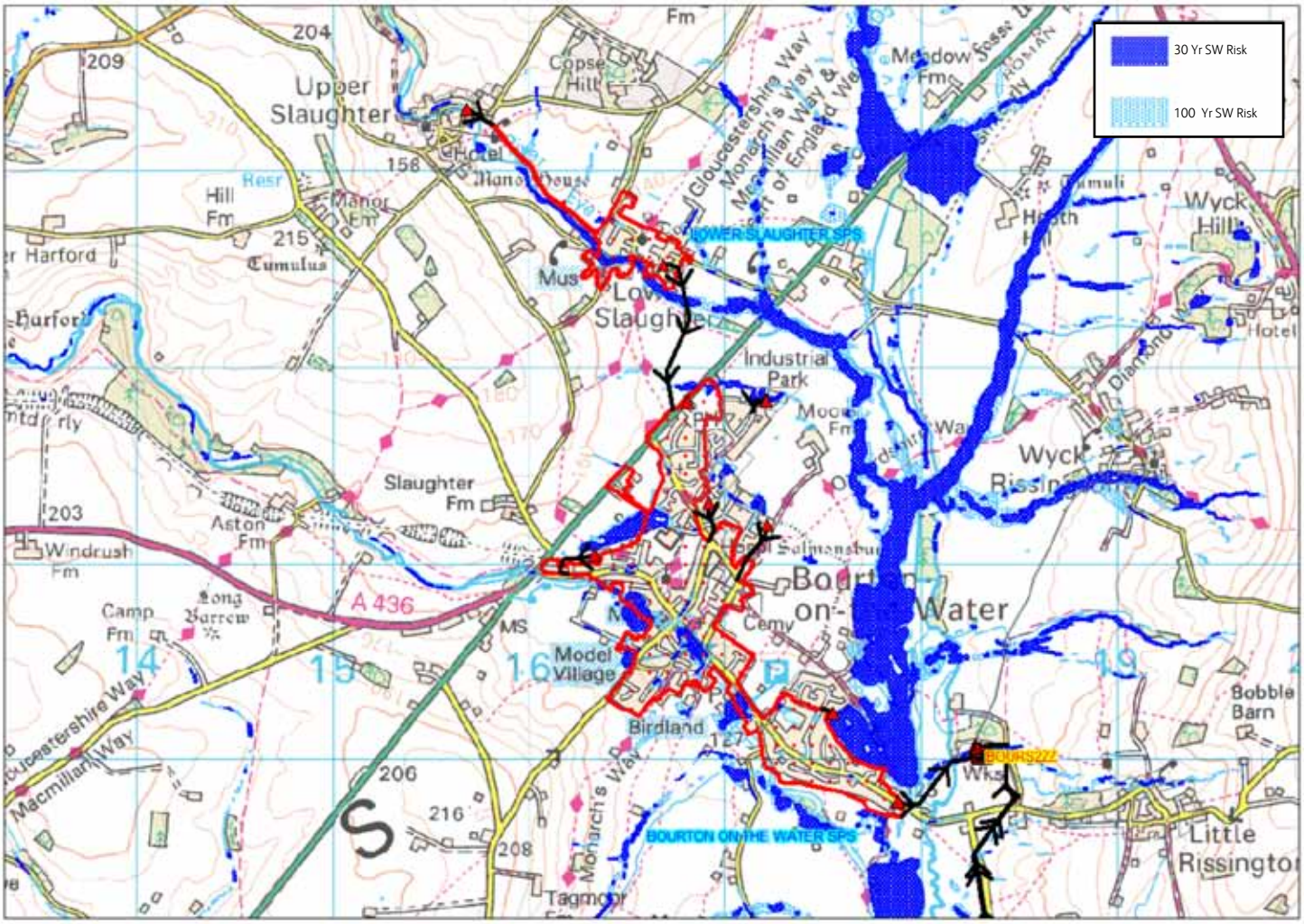
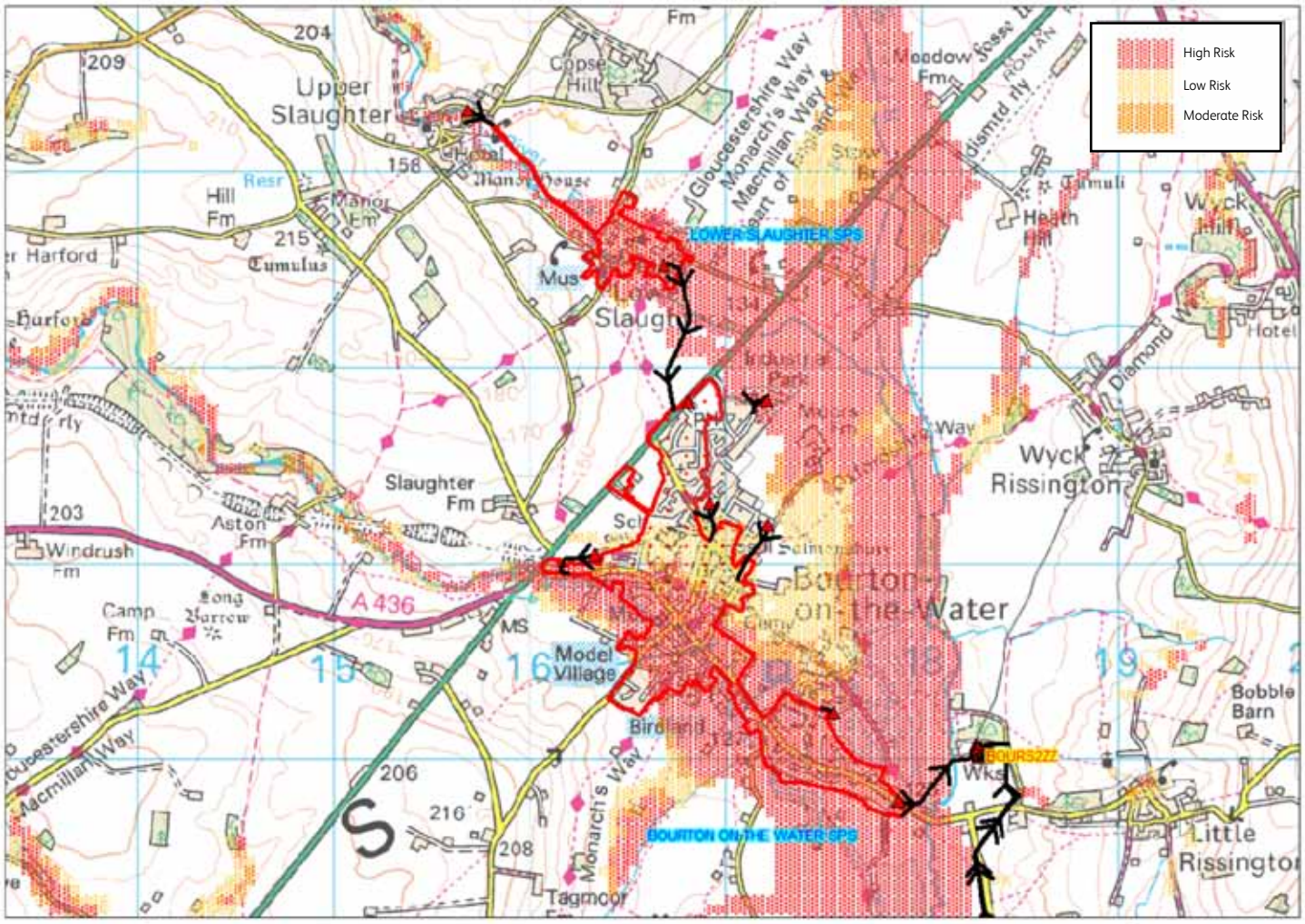


Figure B4 Groundwater flood risk for Bourton-on-the-Water based on ESI plans

This groundwater flood risk map information has been sourced from ESI Ltd.



ESI Groundwater Flood Risk Map of England and Wales © www.esinternational.com

Photographs taken during wet weather of 2013/14

Photo 1 – Flooding off Leasow Lane. Potential source of inflows from inundated manholes and sewer lines.

Photo 2 – Rissington Road. Potential consequential river flooding from the River Windrush bursting its banks.

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