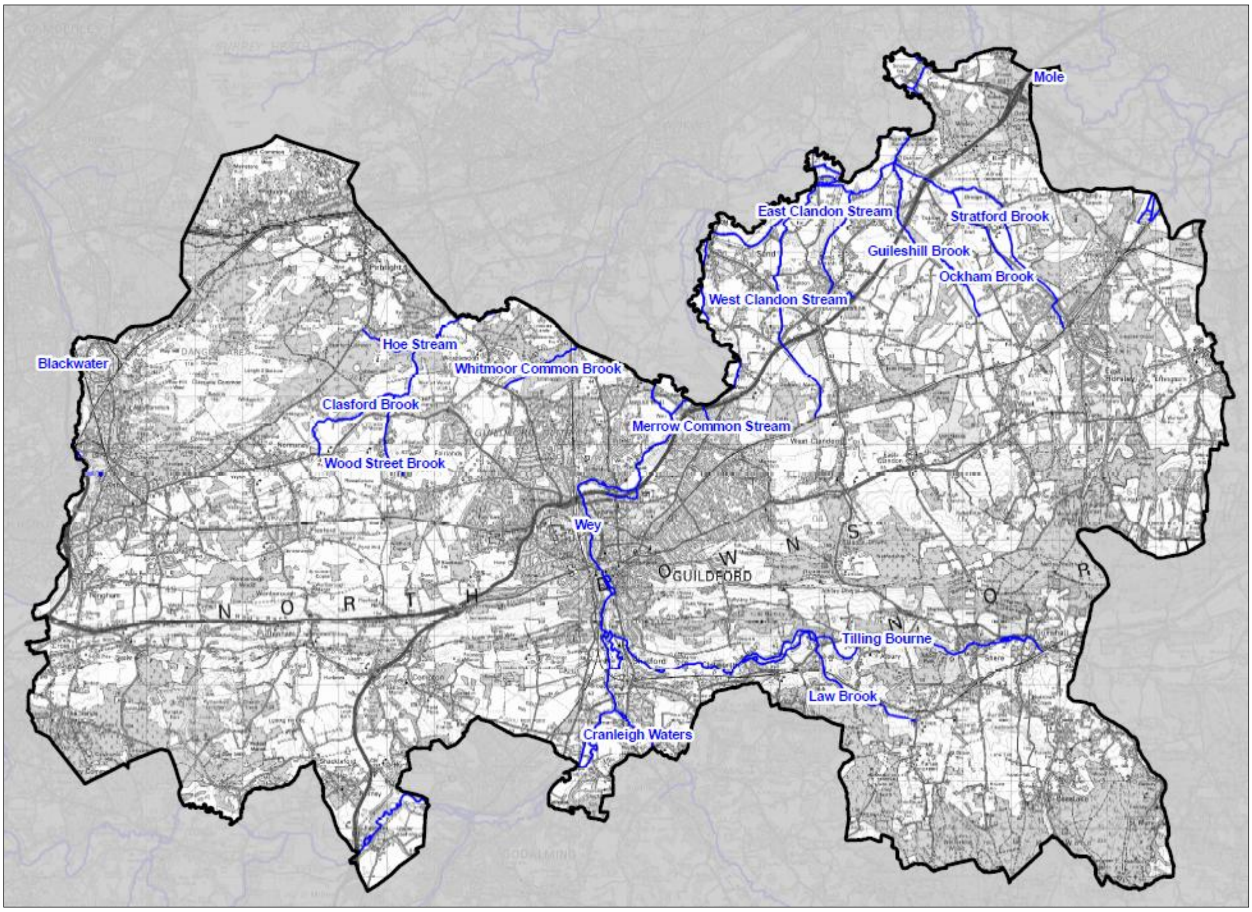
Guildford Borough Strategic Flood Risk Assessment Final Volume 2 – Technical Report

January 2016



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Executive Summary

Capita Property and infrastructure were commissioned in June 2014 by Guilford Borough Council (GBC) to update their Strategic Food Risk Assessment (SFRA). Capita Symonds (now Capita Property and infrastructure) produced the original SFRA in 2009, however since then there have been a number of policy and data updates including the release of National Planning Policy Framework (NPPF) in March 2012. Furthermore there has been revised hydraulic modelling on the River Wey and the release of the Updated Flood Map for Surface Water (UFMfSW) and Reservoir Inundation Mapping.

This is Volume 2, the Technical Report, assessing flood risk from all sources across Guildford borough. This should be read in conjunction with Volume 1, the Decision Support document, and should be supported by the Flood Risk Maps in Volume 3.

"There are approximately 78 hectares of 1 in 100 year floodplain in Guildford Urban Area. Of this, about 62 hectares are defined as functional floodplain."

The Guildford borough area contains localised areas that are prone to flooding from a range of processes including: fluvial, surface water, sewer, groundwater, canal and reservoir flooding.

Across the borough, the most significant source of flooding is the River Wey and the River Blackwater and their tributaries, however surface water flooding can also be locally significant and in areas underlain by certain geology groundwater flooding is also a risk. The risk of flooding from artificial sources is limited and largely restricted to the areas close to embanked sections of the Basingstoke Canal.

Detailed hydraulic modelling has been used to define and analyse the functional floodplain along the River Wey. From this, it has been calculated that there are around 78 hectares of 1 in 100 year floodplain in Guildford Urban Area. Of this, about 62 hectares are defined as functional floodplain. Although the area is not expected to increase with additional flows expected as a result of climate change, it highlights the need to carefully consider land use planning within the already developed areas.

Throughout the document, policy considerations have been highlighted. These include adopting planning policy that protects against unsuitable development of the natural floodplain, limiting increased surface water runoff by adopting sustainable urban drainage systems and conforming to local and regional flood risk management strategies.

1. Introduction

Guildford Borough SFRA provides a broad scale assessment of flood risk. This document is the Volume 2: Technical Report of Guildford Borough SFRA, and should be read in conjunction with Volume 1: Decision Support Document. Volume 1 provides information on how to interpret Guildford Borough SFRA results to inform land use planning, flood warning, emergency planning and determination of planning applications.

This document outlines and describes the strategy adopted to assess strategic flood risk issues within Guildford borough. The principal requirement for adopting a strategic approach to the assessment and consideration of flood risk is in accordance with advice given in National Planning Policy Framework (NPPF) 2012 and Planning Practice Guidance: Flood Risk and Coastal Change, 2014 (PPG).

This document does not replace, and should be read in conjunction with, national and regional policy including NPPF and relevant regional policy. The SFRA does not replace the responsibility at a broader level to consider wider catchment flood risk management approaches and solutions, nor does it remove the requirement for appropriately focused local/site FRA's.

The assessment evaluates risk as the product of the probability and the consequence of a particular event. Probability is defined as the frequency and magnitude of floods that are generated by fluvial flows and intense rainfall activity. The consequence is defined as the impact of floodwater on receptors (people, property, land, etc). This approach is sympathetic to the concept of source, pathway and receptor now adopted for flood risk management.

The study uses the best available information to assess flood risk. This includes the most up to date Environment Agency (EA) Flood Zones , and other information, including the Surrey County Council Preliminary Flood Risk Assessment (PFRA), the River Thames Catchment Flood Management Plan (CFMP) (2009), Guildford Surface Water Management Plan (Phases 1-3) and the Updated Flood Map for Surface Water (December 2013). The assessment also includes updated modelling along the River Wey through the Study Area. This will enable a broad assessment of the Flood Risk for the existing conditions within the study area.

This report is a full technical report documenting the assumptions, processes and assessment undertaken in the development of the SFRA. It is intended to serve as a transparent record of the decisions and methodology that led to the outcomes of the SFRA.

2. Catchment Summary

2.1 The Catchment

Within Guildford borough the principle catchment is that of the River Wey, although the western part of the borough is within the catchment of the River Blackwater which flows along the western boundary of the borough through Tongham, Ash and Ash Vale. Volume 3, Figure 1 provides an overview of the River Wey and River Blackwater catchments within Guildford borough, including the main tributaries.

2.1.1 The Wey Catchment

The total River Wey catchment area is 900 km² and is predominantly rural in nature. The total length of the main river is 92km, with a fall of 190m through the catchment.

The River Wey is navigable from its confluence with the River Thames to Godalming. It includes a number of navigation channels separate from the main river, with water levels regulated by structures such as locks and weirs. Where the River Wey and its tributaries pass through urban areas such as Guildford, Godalming, Farnham and Weybridge the channel is engineered and canalised to varying degrees. The River Wey and a number of its tributaries contain a large number of mill structures, side channels, and divisions within the Study Area.

Flood risk management measures within the catchment are confined to localised flood bunds and bank protection, there are no formal flood defences within the study area. Schemes to improve channel capacity have been implemented in Farnham and Weybridge.

There are two main tributaries in the upper Wey catchment, the North Wey and the South Wey. The source of the South Wey is in the vicinity of Liphook and the source of the North Wey is in the vicinity of Alton. These two watercourses combine between Farnham and Goldalming (at Tilford) and the confluence lies just within Guildford borough; from this point the watercourse is known as the River Wey.

Upstream of Guildford the Wey is joined by two main tributaries within the study area. These are the Tillingbourne which flows from the east through a number of villages to join the Wey near Shalford and Cranleigh Waters which runs only a very short distance within Guildford borough before joining the Wey at Peasmarsh. The Tillingbourne rises near the village of Abinger Hammer and flows approximately 50km to its confluence with the River Wey through the villages of Shere, Chilworth and Shalford. The Law Brook is a tributary of the Tillingbourne which rises near the village of Hoe and flows through Brook and Shalford Common before meeting the Tillingbourne a little upstream of the Wey confluence at Shalford. Historically the Tillingbourne has been used as a source of power and there are many mills and weirs located along its length.

Downstream of Guildford urban area, four small tributaries enter the River Wey on the east bank, including the Ockham Mill Stream, Guileshill Brook and Stratford Brook. In addition the Hoe Stream joins the Wey on the west bank within Woking just downstream of the current study area, although its headwaters around Normandy are within Guildford borough. The Hodge Beck, which runs through Pirbright, is a tributary of the Stanford Brook which runs from Pirbright Common past the Pirbright Research Laboratory and is in turn a tributary of the Hoe Stream which it joins some distance downstream of the study area near Mayford in Woking borough.

The Basingstoke Canal and the Wey and Godalming Navigation are also within the study area. The Wey Navigation starts at Millmead Weir just upstream of Guildford urban area, and runs downstream alongside the course of the River Wey to the Thames, the Godalming Navigation runs upstream of Guildford. Both navigation channels run in the valley bottom and make use of both the main river channel and parallel and interconnected navigation channels where these are needed. The Wey and Godalming Navigations are owned by the National Trust.

The Basingstoke Canal also runs within the study area, firstly between Brookwood and Deepcut and then alongside the River Blackwater between Ash Vale and Ash where it crosses the River Blackwater and continues west. The Basingstoke Canal connects the River Wey Navigation just upstream of New Haw Lock (in the adjoining Woking borough) and ends at the Greywell Tunnel. Unlike the Wey and Godalming Navigations the Basingstoke Canal is a contour canal and cuts across the Wey catchment, the Blackwater catchment and the Whitewater catchment forming a connection to the town of Basingstoke to the west. Because it cuts across catchments the Basingstoke Canal is in places embanked and the water level maintained above surrounding land. The Wey and Godalming Navigations and the Basingstoke Canal are covered in more detail in Section 9 of this report.

2.1.2 The Blackwater

The River Blackwater partially marks the western boundary of Guildford borough and the settlements of Ash, Ash Vale, Tongham and eastern parts of Aldershot are within the Blackwater catchment. The Blackwater Valley is fairly heavily urbanised. Beyond the study area the Blackwater continues to pass through the towns of Farnborough, Frimley, Camberley, Blackwater, Sandhurst and Yateley before joining the Whitewater 7.5km west of Yateley.

The source of the Blackwater is at Runfold just south of Aldershot, at Rowhill Nature Reserve. There are no major tributaries which join the Blackwater within the study area. The Blackwater and its major tributaries, the Whitewater, Hart and Fleet Brook, together have a catchment area of approximately 360km^2.

2.2 Topography

To the south of the study area are the edges of the south downs and the topography is quite variable including notable areas of higher ground such as the topographic ridge of the Hogs Back, in the north the study area forms part of the edges of the London Basin and the topography is gentler and more low lying. Through this landscape the River Wey and the Blackwater have cut south-north valleys which are well defined topographically and especially on the River Wey the river floodplain is well developed.

In the Wey Valley the meandering floodplain increases in width as it moves northwards. In the upstream sections of the borough, the floodplain is approximately 250m wide. Downstream of the study area through Woking the main River Wey floodplain widens to approximately 2.0km. Generally the floodplain reduces in width where the river flows through the urban areas.

Volume 3, Figure 2 shows the topography of the Study Area.

2.3 Regional Geology

The geology of Guildford borough is characterised by three main rock types. In the south of the borough the geology is dominated by the Lower Greensand formation, typically a sandstone of varying character, in the far south east corner there may be limited areas underlain by the Weald Clay particularly the small area to the south and east of the village of Peaslake. Overlying the Greensand is a thin band of Chalk which runs east-west through the study area forming the pronounced ridge of the Hogs Back and underlying southern and central areas of Guildford urban area. To the north of this the geology is dominated by the London Clay and the tributaries of the River Wey downstream of Guildford are likely to be developed on the clay rather than the areas of chalk with their headwaters marking the geological divide. The Chalk and the Greensand are relatively permeable rock types, this means water can drain into them and pass through them with relative ease. Permeable rock type are the most likely to be a source of groundwater flooding. The London Clay is very impermeable and water is unlikely to soak into the ground easily in areas underlain by London (or Weald) clay.

To the west towards the river Blackwater the chalk outcrop becomes much thinner and the chalk is much less important within the Blackwater Valley. The Blackwater rises as springs in Bagshot Beds sandstone, overlying London Clay. As the river flows north, the catchment geology mainly consists of

Bracklesham Beds sandstone (which overlie the Bagshot Beds), overlaid by patches of Barton Sand in Farnborough and Aldershot.

In both the Wey and the Blackwater Valleys there are significant deposits of geologically recent river gravels which may have locally perched water tables within them.

3. Asset and Structure Data

3.1 Introduction

Flood Defences are built to help reduce the occurrence, and therefore consequences of flooding. Some structures provide flood defence benefits, however they are also built to manage low flows or are part of the infrastructure network. These assets can be owned, operated and maintained by the Environment Agency (EA), Local Authorities, private business and/or local residents.

In addition to defences, infrastructure such as major roads and railway lines can influence river flows. Although these features are not considered flood defences they influence river flows and floodplain extents.

3.2 Flood Defences

There are approximately 673m of flood defences within Guildford borough. There are also isolated flood relief facilities including flood relief channels and culverts, as well as flood bunds and raised embankments. The EA provided the location of the defences within the Study area. These are all areas of high ground, maintained by the EA or private land owners. Volume 3, Figure 14 shows the location of these defences along the River Wey.

The River Wey Improvement Scheme was created in the 1930s, and the Broadmead and Newark channels are constituents of this. The scheme involved increased conveyance in the River Wey channel and the standard of protection provided by this scheme is very low. There are two culverts (at Stoke Mill on the A3 and Ash on the A331, Blackwater Valley Road) which are compensatory channels to mitigate against the road embankments splitting the floodplain.

Landowners are responsible, under common law, for maintaining the bed and banks of any watercourses that run through their land in a state which avoids flooding on their neighbours' or other land. This common law duty also extends to keeping watercourses and culverts clear of anything that could cause an obstruction, either on their own land or downstream if it is washed away.

3.3 Structures over and along Watercourses

There are a number of existing structures over watercourses inside the Study Area. The structures include vehicular bridges, pedestrian bridges, pipe bridges, and railways.

Within the study area the River Wey is crossed numerous times by road bridges, major road crossings (from north to south) include the A248 crossing between Peasmarsh and Broadford, the A31 junction within Guildford town centre which spans the River Wey, the A3 crosses the River Wey at a relatively high level just north of the town centre as does the A320. Near Broadford the railway branch line towards Dorking crosses the Wey and also crosses the headwater streams of the Tillingbourne further to the east.

All hydraulically significant structures have been included in the hydraulic models used in the production of this SFRA.

Within the study area there are numerous small land drains and surface water courses that are within private ownership. The condition and maintenance of these watercourses, and in particular the structures along them can be locally important in terms of flooding. Where specific issues are identified GBC have in the past taken action to remedy these, however it should be noted that the responsibility for maintenance often rests with the land owner (the Riparian Owner) who may be a private individual or in many cases the Highways Authority or other government body.

3.4 Flood Alleviation Schemes

The EA provided information surrounding the proposed flood alleviation schemes within Guildford borough. There are currently five schemes under investigation or design, detailed in Table 3-1 below.

Table 3-1 – Planned flood alleviation studies and schemes

Project Name	Brief Project Description
Guildford Initial Assessment	A desk-top study to investigate potential schemes to reduce flood risk in Guildford.
William Road PLP	Installation of appropriate Property Level Protection measures in William Road, Guildford.
Ash surface water scheme	The outcomes of the project will inform the most appropriate flood mitigation measures which can be implemented to protect properties from the risk of flooding. These could include attenuation schemes, SUDS, and property-level protection. The local community will benefit from reduced flood risk to their properties and damages to their belongings being avoided.
Ashenden Road Surface water scheme	The Guildford Surface Water Management Plan has identified this location as being an area particularly vulnerable to flooding. Further investigation and computer modelling which will be carried out as part of the preliminary studies is anticipated to inform a range of surface water schemes, including attenuation ponds and sustainable drainage systems (SUDS) to manage surface water flood risk catering up to 1 in 100 plus climate change return period. Increasing the capacity of the ordinary watercourse will also be considered as appropriate.
Flexford Flood Relief Scheme	Implement appropriate surface water mitigation measures in Flexford, Normandy as recommended by the study carried out by GBC in 2013/2014.
Mill Lane, Pirbright scheme	Funding has been raised by Pirbright Parish Council and Worplesdon Parish Council to carry out a study of the Hodge Brook catchment to understand the hydraulics of the area and suggest feasible options for flood alleviation measures.

3.5 Maintenance

The EA has **permissive powers** to maintain and improve watercourses designated as 'Main River' and associated structures for the efficient passage of river flow and the management of water levels. The EA also has a general supervisory duty for all flood risk management activities.

As the operating authority, Councils have the regulatory and supervisory role for flood defences on all ordinary watercourses which are not within the area of an internal drainage board (IDB). Culverts under roads are generally the responsibility of the relevant Highways Authority.

Riparian owners have responsibilities to maintain any watercourse that passes through their land ownership. This includes all streams, ditches and river channels and any structures on them that fall within riparian ownership. Riparian owners are not always aware of their responsibilities in relation to watercourses, and this can lead to poor maintenance along minor watercourses in particular. Evidence that this is an issue within Guildford borough is provided by the high number of incidents (particularly in Ash and Ash Vale) resulting from blocked or collapsed culverts and pipes and blocked grills on culverts. The EA Leaflet “Living on the Edge” 4th edition 2013 provides information on the legal responsibilities of Riparian Owners and is available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297423/LIT_7114_c70612.pdf

4. Flooding from Rivers

The assessment of fluvial sources of flooding in Guildford borough contained in this SFRA concentrates on the two principle watercourses, the River Wey and the River Blackwater and their tributaries. The results of modelling on the Lower Wey, completed in 2009 and the River Blackwater, completed in 2007 have been used to assess fluvial flood risk within Guildford borough.

4.1 Causes and Classifications

Flooding from rivers occurs when water levels rise higher than bank levels, causing floodwater to spill across adjacent land (floodplain). The main reasons for water levels rising in rivers are:

- intense or prolonged rainfall causing runoff rates and flow to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet antecedent (the preceding time period) conditions and where there are significant contributions of groundwater;
- constrictions in the river channel causing flood water to backup;
- blockage of structures or the river channel causing flood water to backup.

Fluvial flooding within Guildford urban area firstly rise from rapidly responding water levels in the Cranleigh Waters tributary, then remain high during a flood event due to the arrival of water from the Upper Wey Catchment. The Cranleigh Waters can contribute almost as much flow to the Lower Wey as the whole of the Upper Wey catchment. Flooding in the Blackwater catchment results from intense flashy events as well as prolonged, high magnitude events. Poor maintenance of structures on smaller watercourses has also been identified as a factor exacerbating fluvial flooding.

The consequences of river flooding depend on how hazardous the flood waters are and what the receptor of flooding is. The hazard of river flood water is related to the depth and velocity, which depends on:

- the magnitude of flood flows;
- size, shape and slope of the river channel;
- width and roughness of the floodplain; and
- types of structures that cross the channel.

Flood hazard can vary greatly throughout catchments and even across floodplain areas. The hazard posed by floodwater is proportional to the depth of exposure, the velocity of flow and the speed of onset of flooding. Hazardous river flows can pose a significant risk to exposed people, property and infrastructure. Whilst low hazard flows are less of a risk to life (shallow, tranquil water), they can disrupt communities, require significant post-flood cleanup and can cause costly and possibly structural damage to property.

4.2 Data Collection

Information on fluvial flooding in the study area was collected from GBC, SCC and the EA in the form of flood incident databases and flood outlines, as detailed in Volume 1, Appendix A. The EA also provided GIS layers showing Flood Zones 2 and 3, as well as detailed hydraulic model outlines. Information has been collated by source and flood type and is analysed in the following section.

4.3 Assessment of Fluvial Flooding in Guildford Borough

4.3.1 **Historical Fluvial Flood Events**

Volume 3, Figure series 4A and 4B show all available information relating to historic fluvial flood events. These include the EA historic flood map and recorded outlines, as well as fluvial flood incidents recorded in the EA flood incident and Surrey County Council (SCC) wetspots database.

4.3.1.1 River Wey Catchment

The town of Guildford is built around the River Wey and owes its name and location to an easy place to ford over the river. Large recent floods have been recorded in the borough and the historic record suggests large floods have occurred throughout the borough's history. Large river flooding incidents within the Wey catchment have been recorded during the following periods:

- February 1900
- January 1928
- September 1968
- December 1979
- February 1990
- October-November 2000
- December 2002 – January 2003
- October 2006
- July 2007
- December and January 2013-2014

4.3.1.2 River Blackwater Catchment

Many storms that have occurred within the catchment area of the Blackwater have resulted in damage to property, infrastructure and inundation of roads. Events have occurred in the rural and urban part of the catchment; however rural events with little impact have a less comprehensive record. The events of particular note are detailed below.

Large River flooding incidents within the Blackwater catchment have been recorded during the following periods:

- September 1968
- February 1990
- October-November 2000
- August 2006
- July 2007
- November 2013
- January 2014

4.3.2 Environment Agency Flood Risk Maps

The Environment Agency (EA) holds a dataset of Flood Zones for all catchments greater than 3km^2 in size. The EA Flood Zones for Guildford borough are shown in Volume 3, Figure 3, of this SFRA and are available online on the EA's website. The zones are primarily based on the results of their national generalised broad scale modelling (JFLOW). In some locations they are also based on historic information and more detailed hydraulic modelling. The detailed hydraulic modelling will supersede JFLOW results where they are available. Flood Zones are the starting point of the Sequential Test and refer to the probability of river and sea flooding only, ignoring the presence of existing defences.

The maps produced as part of this SFRA are current at the time of publication. The EA flood maps for planning are updated regularly, and are available online at:-
http://apps.environment-agency.gov.uk/wiyby/37837.aspx

Table 4-1 shows the EA Flood Zone definitions as defined by the Planning Practice Guidance: Flood Risk and Coastal Change document.

Table 4-1 – Definition of Flood Zones (Table 1, PPG[1])

Flood Zone	Definition
Zone 1 - Low probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3
Zone 2 - Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a - High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b - The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the EA. (Not separately distinguished from Zone 3a on the Flood Map)

Flood Zone 2 and Flood Zone 3 have been mapped using the GIS layers received from the EA, and are shown in Volume 3, Figure series 3. Flood Zone 3b has been defined according to hydraulic modelling, as outlined in section 4.3.4.

4.3.3 Detailed Hydraulic Modelling Flood Risk Maps

4.3.3.1 River Blackwater Flood Risk Mapping Study, October 2007 (PBA)

The EA completed the River Blackwater Flood Risk Mapping study in October 2007. This study aimed to produce flood maps for the Blackwater catchment between Aldershot and the rivers confluence with the River Loddon. The study utilised a hydrological routing model of the Loddon catchment (including the River Loddon, River Whitewater, River Blackwater, and Basingstoke Canal) and involved the development of a hydraulic model of the River Blackwater. Both models were developed using the software package ISIS.

The study produced 20%, 5%, 1% and 1% plus climate change flood extents for the undefended and defended case. The only structure considered a defence within the Blackwater model was the Cove Brook Flood Alleviation Scheme. The study did not fully assess the impacts of removing this defence. The Cove Brook Flood Alleviation Scheme is outside the Study Area; and as it is downstream of the Study Area will not influence on flooding along the Blackwater within the Study Srea. The EA used the 1% undefended flood extents from the Blackwater study, to update Flood Zone 3 on the current Flood Map in 2008. The EA used the results to update the flood extent along the River Blackwater from upstream of the London to Southampton railway crossing and from the M3 at Camberley to the confluence with the River Loddon. This was due to the uncertainty in the undefended flood extent along the Cove Brook (outside of the study area) and some additional modelling work proposed on the Balmoral Stream adjacent to the Blackwater.

Since the study has been completed, the results have been processed for NFCDD purposes, and the modelled flood outlines have been received for this study. The undefended outlines for the 1 in 20 year, 1 in 100 year, 1 in 100 year plus climate change outlines have been mapped in Volume 3, Figure series 5B. As the 1 in 1000 year outline was unavailable, the EA Flood Zone 2 has been mapped.

4.3.3.2 Lower Wey Remodelling Flood Study, December 2009 (Mott MacDonald)

The main objective of this study was to produce design flows and water levels for the River Wey and principal tributaries. The study covers the urban areas from Farnham through Haslemere, Godalming, Guildford, Woking, Byfleet and Weybridge.

[1] Planning Practice Guidance, Flood Risk and Coastal Change, April 2015

The hydrological modelling approach for the Lower Wey catchment was to derive hydrograph inputs at different points within the catchment for the hydraulic model, using the ReFH rainfall runoff model. Design flows at key locations for chosen return periods were derived using FEH methodologies. The hydrographs derived from the ReFH rainfall runoff models were scaled to achieve design flows obtained from the FEH statistical method for target return periods at key catchment locations. Seven one-dimensional (1D) hydraulic models of the Main Rivers in the Lower Wey and its tributaries have been built using the full hydrodynamic facilities within ISIS. These represent 164 km of river channels. Five two-dimensional (2D) hydraulic models (Godalming, Guildford, Byfleet and Weybridge, Cranleigh Waters, and Woking) have been built to simulate design flood events for five major urban areas in the Wey catchment, using ISIS and TUFLOW in conjunction. ISIS is used as the 1D model representing the river channels, and TUFLOW as the 2D model representing the floodplain that the river channels spill into.

The 1D and 2D stamped results of this study were provided by the EA. The outlines for the 1 in 20 year, 1 in 100 year, 1 in 100 year plus climate change and 1 in 1000 year return periods have been mapped in Volume 3, Figure series 5B.

4.4 Discussion of Fluvial Flooding in Guildford Borough

4.4.1 Historical Fluvial Flood Events

Volume 3, Figure 4A indicates that fluvial flood incidents are concentrated within Guildford Town Centre, along the River Wey. The EA historic flood map shows widespread flooding along the whole length of the Lower Wey. Fluvial Flood events have also been reported along the River Blackwater and Hoe Stream. The Historic Flood Incidents database provided by the EA, which logs incidents reported by the public, shows that 184 flood incidents have been reported within Guildford Town Centre (GU1 and GU2 postcode areas) along the Wey since 2000. There have also been a number of reported fluvial flood incidents along the River Blackwater, again corresponding to the EA historic flood map. The SCC wetspots database, which records areas of the highway network susceptible to flooding and the status of work being done to resolve issues, identifies that the A31, A322 and A3100 have been impacted by fluvial flooding.

4.4.2 Fluvial Flood Risk Information from the Guildford SWMP

Table 4-2 summarises the historical and predicted fluvial flood risk identified as part of the Guildford Surface Water Management Plan.

Table 4-2 – Fluvial Flood Risk information identified from within the Guildford SWMP

Identified Hotspot	Summary of historical fluvial flood risk	Summary of predicted fluvial flood risk
Fairlands	Encroachment of the watercourse channel is causing restrictions on the watercourse and causing flooding on low lying right bank areas of Gumbrells Close. Low lying properties adjacent to the watercourse and Fairlands Community Centre Village hall and surgery are reported to flood as a result of poor maintenance and blockages of the watercourse.	Hydraulic modelling identifies significant flood risk to properties adjacent to the watercourse in this area. Watercourses should be well maintained to maximise conveyance and reduce flood risk.
Applegarth	Flooding in Hunts Close as a result of natural topography.	

Identified Hotspot	Summary of historical fluvial flood risk	Summary of predicted fluvial flood risk
Jacobswell	Jacobs Well Road and Oak Tree Close experience flooding due to high water levels breeching the gap in the existing embankment.	Maintenance of the trash screen and reducing blockages is important for limiting fluvial flood risk.
East Horsley	Overtopping of the watercourses in the area may cause flooding experienced at Kingston Avenue, Old Rectory Lane and Ockham road south.	A lack of detailed understanding of the flood mechanisms mean mitigation measure proposals are not appropriate, but that more modelling is carried out.
Burpham	Gosden Hill Road, Glendale Drive, Winterhill Way, London Road, devoil Close and Suffolk Drive at at risk of flooding due to close proximity to the watercourse	Upstream storage and ground level alteration may limit future flood risk in this area.

4.4.3 EA Flood Zones

Volume 3, Figure 3 shows the EA Flood Map across Guildford borough. In the North West of the study area, the flood zones from the Hoe Stream, Clasford Brook, Wood Street Brook and Whitmoor Common Brook are mostly constrained to the rural river valleys. There may be some fluvial risk identified at Bullswater Common and through Pirbright, however the flood zones mostly cover forested woodland or rural fields. Along the River Blackwater, the flood zones identify western areas of Ash as being at fluvial flood risk from the 1 in 100 and 1 in 100 year outlines. Through Ash Vale, there is greater disparity between Flood Zone 2 and Flood Zone 3; Flood Zone 3 is constrained to the west of the railway line.

In the North East of the study area, Flood Zone 2 and Flood Zone 3 along the River Wey are predominantly the same. The flood zones extend far out of bank along the main river channel, however the floodplains are mostly undeveloped. The tributaries in this area, including West Clandon and East Clandon Streams, and the Stratford, Guileshill and Ockham Brooks have narrow flood plains, also with limited flood risk to residential areas, except through the south and east of Horsley. Fluvial flood risk identified by the EA Flood Map along the Tillingbourne and Law Brook is very low, the Flood zones are very narrow and only very small areas are at risk from the 1 in 1000 year or greater fluvial flood event.

South of Guildford town, Flood Zone 2 and Flood Zone 3 are extensive, but mostly only pose a risk to a limited number of small settlements around Peasmarsh. Fluvial flood risk through Guildford town centre is quite significant. Flood Zone 2 and Flood Zone 3 identify highly urbanised areas, including residential and industrial developments as well as communication links including the mainline railway and many A-roads.

4.4.4 Detailed Hydraulic Modelling

This section provides greater detail than the EA Flood Zones specifically in relation to the ‘Functional Floodplain’ and the impacts of climate change. These have been mapped in Volume 3, Figure series 5B. For the purposes of this study, the defended outlines, including informal raised defences such as flood bunds and embankments have been mapped and analysed. The results of the hydraulic model outlines have been summarised in Table 4-3.

5% annual probability of occurrence (1 in 20 year outlines)
In accordance with NPPF consideration should be given to development deemed to be in the Functional Floodplain. The Functional Floodplain comprises land where water has to flow or be stored

in times of flood. Discussions with GBC and the EA have concluded that for this update of the SFRA, the 5% annual probability of occurrence event will be used as a starting point to define the 'Functional Floodplain' across the borough.

It should be noted that information on the 1 in 20 year floodplain could only be provided where detailed hydraulic modelling has been carried out. Modelling of a small number of tributaries within the Wey catchment has not been completed as part of this SFRA and EA Flood Zones have been used to assess risk in this area. Where detailed modelling and the 1 in 20 year outline is unavailable, the EA Flood Zone 3 has been used to define the extent of the Functional Floodplain. This has been further subdivided into developed and undeveloped zones for the purposes of planning. Further discussion on the definition of Flood Zone 3b can be found in Volume 1, section 2.6.

1% annual probability of occurrence (1 in 100 year outlines)
The flood extents associated with the 1% flood event are available for the River Blackwater and River Wey following are shown in Volume 3, Figure series 5B.

0.1% annual probability of occurrence (1 in 1000 year outlines)
The 0.1% flood represents an extreme event and is significantly larger than the 1% floodplain in some areas as a result of increased flows, however, generally flooding mechanisms within the study area remain the same. Due to the well defined river floodplains which exist on many of the watercourses within the study area, the increase in flows associated with the 0.1% flood event have a minimal impact on flood extent in many areas within the Study Area. The flood extents associated with the 0.1% flood event are shown in Volume 3, Figure series 5B.

Climate Change
The Planning Practice Guidance for Flood Risk and Coastal Change states that 'A Strategic Flood Risk Assessment is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that changes or development in the area will have on flood risk'.

The latest guidance recommends a 20% increase in peak river flows is used to assess the impacts of climate change on rivers for time horizons between 2025 and 2115 (PPG, 2014). Climate change has been investigated to provide more detailed information upon which to make land use planning decisions. It will be up to the decision-maker to select the most appropriate time horizon for the specific land use they are investigating. The 1 in 100 year flood event with a 20% increase in flows was assessed as part of the EA's River Blackwater Model update and Lower Wey Study and therefore these results have been used in this SFRA. The flood extents for a 1% flood event adjusted for climate change are shown in Volume 3, figure series 5B.

Table 4-3 – Summary of available hydraulic model results

Flood Event	River Wey	River Blackwater
5% annual probability of occurrence (1 in 20 year outlines)	South and North of Guildford Town Centre, the River Wey flows through predominantly rural River Valleys and green open space, including Shalford Park and Woolgers Wood. Although the extent of the 5% AEP events are wide, there is limited potential impact. The River channel and fluvial floodplain becomes urbanised within Guildford town just north of the Rowing Club, and the 5% AEP event outlines are narrower. Residential and commercial buildings within 100m of the channel are at	The River Blackwater is mapped as flowing out of bank during the 5% AEP event, however flood extents are limited to the Gold Valley Lakes and Willow Park wetland area. Some residential properties along Lakeside Road are shown to be risk during the 5% AEP event. Flow paths elsewhere in the area are generally constricted by raised railway embankments. Most of the Functional Floodplain through Ash and Ash Vale is currently undeveloped, and therefore although the risk is

Flood Event	River Wey	River Blackwater
	risk of flooding. Low lying properties east of Walnut Tree close and Woodbridge Meadows are at high risk of flooding. In the North of the town, the 5% AEP outlines apart from the Retail Centre and surrounding areas, most of the spaces at risk of flooding, are undeveloped open green space.	high, the potential impact to the area would be low.
1% annual probability of occurrence (1 in 100 year outlines)	Along the River Wey, the 1% AEP event outlines are mostly very similar to the 5% AEP outlines described above. At Trunley Heath, the 1% AEP outlines extend much further to the south east, however there is no increased flood risk as there is no development. Through Guildford Town Centre, the 1% AEP outlines show large areas of the industrial estate north of the A25 at medium risk of flooding. Properties north of the river along Stoughton Road are also at risk. In the north of the Study Area, areas surrounding the Sewerage Works at Wisley are at risk of flooding from the River Wey.	Outlines from the 1% AEP event are very similar to the Functional Floodplain along the River Blackwater. The outlines are also restricted by railway embankments. Flooding is generally confined to the Gold Valley Lakes and Willow Park area, however there are an increased number of properties at flood risk from the 1% AEP event along Lakeside Road.
1% annual probability of occurrence plus climate Change (1 in 100 year plus climate change outlines)	Along the length of the River Wey through the borough, there is no significant increase in fluvial flood risk from the 1% plus climate change compared to the 1% AEP event, except at Broadford Road in Shalford.	A 20% increase in flow along the River Blackwater is expected to increase the extent of flooding to the north of Ash Vale, along the B3165. In other areas of the Blackwater Valley, the 1% AEP plus climate change event is mapped to show a very similar extent to the 1% AEP event.
0.1% annual probability of occurrence (1 in 1000 year outlines)	Due to well defined river channels, the 0.1% AEP outline is not significantly larger than the 1% AEP event outline. No residential settlements apart from Guildford Town Centre are expected to experience an increased risk of fluvial flooding compared to the 5% or 1% AEP events. Through Guildford Town Centre, the Crown Court and police station are also at low risk of	The 2007 River Blackwater Flood Study did not produce any 0.1% AEP outlines, and therefore the EA Flood Zone 2 outlines have been used to assess flood risk. Through Ash, the 0.1% outlines are very similar to 5%, and 1% outlines, confined to wetland floodplains with little risk to residential areas. North of the railway line, the 0.1% outlines are much more extensive, and many

Flood Event	River Wey	River Blackwater
	flooding from the River Wey.	properties west of the B3206 in Ash Vale are at risk of fluvial flooding from the River Blackwater.

4.5 Management of Fluvial Flooding in Guildford Borough

4.5.1 Messages from the Thames Catchment Flood Management Plan (December 2009)

The EA has prepared a Catchment Flood Management Plan for the River Thames catchment within which the River Wey, the Hoe Stream and the Upper and Middle Blackwater are specifically considered. The Thames CFMP considers on a broad scale how flood risk can be expected to change on a 50 – 100 year timescale taking into account climate and land use change and will be used to set EA policy and to target investment in flood risk management. It is important that the policies GBC develops as a result of the SFRA are consistent with the policy framework outlined in the Thames CFMP.

The Rural Wey sub-area

Policy Option 2:
Areas of low to moderate flood risk where there is potential to reduce existing flood risk management actions.

Vision and preferred policy:

- Maintain, and where possible maximise, the flow of water in the rivers through the towns.
- In the undeveloped areas, maintenance will be reduced to allow the flood plain to flood more frequently, allowing efforts to be focused where it is most beneficial.
- To ensure that high risk areas can prepare and respond accordingly, work will be complimented with increased flood warning and awareness measures.
- New habitat generation will aid increased biodiversity in the sub area.
- Where possible, opportunities for recreation and navigation will be improved also, through the relationship between the EA and the National Trust.

The proposed actions to implement the preferred policy:

- Maintenance of the capacity of watercourses in towns and villages through ongoing annual EA maintenance programme. Levels of maintenance elsewhere will be reduced.
- Safeguarding of the natural floodplain from inappropriate development by working with Local Authority partners. This will provide local social and economic benefits (by reducing flood risk) and environmental benefits (by allowing flooding).
- Working with Local Authority partners to ensure that plans are prepared to respond to flooding. This will help communities to work with local organisations and produce community flood plans.

The Guildford and Hoe Stream sub-areas

Policy Option 5:
Areas of moderate to high flood risk where it is generally possible take further action to reduce flood risk. We recognise the challenge of this policy and that we will not be able to reduce the risks everywhere.

Vision and preferred policy:

- There are major technical obstacles which mean any solutions will be expensive, provide different levels of protection and not benefit everyone in the affected communities. The EA is confident of being able to bring forward proposals that will reduce the risk to many people.
- Where major flood defences are not a realistic option in the foreseeable future, the most sustainable way of reducing flood risk will be through floodplain management.
- In areas of redevelopment; resilience and resistance measures can be incorporated into new buildings.
- The partnership between the EA and GBC can be used to develop and achieve sustainable and flood compatible floodplain use. Flood awareness and emergency response will have an important role to play in all areas.

The proposed actions to implement the preferred policy:

- In the short-term, partners will be encouraged to develop policies, strategies and initiatives to increase the resistance and resilience of all new development at risk of flooding. The EA will look at protecting land that may be needed to manage flood risk in the future, and work with partners to identify opportunities for this and to recreate river corridors in urban areas.
- In the longer-term, land and property owners need to adapt the urban environment to be more flood resilient. This includes the refurbishment of existing buildings to increase resilience and resistance to flooding. Management of flood consequences will be promoted by working with EA partners to improve public awareness and local emergency planning, for example identifying critical infrastructure at risk and producing community flood plans.

The Upper and Middle Blackwater sub-area

Policy Option 4:
Areas of low, moderate or high flood risk where the flood risk is already being managed effectively but further actions will need to be taken to keep pace with climate change.

Vision and preferred policy:

- Managing the consequences of flooding will be the main feature of future flood risk management in these places.
- The proposed expansion of these places will need flood risk to be considered and inform the location, layout and design of new development.
- Local Authority Strategic Flood Risk Assessments (SFRAs) should ensure development is located with consideration of the flood risk, preventing the need for costly flood defences and management in the future. The EA will continue to influence and inform these decisions at the regional, county and local scales.
- In the long-term the urban environment should be adapted to make it more resilient to flooding. It is hoped that rivers will become part of the urban landscape instead of being hidden away in culverts and revert to more natural conditions where possible.
- Options to reduce the probability of flooding in some areas will be considered, although as there are many sources of flooding mean it will not be possible to do this everywhere. Some interventions will rely on local opportunities; either to increase the flow of the watercourses by modifying or removing obstructions, or to store water.
- The EA wishes to make it possible that awareness and response to rapid flooding from heavy rainfall is improved. The challenge is to ensure that the urban expansion in these areas does not lead to an increase in flood risk.
- The EA will work with partners to bring about gradual improvements in modified watercourses and put in place policies that bring about long-term adaptation of the urban environment.

The proposed actions to implement the preferred policy:

- Development should be located in areas of lowest flood risk and incorporate a layout and design that is resilient to flooding. Strong recommendations in SFRAs and policies in Local Development Documents LDDs) will help to ensure this.
- Partners will identify opportunities to reduce flood risk by recreating river corridors in urban areas.
- New and re-development should allow space for water, wildlife and recreation in their site layout and design.

- The EA will support partnerships to identify those areas that are most vulnerable to other types of flooding, for example through Surface Water Management Plans (SWMPs) and encourage initiatives to manage these risks.
- The EA hopes to maintain the existing capacity of the river system by keeping the channels clear and free from obstruction to reduce the impacts of more frequent flood events.
- Promotion of greater awareness of flood risk amongst organisations and communities will focus actions to reduce the impact of flooding.
- The EA will develop policy and prioritise future flood management investment guided by the policy unit recommendations from the CFMP.

4.5.2 Planning Policy specific to Guildford Borough

The information within the SFRA will be used by GBC to develop specific planning policy and guidance for Guildford borough that takes full account of flood risk now and in the future. These policies will be reported within future updates of the SFRA and will take account of the EA's approach to flood risk management in the Wey catchment as described in the relevant sections of the Thames CFMP.

The planning policy and guidance which will be developed by GBC may include some of the following measures:

- Enhancement of the natural flood management role played by the River Wey floodplain to achieve betterment, in conjunction with the requirements of national planning policy.
- Adoption of planning guidance within Guildford town centre to ensure any development that is permitted within areas at risk of flooding is designed to be resistant and resilient to flooding and be safe. Where such development is permitted, it may be appropriate to provide mitigation for any loss of flood storage volume and wherever possible measures should be provided which deliver and overall reduction in flood risk.
- In areas where insufficient information on flood risk currently exists, there should be a requirement for those proposing the developments to provide detailed flood information.
- Enhanced communication of Riparian responsibilities to existing Riparian owners on small watercourses and ditches throughout the borough.
- Continue to collect and record complete information on fluvial flood events that are reported to them.

5. Flooding From Surface Water

5.1 Description

Overland flow occurs when intense, often short duration rainfall is unable to soak into the ground or enter drainage systems. It is made worse when soils are saturated so that they cannot accept any more water. The excess water then ponds in low points, overflows or concentrates in minor drainage lines that are usually dry. This type of surface water flooding is usually short lived and associated with heavy downpours of rain. Often there is limited warning before this type of localised flooding occurs. Surface water runoff can cause localised flooding in natural valleys as normally dry areas become inundated and in natural low spots where water may collect.

Drainage basins or catchments vary in size and shape, which has a direct effect on the amount of surface runoff. The amount of runoff is also a function of geology, slope, climate, rainfall, saturation, soil type and vegetation. Geological considerations include rock and soil types and characteristics, as well as degree of weathering. Porous material (sand, gravel, and soluble rock) absorbs water more readily than fine-grained, dense clay or unfractured rock and has a lower runoff potential. Poorly drained material has a higher runoff potential and is more likely to cause flooding. Urban settlements often have large areas of impermeable surfaces, such as roads, pavements and driveways, which behave similarly to poorly drained materials.

5.1.1 Causes and Classifications

Rainfall that infiltrates into the soil but resurfaces further down the hill is classified as surface water. The water in lakes, marshes and reservoirs is also classified as surface water. Water flowing over the ground surface that has not entered a natural channel or artificial drainage system is classified as surface water runoff or overland flow.

Surface runoff is the overland flow of water. The volume of surface runoff will usually depend on catchment size and shape, geology, slope, climate, rainfall, saturation, soil type and vegetation. Poorly drained material has a higher runoff potential and is more likely to cause flooding.

In urban areas, rainwater is frequently drained into surface water sewers or sewers containing both surface and waste water known as “combined sewers”. Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked or is of inadequate capacity, and will continue until the water drains away.

Surface water flooding can occur in rural and urban areas, but usually causes more damage in the latter. Urban areas can be inundated by flow from adjacent farmlands. Flood pathways include the land and water features over which floodwater flows. These pathways include drainage channels, rail and road cuttings. Flood management infrastructure can also serve as a flood pathway. Developments that include significant impermeable surfaces, such as roads and car parks may increase the occurrence of surface water runoff. Urban areas usually have extensive drainage or sewer systems. Blockage or constraints to these sewer systems can exacerbate surface water flooding.

Flooding from land can also occur when structures used to manage flooding fail. For example, flooding would be worse if a culvert were to collapse or block. Note: these are culverts to manage surface water runoff, not urban drainage systems or rivers.

Developments which are close to artificial drainage systems, or located at the bottom of hillslopes, in valley bottoms and hollows, may be more prone to flooding. This may especially be the case in areas that are downslope of land that has a high runoff potential including agricultural land, impermeable areas and compacted ground.

5.1.2 Impacts of surface water flooding

Surface water flooding can affect all forms of the built environment, including:

- Residential, commercial and industrial properties;
- Infrastructure, such as roads and railways, telecommunication system and sewer systems;
- Agriculture;
- Amenity and recreation facilities.

Often surface water flooding can be short-lived, lasting only as long as the rainfall event. However flooding may persist in low-lying areas where ponding occurs. Flooding may occur as sheet flow or as rills and gullies causing increased erosion of agricultural land. This can result in 'muddy floods' where soil and other material are washed onto roads and properties, requiring extensive clean-up.

Both rural and urban land use changes are likely to alter the amount of surface water in the future. Future development is also likely to change the position and numbers of people and/or developments exposed to flooding (Defra 2004).

5.2 Data collection

Information on surface water flooding in the study area was collected from the stakeholders, as detailed in Volume 1, Appendix A. Most of the data were collected from the Guildford SWMP and the Ash Surface Water Study. The Updated Flood Map for Surface Water was received from the EA. GBC, SCC and the EA provided surface water flood records in the form of an incident database. SCC also provided the Guildford Surface Water Management Plan. Information has been collated by source and flood type and is presented in the following section.

5.3 Historical Surface Water Flooding

The various sources of recorded surface water flood incidents have been summarised below.

5.3.1 EA Historical Flood Incidents Database

Within Guildford borough there have been 21 incidents reported to the EA that have been attributed to surface water flooding. Most of these occurred in July 2007 following a large summer storm. Many of the events were concentrated in the west of the catchment surrounding Ash. Other surface water flood events were reported in December 2012 and 2013. It should be noted that the number of reported events may not be wholly representative of the extent of flooding, as over time there has been a decrease in public tendency to report flooding incidents due to changes in insurance policy.

5.3.2 Surrey County Council Wetspot database

The wetspots database has been provided by Surrey County Council. It is a database recording highways susceptible to surface water flooding. The database has many attributes, including the state of the wetspot (current, reduced, pending review and dormant) and what is being done to address the issue.

Across the borough, 119 incidents relating to the public sewer, highway systems or runoff have been recorded. These are spread throughout the borough, but are all reported along roads, as this is where the surface water mostly causes issues. The wetspot database has many attributes, including the state of the wetspot (current, reduced, pending review and dormant) and what is being done to address the issue.

5.3.3 EA recorded outlines

Within the EA recorded outlines GIS layer, only events from 2003 were attributed to surface water flooding. 70 surface water flood incidents were reported during this event as a result of exceeded channel capacity. Most of these are recorded in close proximity to the River Wey, in the north west of the borough.

5.3.4 Sandbag drop locations

GBC issues sandbags to the public. There are 22 strategic distribution locations in rural areas, as part of the environmental management plan. The distribution of sandbag requests correlates closely with recorded historic flood incidents in the study area. No updated records of sandbag drop locations were received as part of this study. Records show concentrated locations within Guildford Town Centre, along the floodplain of the River Wey, as well as isolated areas across the urban suburbs of Guildford Town during the 2000, 2006 and 2007 flood events. GBC confirmed that sandbags were given out during the Christmas 2013 flood event. However, no GIS records of the 2013 sandbag drop locations were provided as part of the 2015 SFRA.

5.4 Assessing Flooding from Surface Water

5.4.1 Updated Flood Map for Surface Water (2014)

The Updated Flood Map for Surface Water (uFMfSW) GIS data has been provided by the EA. The dataset contains hazard information for predicted flood velocities and depths, which are shown in Volume 3 Figure series 6A and 6B respectively. These maps are more detailed than the second generation flood map for surface water (known as the Flood Map for Surface Water FMfSW), and have been generated based on a JFLOW model using a 5m grid size and detailed hydrology. The updated flood map model includes representation of buildings, structures and road networks.

The map shows areas that are at risk of surface water flooding for the 1 in 30, 1 in 100 and 1 in 1000 year probabilities. These categories have been used to broadly assess which areas are at higher risk of surface water flooding. Areas within the borough where there are concentrated areas of predicted surface water flooding have been described as most susceptible. Quantifying risk depends on many other factors, including antecedent conditions and drainage maintenance conditions. Historic records of surface water flooding may indicate an increased risk; however, attention to the problems in these areas may change the associated risk through time.

5.5 Discussion of Surface Water Flooding in Guildford Borough

The following discussion summarises the risk from surface water flooding in the study area. The discussion utilizes the outputs from the uFMfSW and the SMWP.

A large percentage of the Study Area is currently undeveloped, therefore surface water runoff and drainage is relatively unchanged from the Greenfield condition in the more rural areas. The most intensive existing development within the Study Area is predominantly in Guildford and Ash urban centres and the associated suburbs, but there is also considerable development in other smaller settlements. The Thames CFMP identifies the management of surface water runoff to be very important within this catchment.

Surface water runoff from these developed areas is very likely to result in increased water levels within the River Wey and Blackwater compared to the natural catchment river levels. Although this has not been quantified, it is generally accepted that a positive drainage system associated with development increases the peak flow rate from a development area and therefore in the receiving watercourses.

The majority of Guildford borough is shown at low or very low risk of surface water flooding, both by the uFMfSW and SWMP outlines. Areas at increased risk of surface water flooding are predominantly within the fluvial floodplains and more densely built up urban areas, including Guildford Town Centre and northern and western areas including Ash. The majority of the areas mapped as high risk, (1 in 30 year flood) are adjacent to the fluvial river channels in rural and undeveloped areas. Some areas within Guildford town centre are subject to high risk from surface water, along the ordinary watercourse and tributary drainage networks and along roads. These areas include Merrow, Burpham, Woodride Hill and Guildford Town Centre. Although flood risk is indicated as high along these routes, the extent of the outlines are very narrow. Many of the highways within the main settlements are also shown to be at high risk. The identified high risk along the road networks may be a result of preferentially lowering roads within the Digital Terrain Model (DTM) used to generate the outlines.

A broad review was carried out of the recorded surface water flood events and the modelled surface water datasets. The records of surface water flooding broadly align with the modelled outputs and should be referenced and reviewed when determining the flood risk in local areas.

The Guildford SWMP (November 2013) highlights the surface water flooding hotpots within the borough. These areas and key conclusions are identified in Table 5-1. More detailed information is included within Guildford SWMP, which is publically available online:

http://www.guildford.gov.uk/media/15895/Guildford-Surface-Water-Management-Plan/pdf/Guildford_Surface_Water_Management_Plan_-_Draft_Report.pdf

Table 5-1 – Discussion of surface water flood risk at hotspot locations identified in the Guildford SWMP

Identified Hotspot	Summary of historical surface water flood risk	Summary of predicted surface water flood risk
Flexford	Beech lane experiences over land flows from surrounding woods and agricultural land due to the steep nature of the catchment. Poor roadside drainage causes frequent flooding. Orchard Close experiences flooding because of steep slopes from the rail network and restricted drainage paths. Flexford, 250mm pipe running into a 150mm pipe causes flooding	Capacity assessment indicates that restricting culverts may only be able to carry peak flows up to the 1 in 20 year event for conservative estimates, not including blockages. Interception or diversion of flows away from properties and or upstream storage to attenuate flows would be necessary to reduce flood risk in these areas
Applegarth	Flooding on Roman Farm Road is caused by exceedance of highway and sewer drainage networks. Pond Meadow and Stoney Brook flooded as a result of runoff from Kings College Playing Fields	The SWMP recommends measures including re-arrangement of the drainage networks and implementation of road humps to direct water away from vulnerable areas
Ashenden Estate	Primary flooding mechanism thought to be due to exceedance from culverted watercourse	Provision of storage within playing fields may reduce runoff volumes and limit sewer capacity exceedance
Send	Deficiencies in the highway drainage network causes flooding along Send Road. Dropped kerbs and a lack of gullies means houses on the eastern side of send road are flooded	Preventative measures during times of flood including sandbags are used to limit flood risk, however causative measures including developing gullies would reduce flood risk
Ripley	Water flowing along Ripley High Street due to poor highway gully drainage and pluvial runoff which congregates on the High Street cause surface water flooding in this area	Maintaining the ditch running adjacent to Grove Heath North may prevent overtopping onto the main road. Flood storage area development to the south of Ripley would also limit runoff
Burpham	Glendale Drive, Gosden Hill Road and Merrow Lane are thought to flood as a result of blockages at culvert inlets	Enhanced maintenance would limit future surface water flood risk.

The Ash Surface Water Study (October 2014) also highlights hotspots that needed further assessment. The proposed areas for further assessment as part of the Study are provided in Table 5-1. These are the locations where both historic flooding information and predictive data indicate that the area is at high risk of surface water flooding. More detailed information is included within the Ash Surface Water Study, which is publically available online:

http://www.guildford.gov.uk/media/17210/Ash-Surface-Water-Draft/pdf/Ash_SW_Study_Revised_Technical_Report_Rev_4.pdf

Table 5-2 – Discussion of surface water flood risk at hotspot locations identified in the Ash Surface Water Study

Identified Hotspot	Information from wetspot database	Possible cause of flooding
Tongham / Oxenden Road	Poyle Road junction with The street: flat system and historical problems with debris – cleared in 2008.	There is no recorded information about most of the flood calls and sandbag requests. 3 in the south of the hotspot (New Road and The Street) were due to blocked drainage. The wetspot database indicates a problem with blocked drainage in the south, but north of the 3 calls. There are several areas of predicted surface water flooding. Therefore surface water and associated maintenance requirements are the most probable cause of flooding.
Ash Green	Pilgrims view/Green Lande East/Hazel Road: Surcharging highway manhole flooding No 14. Residents out of homes in the area for 6 months after Oct 2006 flooding.	Surface water mapping indicates properties on the streets named in the wetspot database are in a surface water flow path. There may be associated problems with highway drainage. This area is being considered already by Guildford Borough Council for a flood alleviation scheme, so will not be taken forward as part of this Study.
Ash Lodge Drive	Ash Lodge Drive/Loddon Way: no information is available. Southlands Road: several causes reported including a gully problem, ditch problem and runoff from high ground. Grange Road: Runoff from Church Lane overtops kerbs. Most of the kerbs have been raised as a quick fix.	There is predicted surface water flooding problems in most of the areas with historical problems. Therefore surface water appears to be the dominant flooding mechanism. Some of the flood calls also seem to be related to the function of the sewer and highway drainage network which will need to be considered. Recent flooding in the area (December 2013) also indicates issues of surface runoff, capacity of culverts, and operation of the drainage network.
Ash Station Area (Harpers Road)	Ash Hill Road: 8 houses flooded as well as a car showroom and service area. Cause unknown. GBC have done some work since this report so current extent of problem is unknown. Harpers Road: The problem may have been resolved by connecting road gullies into a nearby ditch.	There is a lot of predicted surface water flooding in this hotspot. The wetspot information suggests surface water causes flooding in these locations, but there is little other information about the causes of flooding. There is a watercourse draining through this area which may be under capacity, and is culverted in some locations.

Ashurst/ Lakeside Road	There are no wetspots in this hotspot.	The western two thirds of this hotspot are in the EA Flood Zone 3. All the sandbag requests and flood calls are within this area. The river floodplain is likely to be the dominant cause of flooding, however further investigation is needed into some of the flood calls and sandbag requests in the western end of the hotspot.
Ash Vale South	Fir Acre Road: The first comment indicates that the problem here has been resolved; however a subsequent comment notes the carriageway and footpaths flooded, with a reference to the pipes at the end of the road.	There is no information about the cause of flooding in the south in the historical information, however all the flood calls and sandbag requests are in the western half of the hotspot where there is predicted surface water flooding and therefore this is likely to be the cause. In the north there is little predicted surface water flooding and a large variety of sources cited in the historical data. Therefore further research is needed into these.
Shawfield Road / Longacre Road	Shawfield Road: Problems with a ditch that GBC has now verbally committed to clearing 2 times per year. Repairs to the existing system are suggested as well as 3 or 4 new gullies to run water into the ditch	There are 5 residential properties predicted to flood in the west of the hotspot, but no historical record of any flooding. Most of the sandbag requests and flood calls are on Shawfield Road and information about the westpot located on this road suggests the cause is problems with water on the highway draining into a ditch that is often partially blocked. This suggests the operation of the drainage network is the dominant problem, rather than a capacity issue. Following public consultation this area was included in the Ash Station Area.
Ash Vale North	Frimley Road: There was an incident of a pipe blocked under the road. Nothing further was recorded.	2 of the properties predicted to be at risk of surface water flooding have no sandbag requests or flood calls associated with them. The other 2 residential properties predicted to flood have 1 sandbag request associated with them, but there is no information recorded about the incident. There are small pockets of predicted surface water flood risk, but many of these do not coincide with the flood calls and sandbag requests. There are some issues relating to sewer flooding and gullies, but no information is available for most of the hotspot.
Wharf Road	No data in wetspot database	Issue known to GBC and SCC so not taken forward for this study as agreed with the Project Board.

5.5.1 Climate Change

Future climate change projections indicate that more frequent short- duration, high intensity rainfall and more frequent periods of long duration rainfall are to be expected. Studies into the impact of climate change on surface water are ongoing. Research from the Living with Environmental Change study led by NERC (2013) may feed into UK Flood Risk and Coastal Erosion Risk Management Strategy. Indirect impacts of climate change on land use and land management may also change future flood risk.

In the absence of certainty, NPPF advocates a precautionary approach. Sensitivity ranges are suggested for peak rainfall intensities over various time horizons. As our understanding of the impacts of climate change improves, these guidelines are likely to be revised. It is imperative that the SFRA is reviewed appropriately.

5.6 Management of Surface Water Flooding in Guildford Borough

What is the SuDS Approach?

The SuDS approach is centred on mimicking natural drainage. SuDS encourages the management of water as close to its source as possible, using features that collect, filter, store and/or infiltrate water using mechanisms similar to that found in nature. SuDS practices should be designed taking the following criteria into consideration:

- water quantity;
- water quality; and
- amenity/biodiversity.

5.6.1 Water Quantity

SuDS practices can play a key role in managing surface water through two mechanisms: runoff rate and storage volumes. As SuDS features often utilize pervious surfaces, they reduce runoff rates from the site compared to conventional development comprised primarily of impervious surfaces. SuDS can also help supplement the volume of water that must be stored on-site (attenuation volume) to achieve the desired runoff rate from the site. SuDS practices can store and/or infiltrate surface water into the surrounding soil, providing the necessary for attenuation storage for frequent rainfall events.

5.6.2 Water Quality

SuDS techniques help to improve surface water quality through the use of a ‘Management Train,’ which recommends incorporating a chain of techniques throughout a development, (as outlined in CIRIA C697 (Woods Ballard *et al*, 2007)), where each component adds to the performance of the whole system. The Management Train approach consists of four stages:

- **Prevention** good site design and upkeep to prevent runoff and pollution (e.g. limited paved areas, regular pavement sweeping)
- **Source control** runoff control at/near to source (e.g. rainwater harvesting, green roofs, pervious pavements)
- **Site control** water management from a multitude of catchments (e.g. route water from roofs, impermeable paved areas to one infiltration/holding site)
- **Regional control** integrate runoff management from a number of sites (e.g. into a wetland).

5.6.3 Amenity/Biodiversity

As SuDS techniques can be integrated within the fabric of a site they provide opportunities to create amenity areas and improve the site's biodiversity. Many SuDS techniques are landscaped with grasses and/or plantings that help to create green streets, neighbourhoods and commercial/industrial properties. SuDS can also be implemented as part of multi-functional places, enabling both the management of surface water and other uses like recreation within the same space.

5.7 SuDS Techniques

There are a wide range of SuDS techniques available for use throughout the four stages of the Management Train. Techniques available to manage the quantity of surface water typically operate in combination or solely on the basis of the following two main principles:

- Infiltration
- Attenuation

The effectiveness of techniques in achieving the goals of attenuating discharges, reducing pollution and providing amenity benefit will depend on a number of other factors such as filtration, settlement and oxidation.

The SuDS Manual (C697)[2] provides a summary of SuDS techniques and their suitability to meet the three goals of sustainable drainage systems (water quantity, water quality and amenity biodiversity) and their suitability within the stages of the Management Train. Table 5.3 presents a summary of a variety of SuDS techniques along with their suitability in achieving the goals of sustainability and their place within the Management Train.

[2] CIRIA, The SUDS Manual (C697), March 2007

Table 5.3: Summary of SuDS Techniques and their Suitability to meet the three goals of sustainable drainage systems

Management Train	SuDS Technique	Description	SuDS Principle	Water Quantity	Water Quality	Amenity Biodiversity
Source; Prevention	Green roofs	Layer of vegetation or gravel on roof areas providing absorption and storage.	Attenuation	●	●	●
Source; Prevention	Rainwater harvesting	Capturing and reusing rainwater for domestic or irrigation uses.	Attenuation	●	○	○
Source; Prevention	Permeable pavements	Infiltration through the surface into underlying layer.	Infiltration	●	●	○
Source	Filter drains	Drain filled with permeable material with a perforated pipe along the base.	Infiltration	●	●	X
Source	Infiltration trenches	Similar to filter drains but allows infiltration through sides and base.	Infiltration	●	●	X
Source	Soakaway	Underground structure used for store and infiltration.	Attenuation	●	●	X
Source	Bio-retention areas	Vegetated areas used for treating runoff prior to discharge into receiving water or infiltration	Attenuation	●	●	●
Source; Site	Swales	Grassed depressions, provides temporary storage, conveyance, treatment and possibly infiltration.	Attenuation	●	●	○
Site	Sand filters	Provides treatment by filtering runoff through a filter media consisting of sand.	Infiltration	●	●	X
Site; Regional	Basins	Dry depressions outside of storm periods, provides temporary attenuation, treatment and possibly infiltration.	Attenuation	●	●	○
Site; Regional	Ponds	Designed to accommodate water at all times, provides attenuation, treatment and enhances site amenity value.	Attenuation	●	●	●
Site; Regional	Wetlands	Similar to ponds, but are designed to provide continuous flow through vegetation.	Attenuation	●	●	●

Key: ● – highly suitable, ○ - suitable depending on design, X – unsuitable

5.8 Design of SuDS techniques

Detailed guidance for the design of SuDS, including specific guidance for individual SuDS techniques is available in the CIRIA SuDS Manual C697, and the associated document 'Site Handbook for the Construction of SuDS, C698 (Woods Ballard *et al*, 2007a). These publications provide best practice guidance on the planning, design, construction, operation and maintenance of SuDS to ensure effective implementation within developments.

The design of SuDS measures should be undertaken as part of a drainage strategy and design for a development site. A ground investigation should form part of the SuDS assessment to determine ground conditions and the most appropriate SuDS technique(s). Hydrological analysis should be undertaken using industry approved procedures to ensure an appropriate design is developed. This should account for the effects of climate change over the lifetime of the proposed system/development and based on an agreed permitted rate of discharge from the site.

During the design process, liaison should take place with the authority responsible for the receiving water body and any organisations involved in the long term maintenance of the system. This may include liaison with GBC, the EA (Thames region) and Thames Water. Liaison with these organisations should focus on establishing a suitable design methodology, any restrictions and provision for the long-term maintenance of the SuDS system.

5.9 Incorporating SuDS into a site plan

The flexibility of SuDS to be placed throughout a site, to meet a variety of criteria and be integrated within the urban fabric means that it is suitable for a wide range of land use types, site topographies and geology. Often a successful SuDS solution will utilise a number of techniques in combination, providing flood risk, pollution and landscape/wildlife benefits to the site and surrounding area. This section provides some guidance on how to incorporate SuDS techniques as part of the master planning and outline planning stages. It has been adapted from C687 Planning for SuDS.

5.9.1 Examine site topography and geology

During this stage, characterize the existing site topography to determine natural flow paths. Bedrock and superficial geology can be used as an initial tool to determine locations where SuDS techniques should be located to maximize their infiltration potential. More in-depth analysis of soil conditions, including borehole testing and soakage testing are required to confirm the suitability of SuDS techniques and their ideal placement upon the site.

5.9.2 Create a spatial framework for SuDS

The next step in the planning process is to develop an estimate of impermeable (paved roadway and buildings) and permeable surface across the site. This information is used to assess pre- and post-development runoff rates and volume, from which attenuation storage/infiltration targets can be set. The number, type(s) and size of SuDS practices can then be determined as part of the surface water management scheme at the site.

5.9.3 Look for multi-functional spaces

Planners should look for areas of the site where SuDS practices could be integrated within the urban fabric, for instance locating SuDS in planned green space, within a play area.

5.9.4 Integrate the street network with SuDS

The street network is one of the most important areas to incorporate SuDS. Swales can be located along the road network to accept street runoff, tree planters can be configured to accept runoff from roads and car parks and the use of rain gardens and bioretention techniques can be used to create 'green streets' that improve the amenity of a property. Large below-ground storage/infiltration practices can also be located beneath the street network or car parks. Pervious pavement materials are ideal for car parks and parking lay-bys.

A common concern with incorporating SuDS in developments is the belief that all SuDS are 'land hungry' and significantly impact on the developable area of sites. By applying the principles discussed above, SuDS can be considered at the earliest opportunity, ensuring that they are integrated within the site using as little land as possible, whilst creating multi-functional spaces that improve the amenity value of the property. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS, however, each development site must offset its own increase in runoff; attenuation cannot be "traded" between developments.

Pre application advice on surface water drainage can be found on SCC's website:

http://new.surreycc.gov.uk/people-and-community/emergency-planning-and-community-safety/flooding-advice/more-about-flooding/suds-planning-advice

5.10 SuDS Constraints

The underlying ground conditions of a development site will often influence the type(s) of SuDS technique suitable at an individual site. While this will need to be determined through ground investigations carried out on-site, an initial assessment of the site's suitability to the use of SuDS can be obtained from a review of the available soils/geological survey of the area.

Much of Guildford borough is located on the Weald Clay which is an unsuitable geology for the use of infiltration based SuDS. In these areas sustainable drainage can be achieved by the use of ponds, swales, wetlands and other such methods which do not rely on infiltration into the ground. Some areas of the borough, particularly around Guildford itself, are located on Chalk, in these areas infiltration based methods may be appropriate. However, there are a number of groundwater abstractions around Guildford and parts of the town lie within a Source Protection Zone which may limit the use of infiltration based SuDS. It is recommended that for all sites where infiltration drainage is proposed on site tests are carried out to determine specific infiltration rates.

It is recommended that developers should consult GBC, the EA, and relevant service authorities and Utility Companies at the earliest stage of the development process to establish the best solution for a particular site.

During the design process, in addition to considering the properties of the underlying soils and strata it is necessary to also consider the sensitivity of the receiving water body and any previous uses of the site.

The use of SuDS can be limited based on a number of constraints, which include:

- Groundwater vulnerability and potential contamination of an aquifer;
- Current or target water quality of a receiving watercourse;
- The presence of groundwater Source Protection Zones and potential contamination of a potable water source;
- Restrictions on infiltration on contaminated land to prevent the spread of contamination; and,
- Restricted area on development sites where housing densities are high.

5.10.1 Groundwater Vulnerability

Groundwater resources can be vulnerable to contamination from both direct sources (e.g. into groundwater) or indirect sources (e.g. infiltration of discharges onto land). Groundwater vulnerability within the study area has been determined by the EA based on a review of aquifer characteristics, local geology and the leachability of overlying soils.

The vulnerability of the groundwater is important when advising on the suitability of SuDS. The EA is the responsible drainage authority for any discharges to groundwater and should be consulted on proposals to discharge to ground. Groundwater vulnerability for the study area can be assessed by reviewing the most up-to-date maps on the EA's website.

5.10.2 Groundwater Source Protection Zones

In addition to groundwater vulnerability, the EA also defines groundwater Source Protection Zones (SPZs) around groundwater abstraction points. Source Protection Zones are defined to protect areas of groundwater that are used for potable supply, including public/private potable supply, (including mineral and bottled water) or for use in the production of commercial food and drinks.

SPZs are defined based on the time it takes for pollutants to reach an abstraction point. Depending on the nature of the proposed development and the location of the development site with regards to the SPZs, restrictions may be placed on the types of SuDS appropriate to certain areas.

Any restrictions imposed on the discharge of site generated runoff by the EA will be determined on a site by site basis using a risk based approach. SPZ for the study area can be assessed by reviewing the most up-to-date maps on the EA's website.

5.10.3 Water Quality

Under the Water Framework Directive all member states are required to take steps to achieve good ecological status of water bodies by 2015. To achieve this, discharges to watercourses draining development areas will require pre-treatment to remove oils and contaminants. Appropriately designed SuDS can assist developments improve water quality discharges through passive treatment, whilst additionally providing ecological benefit to a development or local area.

5.10.4 Contaminated Land

Previous site uses can leave a legacy of contamination that if inappropriately managed can cause damage to local water bodies. During the design of SuDS it is essential to have regard to the nature of potential ground contamination.

Particular restrictions may be placed on infiltration based SuDS, forcing consideration of attenuation based systems. Early discussion with the authority responsible for the receiving water body should be undertaken to establish the requirements of SuDS on contaminated sites.

5.10.5 High Development Densities

Where developments are required to achieve high development densities it is essential that the requirement for SuDS and their constraints are identified early in the site master planning process. High development densities can restrict the land area available for SuDS, which if mandatory can affect the ability of a site to gain planning permission.

Early consideration of SuDS enables the drainage requirements to be integrated with the design, limiting the impact they have on developable area and development densities.

5.11 Application of Sustainable Drainage Systems in Guildford Borough

5.11.1 Available Datasets

The British Geological Society (BGS) produce a range of datasets which provide information surrounding the suitability of the ground for infiltration SuDs, The selection and design of an appropriate system depends on the properties of the ground and in particular the following four factors:

- the presence of severe constraints that must be considered prior to planning infiltration
- the drainage potential of the ground
- the potential for ground instability when water is infiltrated
- the protection of groundwater quality

The Infiltration SuDS Map is based on 15 nationally derived subsurface property datasets, some of which are a result of direct observations, whilst others rely on modelled data.

The dataset is structured using the above four factors, and allows consideration of the subsurface permeability, the depth to groundwater, the presence of geological floodplain deposits, the presence of artificial ground, ground stability (soluble rocks, collapsible ground, compressible ground, running sand, shallow mining, landslide and shrink swell clays), potential for pollutant attenuation and the EA's source protection zones.

The maps show data at 1:50,000 scale. The following datasets were purchased for use in this SFRA (2015).

5.11.2 Infiltration SuDs Map: Detailed

The detailed map provides the data layers described above, along with a further 20 individual, bespoke data layers. These data layers provide information on the properties of the ground, which can be used to guide local SuDS planning and design.

The data can be used to determine the likely limitations present at a site and make preliminary decisions on the type of infiltration SuDS that may be appropriate. We anticipate that this map will be used by planners, developers, consultants and SuDS Approval Bodies.

5.11.3 Drainage Summary Map

The summary map comprises four summary layers, providing an indication of the suitability of the ground for infiltration SuDS. The layers summarise: the presence of severe constraints; the drainage potential of the ground; the potential for ground instability as a result of infiltration and the susceptibility of the groundwater to contamination. The layer is derived from the following datasets:

- Infiltration constraints summary
- Superficial deposit permeability
- Superficial deposit thickness
- Bedrock permeability
- Depth to water level
- Geological indicators of flooding

This map is anticipated to be of use in strategic planning and not for local assessment. It does not provide specific subsurface data or state the limitations of the subsurface with respect to infiltration.

These dataset have been used to assign areas with the classifications assigned in Table 5-4:

Table 5-4 – Drainage Summary Map classifications

Score	Description	Typical Storage Capacity
1	Highly compatible for infiltration SuDS	The subsurface is likely to be suitable for free-draining infiltration SuDS
2	Probably compatible for infiltration SuDS	The subsurface is probably suitable for infiltration SuDS although the design may be influenced by the ground conditions
3	Opportunities for bespoke infiltration SuDS	The subsurface is potentially suitable for infiltration SuDS although the design will be influenced by the ground conditions
4	Very significant constraints are indicated	There is a very significant potential for one or more geohazards associated with infiltration

5.11.4 SuDS Suitability Assessment

For this high level SFRA study, the infiltration constraints layer within the drainage summary map has been analysed to provide a summary of the locations suitable for infiltration SuDS techniques across Guildford borough. The data contained within the detailed SuDS Map should be referred to at the detailed FRA stage to highlight any further or site specific constraints on SuDS and relevant applications for surface water management.

5.11.5 Drainage Summary Layer

The Infiltration constraints layer, which provides an indication of the extent to which the ground will be suitable for infiltration SuDS with respect to drainage, based on the geology and hydrogeology of the subsurface should be used to advise the methods and location of SuDS. Volume 3, Figure 11 shows the BGS Drainage Summary dataset across Guildford borough.

Within the borough, the main areas that are highly compatible for infiltration SuDS include a central band through the borough and large areas in the South East and North West of the borough. In these areas the subsurface is likely to be suitable for free-draining infiltration SuDS as a result of permeable soils and chalk bedrocks. In the northern half of the borough, there are many areas where SuDS infiltration techniques are ‘probably compatible’. Again this is a result of underlying permeable chalk bedrock and deep water tables.

Areas away from the floodplain, which may be characterized by spatially variable permeability or a water table that may be within 1m of the base of the infiltration system, or both are probably compatible for infiltration SuDS, but the system design may be influenced by the local ground conditions.

Along the main river channels there are very significant constraints on infiltration SuDs techniques, mostly because of shallow water tables. There are also large areas across the west of the borough which have very significant constraints on infiltration SuDs techniques.

5.12 Adoption and Maintenance of SuDS

To ensure approval of a proposed SuDS scheme is critical that developers consult with GBC, the Highways Agency, Thames Water and any other applicable parties to discuss the adoption and maintenance of SuDS techniques and associated drainage infrastructure.

At the time of writing (September 2015), the GBC Drainage and Flood Risk Engineers are currently still forming a strategy for the adoption and maintenance of SuDS within Guildford borough, in consultation with SCC.

All major planning applications will need to set out who will be responsible for maintaining and inspecting the drainage system for the lifetime of the development and include a detailed SuDS maintenance plan. Developers will need to consult with the GBC drainage and flood risk engineer to ensure that proposals are compliant with NPPF, the non-statutory technical standards for sustainable drainage, GBC Local Plan and any forthcoming SuDS guidance from Guildford borough.

Sewerage undertakers are responsible for surface water and foul drainage from developments, where this is adopted via adopted sewers. Thames Water is the sewerage undertakers within the study area.

5.13 Further Guidance on SuDS

- CIRIA C635 Designing for Exceedance in Urban Drainage – Good Practice (2006)
- CIRIA C687 Planning for SuDS – Making it Happen (2010)
- CIRIA C697 The SUDS Manual (2007)
- CIRIA C698 Site Handbook for the Construction of SuDS (2007)
- Communities and Local Government – Guidance on the Permeable Surfacing of Front Gardens (2009)
- London Borough of Islington - Promoting Sustainable Drainage Systems (2013)
- CIRIA C609 Sustainable Drainage Systems – Hydraulic, structural and water quality advise (2004)

6. Flooding from Sewers

Flooding from sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure. Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure.

6.1.1 Causes and Classifications

The main causes of sewer flooding are:

- Lack of capacity in sewer drainage networks due to original under-design.
- Lack of capacity in sewer drainage networks due to an increase in demand (such as climate change and/or new developments).
- Lack of capacity in sewer drainage networks due to events larger than the system designed event.
- Lack of capacity in sewer drainage networks when a watercourse is fully culverted (lost watercourses), thus removing floodplain capacity.
- Lack of maintenance of sewer networks which leads to a reduction in capacity and can sometime lead to total sewer blockage.
- Water mains bursting/leaking due to lack of maintenance or as a result of damage.
- Groundwater infiltration into poorly maintained or damaged pipe networks.
- Restricted outflow from the sewer systems due to high water levels in receiving watercourses.

The impact of sewer flooding is usually confined to relatively small localised areas. When flooding is associated with blockage or failure of the sewer network, flooding can be rapid and unpredictable. Flood waters from this source are also often contaminated with raw sewage and pose a health risk. The spreading of illness and disease can be a concern to the local population if this form of flooding occurs on a regular basis.

Drainage systems often rely on gravity assisted dendritic systems, which convey water in trunk sewers located at the lower end of the catchment. Failure of these trunk sewers can have serious consequences, which are often exacerbated by topography, as water from surcharged manholes will flow into low-lying land which may already be suffering from other types of flooding.

The modification of watercourses into culverted or piped structures can result in a reduced capacity. Excess water may be sent along unexpected routes as its original channel is no longer present and the new system cannot absorb it.

Whilst an area affected by sewer flooding is often localised, the quality of water can be poor. Flooding of combined sewers can lead to contaminated water entering properties nearby watercourses.

Sewer flooding is likely to have a high concentration of solid, soluble and insoluble contaminants. This can lead to a reduction in the environmental quality of receiving watercourses. Flooding of contaminated land (such as landfills, motorways, and petrol station forecourts) will transport contaminants such as organics and metals to vulnerable receptors if the respective drainage systems are not designed to treat the water.

6.2 Data Collection

All Water Companies have a statutory obligation to maintain a register of properties/areas which have reported records of flooding from the public sewerage system, and this is shown on the DG5 Flood Register. This includes records of flooding from foul sewers, combined sewers and surface water sewers which are deemed to be public and therefore maintained by the Water Company. Thames Water provided extracts of the DG5 register for the GBC study area (for the 2015 issue of Guildford Borough SFRA).

The aim of the DG5 levels of service indicators is to measure the frequency of actual flooding of properties and external areas from the public sewerage system by foul water, surface water or combined sewage. It should be noted that flooding from land drainage, highway drainage, rivers/watercourses and private sewers is not recorded within the register. In addition, the records do not account for the effect of any capital works designed to alleviate flooding.

6.3 Historical Sewer Flooding

The data provided by Thames Water for use in this SFRA shows postcodes where properties are known to have experienced sewer flooding prior to September 2014. The DG5 register holds records of 64 flood incidents resulting in internal property flooding, and 208 external flooding incidents, as shown in Figure 6-1 and Figure 6-2. The records indicate that internal property flooding occurs predominantly for the larger scale flooding events (1 in 20 year recurrence probability), whilst more external flooding has been reported during smaller scale events. Volume 3, Figure 7 provides a broad overview map of flood incidents in the borough as it is not property specific, instead providing information in postcode sectors (a four digit postcode). The majority of the incidents are located in the postcode areas adjacent to the River channels; otherwise the events were sporadic, and no further details are available.

Figure 6-1 – Total internal property flooding from sewers within Guildford borough (data prior to September 2014)

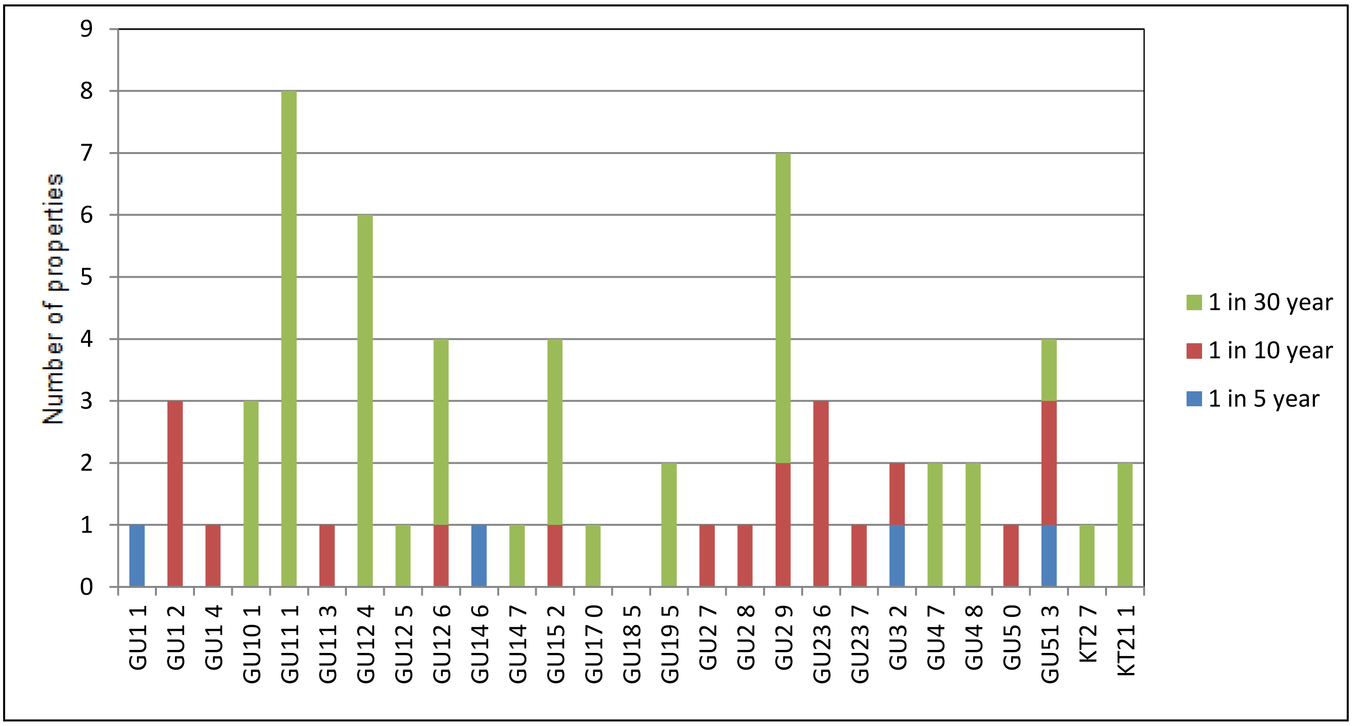
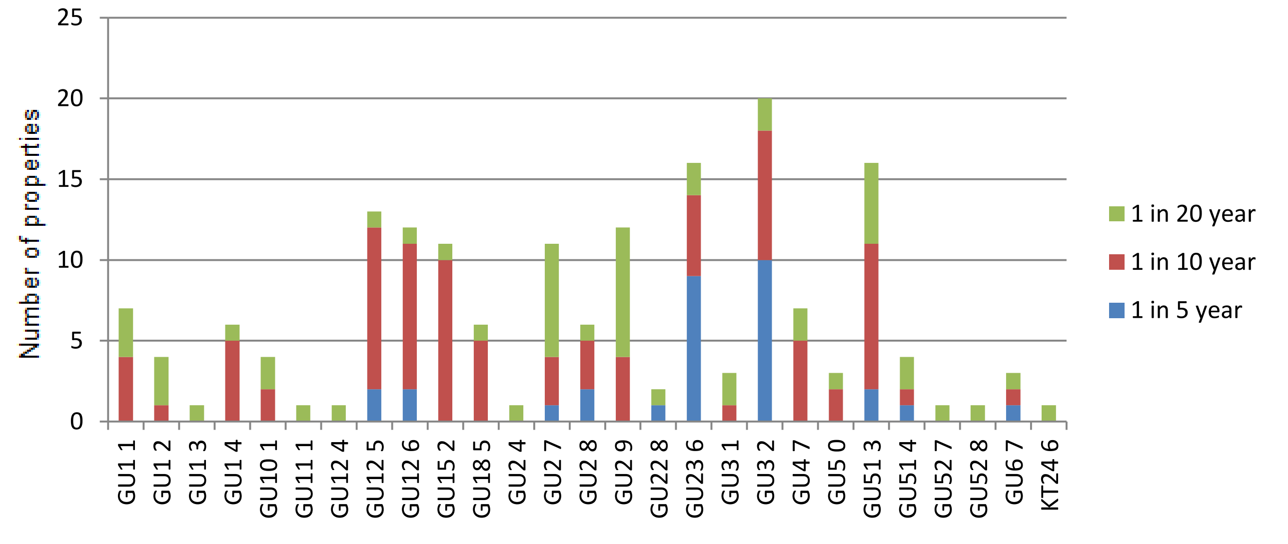


Figure 6-2 - Total external property flooding from sewers within Guildford borough (data prior to September 2014)



Historic Incidents of sewer flooding may indicate areas at higher risk than others, however the urban drainage system is maintained and where improvements have been completed the risk may be significantly lowered making the historic occurrence of flooding an inadequate indicator of future problems.

6.4 Assessing Flooding From Sewers

The three most appropriate methods for assessing the risk of flooding from sewers within the SFRA are:

- Review of historical data - qualitative review of areas at risk and/or GIS analysis to create a buffer zone around locations of known risk. *This method was used during the SFRA.*
- Reference to existing studies like the GBC SWMP and the Ash Surface Water Study. *This method was used during the SFRA.*
- Urban drainage modelling - model the urban drainage network and determine locations likely to flood. Historically urban drainage models have been unable to provide a representation of the integrated impact of different flood mechanisms (i.e. river flooding with sewer flooding), however software packages such as TUFLOW are now able to jointly model these sources. *This is too detailed for the SFRA; however urban drainage modelling was completed as part of the Guildford SWMP in 2013 and the Ash Surface Water Study in 2014.*

6.5 Discussion of Sewer Flooding in Guildford Borough

Sewer flooding is a particularly damaging source of flooding because of the after affects associated with this type of flooding. Sewer flooding is often combined with surface water flooding when combined sewerage and drainage systems surcharge. In the study area this type of flooding is more likely to occur in dense urban areas, which could include Guildford Town Centre and Ash.

The use of historic data to estimate the probability of sewer flooding is the most practical approach, however does not take account of possible future changes due to climate or future development. Historic results should also be viewed with caution as the sewer network is constantly being maintained, upgraded and improved. Thus flooding issues may be relatively short lived (<10 years). If identified by the EA or the water company as a major risk, sewer flooding will need to be assessed in greater detail in individual flood risk assessments.

6.5.1 Climate Change

Climate change is expected to impact sewer flooding by increases in rainfall intensity. This may require new infrastructure to be designed with greater capacities and existing infrastructure may require upgrading to maintain the same level of service. The relevant climate change predictions contained with NPPF are reproduced in Table 6-1.

Table 6-1 – Predicted increase in rainfall intensity with climate change

	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	5%	10%	20%	30%

6.6 Management of Sewer Flooding in Guildford Borough

Flooding from sewers or urban areas can theoretically be managed with engineering works for any size event. However such works are not always economically or environmentally sustainable. Improvements to urban drainage can also lead to rapid rainfall runoff into rivers, increasing flood risk downstream and potentially transporting contaminants.

The National Planning Policy Framework recommends that Sustainable Urban Drainage Systems (SuDS) are used to decrease the probability of flooding by limiting the peak demand on urban drainage infrastructure. All new developments, and wherever possible existing networks, are also advised to separate out foul drainage from surface water drainage to ensure that any flooding that does occur is not contaminated.

6.6.1 Planning Considerations

The information within the SFRA will be used by GBC to develop specific planning policy and guidance for Guildford borough that takes full account of flood risk now and in the future. These policies will be reported within future updates of the SFRA.

The planning policy and guidance which will be developed by GBC, discussed in Volume 1, may include some of the following measures:

- In areas where insufficient information on flood risk currently exists, there should be a requirement for those proposing the developments to provide detailed flood information.
- The adoption of SuDS on all new developments in line with national planning guidance and non-statutory Technical Standards for SuDS, following consultation with the GBC drainage engineers and LLFA. Surface water flood risk should be sought to be reduced following development through the application of SuDS.
    - *Note; at the time of writing, GBC are discussing the responsibility for adopting SuDS. Following clarification, GBC Guidance should be followed*
- Continue to collect and record complete information on surface water and sewer flood events that are reported to them.

7. Flooding from Groundwater

Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land. Groundwater floods may emerge from either point or diffuse locations. They tend to be long in duration developing over weeks or months and prevailing for days or weeks.

There are many mechanisms associated with groundwater flooding, which are linked to high groundwater levels, and can be broadly classified as:

- Direct contribution to channel flow.
- Springs erupting at the surface.
- Inundation of drainage infrastructure.
- Inundation of low-lying property (basements).

Groundwater levels rise and fall in response to rainfall patterns and distribution, with a time scale of months rather than days. The significance of this rise and fall for flooding, depends largely on the type of rock it occurs in, i.e. how permeable to water the rock is, and whether the water level comes close to or meets the ground surface.

Groundwater flood events have been recorded in various aquifer units (including Cretaceous Chalk, Limestones, river terrace gravels). Compared to other aquifer units, Chalk is more vulnerable to groundwater flooding because of its geological formation. It contains many pores and fissures which can result in rapid rises in groundwater levels, which take a long time to recede.

The primary controls on the distribution and timing of groundwater flooding include:

- Spatial and temporal distribution of rainfall.
- Spatial distribution of aquifer properties.
- Recharge mechanisms.
- Spatial distribution of geological structures (drift deposits, stratigraphy).
- Efficiency of the surface drainage network.

The likelihood of an area experiencing groundwater flooding can largely be determined on a broad scale through an analysis of the previous meteorological conditions and geological knowledge. This can be helped by the analysis of groundwater boreholes and historic information.

7.1.1 Causes of high groundwater levels

High groundwater levels can result from the combination of geological, hydrogeological, topographic and recharge phenomena and can mostly be associated with the seven mechanisms described in Table 7-1. Each has been described using the source-pathway- receptor model.

Table 7-1 – Causes of high groundwater levels

Flooding phenomenon	Sources	Pathways	Receptors	Hazard	Characteristics
Rising groundwater levels in response to prolonged extreme rainfall (often near or beyond the head of ephemeral streams)	Long duration rainfall	Permeable geology, mainly chalk	People, properties, environment	Basement flooding/rural ponding	Responsible for the large majority of groundwater flooding. May occur a few days after the rainfall or up to several weeks after. Usually lasts for a number of weeks. An increase in the baseflow of channels, which drain aquifers, is often associated with elevated groundwater levels and may lead to an exceedance of the carrying capacity of these channels. Floodwaters are most often clear and so this form of groundwater flooding may be referred to as 'clear water flooding'. High groundwater levels may also inundate sewer and storm water drainage networks, exceed capacity and lead to flooding in locations, which would otherwise be unaffected. This flooding can be associated with pollution.
Rising groundwater levels due to leaking sewers, drains and water supply mains	Water in water mains, drainage and sewerage networks	Cracks in pipes/permeable strata	People, properties, environment	Basement flooding/water quality issues	Leakage from sewer, storm water and water supply networks can lead to a highly localised elevation in groundwater levels, particularly where the leak is closely associated with chalk bedrock.
Groundwater rebound owing to rising water table and failed or ceased pumping	Groundwater	Permeable geology and artificial pathways e.g. adits	Property, commercial	Basement flooding / flooding of underground infrastructure	Where historic heavy abstraction of groundwater for industrial purposes has ceased, a return of groundwater levels to their natural state can lead to groundwater flooding. This process can potentially cover large areas or maybe associated.
Upward leakage of groundwater driven by artesian head	Groundwater emerging from boreholes or through permeable geology	Artesian aquifer and connection to surface	*Property*	Basement flooding / flooding at surface	Mainly associated with short duration and localised events this process can lead to significant volumes of discharge. It can occur in locations where boreholes have been drilled through a confining layer of clay to reach the underlying aquifer.
Inundation of trenches intercepting high groundwater levels	Groundwater	Permeable geology	Property	Routing of floodwaters	The excavation and fill of engineering works with permeable material can create groundwater flow paths. High groundwater levels maybe intercepted, resulting in flooding of trenches and land to which they drain.
Other – alluvial aquifers, aquifer, sea level rise	Rivers, rainfall, sea	Floodplain gravels, permeable geology	Property, environment	Basement flooding / flooding at surface/saline intrusion.	Other mechanisms of groundwater flooding include leakage of fluvial flood waters through river gravels to surrounding floodplains e.g. behind flood defences; and a rise in groundwater levels as a result of adjacent sea level rise as a result of the discharge boundary rising.

7.1.2 Impacts of groundwater flooding

The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity.
- Overflowing of sewers and drains – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding.
- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply.
- Inundation of farmland, roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient, however the inundation of hard-standing areas can lead to structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences.
- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. The long duration of flooding can outweigh the lead time which would otherwise reduce the overall level of damages.

Additionally groundwater flooding can cause a change in the structural properties of clay overlying chalk aquifers. This may cause costly damage to structures in the ground and the buildings that they support.

Groundwater flooding has always occurred. It generally occurs more slowly than river flooding and in specific locations. The rarity of groundwater flooding combined with the mobility of the population means that people often do not know there is a groundwater flood risk.

New developments are particularly at risk because little consideration is given to groundwater as a source of flooding in the planning process. The sparse frequency of groundwater flood events can contribute to poor decision-making. The economic and social costs of groundwater flooding are compounded by the relative long duration of events.

The nature and occurrence of groundwater flooding in England is highly variable. In England, 1.7 million properties are located in the Groundwater Emergence Maps (GEMS) zones and therefore are at risk of groundwater flooding[3]. The occurrence of groundwater flooding is very local and often results from the interaction of very site specific factors, e.g. aquifer properties, topography, man-made structures etc.

In general terms groundwater flooding rarely poses a risk to life. However groundwater flooding can be associated with significant damage to property.

Guildford urban area is underlain by superficial drift deposits (mainly river terrace deposits in the river valleys) and deeper solid geology consisting of clay, sandstone and chalk.

Areas underlain by Chalk and Sandstone (Greensand) include much of Guildford urban area, especially the southern areas of the town centre. Ash, Ash Vale and Pirbright are most probably underlain by clay and therefore groundwater flooding is unlikely to be an issue in these areas.

7.2 Data collection

Information surrounding groundwater flooding has been collected from GBC, SCC, the EA and the British Geological Society, as set out in Volume 1, Appendix A.

[3] http://nora.nerc.ac.uk/510064/1/OR15016.pdf

7.3 Historical Groundwater Flooding

There are very few records of groundwater flooding across the borough. The Surrey County Council wetspot database does not attribute any of the incidents to groundwater. The EA flood incident database also does not identify groundwater as the source of any of the reported incidents. The lack of incidents recorded may not be reflective of the occurrence of groundwater flooding, as groundwater flooding may occur following prolonged rainfall events simultaneously with other types of flooding.

7.4 Assessing Flooding from Groundwater

Following the particularly wet winter of 2000/2001, the British Geological Survey produced a national dataset on the susceptibility of groundwater flooding. The dataset is based on geological and hydrogeological information and can be used to identify areas where geological conditions could enable groundwater flooding to occur and where groundwater may come close to the surface. It is important to note that it is a susceptibility set, and does not indicate hazard or risk.

The EA also produces an ‘Areas susceptible to groundwater flooding map’, which is based on some of the information from the BGS maps and information on superficial deposits. Again the dataset identifies susceptibility and not risk.

The British Geological Society groundwater susceptibility Maps are considered to be more detailed and accurate and have a finer resolution to the EA maps, and therefore identifying groundwater susceptibility in Guildford borough has been done based on this dataset. The dataset is classified into four subgroups, as shown in Table 7-2.

Table 7-2 – BGS susceptibility to groundwater flooding classifications

Classification	Description
A	**Limited potential for groundwater flooding to occur:** based on rock type and estimated groundwater level during periods of extended intense rainfall.
B	**Potential for groundwater flooding of property situated below ground level:** based on rock type and estimated groundwater level during periods of extended intense rainfall. Where this may have an impact, you are advised to check that this has not been a problem in the past at this location and/or that measures are in place to sufficiently reduce the impact of the flooding.
C	**Potential for groundwater flooding to occur at surface:** based on rock type and estimated groundwater level during periods of extended intense rainfall. You are advised to check that this has not been a problem in the past at this location and/or that measures are in place to sufficiently reduce the impact of the flooding.
Elsewhere	Not considered to be prone to groundwater flooding: based on rock type.

7.5 Discussion of Groundwater Flooding in Guildford Borough

The underlying geology in the central part of the borough is comprised of Cretaceous Chalk, which is known to be vulnerable to groundwater flooding. A band of greensand runs across the catchment to the south of the chalk and may also be a source of groundwater flooding. In the far south east and north of the catchment the geology is dominated by clay (London Clay in the north, Weald Clay in the south east) and as a result groundwater flooding is very unlikely in these areas.

The BGS susceptibility to groundwater flooding dataset has been analysed to identify areas within the borough at risk from groundwater flooding. These results have been summarised below. The BGS dataset is a susceptibility dataset: it does not indicate hazard or risk and does not provide any information on the depth to which groundwater flooding occurs, or the likelihood of the occurrence of an event of a particular magnitude.

The BGS Susceptibility to groundwater flooding map is shown in Volume 3, Figure 8.

In the northern half of the borough, there is a wide band where there is very limited potential for groundwater flooding to occur, as a result of predominantly Thames Group sedimentary bedrock. Where ordinary watercourses and river channels intersect this band, there is elevated flood risk from groundwater.

Across the north west and south east corners of the study, flood risk from groundwater is relatively low; identified as Class A, with limited potential for groundwater flooding to occur. This is based on the rock type and modelled groundwater level.

A large central band through the borough is shown as Class C. These areas are identified as having potential for groundwater flooding to occur at the surface based on rock type and estimated groundwater level during periods of extended intense rainfall. Small margins around the perimeter of Class C show class B, with potential for groundwater flooding of property situated below ground level. The central and north western areas of the borough, where the geology is much less permeable, there is very limited susceptibility to groundwater flooding.

The broad scale analysis in the SFRA has identified areas where there is potential for groundwater emergence and has therefore identified the areas where consideration should be given to groundwater flooding during detailed flood risk assessments.

7.5.1 Climate Change

There is currently no research specifically considering the impact of climate change on groundwater flooding. The mechanisms of flooding from aquifers are unlikely to be affected by climate change, however if winter rainfall becomes more frequent and heavier, groundwater levels may increase. Higher winter recharge may however be balanced by lower recharge during the predicted hotter and drier summers.

7.6 Management of Groundwater Flooding in Guildford Borough

The information within the SFRA will be used by GBC to develop specific planning policy and guidance for Guildford borough that takes full account of flood risk now and in the future. These policies will be reported within future updates of the SFRA.

The planning policy and guidance which will be developed by GBC, discussed in Volume 1, may include some of the following measures:

- The requirement for all new development proposed within areas potentially at risk of groundwater flooding to be accompanied by an assessment of the groundwater flood risk at that specific location. Where a formal FRA is required for a site this may form part of the FRA, elsewhere a separate document dealing with issues of groundwater flooding may be required.

Flooding from Artificial Sources

7.7 Description

NPPF describes non-natural or artificial sources of flooding such as reservoirs, canals and lakes where water is retained above natural ground level. NPPF also includes operational and redundant industrial processes including mining, quarrying, and sand and gravel extraction as they may increase water depths and velocities in adjacent areas. In addition to this the impacts of flood management infrastructure and other structures need to be considered. Flooding may result from a facility being overwhelmed or from failure of a structure. Failure of structures can result in rapid, deep flowing water which poses a serious hazard, threatening life and potentially causing major property damage. Failure of pumps may also result in flooding.

For the purpose of the SFRA, flooding from artificial sources has been defined as that arising from failure of man-made infrastructure or human intervention that causes flooding. This includes failure of canals or reservoir embankments, as well as activities such as ground water pumping. To understand flooding from artificial sources the whole hydrological and drainage system must be considered, along with the potential for interaction with other sources of flooding.

The spatial and temporal extent of flooding from artificial sources is highly variable. For example the likelihood of a new reservoir failing is very low compared to that of a canal embankment that is more than one hundred years old. However the consequences of a reservoir failing is potentially catastrophic in comparison to a local canal embankment breaching.

Increased urbanisation, aging infrastructure and the impacts of climate change all result in the requirement for consideration of flooding from artificial sources within the development process.

The primary potential source of artificial flood risk in Guildford borough is from the Basingstoke Canal which is located within the study area and is occasionally raised above surrounding ground.

Reservoirs are artificial lakes, used to store water for various uses. They can be either modified natural structures or completely man-made. An 'attenuation' or 'impoundment' reservoir is used to prevent flooding to lower lying lands or regulate flows for abstraction and irrigation purposes. Control reservoirs collect water at times of excess (or unseasonably high) rainfall, then release it slowly on demand or over the course of the following weeks or months.

Managed or un-managed reservoir release may increase floodwater depths and velocities in adjacent areas. Reservoir flooding may occur as a result of failure of a reservoir’s civil structure due to the system being overwhelmed; or malfunction of the water level control system. A number of ponds, lakes and reservoirs have been identified, including Mytchett Lake, which is part of the Basingstoke Canal. The Mytchett Lake is located just outside Guildford borough boundary.

7.7.1 Reservoirs Act

Reservoirs with an impounded volume in excess of 25,000 cubic metres (measured above natural ground level) are governed by the Reservoirs Act 1975 and the Flood and Water Management Act 2010. The Reservoir Act makes owners (undertakers) responsible for the safety of their reservoirs and they are obliged to ensure assessments are undertaken by appropriately qualified engineers on a routine basis.

As Enforcement Authority the EA has the following key roles:

- Surveillance - maintaining a register of reservoirs for England and Wales.
- Enforcement - achieving compliance.

For reservoirs below the threshold of 25,000 cubic metres above ground volume, regulation is managed by the Health and Safety Executive and they carry out inspections in accordance with the Health and Safety at Work Act.

The EA has a register of reservoirs and undertakers, as well as a set of risk maps for all reservoirs greater than 25,000 cubic meters.

7.8 Data collection

Flood outlines indicating the extent of flooding was received from the EA. The outlines show the predicted extents should the reservoirs fail, and release all of the water they hold. The Basingstoke Canal centre-line was received from Basingstoke Canal Authority (BCA). Correspondence (September 2014) confirmed that there are no known flood events that have occurred as a result of embankment failure in Guildford borough. Work done by Capita in the 2009 SFRA showing areas at risk of flooding from the Basingstoke Canal has been re-digitised.

7.9 Discussion of Flooding from the Artificial Sources in Guildford Borough

7.9.1 Flood Risk from Reservoirs

Reservoir flooding is extremely unlikely to happen; there has been no loss of life in the UK from reservoir flooding since 1925. Although potentially large uncontrolled releases of water from the reservoirs could result in deep and fast moving floodwaters and place people’s lives in danger, the probability of occurrence is very low, and therefore flood risk is considered as low. It is also important to note that the outlines mapped show the flood extents should the reservoir release all of the water it holds, which is also extremely unlikely.

There are a number of reservoirs that could affect areas within the borough. Often the reservoirs are located along the watercourse, and therefore flood outlines follow natural drainage paths.

South of Guildford urban area, along the River Wey, there is flood risk from Broadwater Lake, owned by Waverley Borough Council, and Vachery Pond. Further downstream in the north of the borough, there is flood risk from Clandon Park Reservoir.

In the west of the borough, along the River Blackwater, there is flood risk from Mytchett Lake, owned by SCC.

Most of the areas at risk are open space and rural, so the impacts of the flooding would be very low. Therefore, the flood risk from reservoirs across Guildford borough is considered to be very low. The risk of reservoir flooding is shown on Figure Series 9, in Volume 3.

7.9.2 Flood Risk from the Basingstoke Canal

The Basingstoke Canal stretches between the villages of Greywell in Hampshire and Woodham in Surrey. Conceived as an agricultural waterway to connect the area of North East Hampshire with the London markets, the Basingstoke Canal took seven years to complete with construction starting in 1787 and being completed in 1794. The canal stretches for a distance of 32 miles (51km) incorporating 29 locks to raise the canal from the River Wey up to the plateau in Hampshire which is 245ft (75m) above sea level. The flood risk from the Canal in response to high rainfall and breach is highlighted below, but it should also be noted that the Canal plays an important role in draining rainwater away from properties and helps prevent flooding in these areas.

The Basingstoke Canal is a contour canal. This means that as far as possible the canal is built around the side of the hills on a contour maybe 5m above the normal ground level. Where the canal crosses a valley to pick up the next hill, it is raised on an embankment. Where a large hill blocks the path of the canal and it was not economical to follow the contour around the hill then the hill was excavated to form a cutting which carries the canal through the hill in a manmade valley. If the hill was too high to form a cutting, then as a last resort, the canal would be carried through the hill in a tunnel. Where the local ground level starts to drop away, the canal is carried on an embankment of steadily increasing height until it approaches the 5m height at which time a lock is inserted into the system to lower the canal by 2 or 3 m to the next contour line. This system of following contours eventually brings the canal to the same level as the Wey Navigation at New Haw near Byfleet in Surrey. Over its 32 mile length, it remains level for the 15 miles from Greywell to Aldershot in Hampshire and then drops by approx 60m over the next 17 miles to the Wey Navigation in Surrey. When the canal was built it was only required to excavate a ledge around a hill, the spoil was then piled up on the downhill side of the excavation to form a bank to keep the water in, and hence total excavation and haulage distances were reduced.

By 1964, the canal was almost completely derelict as The New Basingstoke Canal Company had allowed maintenance issues to mount. On September 15th 1968, due to its neglect and following a period of exceptionally heavy rain, the canal burst its banks in two places, an event which led to the restoration of the Basingstoke Canal. The canal is now fully navigable, and connects to the River Wey Navigation, which in turn joins the River Thames.

After the realisation that the canal could not be managed as two halves, both Hampshire County Council and Surrey County Council, handed control of management and maintenance of the Basingstoke Canal to the Basingstoke Canal Authority.

7.9.3 Interaction of the Canal with Other Watercourses

Within the Study Area flooding has been recorded in the vicinity of the Basingstoke Canal at Shawfield Road, Ash, in 1998. It is unknown whether the source of this flooding was the canal. The 30m weir on the Ash reach of the canal embankment discharges into an open channel maintained by the EA, which itself discharges into the River Blackwater. Under severe weather conditions the River Blackwater may flood and cause surcharging of this open channel. Discharge from the Ash embankment weir may result in overtopping of the open channel and a backwater effect in the land drains from Shawfield Road potentially resulting in flooding. This situation is further complicated and compromised by the privately owned fishing lake, which has installed a weir that discharges into this same drainage ditch. Shawfield Road flooded under severe weather conditions (August 2006) with the only discharge from the canal being 50mm flowing over the set weir crest. The flooding mechanisms in this area are complex and further investigation may be merited at individual sites.

As mentioned above sections of the Basingstoke Canal are embanked above surrounding levels. The work done to evaluate flood risk from the Basingstoke Canal in the 2009 SFRA has been re-digitised, and is shown in Volume 3, Figure 10. The maps show the indicative areas that are liable to flood in the event of an embankment breach and also the areas subject to residual flood risk from the Basingstoke Canal. These areas have been identified according to the mechanisms outlined below:

7.9.4 Breach of embankment

Throughout the Study Area, the Basingstoke Canal passes through low-lying land, (which at some sites was originally marshland and has been historically drained for development). Consequently the land particularly to the south of the canal has extensive drainage ditch networks in place. In the event of the canal breaching its banks, these drainage ditches would back-up or may have a surcharge effect and waterlog the surrounding areas causing flooding. This will affect drainage and possibly result in flooding remote from the canal.

7.9.5 Culvert Failure

There are many culverts under the Basingstoke Canal within the Study Area. These culverts enable the canal to pass over many minor watercourses. A blockage or collapse (resulting in blockage) of any of these culverts could result in extensive flooding and could also surcharge the land drainage system.

7.9.6 Flood Risk Associated with a Breach of the Canal

Flooding is a risk that must be considered in association with the Basingstoke Canal. As discussed earlier the contour style construction of the Basingstoke Canal requires that a ledge be excavated around the hill, for which the spoil is then placed on the downhill side of the excavation to form a bank to retain water. This form of construction is considered a low risk if construction is to currently accepted standards - spoil forming water retaining embankments 'keyed' into the hillside, is properly compacted in layers, has a well drained core to prevent saturation and potential slippage, and has a slope constructed to match angle of repose of the material used. It has been reported (2009) that the Basingstoke Canal embankment is not 'keyed' into the hill side, compaction is only a result of gravity over the past 200 years, there is no core drainage, and the embankments have slopes which exceed currently accepted standards. These factors make the Basingstoke Canal embankment inherently prone to failure.

There are historic records of the canal breaching its banks. Due to a lack of routine maintenance and a period of exceptionally heavy rainfall, the Basingstoke Canal breached its banks in two places on September 15th 1968. The first breach was at Farnborough and the second at Aldershot. The Aldershot breach caused limited damage, but did leave a substantial opening in the Ash embankment. Should the breach occur today it has potential to cause substantial damage. The Aldershot section of the canal is outside of the study area for this SFRA.

In addition to increased water levels within the canals as a direct effect of excessive rainfall, flood risk has been increased by large amounts of surface water runoff that have been diverted from road drains, camp parade grounds and railway line drainage into the canal during its working life.

The flood risk posed by the Basingstoke Canal has been considered within the Weir Protocols (instructions on the operation of the canal weirs held by the Basingstoke Canal Authority) and draining down procedures produced by The Basingstoke Canal Authority. There are three protocols in place for the Basingstoke Canal; Summer, Winter and Emergency (or severe weather) Protocols.

Summer Weir Protocols ensures that the adjustable sections of weirs in the Surrey section of the canal will be restored to their normal working heights to maintain full water levels in the canal. Winter Weir Protocols require the adjustable sections of weirs on the Surrey section of the canal to be reduced in height by 100mm to establish a flow on the canal towards the weirs. In the event of extreme rainfall or a canal emergency, the protocol states that the canal should be isolated into discrete sections, which can then be controlled via the use of sluices. In the case of a dire emergency it is advised in the protocol that the sluices are fully drawn to allow canal water to drain quickly. Although this would result in an immediate relief of flood risk to the area, it is likely that this action could cause flooding problems elsewhere in the vicinity. In such an event the EA would be informed of this magnitude of weir movement. It should be noted that flood risk from the Basingstoke Canal is considered a residual risk. In accordance with NPPF downhill of the retaining embankment may be classified as a Rapid Inundation Zone. This is an area which is at risk of rapid flooding should a flood defence structure be breeched or overtopped. According to NPPF, wherever possible, new development should be located outside the Rapid Inundation Zone and away from existing flood defences. It is important that the residual risk of flooding from the canal is identified and that all applications for sites around the canal, even those that do not fall within flood zone 2 or 3, are required to provide an assessment of the risks to the site from a canal breach.

7.9.7 The Wey Navigation

The Wey Navigation is managed by the National Trust. The navigation is a combination of engineered channels separate from the river, and sections of navigable river. The sections of navigable river will flood with the river naturally, and therefore the extent of flooding is indicated by the modelled fluvial flood extents. The engineered sections should not flood, and are controlled by various weirs and gates. However some of the engineered sections are on perched embankments and therefore there is a small risk of breach or failure. Should there be a failure the gates controlling water flow through the engineered section of the navigation could be operated to isolate the breached section. Although a specific breach analysis has not been done as part of this SFRA it is anticipated that the flooding resulting from a breach would be within the extents of flooding indicated on the fluvial flood maps.

7.10 Management of Flooding from Artificial Sources in Guildford Borough

The information within the SFRA will be used by GBC to develop specific planning policy and guidance for Guildford borough that takes full account of flood risk now and in the future. These policies will be reported within future updates of the SFRA.

The planning policy and guidance which will be developed by GBC, discussed in Volume 1, may include some of the following measures:

- In areas where insufficient information on flood risk currently exists, there should be a requirement for those proposing the developments to provide detailed flood information.
- Continue to collect and record complete information on flood events from artificial sources that are reported to them.
- The requirement to provide inundation mapping and/or breach modelling for all sites which may potentially be impacted by a breach in the Basingstoke Canal.
- New development should be located outside the rapid inundation zones associated with the Basingstoke Canal unless it can be proved to the satisfaction of GBC that development in these areas can be made safe.
- New development should not be located immediately downstream of any reservoirs, and developments in close proximity should consider the reservoir flood risk map. This should be a risk based decision.
- Development proposed within 50m of the River Wey navigation should provide details of any potential risk from embankment or structure failure on the navigation and incorporate flood management measures where appropriate.

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8. Uncertainties in Flood Risk Assessment

When assessing risk, the impact of uncertainties associated with the predictions of the hazard and the consequences should be recognised and appreciated so informed decisions can be made.

This SFRA addresses the inherent uncertainties and where necessary seeks to institute measures for their reduction.

The strategy for risk management requires that all phases of the planning and implementation process are fully co-ordinated. The level of detail on flood risk assigned to particular proposals will be limited by the information available at the time of the submission of respective planning applications. It should be noted that the outputs of the SFRA are only as good as the data inputs.

Guildford Borough SFRA is owned by GBC and should be kept as a live document, reviewed and updated as necessary as the best available information is improved or the inherent uncertainties identified are reduced. Ownership of the SFRA document and maps within GBC will be established by the SFRA Steering Group. In particular it should be noted that an improvement in topographic data may result in a change in the flood extents presented in this SFRA. The implementation of measures or strategic options may change the Actual Risk, Residual Risk and Flood Hazard.

Other future uncertainties that will affect the estimate of flood risk in the Study Area during the course of the planning and implementation of the Guildford development options include (but are not limited to):

- Updated hydrological and hydraulic modelling studies.
- Changes to the upstream catchment and river channel.
- Changes in land use within and upstream of the study area.
- Revision of climate change predictions.

It is probable that development proposals will be a focus for the collection of better data in the future and the catalyst for commissioning studies that lead to a reduction in the uncertainty in the magnitude or frequency of influential parameters, i.e. the improvement of hydrometric data, or completion of new hydraulic models on previously unmodelled reaches. A prudent response is to use the best available data at each stage of the planning process and prepare proposals that are respectively precautionary in accordance with the advice in PPG and flexible with respect to uncertainty. The need to prepare stand alone Flood Risk Assessments in support of the submission of particular planning applications will serve to highlight information that would be the trigger for a review of Guildford Borough SFRA.

The Guildford Borough SFRA is based on information that will inevitably be amended by better data, changes in the baseline condition due to development and changing institutional and policy conditions. To be robust and able to withstand challenge in the planning process there is a need to ensure Guildford Borough SFRA reflects conditions at the time particular evaluations are made. Failure to maintain the SFRA may reduce the effectiveness of flood risk management measures, delay plan making and development processes; and potentially lead to the neglect of flood risk considerations and the failure to capture strategic responses and interventions.

The Planning Policy Team at GBC will have the prime responsibility for managing and maintaining this SFRA. The SFRA will be reviewed annually as part of the Monitoring Report.

8.1 Flood Risk from Rivers

The following section summarises the uncertainties associated with the hydraulic modelling on the River Wey.

The flows predicted using the hydrological analyses for the River Wey rely on data from a system of gauges that are generally not accurate at high flow magnitudes;

- The impact of global warming could result in a 20% increase in the magnitude of predicted peak flow contributions to the watercourses within the Study Area;
- Best available topographic data was used in production of the flood extents. However this topographic data is of limited accuracy due to the techniques used for its production. This has a significant bearing on the uncertainty and accuracy of the flood mapping produced;
- Not all watercourses in the Study Area have been specifically hydraulically modelled for this SFRA. Quantification of flood risk on these watercourses is subject to greater uncertainty; and
- The historic record of flooding is not complete and could be supplemented in future updates of the SFRA.

8.2 Flood Risk from Surface Water

The supporting guidance document to the UFMfSW highlights the limitations inherent to the dataset. The following uncertainties therefore apply to the flood risk from surface water:

Although the uFMfSW is a significant improvement on past nationally produced surface water flood mapping, it is important not to lose sight of the limitations which remain. These include the following:

- The methodology assumed a single drainage rate for all urban areas within the nationally produced modelling unless LLFAs were able to provide better local data. Modelled flood extents are particularly sensitive to the way drainage is taken into account. Omitting large subsurface drainage elements such as flood relief culverts and flood storage can also significantly affect the modelled pattern of flooding.
- The nationally produced modelling assumes a free outfall and so does not take into account tide locking or high river levels which may prevent surface water from draining away freely.
- Limited recorded surface water flood data exists for LLFAs , so in many places LLFAs have not yet been able to validate the nationally produced modelling.
- As with many other flood models:
    - The input information, model performance and modelling that was used to create the nationally produced modelling varies for different areas. For example, in many areas, the ground level data is based on detailed LIDAR information, but where this is not available ground levels are much less accurate. Similarly, models of this type tend to perform better in steeper rural areas than in flat urban areas. These variations affect the reliability of the mapped flood extents and, in turn, the suitability for different applications.
    - uFMfSW does not take individual property threshold heights into account so the map shows areas that may potentially flood but cannot accurately predict the impacts on individual properties.
    - The flood extents show predicted patterns of flooding based on modelled rainfall. The patterns of flooding from two similar storm events can vary due to many local circumstances.

Consequently these maps cannot definitively show that an area of land or property is, or is not, at risk of flooding, and the maps are not suitable for use at an individual property level.

8.3 Flood Risk from Sewers

Assessing the risk of sewer flooding over a wide area is limited by the lack of data and the quality of data that is available. Furthermore, flood events may be a combination of surface water, groundwater and sewer flooding.

An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are complex and require detailed information. Obtaining this information can be problematic as datasets held by stakeholders are often confidential, contain varying levels of detail and may not be complete. Sewer flood models require a greater number of parameters to be input and this increases the uncertainty of the model predictions.

Existing sewer models are generally not capable of predicting flood routing (flood pathways and receptors) in the above ground network of flow routes (for example streams, dry valleys, and highways).

Use of historic data to estimate the probability of sewer flooding is the most practical approach; however it does not take account of possible future changes due to climate change or future development. Nor does it account for improvements to the network, including clearance of blockages, which may have occurred.

8.4 Flood Risk from Groundwater

The supporting document to the British Geological Society outlines the limitations of the dataset and highlights the importance of using the information in conjunction with other flood risk data. The following is taken from the supporting document.

The susceptibility data is suitable for use for regional or national planning purposes where the groundwater flooding information will be used along with a range of other relevant information to inform land-use planning decisions. It might also be used in conjunction with a large number of other factors, e.g. records of previous incidence of groundwater flooding, rainfall, property type, and land drainage information, to establish relative, but not absolute, risk of groundwater flooding at a resolution of greater than a few hundred metres. The susceptibility data should not be used on its own to make planning decisions at any scale, and, in particular, should not be used to inform planning decisions at the site scale. The susceptibility data cannot be used on its own to indicate risk of groundwater flooding.

8.5 Flood Risk from Artificial Sources

The reservoir flood map outline shows the largest area that might be flooded if the reservoir fails and releases all of the water it holds, which is extremely unlikely, and is a prediction of worst case scenario. Actual flood risk is considered to be much lower than these outlines show. The flood map does not include smaller reservoirs or reservoirs commissioned after 2009 (when mapping began).

Flood risk from the Basingstoke Canal has been assessed based on areas susceptible to breach, failure and overtopping. Degradation as well as maintenance of embankments and sluices will affect the risk of failure, which has not been considered in the assessment.

9. Summary

Evidence collected through this Level 1 SFRA highlights the areas in Guildford borough that are susceptible to flooding from a variety of sources. Flood sources include:

- Fluvial
- Surface Water
- Groundwater
- Sewers
- Artificial Sources.

Fluvial flood risk is concentrated along the River Valleys of the Wey and Blackwater and their tributaries. The areas at risk are constrained to well defined valley topography and there is little difference between the 1% AEP and 0.1% AEP event outlines. A 20% increase in river flows as a result of predicted climate change also do not show a very significant increase in flood risk to the developed areas of the borough. The main areas impacted by fluvial flood risk are Ash and Ash Vale along the Blackwater and Guildford town centre. In other areas, the floodplains remain largely undeveloped. The Functional Floodplain has been defined by the 5% AEP event where detailed modelling is available, and the developed areas along the banks of the River Wey through Guildford are at risk.

Surface water and sewer flooding have been considered using recorded incidents by the EA, GBC and SCC. Flood risk has been evaluated using the UFMfSW also. Most of the surface water flood risk is concentrated in the developed areas of Ash, Ash Vale and Guildford urban area, and are mostly parallel with the natural drainage patterns of ordinary watercourses Maintenance of small watercourses and structures has an important impact on local flooding mechanisms.

Groundwater flooding has been assessed using data from the British Geological society, and large areas along the River Valleys of the Blackwater and Wey have been identified as having potential for groundwater flooding to occur at the surface, based on underlying river terrace soils and Chalk and Greensand geology, combined with recorded depths to the water table. There are large areas in the northern half of the borough that are at very low risk of flooding from groundwater.

Areas that lie below the Basingstoke Canal that are currently protected by embanked ground are at low risk of flooding from the Canal due to breach of embankment or overtopping. These areas have been identified as south of Pirbright and a stretch to the east of Ash. Areas along the main River channels are at risk of flooding from the Broadwater Lake, Vachery Pond, Clandon Park and Mytchett Lake reservoirs. Although the consequences of reservoir failure are high, the probability of occurrence is very low and therefore flood risk from reservoirs is considered low.

Appendix A
Glossary

Term	Definition
Alluvium	Sediments deposited by fluvial processes / flowing water
Annual Exceedance Probability (AEP)	The probability of an event occurring within any one given year.
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Attenuation	In the context of this report - the storing of water to reduce peak discharge of water
Breach	An opening – For example in the sea defences
Brownfield	Previously developed land, usually of industrial land use within inner city areas.
Catchment Flood Management Plan	A high-level planning strategy through which the EA works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert/culverted	A channel or pipe that carries water below the level of the ground.
Drift Geology	Sediments deposited by the action of ice and glacial processes
EA Flood Zone 1	Low probability of flooding
EA Flood Zone 2	Medium probability of flooding. Probability of fluvial flooding is 0.1 – 1%. Probability of tidal flooding is 0.1 – 0.5 %
EA Flood Zone 3a	High probability of flooding. Probability of fluvial flooding is 1% (1 in 100 years) or greater. Probability of tidal flooding is 0.5%(1 in 200 years)
EA Flood Zone 3b	Functional floodplain
Estuary	A tidal basin , where a river meets the sea, characterised by wide inlets
Exception Test	The exception test should be applied following the application of the Sequential Test. Conditions need to be met before the exception test can be applied.
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood Resilience	Resistance strategies aimed at flood protection
Flood Risk	The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption)
Flood Risk Assessment	Considerations of the flood risks inherent in a project, leading to the development actions to control, mitigate or accept them.
Flood storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone	The extent of how far flood waters are expected to reach.

Fluvial	Relating to the actions, processes and behaviour of a water course (river or stream)
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Functional Floodplain	Land where water has to flow or be stored in times of flood.
Freeboard	Height of the flood defence crest level (or building level) above designed water level.
GIS	Geographic Information System – A mapping system that uses computers to store, manipulate, analyse and display data
Greenfield	Previously undeveloped land.
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Highly Vulnerable Developments	Developments that are at highest risk of flooding.
Hydraulic Modelling	A computerised model of a watercourse and floodplain to simulate water flows in rivers too estimate water levels and flood extents.
Hydrodynamic Modelling	The behaviour of water in terms of its velocity, depth and hazard that it presents.
Infiltration	The penetration of water through the grounds surface.
Infrastructure	Physical structures that form the foundation for development. Inundation Flooding.
LiDAR	Light Detection And Ranging – uses airborne scanning laser to map the terrain of the land.
Local Development Framework (LDF)	The core of the updated planning system (introduced by the Planning and Compulsory Purchase Act 2004). The LDF comprises the Local Development Documents, including the development plan documents that expand on policies and provide greater detail. The development plan includes a core strategy, site allocations and a proposals map.
Local Planning Authority	Body that is responsible for controlling planning and development through the planning system.
Main River	Watercourse defined on a 'Main River Map' designated by DEFRA. The EA has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Overtopping	Water carried over the top of a defence structure due to the wave height exceeding the crest height of the defence.
Reach/ Upper reach	A river or stream segment of specific length. The upper reach refers to the upstream section of a river.
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
Risk	The probability or likelihood of an event occurring.
River Catchment	The areas drained by a river
SAR	Synthetic Aperture Radar - a high resolution ground mapping technique, which uses reflected radar pulses.
Sequential Test	Aims to steer development to areas of lowest flood risk.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban

	drainage system.
Solid Geology	Solid rock that underlies loose material and superficial deposits on the earth's surface
Source Protection Zone	Defined areas in which certain types of development are restricted to ensure that groundwater sources remain free from contaminants.
Standard of Protection	The flood event return period above which significant damage and possible failure of the flood defences could occur.
Storm surge	A high rise in sea level due to the winds of the storm and low atmospheric pressure.
Sustainability	To preserve /maintain a state or process for future generations.
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs
Tidal	Relating to the actions or processes caused by tides.
Topographic survey	A survey of ground levels.
Tributary	A body of water, flowing into a larger body of water, such as a smaller stream joining a larger stream.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

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