Gloucester City Council Level 2 Strategic Flood Risk Assessment

Final Report

September 2019

www.jbaconsulting.com

Gloucester City Council

This page is intentionally left blank.

JBA Project Manager

Joanne Chillingworth
The Library
St Philip's Courtyard
Church End
Coleshill
B46 3AD

Revision History

Revision Ref/Date	Amendments	Issued to
29/03/2019 v1.0	Draft Report	Gloucester City Council
31/07/2019 v1.0	Addressed GCC, LLFA and EA comments	Gloucester City Council
22/08/2019 v2.0	Addressed final City Council comments	Gloucester City Council
06/09/2019 v3.0	Addressed final City Council comments	Gloucester City Council

Contract

This report describes work commissioned by Gloucester City Council, by an email dated 17th February 2019. Joanne Chillingworth and Lucy Finch of JBA Consulting carried out this work.

Prepared by ..... Lucy Finch BSc
Analyst

Joanne Chillingworth BSc MSc MCIWEM C.WEM
Principal Analyst

Reviewed by ..... Hannah Coogan BSc MCIWEM C.WEM
Technical Director

Purpose

This document has been prepared as a Final Report for Gloucester City Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Gloucester City Council.

Acknowledgements

We would like to acknowledge the assistance of:

- Gloucester City Council;
- Gloucestershire County Council;
- Environment Agency;
- Severn Trent Water; and
- Canal and River Trust.

Copyright

Carbon Footprint

A printed copy of the main text in this document will result in a carbon footprint of 371g if 100% post-consumer recycled paper is used and 472g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is aiming to reduce its per capita carbon emissions.

Executive summary

Introduction and context

This Level 2 Strategic Flood Risk Assessment (SFRA) 2019 document undertakes a Level 2 assessment of site options identified for potential allocation within the City Plan. It builds upon the Level 1 SFRA (2007) and Level 2 SFRA (2011) originally published by the Gloucester, Cheltenham and Tewkesbury Joint Core Strategy (JCS) group and subsequent Addendums, but it is specific to Gloucester City administrative area.

It involves the assessment of new proposed development sites of which there are 24 being assessed in this Level 2 assessment. In addition, since the previous SFRAs were published, there have been updates to national and local planning policy and guidance. This 2019 Level 2 SFRA has updated information on surface water management and Sustainable Drainage Systems (SuDS), guidance for site-specific Flood Risk Assessments (FRAs) and opportunities to reduce flood risk to existing communities within Gloucester City, due to the revisions to national and local planning policy and guidance.

SFRA objectives

The Planning Practice Guidance (PPG) advocates a tiered approach to risk assessment and identifies the following two levels of SFRA:

- **Level One:** where flooding is not a major issue in relation to potential development sites and where development pressures are low. The assessment should be sufficiently detailed to allow application of the Sequential Test.
- **Level Two**: where land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development creating the need to apply the NPPF's Exception Test. In these circumstances, the assessment should consider the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

The objectives of this Level 2 SFRA update are to:

1 Provide individual flood risk analysis for site options using the latest available flood risk data, thereby assisting the Council in applying the Exception Tests to its proposed site options in preparation of its Local Plan.

2 Where available, re-run existing hydraulic modelling to account for the effects of climate change and any residual risk. Where flood risk information is unavailable or limited, conduct appropriate hydraulic modelling where possible to determine the flood risks to the proposed site options.

3 Using available data, provide information and a comprehensive set of maps presenting flood risk from all sources for each proposed site options.

4 Where the Exception Test is required provide recommendations for making the site safe throughout its lifetime.

5 Take into account most recent policy and legislation in the NPPF, PPG and the Council's Supplementary Planning Guides. Using the documents provided, updating information on the requirements for site-specific FRAs, considerations for suitable surface water management methods and opportunities to reduce flood risk to the existing communities.

Level 2 SFRA outputs

The Level 2 assessment includes detailed assessments of the proposed site options. These include:

- An assessment of all sources of flooding including fluvial flooding, surface water flooding, groundwater flooding, mapping of the functional floodplain and the potential increase in fluvial flood risk due to climate change and blockage scenarios.

- Reporting on current conditions of flood defence infrastructure, where applicable.
- An assessment of existing flood warning and emergency planning procedures, including an assessment of safe access and egress during an extreme event.
- Advice and recommendations on the likely applicability of sustainable drainage systems for managing surface water runoff.
- Advice on appropriate policies for sites which could satisfy the first part of the Exception Test and on the requirements necessary for a site-specific FRA, supporting a planning application to pass the second part of the Exception Test.

Summary of Level 2 SFRA

Gloucester City Council provided 24 sites in total, which were screened against flood risk information. Of these 24 sites, 7 were taken forward to a Level 2 SFRA and detailed site summary tables have been produced. These sites are shown to be at risk of fluvial flooding from watercourses running either through or adjacent to the site.

The summary tables set out the flood risk to each site, including maps of extent, depth and velocity of flooding as well as hazard mapping for the 100-year defended event. Climate change mapping has also been produced for each site to indicate the impact which different climate change allowances may have on the site. Each table also sets out the NPPF requirements for the site as well as guidance for site-specific FRAs. A broadscale assessment of suitable SuDS options has been provided, giving an indication where there may be constraints to certain sets of SuDS techniques. This assessment is indicative and more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. It may be possible that those SuDS techniques highlighted as possibly not being suitable can be designed to overcome identified constraints. Where deemed required, culvert blockages were also presented to assess residual risk to sites.

To accompany each site summary table, there is an Interactive Geo-PDF map, with all the mapped flood risk outputs per site. This is displayed centrally, with easy-to-use 'tick box' layers down the right-hand side and bottom of the mapping, to allow easy navigation of the data.

The following points summarise the Level 2 assessment:

- All seven sites taken forward for a Level 2 assessment are covered by detailed Environment Agency hydraulic models: SA07 is covered by the Dimore Brook 2009 ESTRY-TUFLOW model, SA02 is covered by the Wotton Brook 2007 ISIS-TUFLOW model, SA08 and SA18 are covered by the River Twyver 2006 2D TUFLOW model and SA09, SA13 and SA24 are covered by the River Severn tidal model.
- All sites with a detailed Level 2 summary table are at fluvial flood risk. The degree of flood risk varies, with some sites being only marginally affected along their boundaries, and other sites being more significantly affected, which will require more detailed investigations on sequential site layouts, SuDS possibilities, safe access and egress etc.
- The majority of sites are at risk from surface water flooding, with more areas of ponding in the higher return period events. Surface water tends to follow topographic flow routes, for example along the watercourses or isolated pockets of ponding where there are topographic depressions. Surface water should be considered when assessing safe access and egress to and from the site.
- Climate change mapping indicates that flood extents will increase. As a result, the depths, velocities and hazard of flooding may also increase. The

significance of the increase tends to depend on the topography of site and the percentage allowance used. The Council and the Environment Agency require the 100-year plus 35% and 100-year plus 70% climate change scenarios to be considered in future developments. It should be noted that these figures may be subject to change over the lifetime of this Level 2 SFRA.

- Blockage locations were determined by visual inspection of the OS mapping and LIDAR in the vicinity of the site, to determine whether a structure upstream, downstream, or within the site could have an impact on the site. These may need to be considered as part of a site-specific assessment.
- No sites are located in a Groundwater Source Protection Zone or a Nitrate Vulnerable Zone.
- Site SA13 – Land at St Oswalds is the only site which has areas within it designated by the Environment Agency as being a historic landfill site. For this, site ground investigation will be required to determine the extent of the contamination and the impact this may have on SuDS. Pre-application discussions with the Environment Agency should be undertaken for this site in particular, as there are specific requirements for drainage due to the contamination and land movement from historic landfill.
- A strategic assessment was conducted of SuDS options using regional datasets. A detailed site-specific assessment of suitable SuDS techniques would need to be undertaken at site-specific level to understand which SuDS option would be best.
- For a number of sites, there is the potential for safe access and egress to be impacted by fluvial or surface water flooding. Consideration should be made to these sites as to how safe access and egress can be provided during flood events, both to people and emergency vehicles.

Recommendations

Assessing flood risk and developments

- The NPPF supports a risk-based and sequential approach to development and flood risk in England, so that development is located in the lowest flood risk areas where possible; it is recommended that this approach is adopted for all future developments within the City.
- A site-specific FRA is required for all sites in Flood Zone 2 or 3; developments over 1ha in Flood Zone 1; for developments less than 1 ha in Flood Zone 1 where there is a change to vulnerability classification or where the development could be affected by sources of flooding other than rivers and the sea; and for all developments located in an area which has been highlighted as having critical drainage problems (of which there are currently none in Gloucester). The FRA should be proportionate to the degree of flood risk, as well as the scale, nature and location of the development.
- It is recommended that the impact of climate change to a proposed site is considered as part of a FRA and that the percentage increases which relate to the proposed lifetime of the development and the vulnerability classification of the development is accounted for. This should be informed by latest Environment Agency guidance and requirements of Gloucester City Council.
- At a site-specific level, for any developments shown to be at residual flood risk, for example from a breach or overtopping (e.g. reservoir, canal, perched watercourse), it is recommended that a detailed hydraulic modelling study is carried out using Environment Agency guidance to assess the residual risk.

- Opportunities to reduce flood risk to wider communities could be sought through the regeneration of Brownfield sites and through reductions in the amount of surface water runoff generated on a site. The functional floodplain should be protected from development and returned to greenfield status (where possible).
- The Local Planning Authority (LPA), the Environment Agency and LLFA should be consulted to confirm the level of assessment required and to provide any information on any known local issues.
- When assessing sites not identified in the City Plan (windfall sites), developers should use evidence provided in this SFRA to apply the Sequential Test as well as provide evidence to show that they have adequately considered other reasonably available sites.
- The FRA should demonstrate that developments do not increase the likelihood or intensity of flood risk to third party development.
- To demonstrate the Exception Test has been passed, flood resilience design and emergency planning must be accounted for.
- The Environment Agency may require developers to consider the impacts of more extreme events in the appraisal of flood resilience design and emergency planning, i.e. the 100-year plus 70% climate change event for More Vulnerable developments in the Severn River Basin District.

Future developments

Development must seek opportunities to reduce the overall level of flood risk at the site, for example by:

- Reducing volume and rate of surface water runoff based on local planning policy and LLFA Guidance
- Locating development to areas with lower flood risk
- Leaving an 8m easement from top of bank to development on main rivers and ordinary watercourses to manage flood risk, facilitate watercourse access and provide green corridors
- Creating space for flooding
- De-culverting and removal of redundant structures
- Integrating green infrastructure into mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

The LPA should consult the PPG and Environment Agency's 'Flood Risk Standing Advice (FRSA) for Local Planning Authorities', published in March 2014, when reviewing planning applications for proposed developments at risk of flooding.

At the planning application stage, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances, published by the Environment Agency in February 2016 and due to be updated in 2019 to reflect UKCP18 data), inform development zoning within the site and prove, if required, whether the Exception Test can be passed.

The Sustainable Drainage SPG contains local requirements and guidance, some of which may differ from national guidance. This SPG will contain guidance relating to site-specific FRAs as well as drainage strategies.

It is recommended that as part of the early discussions relating to development proposals, developers discuss requirements relating to site-specific FRAs and drainage strategies, to identify any potential issues that may arise from the development proposals. The Council may seek technical advice and views from other Flood Risk Management Authorities; however, the

Council's pre-planning application advice service is separate to similar pre-application consultation services provided by other Risk Management Authorities (e.g. the EA) and the Council would expect developers to obtain pre-application advice from the relevant Risk Management Authority on a separate basis.

Promotion of SuDS

- A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals. New or re-development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff. Where possible developments must utilise the most sustainable form of drainage systems, in accordance with the SuDS hierarchy.
- Development should aim to achieve Greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough and if soils have adequate permeability to allow for SuDS techniques that are designed to encourage infiltration.
- Where sites lie within or close to aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration. Further restrictions may still be applicable, and guidance should be sought from the LLFA.
- Developers need to ensure that new development does not increase the surface water runoff rate from the site and should therefore contact the LLFA and other key stakeholders at an early stage to ensure surface water management is undertaken and that SuDS are promoted, implemented and designed to overcome site-specific constraints.
- Where SuDS are provided as part of a development, applicants should detail how it will be maintained in the long term.
- Drainage design requirements are set out in the Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG). The SPG states that Gloucester City Council will require the developed rate of runoff to be no greater than the greenfield runoff rate for a range of annual flow rate probabilities, up to and including the 6 hour 1 per cent AEP event (1 in 100-year) with an allowance for climate change.
- Gloucester City Council require developments to meet the CIRIA C753 water quality recommendations. All watercourses in Gloucester are currently classed as 'failing' and a requirement of the WFD is for these watercourses to achieve a 'good' status.
- The surface water discharge rate from brownfield sites should ideally be reduced to replicate greenfield rates. As a minimum, the surface water discharge rate on brownfield sites should be reduced by 40%, or the level set out in the latest Gloucester City/Gloucestershire County Council guidance, whichever is greater.
- Where long term storage is not provided, the peak discharge rate shall be limited to QBar (mean annual flood).

Infrastructure and access

- Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard should be identified and the use of developer contributions considered to fund improvements and

maintenance, in some cases in relation to the EA's Flood Warning Service (e.g. maintenance and improvements to flood gauges). None of the sites assessed in this Level 2 assessments are protected by formal flood defences, though this should be a consideration for any future windfall sites which may be located near to flood defences.

- Safe access and egress for residents and emergency and service vehicles will need to be demonstrated at all development sites.

Strategic flood risk solutions

- Floodplain restoration represents the most sustainable form of strategic flood risk solution, by allowing watercourses to return to a more naturalised state.
- The construction of new upstream storage schemes as part of upstream catchment-based approaches could be considered on a number of watercourses within the City; any which are rural in their upper reaches but have high levels of flood risk to urban areas in the downstream reaches are potential candidates, as the open land in the upper reaches can potentially provide the space for an attenuation area, providing benefit to the urban area downstream.
- If flood defences are to be constructed to protect a development site, it should be demonstrated that defences will not have a resulting negative impact on flood risk elsewhere, and that there is no net loss in floodplain storage.

Future flood management in Gloucester City

Gloucestershire County Council's Local Flood Risk Management Strategy (LFRMS) identifies policies and procedures to assist them with achieving and delivering the LFRMS. As the LLFA, Gloucestershire County Council will set out to achieve these by adopting a leadership role in Flood Risk Management in Gloucestershire, working in collaboration with key stakeholders and partners, including Gloucester City Council, to enable capacity building and transparent knowledge-sharing across the County, and to ensure SuDS are effectively accounted for in new developments. Cross-authority working should also include community engagement, to manage expectations about what can be achieved from a funding perspective and to help communities to become more self-resilient.

Contents

List of Figures

List of Tables

Abbreviations and glossary of terms

Term	Definition
1D model	One-dimensional hydraulic model
2D model	Two-dimensional hydraulic model
AEP	Annual Exceedance Probability – The probability (expressed as a percentage) of a flood event occurring in any given year.
AStGWf	Areas Susceptible to Groundwater flooding
Brownfield	Previously developed parcel of land
CC	Climate change - Long term variations in global temperature and weather patterns caused by natural and human actions.
CDA	Critical Drainage Area - A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, Main River and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.
CFMP	Catchment Flood Management Plan- A high-level planning strategy through which the Environment Agency 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.
CIRIA	Construction Industry Research and Information Association
Cumecs	The cumec is a measure of flow rate. One cumec is shorthand for cubic metre per second; also m^3/s.
Defra	Department for Environment, Food and Rural Affairs
Design flood	This is a flood event of a given annual flood probability, which is generally taken as: fluvial (river) flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year), or; tidal flooding with a 0.5% annual probability (1 in 200 chance each year), against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.
DTM	Digital Terrain Model
EA	Environment Agency
EU	European Union
Exception Test	Set out in the NPPF, the Exception Test is a method used to demonstrate that flood risk to people and property will be managed appropriately, where alternative sites at a lower flood risk are not available. The Exception Test is applied following the Sequential Test.
FCERM	Flood and Coastal Erosion Risk Management
FEH	Flood Estimation Handbook
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).
Flood Map for Planning	The Environment Agency Flood Map for Planning (Rivers and Sea) is an online mapping portal which shows the Flood Zones in England. The Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences and do not account for the possible impacts of climate change.
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG (Welsh Assembly Government).

Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Flood and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
FWA	Flood Warning Area
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a River
FRA	Flood Risk Assessment - A site-specific assessment of all forms of flood risk to the site and the impact of development of the site to flood risk in the area.
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FSA	Flood Storage Area
FWMA	Flood and Water Management Act
FWS	Flood Warning System
GI	Green Infrastructure – a network of natural environmental components and green spaces that intersperse and connect the urban centres, suburbs and urban fringe
Greenfield	Undeveloped parcel of land
Ha	Hectare
IDB	Internal Drainage Board
Indicative Flood Risk Area	Nationally identified flood risk areas based on the definition of 'significant' flood risk described by Defra and WAG.
JBA	Jeremy Benn Associates
Jflow	2D generalised hydrodynamic modelling software.
LFRMS	Local Food Risk Management Strategy
LIDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority - Local Authority responsible for taking the lead on local flood risk management
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NFM	Natural Flood Management
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NRD	National Receptor Database
NRIM	National Reservoir Inundation Mapping
NVZs	Nitrate Vulnerability Zones
Ordinary Watercourse	All watercourses that are not designated Main River. Local Authorities or, where they exist, IDBs have similar permissive powers as the Environment Agency in relation to flood defence work. However, the riparian owner has the responsibility of maintenance.

PFRA	Preliminary Flood Risk Assessment
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial flooding	Flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse or cannot enter it because the network is full to capacity.
PPS25	Planning Policy Statement 25: Development and Flood Risk – superseded by the NPPF and PPG
RBMP	River Basin Management Plan
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Return Period	Is an estimate of the interval of time between events of a certain intensity or size, in this instance it refers to flood events. It is a statistical measurement denoting the average recurrence interval over an extended period of time.
Riparian owner	A riparian landowner, in a water context, owns land or property, next to a river, stream or ditch.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Risk Management Authority (RMA)	Operating authorities who's remit and responsibilities concern flood and/or coastal risk management.
RoFfSW	Risk of Flooding from Surface Water (formerly known as the Updated Flood Map for Surface Water (uFMfSW)
Sequential Test	Set out in the NPPF, the Sequential Test is a method used to steer new development to areas with the lowest probability of flooding.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
SMP	Shoreline Management Plan
SoP	Standard of Protection - Defences are provided to reduce the risk of flooding from a river and within the flood and defence field standards are usually described in terms of a flood event return period. For example, a flood embankment could be described as providing a 1 in 100-year standard of protection.
SPD	Supplementary Planning Document
SPZ	(Groundwater) Source Protection Zone
Stakeholder	A person or organisation affected by the problem or solution or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
SuDS	Sustainable Drainage Systems - Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques
Surface water flooding	Flooding as a result of surface water runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse or cannot enter it because the network is full to capacity, thus causing what is known as pluvial flooding.

SWMP	Surface Water Management Plan - The SWMP plan should outline the preferred surface water management strategy and identify the actions, timescales and responsibilities of each partner. It is the principal output from the SWMP study.
WFD	Water Framework Directive – Under the WFD, all waterbodies have a target to achieve Good Ecological Status (GES) or Good Ecological Potential (GEP) by a set deadline. River Basin Management Plans (RBMPs) set out the ecological objectives for each water body and give deadlines by when objectives need to be met.

This page is intentionally left blank.

1 Introduction

1.1 Purpose of the Strategic Flood Risk Assessment

> ***"Strategic policies should be informed by a strategic flood risk assessment, and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting, local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards.".***
>
> (National Planning Policy Framework, paragraph 156)

This Level 2 Strategic Flood Risk Assessment (SFRA) 2019 document provides a Level 2 assessment of strategic sites identified for potential allocation within Gloucester City.

1.2 Levels of SFRA

The Planning Practice Guidance (PPG) advocates a tiered approach to risk assessment and identifies the following two levels of SFRA:

- **Level One:** where flooding is not a major issue in relation to potential development sites and where development pressures are low. The assessment should be sufficiently detailed to allow application of the Sequential Test.
- **Level Two:** where land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development creating the need to apply the National Planning Policy Framework's (NPPF) Exception Test. In these circumstances, the assessment should consider the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding.

This update fulfils the requirements of a **Level 2** SFRA.

1.3 SFRA objectives

The objectives of this 2019 Level 2 SFRA are to:

1 Provide individual flood risk analysis for site options using the latest available flood risk data, thereby assisting the Council in applying the Exception Tests to its proposed site options in preparation of its Local Plan.

2 Where available, re-run existing hydraulic modelling to account for the effects of climate change.

3 Using available data, provide information and a comprehensive set of maps presenting flood risk from all sources for each site option.

4 Where the Exception Test is required, provide recommendations for making the site safe throughout its lifetime.

5 Take into account most recent policy and legislation in the NPPF, PPG and the Council's 2013 Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG). Using these documents provided, updating information on the requirements for site-specific Flood Risk Assessments (FRAs), considerations for suitable surface water management methods and opportunities to reduce flood risk to the existing communities.

1.4 Context of the Level 2 assessment

A Gloucestershire-wide **Level 1 SFRA** was commissioned in 2007 by Gloucestershire County Council, in partnership with its Local Authorities including Gloucester City; the reports were published in 2008. Following this, a **Level 2 SFRA** was published in October 2011 to support the preparation of the Gloucester, Cheltenham and Tewkesbury JCS by assessing sites likely to be developed in flood risk areas. A subsequent **Level 2 Addendum** assessment was then carried out for the JCS in 2012 for additional site options. A **Level 2 SFRA data review** was also produced in January 2017 to support Gloucester City's Strategic Assessment of Land Availability (SALA).

The Joint Core Strategy was adopted in December 2017; its strategic development plan sets out how the area will develop between 2011 and 2031. Following the adoption, an Issues and Options Consultation took place between November 2018 and January 2019.

This 2019 Level 2 SFRA builds on the work undertaken in those previous studies, rather than completely replacing it, but is specific only to Gloucester City. It involves the site-specific assessment for 24 new site options. In addition, there have been updates to national and local planning policy and guidance. This Level 2 SFRA has updated information on surface water management and sustainable drainage systems (SuDS), guidance for site-specific FRAs and opportunities to reduce flood risk within Gloucester due to the revisions to national and local planning policy and guidance.

1.5 SFRA Study Area

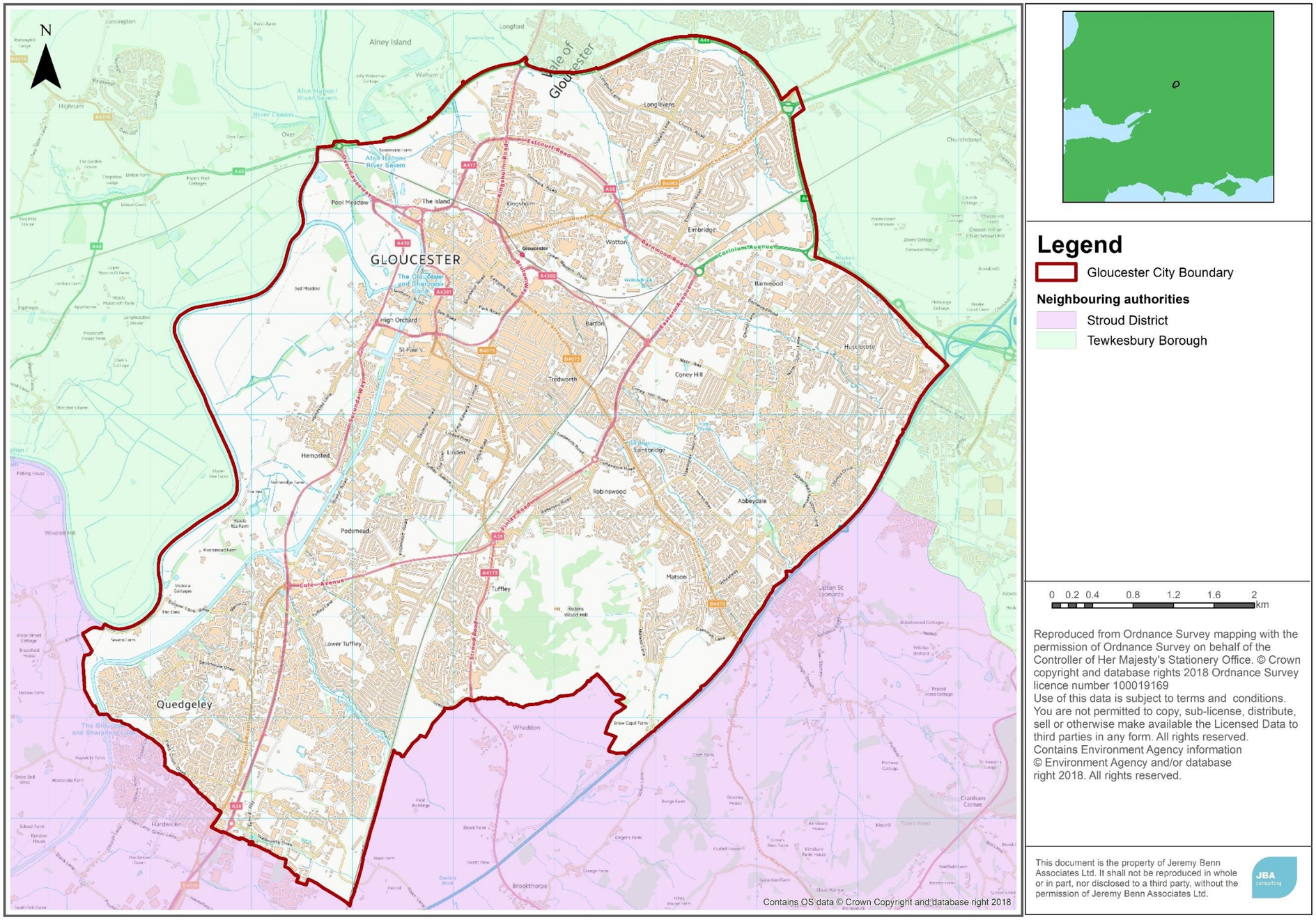
Gloucester City administrative area lies within the county of Gloucestershire and covers an area of approximately 40.54km^2 with a population of approximately 121,921 (2011 Census).

The main river in Gloucester is the River Severn, which at this point is tidally influenced. A number of smaller left-bank tributaries flow east to west through Gloucester from the Cotswold Hills.

The City is bounded by 2 other authorities; Tewkesbury Borough to the north and Stroud District to the south and east. The River Severn bounds the City to the west.

An overview of the study area is shown in Figure 1-1.

Figure 1-1 Study area



Legend

Gloucester City Boundary

Neighbouring authorities

Stroud District

Tewkesbury Borough

0 0.2 0.4 0.8 1.2 1.6 2 km

1.6 Consultation

SFRAs should be prepared in consultation with other risk management authorities. The following parties (external to Gloucester City Council) have been consulted during the preparation of this version of the SFRA:

- Environment Agency
- Gloucestershire County Council (LLFA)
- Canal and River Trust
- Severn Trent Water
- Neighbouring authorities including:
    - Tewkesbury Borough Council
    - Stroud District Council

1.7 SFRA user guide

Table 1-1 SFRA user guide

Section	Contents
1. Introduction	Provides a background to the study, defines objectives, outlines the approach adopted and the consultation performed.
2. The Planning Framework and Flood Risk Policy	Includes information on the implications of recent changes to planning and flood risk policies and legislation, as well as documents relevant to the study.
3. The Sequential, risk-based approach	Describes the Sequential Approach and application of Sequential and Exception Tests.
4. Impact of climate change	Outlines the latest EA guidance on climate change and how it has been adopted in this L2 SFRA.
5. FRA requirements and guidance for developers	Identifies the scope of the assessments that must be submitted in FRAs supporting applications for new development. Provides guidance for developers and outlines conditions set by the LLFAs that should be followed.
6. Surface water management and SuDS	Advice on managing surface water run-off and flooding
7. Cumulative impact of development and strategic solutions	Information on the potential cumulative impact of development and potential flood risk solutions in the City, for example flood storage schemes, catchment restoration etc.
8. Sources of information used in preparing the L2 SFRA	Outlines what information has been used in the preparation of this Level 2 SFRA, e.g. technical datasets.
9. Screening of site options	Outlines the sites carried forward to a review of flood risk and an overview of the outputs from the flood risk screening process.
10. Level 2 Assessment Methodology	Outlines the sites taken forward to the L2, what is provided in the site summary tables and associated mapping, and the hydraulic modelling methodology.
11. Summary of Level 2 assessment	Summary of SFRA findings
12. Recommendations	Summary of recommendations.
Appendix A: Level 2 assessment - Site summary tables and Interactive mapping	Overview table of flood risk at each site assessed in the L2 and Interactive Geo-PDF mapping showing the flood risk.

Hyperlinks to external guidance documents/websites are provided in **blue** throughout the SFRA.

Advice to users has been highlighted in **amber boxes** throughout the document.

2 The Planning Framework and Flood Risk Policy

2.1 Introduction

The overarching aim of development and flood risk planning policy in the UK is to ensure that the potential risk of flooding is taken into account at every stage of the planning process. This section of the Level 2 SFRA provides an overview of the planning framework, flood risk policy and flood risk responsibilities, given the changes since the previous SFRA publications. In preparing the subsequent sections of this SFRA, appropriate planning and policy amendments have been acknowledged and taken into account.

SFRAs contain information that should be referred to in responding to the Flood Risk Regulations and the formulation of local flood risk management strategies and plans. SFRAs are also linked to the preparation of Catchment Flood Management Plans (CFMPs), Surface Water Management Plans (SWMPs) and Water Cycle Strategies (WCSs).

2.2 Roles and responsibilities for Flood Risk Management in Gloucester City

There are a number of different organisations in and around Gloucester that have responsibilities for flood risk management, known as Risk Management Authorities (RMAs). These are shown on Table 2-1, with a summary of their responsibilities.

It is important to note that land and property owners are responsible for the maintenance of watercourses either on or next to their properties. Property owners are also responsible for the protection of their properties from flooding. More information can be found in the Environment Agency publication **Owning a watercourse** (2018).

When it comes to undertaking works to reduce flood risk, the Environment Agency and Gloucestershire County Council as LLFA do have powers, but limited resources must be prioritised and targeted to where they can have the greatest effect.

Table 2-1 Roles and responsibilities for flood risk management within Gloucester City

Risk Management Authority	Strategic Level	Operational Level	Planning role
Environment Agency	• Strategic overview for all sources of flooding • National Strategy • Reporting and general supervision	• Main rivers • Reservoirs	• Statutory consultee for development in Flood Zones 2 and 3
Gloucestershire County Council as Lead Local Flood Authority (LLFA)	• Preliminary Flood Risk Assessment • Local Flood Risk Management Strategy	• Surface Water • Groundwater • Ordinary Watercourses (consenting and enforcement) • Ordinary watercourses	• Statutory consultee for all major developments

		(works)	
Gloucester City Council as Local Planning Authority	• Local Plans as Local Planning Authorities	• Determination of Planning Applications as Local Planning Authorities • Managing open spaces under City Council ownership	• As left
Water Companies: *Severn Trent Water*	• Asset Management Plans supported by Periodic Reviews (business cases) • Develop Drainage and Wastewater management plans	• Public sewers	• Non-statutory consultee
Internal Drainage Board: Lower Severn IDB	• Water Level Management Plans	• Ordinary Watercourses within Internal Drainage Districts	• Non-statutory consultee
Highways Authorities: *Highways Agency (motorways and trunk roads)* *Gloucester City Council (other adopted roads)*	• Highway drainage policy and planning	• Highway drainage	• Internal planning consultee regarding highways and design standards and options

2.3 Relevant legislation

The following legislation is relevant to development and flood risk in Gloucester:

- **Flood Risk Regulations (2009)** transpose the EU Floods Directive (2000) into UK law and require the Environment Agency and LLFAs to produce Preliminary Flood Risk Assessments (PFRAs) and identify where there are nationally significant Flood Risk Areas. For the Flood Risk Areas, detailed flood maps and a Flood Risk Management Plan is produced. This is a six-year cycle of work and the second cycle started in 2017. In 2018, the Environment Agency designated Gloucester as a nationally significant 'Flood Risk Area' with regards to fluvial and tidal flood risk.
- **Town and County Planning Act (1990)**, **Water Industry Act (1991)**, **Land Drainage Act (1991)**, Environment Act (2005) and **Flood and Water Management Act (2010)** – as amended and implanted via secondary legislation. These set out the roles and responsibilities for organisations that have a role in FRM.

- **Land Drainage Act (1991)** and **Environmental Permitting Regulations (2016)** also set out where developers will need to apply for additional permission (as well as Planning Permission) to undertake works to an ordinary watercourse or Main River.
- **Water Environment Regulations (2017)** transpose the European Water Framework Directive (2000) into law and require the Environment Agency to produces River Basin Management Plans (RBMPs). These aim to ensure that the water quality of aquatic ecosystems, riparian ecosystems and wetlands reach 'good status'.
- Other environmental legislation such as the Habitats Directive (1992), Environmental Impact Assessment Directive (2014) and Strategic Environmental Assessment Directive (2001) also apply as appropriate to strategic and site-specific developments to guard against environmental damage.

2.4 Relevant flood risk policy and strategy documents

Table 2-2 summarises some of the relevant national, regional and local flood risk policy and strategy documents and how these apply to development and flood risk. There are hyperlinks to the documents in the table. These documents may:

- Provide useful and specific local information to inform flood risk assessments within the local area.
- Set the strategic policy and direction for Flood Risk Management (FRM) and drainage – they may contain policies and action plans that set out what future mitigation and climate change adaptation plans may affect a development site. A developer should seek to contribute in all instances to the strategic vision for FRM and drainage in Gloucester City.
- Provide guidance and/ or standards that informs how a developer should assess flood risk and/ or design flood mitigation and SuDS.

Table 2-2 National, regional and local flood risk policy and strategy documents

	Document, lead author and date	Information	Policy and measures	Development design requirements	Next update due
National	**Flood and Coastal Management Strategy** (Environment Agency) 2011	No	Yes	No	2019
	National Planning Policy Framework and Guidance (MCHLG) 2018/2015	No	No	Yes	2019 updates to NPPG
	Building Regulations Part H (MCHLG) 2010	No	No	Yes	-
Regional	**River Severn Catchment Flood Management Plan** (Environment Agency) 2009	Yes	Yes	No	-
	Severn Tidal Tributaries Catchment Flood Management Plan (Environment Agency) 2009	Yes	Yes	No	-
	Severn River Basin Management Plan (Environment Agency) 2015	No	Yes	No	2021
	Climate Change guidance for development and flood risk (Environment Agency) 2016	No	No	Yes	2019
Local	**Gloucestershire SuDS Design and Maintenance Guide** (Gloucestershire County Council) 2015	No	No	Yes	-
	Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG) (Gloucester City Council) 2013)	No	No	Yes	-

	Document, lead author and date	Information	Policy and measures	Development design requirements	Next update due
	Gloucestershire Surface Water Management Plans (SWMPs) (Gloucestershire County Council) 2014	Yes	Yes	Yes	-
	Gloucestershire Local Flood Risk Management Strategy (Gloucestershire County Council) 2014	Yes	Yes	No	2021
	Drainage and Wastewater Management Plan (Severn Trent Water) due 2023	Yes	Yes	No	-

2.5 Relevant flood risk management studies and documents

2.5.1 Gloucestershire County Council Local Flood Risk Management Strategy (2014)

Gloucestershire County Council is responsible for developing, maintaining, applying and monitoring a LFRMS. The **most recent Strategy** was published in 2014 and is used as a means by which the LLFA co-ordinates Flood Risk Management on a day-to-day basis.

The six high-level objectives proposed in the strategy for managing flood risk include:

- Improve understanding of local flood risk
    - Identify hotspots of flooding, undertake studies in areas of greatest flood risk, establish and maintain an asset register, map flood incidents and investigate locally significant incidents.
- Put in place plans to manage these risks
    - Annually identify and plan local investment needs in flood risk management, ensure local flood risk management achieves wider benefits for local communities and the environment and contributes to achieving environmental objectives and ensure new capital schemes have maintenance regimes which are followed.
- Avoid inappropriate development and ensure new development does not increase flooding elsewhere
    - Ensure LPAs use the best available information on local flood risk to inform spatial planning, work closely with County and City planners, ensure SuDS guidance is followed and seek earlier consultation with developers to ensure they understand and follow drainage requirements at the earliest stage.
- Increase public awareness of flooding and encourage local communities to take action
    - Work with communities to build awareness and develop understanding of flood risk and aim to get them involved in local flood risk management.
- Ensure close partnership working and co-ordination with other risk management authorities in Gloucestershire
    - Improve co-ordination and partnership working with local communities, ensure all RMAs roles and responsibilities are clarified and achieved and facilitate effective sharing of information between RMAs.
- Support response to, and recovery from, flooding incidents
    - Encourage the formation of local flood action groups, encourage communities to sign up to flood warnings and support communities and individuals in the event of floods.

2.5.2 LLFAs, surface water and SuDS

The 2019 NPPF states that: 'Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate' (Para 165). When considering planning applications, local planning authorities should consult the LLFA on the management of surface water in order to satisfy that:

- The proposed minimum standards of operation are appropriate

- Through the use of planning conditions or planning obligations there are clear arrangements for on-going maintenance over the development's lifetime

Gloucestershire Country Council's requirements for new developers on SuDS are set out on their **website**, alongside supporting documents. At the time of writing this SFRA, documents and policies relevant to SuDS and surface water in Gloucester are:

- **SuDS Design and Maintenance Guide** (Gloucestershire County Council, 2015);
- **Standing Advice and Development Guidance** (Gloucestershire County Council, 2015);
- **FRA Guidance** (Gloucestershire County Council, 2015);
- **Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG)** (Gloucester City Council, 2013);
- **SWMPs** for North, Central and South Gloucester (Gloucestershire County Council, 2014)
- **Joint Core Strategy** Policy INF2: Flood Risk Management (Joint Core Strategy, 2017)

The 2019 NPPF states that flood risk should be managed "using opportunities provided by new development to reduce causes and impacts of flooding." As such, Gloucester City Council expects SuDS to be incorporated on minor development as well as major development.

2.5.3 Surface water management plans

Surface Water Management Plans (SWMPs) outline the preferred surface water management strategy in a given location. SWMPs are undertaken, when required, by LLFAs in consultation with key local partners who are responsible for surface water management and drainage in their area. SWMPs establish a long-term action plan to manage surface water in an area and are intended to influence future capital investment, drainage maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

Gloucestershire County Council's SWMPs cover North, Central and South Gloucester and are available on their **website**. The SWMPs identify flooding hotspots and provide recommendations and objectives to reduce flooding in these areas. The outputs from these SWMPs have been used to inform the cumulative impact assessment in Section 7.

2.5.4 Catchment Flood Management Plans

Catchment Flood Management Plans (CFMPs) are a high-level strategic plan providing an overview of flood risk across each river catchment. The Environment Agency use CFMPs to work with other key-decision makers to identify and agree long-term policies for sustainable flood risk management.

North-east of Gloucester City is covered by the **River Severn CFMP** and the rest of the City is covered by the **Severn Tidal Tributaries CFMP**. Gloucester City is covered by "Policy Option 5 – Areas of moderate to high flood risk where we can generally take further action to reduce flood risk in both CFMPs. In the CFMPs there are specific 'actions' to manage flood risk in the area. Those relevant to Gloucester City Council in relation to strategic flood risk mitigation are:

- Ensure floodplains are not inappropriately developed. Follow the 'sequential approach' of NPPF and consider land swapping opportunities.
- Encourage urban best practices in land-use to restore more sustainable natural floodplains and to reduce run-off.
- Maintain flood warning systems and explore opportunities to improve how effective they are.
- Ensure run-off from proposed development is minimised, e.g. SuDS must be encouraged and targeted with planning approvals. Encourage the retro-fitting of SuDS where surface water flooding is already a problem.
- Develop better understanding of flooding from surface water, from drainage systems and from 'non-main' watercourses. Produce a strategy for operation and investment, integrating all these with main rivers, including those where tide-locking causes flooding.
- Review how effective and sustainable each flood defence is, review maintenance operations to make sure they are proportionate to flood risk and remove sediment more frequently from key points on the Dimore Brook.
- Raise awareness of flooding among the public and key partners, especially major operators of infrastructure, allowing them to be better prepared. Encourage them all to increase the resilience and resistance of vulnerable buildings, infrastructure and businesses at risk of flooding.
- Manage the undeveloped floodplain or targeted storage of flood water (north-east Gloucester).
- Encourage compatibility between urban open spaces and their ability to make space for rivers to expand as flood flows occur (north-east Gloucester).
- Maintain flood warning systems and explore opportunities to improve their effectiveness and coverage. Facilitate studies on the River Twyver in Gloucester (north-east Gloucester).
- Seek opportunities to sustain and increase the amount of floodplain grazing on the lower reaches of the Gloucester Streams (tidal Gloucester).

2.5.5 River Basin Management Plans

The WFD requires the production of Management Plans for each River Basin District. River Basin Management Plans (RBMPs) aim to ensure that all aquatic ecosystems, riparian ecosystems and wetlands reach 'good status'. To achieve 'good status', a waterbody must be observed to be at a level of ecological and chemical quality.

Gloucester falls within the Severn River Basin District. The RBMPs highlight a number of actions to a number of issues raised either within the District as a whole or in sub Districts. Further information can be found in the **RBMP** and the **Catchment Based Approach (CaBA) website**.

This page is intentionally left blank.

3 The sequential, risk-based approach

The NPPF advocates a sequential approach to development allocation via the Sequential Test. This approach is designed to ensure areas with little or no risk of flooding (from any source) are developed in preference to areas at higher risk, with the aim of keeping development outside of medium and high flood risk areas (Flood Zones 2 and 3) and other sources of flooding, where possible. The sequential approach can be applied both between and within Flood Zones. Table 3-1 describes the Flood Zones from the Flood Map for Planning.

The preference when allocating land is, whenever possible, to place all new development on land in Zone 1.

However, it is often the case that it is not possible for all new development to be allocated on land that is not at risk from flooding. In these circumstances the Flood Zone maps (that show the extent of inundation assuming that there are no defences) are too simplistic and a greater understanding of the scale and nature of the flood risks is required. In these instances, the Exception Test will be required.

The risk from other sources, such as surface water, smaller watercourses and groundwater also needs to be considered. The information in this SFRA can be used to help screen for such issues. A site in Flood Zone 1 may still be at high risk from other sources.

Table 3-1 Flood Zone descriptions

Zone	Probability	Description
Zone 1	Low	This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
		All land uses are appropriate in this zone.
		For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment.
Zone 2	Medium	This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1% - 1%) or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1% – 0.5%) in any year.
		Essential infrastructure, water compatible infrastructure, less vulnerable and more vulnerable land uses (as set out by NPPF) as appropriate in this zone. Highly vulnerable land uses are allowed as long as they pass the Exception Test.
		All developments in this zone require an FRA.
Zone 3a	High	This zone comprises land assessed as having a greater than 1 in 100 annual probability of river flooding (>1.0%) or a greater than 1 in 200 annual probability of flooding from the sea (>0.5%) in any year Developers and the local authorities should seek to reduce the overall level flood risk, relocating development sequentially to areas of lower flood risk and attempting to restore the floodplain and make open space available for flood storage.
		Water compatible and less vulnerable land uses are permitted in this zone. Highly vulnerable land uses are not permitted. More vulnerable and essential infrastructure are only permitted if they pass the Exception Test.
		All developments in this zone require an FRA.

Zone 3b	Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone in discussion with the LPA and the Environment Agency. The identification of functional floodplain should take account of local circumstances.
		Only water compatible and essential infrastructure are permitted in this zone and should be designed to remain operational in times of flood, resulting in no loss of floodplain or blocking of water flow routes. Infrastructure must also not increase flood risk elsewhere.
		All developments in this zone require an FRA.

Important note on Flood Zone information in this SFRA

The Flood Zones presented in Appendix A Geo-PDFs are the same as those shown on the Environment Agency's '**Flood Map for Planning**' at the time of publication, with the exception of the Dimore Brook, which is not included in the Environment Agency's Flood Zones, therefore the detailed modelled outputs were used to represent Flood Zones 2 and 3 in this area.
The Environment Agency Flood Zones do not cover all catchments or ordinary watercourses. As a result, whilst the Environment Agency Flood Zones may show an area is in Flood Zone 1, it may be that there is actually a degree of flood risk from smaller watercourses not shown in the Flood Zones.
Functional floodplain (Flood Zone 3b) is identified as land which would flood with an annual probability of 1 in 20 years; where detailed hydraulic modelling exists. The 1 in 20-year flood extent has been used to represent Flood Zone 3b (or 1 in 25-year in the absence of 1 in 20-year), provided by the Environment Agency. For areas outside of the detailed model coverage, or where no outputs were available, Flood Zone 3a can be used as a conservative indication. Further work should be undertaken as part of a detailed site-specific Flood Risk Assessment to define the extent of Flood Zone 3b where no detailed modelling exists.

3.1 Applying the Sequential and Exception Test in preparation of a Local Plan

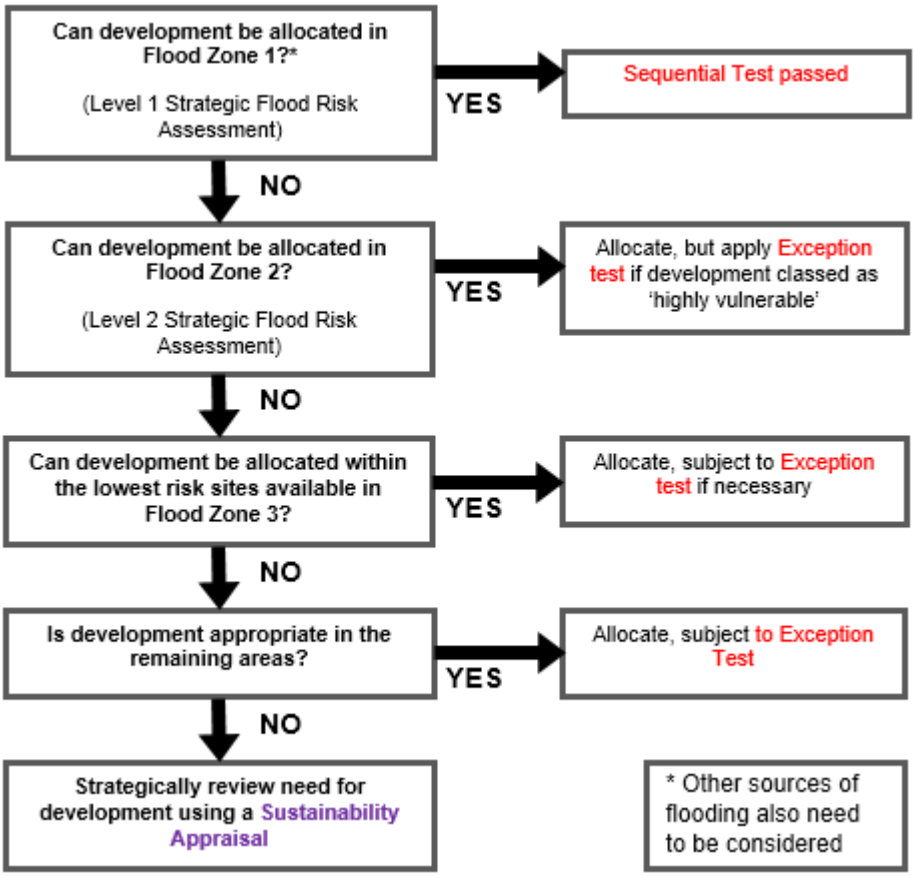
When preparing a Local Plan, the Local Planning Authority should demonstrate it has considered a range of site allocations, using SFRAs to apply the Sequential and Exception Tests where necessary.

The LPA will apply the Sequential Test to strategic allocations. For all other developments, developers must supply evidence to the LPA, with a Planning Application, that the development has passed the test.

The LPA should work with the Environment Agency to define a suitable area of search for the consideration of alternative sides in the Sequential Test. The Sequential Test can be undertaken as part of a Local Plan Sustainability Appraisal. Alternatively, it can be demonstrated through a free-standing document, or as part of Strategic Housing Land or Employment Land Availability Assessments.

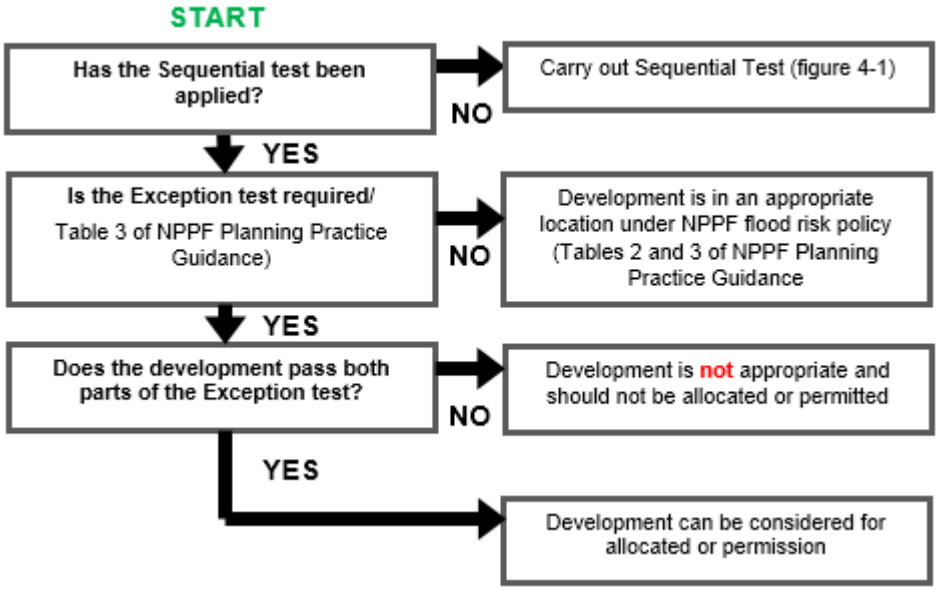
NPPF Planning Practice Guidance for Flood Risk and Coastal Change describes how the Sequential Test should be applied in the preparation of a Local Plan.

Figure 3-1 Applying the Sequential Test in the preparation of a Local Plan



The Exception Test should only be applied following the application of the Sequential Test and as set out in Table 3 of the NPPF Planning Practice Guidance: Flood Risk and Coastal Change. The NPPF PPG describes how the Exception Test should be applied in the preparation of a Local Plan (Figure 3-2).

Figure 3-2 Applying the Exception Test in the preparation of a Local Plan



3.2 Applying the Sequential Test and Exception Test to individual planning applications

3.2.1 Sequential Test

Local circumstances must be used to define the area of application of the Sequential Test (within which it is appropriate to identify reasonably available alternatives). The criteria used to determine the appropriate search area relate to the catchment area for the type of development being proposed. For some sites this may be clear, in other cases it may be identified by other Local Plan policies. A pragmatic approach should be taken when applying the Sequential Test.

Gloucester City Council, with advice from the Environment Agency, are responsible for considering the extent to which Sequential Test considerations have been satisfied and will need to be satisfied that the proposed development would be safe and not lead to increased flood risk elsewhere.

The Sequential Test does not need to be applied for individual developments under the following circumstances:

- The site has been identified in development plans through the Sequential Test.
- Applications for minor development or change of use (except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site).

It is normally reasonable to presume and state that individual sites that lie in Zone 1 satisfy the requirements of the Sequential Test; however, consideration should be given to risks from all sources, areas with critical drainage problems and critical drainage areas and the increasing risk of flooding in the future.

The NPPG provides further detailed guidance in their **Sequential Test for applicants** guidance.

3.2.2 Exception Test

If, following application of the Sequential Test it is not possible for the development to be located in areas with a lower probability of flooding, the Exception Test must then be applied if deemed appropriate. The aim of the

Exception Test is to ensure that more vulnerable property types, such as residential development can be implemented safely and are not located in areas where the hazards and consequences of flooding are inappropriate for the lifetime of the proposed use of the property, therefore climate change may need to be considered. For the Test to be satisfied, both of the following elements have to be accepted for development to be allocated or permitted:

1 *Evidence of wider sustainability benefits to the community should be provided, for instance, through the sustainability appraisal. If a potential site allocation fails to score positively against the aims and objectives of the sustainability appraisal, or is not otherwise capable of demonstrating sustainability benefits, the local planning authority should consider whether the use of planning conditions and/or planning obligations could make it do so. Where this is not possible the Exception Test has not been satisfied and the allocation should not be made.*[1] .

2 *Wider safety issues need to be considered as part of the plan preparation. If infrastructure fails then people may not be able to stay in their homes. Flood warnings and evacuation issues therefore need to be considered in design and layout of planned developments. In considering an allocation in a Local Plan a level 2 Strategic Flood Risk Assessment should inform consideration of the second part of the Exception Test. See further information on making development safe from flood risk and on what is considered to be the lifetime of development.*[2]

The NPPF and **NPPG** provide detailed information on how the Test can be applied.

3.3 Actual and residual flood risk

3.3.1 Actual flood risk

If it has not been possible for all future development to be situated in Zone 1 then a more detailed assessment is needed to understand the implications of locating proposed development in Zones 2 or 3. The assessment of actual risk takes account of the presence of flood defences and provides a picture of the safety of existing and proposed development. It should be understood that the standard of protection afforded by flood defences is not constant and it is presumed that the required minimum standards for new development are that residential development should be protected against flooding with an annual probability of river flooding of 1% (1 in 100 chance of flooding) and tidal flooding of 0.5% (1 in 200 chance of flooding) in any year (whichever is the greater).

The assessment of the actual risk should take the following issues into account:

- The level of protection afforded by existing defences might be less than the appropriate standards and hence may need to be improved if further growth is contemplated.
- The flood risk management policy for the defences will provide information on the level of future commitment to maintain existing standards of protection. If there is a conflict between the proposed

1 NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 024 Reference ID: 7-024-20140306) March 2014

2 NPPF Planning Practice Guidance: Flood Risk and Coastal Change (paragraph 025, Reference ID: 7-025-20140306) March 2014

level of commitment and the future needs to support growth, then it will be a priority for this to be reviewed.

- The standard of safety must be maintained for the intended lifetime of the development. Over time, the effects of climate change will erode the present-day standard of protection afforded by defences and so commitment is needed to invest in the maintenance and upgrade of defences, if the present-day levels of protection are to be maintained, and where necessary, land secured and safe-guarded that is required for affordable future flood risk management measures.
- The assessment of actual risk can include consideration of the magnitude of the hazard posed by flooding. By understanding the depth, velocity, speed of onset and rate of rise of floodwater it is possible to assess the level of hazard posed by flood events from the respective sources. This assessment will be needed in circumstances where consideration is given to the mitigation of the consequences of flooding or where it is proposed to place lower vulnerability development in areas that are at risk from inundation.

3.4 Residual flood risk

3.4.1 Residual Flood Risk

Residual risk refers to the risks that remain in circumstances after measures have been taken to alleviate flooding (such as flood defences). It is important that these risks are quantified to confirm that the consequences can be safely managed e.g. in a failure/breaching of a flood defences scenario.

3.5 Review of developer Flood Risk Assessments

The Council should consult the Environment Agency's 'Flood Risk Standing Advice (FRSA) for Local Planning Authorities', last updated 28 February 2017 and Gloucestershire County Council's **'Flood Risk and Drainage Standing Advice'**, last revised in August 2015, when reviewing planning applications for proposed developments at risk of flooding. In addition to the LLFA's Flood Risk and Drainage Standing Advice, when considering planning permission for developments, planners may wish to consider the following:

- Will the natural watercourse system which provides drainage of land be adversely affected;
- Will a minimum 8m width access strip be provided adjacent to the top of both banks of any Main River and ordinary watercourses for maintenance purposes be appropriately landscaped for open space and biodiversity benefits;
- Will the development ensure no loss of open water features through draining, culverting or enclosure by other means and will any culverts be opened up;
- Have sustainable drainage systems been given priority to manage surface water flood risk;
- Will there be a betterment in the surface water runoff regime; with any residual risk of flooding, from drainage features either on or off site not placing people and property at unacceptable risk; and
- Have flood risk reduction opportunities been sought/improved in the proposed flood risk regime?

4 Impact of Climate Change

The Climate Change Act 2008 creates a legal requirement for the UK to put in place measures to adapt to climate change and to reduce carbon emissions by at least 80% below 1990 levels by 2050.

4.1 Revised climate change guidance

The Environment Agency published **updated climate change guidance** on 19 February 2016, which must now be considered in all new developments and planning applications.

These allowances are based on UK Climate Impacts predictions from 2009 which informed the peak river flow allowances published by the Environment Agency in February 2016.

In 2018, the government published new UK Climate Projections (UKCP18). The Environment Agency are currently using these to update their climate change guidance for new developments. Developers should check on the government website for the latest guidance before undertaking a detailed Flood Risk Assessment. At the time of writing this report, this was due in Spring 2019.

The UKCP18 contains high resolution mapping with peak river flow allowances at 1km grid scale that will be released in Spring 2019. The regional peak river flow allowances in the 2016 guidance may not change but planners and developers may need to consider the finer resolution data where it shows a significant difference to the regional averages.

The UKCP18 high resolution (daily and sub daily) rainfall projections are due to be published in late 2019. Following this, the Environment Agency may update the recommended peak rainfall allowances in their guidance for planners and developers.

The peak river flow allowances show the anticipated changes to peak flow by river basin district within which the subject watercourse resides. Once this is determined, guidance on uplift in peak flows are assigned for three allowance categories, Central, Higher Central and Upper End which are based on the 50th, 70th and 90th percentiles respectively. The allowance category to be used is based on the vulnerability classification of the development and the Flood Zones within which it resides.

These allowances (increases) are provided for three climate change 'epochs':

- Total potential change anticipated for '2020s' (2015 to 2039)
- Total potential change anticipated for '2050s' (2040 to 2069)
- Total potential change anticipated for '2080s' (2070 to 2115)

One or two of the percentiles are provided for each combination of vulnerability and flood zone, which in the latter case provides a 'range' of allowances. The peak river flow allowances show the anticipated changes to peak flow by river basin district, for three future epochs and percentiles, as shown in Table 4-1. The City lies within the Severn river basin district.

Table 4-1 Peak river flow allowances by river basin district

River basin district	Allowance category	Total potential change anticipated for '2020s' (2015 to 39)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Severn	Upper end	25%	40%	70%
	Higher central	15%	25%	35%
	Central	10%	20%	25%

4.1.1 High++ allowances

High++ allowances only apply in assessments for developments that are very sensitive to flood risk and that have lifetimes beyond the end of the century. Further information is provided in the Environment Agency publication, **Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities.**

4.1.2 Which peak river flow allowance to use?

The flood zone and flood risk vulnerability classification should be considered when deciding which allowances apply to the development or the plan. The guidance states the information in the tables below. Note that developments should consider the range of allowances identified for each vulnerability classification.

Flood Zone 2

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure		✓	✓
Highly vulnerable		✓	✓
More vulnerable	✓	✓	
Less vulnerable	✓		
Water compatible	None		

Flood Zone 3a

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure			✓
Highly vulnerable	Development not permitted		
More vulnerable		✓	✓
Less vulnerable	✓	✓	
Water compatible	✓		

Flood Zone 3b

Vulnerability classification	Central	Higher Central	Upper end
Essential infrastructure			✓
Highly vulnerable	Development not permitted		
More vulnerable			
Less vulnerable			
Water compatible	✓		

4.2 Peak rainfall intensity allowance

Increased rainfall affects river levels and land and urban drainage systems. The table below shows anticipated changes in extreme rainfall intensity in small and urban catchments.

For Flood Risk Assessments, both the central and upper end allowances should be assessed to understand the range of impact.

Table 4-2 Peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

4.3 Sea level allowances

Gloucester City is at risk from tidal-influenced flooding from the River Severn. As such, increases in sea level may have an impact on parts of the City and where necessary, this will need to be taken into account. The governments updated climate change guidance provides details of sea level allowance for certain epochs.

4.4 Using climate change allowances

To help decide which allowances to use to inform the flood levels that the flood risk management strategy will be based on for a development or development plan allocation, the following should be considered:

- likely depth, speed and extent of flooding for each allowance of climate change over time considering the allowances for the relevant epoch (2020s, 2050s and 2080s)
- vulnerability of the proposed development types or land use allocations to flooding
- 'built in' resilience measures used, for example, raised floor levels
- capacity or space in the development to include additional resilience measures in the future, using a 'managed adaptive' approach

4.5 Representing climate change in the L2 SFRA

For this SFRA update, the existing hydraulic models provided by the Environment Agency were re-run for climate change scenarios to account for the new climate change guidance. 2D generalised modelling techniques were used to model climate change along the Dimore Brook, as the original model could not be rerun due to missing files.

It should be noted that different mapping techniques have been applied, depending on the type of hydraulic model (e.g. 1D-2D or 1D-only). Ground levels will have been updated in some places along with newer model software versions since some of the much older models were originally run, and hence mapped outputs may differ slightly in some areas compared against the original studies.

Three scenarios were modelled to reflect the three climate change allowances for the '2080s' timeframe in the Severn River Basin District, therefore the 100-year plus 25%, 35% and 70% defended scenario.

The River Twyver model did not produce reliable results for climate change and therefore Flood Zone 2 has been shown as a conservative indication in this area. Updated modelling which will supersede the current model was being undertaken by another consultant at the time of writing this SFRA. Developers should contact Gloucester City Council for the latest updates on this modelling.

More detailed hydraulic modelling in these areas may be required at site-specific Flood Risk Assessment stage to confirm flood risk and climate change impacts.

This modelling was undertaken to assist the Council with the preparation of their Local Plan. Developers will need to undertake a more detailed assessment of climate change as part of the planning application process when preparing FRAs, using the percentage increases which relate to the proposed lifetime and the vulnerability classification of the development. The Environment Agency should be consulted to provide further advice for developers on how best to apply the new climate change guidance.

Climate change mapping has been provided in Appendix A: Geo-PDFs.

4.6 Impact of climate change in Gloucester

The types of climate change impact relevant to Gloucester City are:

- Milder wetter winters
- Hotter drier summers
- Increased rainfall intensity in summer months
- Faster responding catchments/sites
- Surcharging of piped systems and flooding as a result of poor capacity of structures is expected to increase
- Pressure on existing sewer systems effectively reducing their design standard, leading to more frequent flooding
- The prospect of droughts may increase

It is important to remember that even where flood extent may not significantly increase, flooding is likely to become more frequent under a climate change scenario. For example, what is currently an event with a 2% probability of occurring in any one year, may increase to say a 5% probability under climate change.

The impact of an event with a given probability is also likely to become more severe. For example, as water depths, velocities and flood hazard increase, so will the risk to people and property. Although qualitative statements can be made as to whether extreme events are likely to increase or decrease over the UK in the future, there is still considerable uncertainty regarding the magnitude of the localised impact of these changes.

This page is intentionally left blank.

5 FRA requirements and guidance for developers

The report provides a strategic assessment of flood risk in Gloucester. Prior to any construction or development, site-specific assessments will need to be undertaken so all forms of flood risk and any defences at a site are considered in more detail. Developers should, where required, undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances), to inform the sequential approach within the site and prove, if required, whether the Exception Test can be satisfied.

A detailed Flood Risk Assessment (FRA) may show that a site is not appropriate for development of a particular vulnerability or even at all. The Sequential and Exception Tests in the NPPF apply to all developments and an FRA should not been seen as an alternative to proving these tests have been met.

5.1 Principles for new developments

Apply the Sequential and Exception Tests

Developers must provide evidence that the Sequential Test has been passed for windfall developments. If the Exception Test is needed, they must also provide evidence that all parts of the Test can be met for all developments, based on the findings of a detailed Flood Risk Assessment.

Developers should also apply the sequential approach to locating development within the site. The following questions should be considered:

- Can risk be avoided through substituting less vulnerable uses or by amending the site layout?
- Can it be demonstrated that less vulnerable uses for the site have been considered and reasonably discounted? and
- Can layout be varied to reduce the number of people or flood risk vulnerability or building units located in higher risk parts of the site?

Consult with the statutory consultees at an early stage to understand their requirements

Developers should consult with the Environment Agency, Gloucestershire County Council as LLFA and Severn Trent Water as the water and sewerage company, at an early stage to discuss flood risk including requirements for site-specific FRAs, detailed hydraulic modelling and drainage assessment and design.

Consider the risk from all sources of flooding and that they are using the most up to date flood risk data and guidance

The SFRA can be used by developers to scope out what further detailed work is likely to be needed to inform a site-specific Flood Risk Assessment. At a site level, Developers will need to check before commencing on a more detailed Flood Risk Assessment that they are using the latest available datasets. Developers should apply the 2019 Environment Agency climate change guidance and ensure the development has taken into account climate change adaptation measures.

Ensure that development does not increase flood risk elsewhere and in line with the NPPF, seeks to reduce the causes and impacts of flooding

Chapter 6 sets out these requirements for taking a sustainable approach to surface water management. Developers should also ensure mitigation measures do not increase flood risk elsewhere and that floodplain compensation is provided where necessary.

Ensure the development is safe for future users

Consideration should first be given to minimising risk by planning sequentially across a site. Once risk has been minimised as far as possible, only then should mitigation measures be considered. Developers should consider both the actual and residual risk of flooding to the site.

Further flood mitigation measures may be needed for any developments in an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard.

Enhance the natural river corridor and floodplain environment through new development

Developments should demonstrate opportunities to create, enhance and link green assets. This can provide multiple benefits across several disciplines including flood risk and biodiversity/ ecology and may provide opportunities to use the land for an amenity and recreational purposes. Development that may adversely affect green infrastructure assets should not be permitted. Where possible, developers should identify and work with partners to explore all avenues for improving the wider river corridor environment.

Consider and contribute to wider flood mitigation strategy and measures in Gloucester and apply the relevant local planning policy

Wherever possible, developments should seek to help reduce flood risk in the wider area e.g. by contributing to a wider community scheme or strategy for strategic measures, such as defences or natural flood management or by contributing in kind by mitigating wider flood risk on a development site. Developers must demonstrate in an FRA how they are contributing towards this vision.

5.2 Requirements for site-specific Flood Risk Assessments

5.2.1 When is a FRA required?

Site-specific FRAs are required in the following circumstances:

- Proposals of 1 hectare or greater in Flood Zone 1.
- Proposals for new development (including minor development such as non-residential extensions, alterations which do not increase the size of the building or householder developments and change of use) in Flood Zones 2 and 3.
- Proposals for new development (including minor development and change of use) in an area within Flood Zone 1 which has critical drainage problems (as notified to the LPA by the Environment Agency).
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

An FRA may also be required for some specific situations:

- If the site may be at risk from the breach of a local defence (even if the site is actually in Flood Zone 1)
- Where evidence of historical or recent flood events have been passed to the LPA
- In an area of significant surface water flood risk.

5.2.2 Objectives of site-specific FRAs

Site-specific FRAs should be proportionate to the degree of flood risk, as well as appropriate to the scale, nature and location of the development. Site-specific FRAs should establish:

- whether a proposed development will be at risk of flooding, from all sources, both now and in the future, taking into account climate change;
- whether a proposed development will increase flood risk elsewhere;
- whether the measures proposed to deal with the effects and risks are appropriate;
- the evidence, if necessary, for the local planning authority to apply the Sequential Test; and
- whether, if applicable, the development will be safe and pass the Exception Test.

FRAs should follow the approach recommended by the NPPF (and associated guidance) and guidance provided by the Environment Agency, Gloucester City Council and Gloucestershire County Council. Guidance and advice for developers on the preparation of site-specific FRAs include:

- **Standing Advice on Flood Risk** (Environment Agency);
- **Flood Risk Assessment for Planning Applications** (Environment Agency);
- FRA Guidance Note (Environment Agency SHWG area);
- **'Flood Risk and Drainage Standing Advice'** (Gloucestershire County Council, 2015);
- **Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG)** (Gloucester City Council, 2013);
- **Site-specific Flood Risk Assessment: CHECKLIST** (NPPF PPG, Defra).

Guidance for local planning authorities for reviewing flood risk assessments submitted as part of planning applications has been published by Defra in 2015 – **Flood Risk Assessment: Local Planning Authorities**.

5.3 Local requirements for mitigation measures

5.3.1 Site layout and design

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development.

The NPPF states that a sequential, risk-based approach should be applied to try to locate more vulnerable land use away from flood zones, to higher ground, while more flood-compatible development (e.g. recreational space) can be located in higher risk areas. The sequential approach is followed to steer development into areas with the lowest probability of flooding and any assessment should take into account the flood risk vulnerability of land uses.

Waterside areas, or areas along known flow routes, can act as Green Infrastructure, being used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives. Landscaping should ensure safe access to higher ground from these areas and avoid the creation of isolated islands as water levels rise.

5.3.2 Modification of ground levels

Any proposal for modification of ground levels will need to be assessed as part of a detailed flood risk assessment.

Modifying ground levels to raise the land above the required flood level is an effective way of reducing flood risk to a particular site in circumstances where the land does not act as conveyance for flood waters. However, care must be taken as raising land above the floodplain could reduce conveyance or flood storage in the floodplain and could adversely impact flood risk downstream or on neighbouring land. Raising ground levels can also deflect flood flows, so analyses should be performed to demonstrate that there are no adverse effects on third party land or property.

Compensatory flood storage should be provided, and would normally be on a level for level, volume for volume basis on land that does not currently flood but is adjacent to the floodplain (in order for it to fill and drain). It should be in the vicinity of the site and within the red line of the planning application boundary (unless the site is strategically allocated). Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C62430.

Where proposed development results in a change in building footprint, the developer should ensure that it does not impact upon the ability of the floodplain to store or convey water and seek opportunities to provide floodplain betterment.

Raising levels can also create areas where surface water might pond during significant rainfall events. Any proposals to raise ground levels should be tested to ensure that it would not cause increased ponding or build-up of surface runoff on third party land.

5.3.3 Raised floor levels

If raised floor levels are proposed, these should be agreed with Gloucester City Council and the Environment Agency. The minimum Finished Floor Level (FFL) may change depending on the vulnerability and flood risk to the development.

The Environment Agency advises that minimum finished floor levels should be set 600mm above the 100-year plus climate change peak fluvial flood level and 200-year plus climate change peak tidal flood level, where the new climate change allowances have been used (see Chapter 4 for the climate change allowances). An additional allowance may be required because of risks relating to blockages to the channel, culvert or bridge and should be considered as part of an FRA.

Allocating the ground floor of a building for less vulnerable, non-residential, use is an effective way of raising living space above flood levels. Single storey buildings such as ground floor flats or bungalows are especially vulnerable to rapid rise of water (such as that experienced during a breach). This risk can be reduced by use of multiple storey construction and raised areas that provide an escape route.

Similarly, the use of basements should be avoided. Habitable uses of basements within Flood Zone 3 should not be permitted, whilst basement dwellings in Flood Zone 2 will be required to pass the Exception Test. Sleeping accommodation shall not be permitted on a particular floor level if the level of that floor is below the design flood level. Access should be situated 300mm above the design flood level and waterproof construction techniques used.

5.3.4 Flood storage compensation

For any development (both major and minor), that results in built volume below the design flood level (100-year plus climate change flood level), mitigation shall be required for loss in floodplain storage volume.

5.3.5 Development and raised defences

Construction of localised raised floodwalls or embankments to protect new development is not a preferred option, as a residual risk of flooding will remain. Compensatory storage must be provided where raised defences remove storage from the floodplain.

Where development is located behind, or in an area benefitting from defences, the residual risk of flooding must be considered.

5.3.6 Developer contributions

In some cases, and following the application of the Sequential Test, it may be appropriate for the developer to contribute to the improvement of flood defence provision that would benefit both proposed new development and the existing local community. Developer contributions can also be made to maintenance and provision of flood risk management assets, flood warning and the reduction of surface water flooding (i.e. SuDS).

5.4 Resistance and resilience measures

The consideration of resistance and resilience measures should not be used to justify development in inappropriate locations.

Having applied planning policy, there will be instances where developments, such as those that are water compatible and essential infrastructure are permitted in high flood risk areas. The above measures should be considered before resistance and resilience measures are replied on. The effectiveness of these forms of measures are often dependant on the availability of a reliable forecasting and warning system and the use of back up pumping to evacuate water from a property as quickly as possible. The proposals must include details of how the temporary measures will be erected and decommissioned, responsibility for maintenance and the cost of replacement when they deteriorate. The following measures are available:

Permanent barriers: Permanent barriers can include built up doorsteps, rendered brick walls and toughened glass barriers.

Temporary barriers: Temporary barriers consist of moveable flood defences which can be fitted into doorways and/or windows. The permanent fixings required to install these temporary defences should be discrete and keep architectural impact to a minimum. On a smaller scale, temporary snap on covers for airbricks and air vents can also be fitted to prevent the entrance of flood water.

Community resistance measures: These include demountable defences that can be deployed by local communities to reduce the risk of water ingress to a number of properties. The methods require the deployment of inflatable (usually with water) or temporary quick assembly barriers in conjunction with pumps to collect water that seeps through the systems during a flood.

Flood resilience measures: These measures aim to ensure no permanent damage is caused, the structural integrity of the building is not compromised and the clean up after the flood is easier. Interior design measures to reduce damage caused by flooding can include electrical circuitry installed at a higher level and water-resistant materials for floors, walls and fixtures.

5.5 Reducing flood risk from other sources

5.5.1 Groundwater

Groundwater flooding has a very different flood mechanism to any other and so many conventional flood mitigation methods are not suitable. The only way to fully reduce flood risk would be through building design (development form), ensuring floor levels are raised above the water levels caused by a 1 in

100-year plus climate change fluvial event. Site design would also need to preserve any flow routes followed by the groundwater overland to ensure flood risk is not increased downstream.

Infiltration SuDS can cause increased groundwater levels and subsequently may increase flood risk on or off a site. Developers should provide evidence and ensure that this will not be a significant risk.

5.5.2 Surface water and sewer flooding

Developers should discuss public sewerage capacity with the water utility company at the earliest possible stage. It is important that a Surface Water Drainage Strategy (often done as part of a Flood Risk Assessment) shows that this will not increase flood risk elsewhere, and that the drainage requirements regarding runoff rates and SuDS for new development are met. More information on surface water drainage can be found in Chapter 6.

If residual surface water flood risk remains, the likely flow routes and depths across the site should be modelled. The site should be designed so that these flow routes are preserved and building design should provide resilience against this residual risk.

When redeveloping existing buildings, the installation of some permanent or temporary floodproofing and resilience measures could protect against both surface water and sewer flooding. Non-return valves prevent water entering the property from drains and sewers. Non-return valves can be installed within gravity sewers or drains within a property's private sewer upstream of the public sewerage system. These need to be carefully installed and must be regularly maintained.

Consideration must also be given to attenuation and flow ensuring that flows during the 100-year plus climate change storm event are retained within the site if any flap valves shut. This should be demonstrated with suitable modelling techniques.

5.5.3 Reservoirs

The risk of reservoir flooding is extremely low. However, there remains a residual risk to development from reservoirs which developers should consider during the planning stage:

- Developers should contact the reservoir owner for information on:
    - the Reservoir Risk Designation
    - reservoir characteristics: type, dam height at outlet, area/volume, overflow location;
    - operation: discharge rates / maximum discharge;
    - discharge during emergency drawdown; and
    - inspection / maintenance regime.
- The EA online Reservoir Flood Maps contain information on the extents, depths and velocities following a reservoir breach (note: only for those reservoirs with an impounded volume greater than 25,000 cubic metres are governed by the Reservoir Act 1975). Consideration should be given to the extent, depths and velocities shown in these online maps.

Developers should consult the Gloucestershire Local Resilience Forum about emergency plans for reservoir breach.

Developers should use the above information to:

- Apply the sequential approach to locating development within the site.

- Consider the impact of a breach and overtopping, particularly for sites proposed to be located immediately downstream of a reservoir. This should consider whether there is sufficient time to respond.
- Assess the potential hydraulic forces imposed by sudden reservoir failure event and check that that the proposed infrastructure fabric could withstand the structural loads.
- Develop site specific emergency plans if necessary and ensure the future users of the development are aware of these plans

5.6 Flood warning and emergency planning

Emergency planning covers three phases: before, during and after a flood. Measures involve developing and maintaining arrangements to reduce, control or mitigate the impact and consequences of flooding and to improve the ability of people and property to absorb, respond to and recover from flooding. National Planning Policy takes this into account by seeking to avoid inappropriate development in areas of flood risk and considering the vulnerability of new developments to flooding.

The NPPF (paragraph 163) requires site level Flood Risk Assessments to demonstrate that:

"d) any residual risk can be safely managed; and

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan."

Certain sites will need emergency plans:

- Sites with vulnerable users, such as hospitals and care homes.
- Camping and caravan sites.
- Sites with transient occupants e.g. hostels and hotels.
- Developments at a high residual risk of flooding from any source e.g. immediately downstream of a reservoir or behind raised flood defences.
- Situations where occupants cannot be evacuated (e.g. prisons) or where it is safer to remain "in-situ" and / or move to a higher floor or safe refuge area (e.g. at risk of a breach).

Emergency Plans will need to consider:

- The characteristics of the flooding e.g. onset, depth, velocity, hazard, flood borne debris.
- The vulnerability of site occupants.
- Structural safety.
- The impact of the flooding on essential services e.g. electricity, drinking water.
- Flood warning systems and how users will be encouraged to sign up for them.
- Safe access and egress for users and emergency services.
- How to manage the consequences of events that are un-foreseen or for which no warnings can be provided e.g. managing the residual risk of a breach.
- A safe place of refuge where safe access and egress and advance warning may not be possible, having discussed and agreed this first with emergency planners. Proposed new development that places an additional burden on the existing response capacity of the Councils will not normally be appropriate.

Gloucestershire County Council's **'Your Essential Flood Guide: Information and forward planning'** (updated 2012) provides Emergency Planning relevant information that is both general and flood specific. This includes practical advice before, during and after flooding has occurred including, preparation, understanding warnings, actions to limit exposure to risk and recovery.

Further information is available from:

- The **National Planning Policy Guidance**
- The Environment Agency and DEFRA's **standing advice for FRAs**
- Environment Agency's **"How to plan ahead for flooding"**
- Sign up for **Flood Warnings** with the Environment Agency
- The **National Flood Forum**
- GOV.UK - Make a Flood Plan guidance and templates

6 Surface water management and SuDS

6.1 Role of the LLFA and Local Planning Authority in surface water management

In April 2015, Gloucestershire County Council was made a statutory consultee on the management of surface water and, as a result, provides technical advice on surface water drainage strategies and designs put forward for major development proposals.

When considering planning applications, Gloucestershire County Council will provide advice to the Planning Department on the management of surface water. As LPA, Gloucester City Council should satisfy themselves that the development's proposed minimum standards of operation are appropriate and ensure through the use of planning conditions or planning obligations, that there are clear arrangements for on-going maintenance over the lifetime of the development.

It is essential that developers consider sustainable drainage at an early stage of the development process – ideally at the master-planning stage. This will assist with the delivery of well designed, appropriate and effective SuDS.

6.2 Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems (SuDS) are designed to maximise the opportunities and benefits that can be secured from surface water management practices.

SuDS provide a means of dealing with the quantity and quality of surface water and can also provide amenity and biodiversity benefits. Given the flexible nature of SuDS they can be used in most situations within new developments as well as being retrofitted into existing developments. SuDS can also be designed to fit into most spaces. For example, permeable paving could be used in parking spaces or rainwater gardens as part of traffic calming measures.

It is a requirement for all new major development proposals to ensure that sustainable drainage systems for management of runoff are put in place. Likewise, minor developments should also ensure sustainable systems for runoff management are provided. The developer is responsible for ensuring the design, construction and future/ongoing maintenance of such a scheme is carefully and clearly defined, and a clear and comprehensive understanding of the existing catchment hydrological processes and current drainage arrangements is essential.

6.3 Sources of SuDS guidance

6.3.1 C753 CIRIA SuDS Manual (2015)

The **C753 CIRIA SuDS Manual** (2015) provides guidance on planning, design, construction and maintenance of SuDS. The manual is divided into five sections ranging from a high-level overview of SuDS, progressing to more detailed guidance with progression through the document.

6.3.2 Non-statutory Technical Guidance, Defra (March 2015)

Non-Statutory Technical guidance provides non-statutory standards on the design and performance of SuDS. It outlines peak flow control, volume control, structural integrity, flood risk management and maintenance and construction considerations.

6.3.3 Gloucester City Sustainable Drainage Design and Adoption Guide

The Council has produced a number of topic-based Supplementary Planning Documents that have been adopted for the purposes of development control. In 2013, the **Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG)** was published.

The guide highlights the need for Sustainable Drainage, together with the principles and practice used to design the systems. It considers the detailed design and management requirements of SuDS and develops an adoption process required by Gloucester City Council to take responsibility for SuDS in open space. The SPG states that Gloucester City Council will require the developed rate of runoff to be no greater than the greenfield runoff rate for a range of annual flow rate probabilities, up to and including the 6 hour 1 per cent AEP event (1 in 100-year) with an allowance for climate change (allowance to be confirmed with the Council and the EA). It should be noted however, that in line with Gloucestershire County Council's SuDS guidance (section 6.3.4 below), in the absence of long-term storage, the surface water discharge rate shall be limited to QBar (mean annual flood).

6.3.4 Gloucestershire SuDS Design and Maintenance Guide

The **Gloucestershire SuDS Design and Maintenance Guide** was published in November 2015 to provide guidance for developers and relevant professionals on the SuDS requirements within Gloucestershire.

The guide sets out the planning, design and maintenance requirements for SuDS schemes with the aim of producing benefits for the environment and communities whilst enabling developers to achieve compliance with LLFA SuDS requirements to gain SuDS approval.

The document is intended to be complementary to the National Standard for SuDS (2015) and The SuDS Manual (CIRIA C753).

6.4 Other surface water considerations

6.4.1 Discharge rates from brownfield sites

In line with the NPPF, Gloucester City Council seek to use opportunities provided by new development to reduce the causes and impacts of flooding. In order to provide this flood risk betterment, the surface water discharge rate from brownfield sites should ideally be reduced to replicate greenfield rates. As a minimum, the surface water discharge rate on brownfield sites should be reduced by 40%, or the level set out in the latest Gloucester City/Gloucestershire County Council guidance, whichever is greater.

6.4.2 Groundwater Vulnerability Zones

The Environment Agency have published new groundwater vulnerability maps in 2015. These maps provide a separate assessment of the vulnerability of groundwater in overlying superficial rocks and those that comprise of the underlying bedrock. The map shows the vulnerability of groundwater at a location based on the hydrological, hydro-ecological and soil propertied within a one-kilometre grid square.

The groundwater vulnerability maps should be considered when designing SuDS. Depending on the height of the water table at the location of the proposed development site, restrictions may be placed on the types of SuDS appropriate to certain areas. Groundwater vulnerability maps can be found on **Defra's interactive mapping.**

6.4.3 Groundwater Source Protection Zones (GSPZ)

The Environment Agency also defines Groundwater Source Protection Zones (SPZs) near groundwater abstraction points. These protect areas of groundwater used for drinking water. The Groundwater SPZ requires attenuated storage of runoff to prevent infiltration and contamination. Groundwater Source Protection Zones can be viewed on the **Defra website**.

The entirety of Gloucester City does not fall within a Groundwater Source Protection Zone.

6.4.4 Nitrate Vulnerable Zones

Nitrate Vulnerable Zones (NVZs) are areas designated as being at risk from agricultural nitrate pollution. Nitrate levels in waterbodies are affected by surface water runoff from surrounding agricultural land entering receiving waterbodies. The level of nitrate contamination will potentially influence the choice of SuDS and should be assessed as part of the design process. The NVZ coverage can be viewed on the **Environment Agency's online maps**.

The entirety of Gloucester City is not located within a Nitrate Vulnerable Zone.

This page is intentionally left blank.

7 Cumulative impact of development and strategic solutions

7.1 Introduction

Under the 2019 NPPF, strategic policies and their supporting Strategic Flood Risk Assessments (SFRAs), are required to '*consider cumulative impacts in, or affecting, local areas susceptible to flooding*' (para. 156).

When allocating land for development, consideration should be given to the potential cumulative impact of the loss of floodplain storage volume. Whilst the loss of storage for individual developments may only have minimal impact on flood risk, the cumulative effect of multiple developments may be more severe.

7.2 Cross-boundary issues

The topography of Gloucester means that a number of tributaries of the River Severn flow from neighbouring authorities into the study area. As such, future development outside Gloucester can have the potential to affect flood risk to development and surrounding areas, depending on the effectiveness of SuDS and drainage implementation. Gloucester has boundaries with Tewkesbury Borough and Stroud District.

Development control should ensure that the impact on receiving watercourses from development in Gloucester has been sufficiently considered during the planning stage and appropriate development management decisions put in place to ensure there is no adverse impact on flood risk or water quality. Similarly, the cumulative effect of multiple small developments on surface water discharge rates, and hence flooding can be significant. There is therefore the requirement for SuDS on minor development as well as major development.

All developments are required to comply with the NPPF and demonstrate they will not increase flood risk elsewhere. Therefore, providing developments near watercourses in neighbouring authorities comply with the latest guidance and legislation relating to flood risk and sustainable drainage, they should result in no increase in flood risk within Gloucester City.

The effect of proposed development in neighbouring authorities on Gloucester has been considered in the cumulative impact assessment.

7.3 Cumulative impact assessment

7.3.1 Methodology

To assess which catchments are at the highest risk of flooding and where the cumulative impact of development may have the biggest effect, the following methodology was used:

- Gloucester was split into catchments using the WFD river catchments, Flood Estimation Handbook (FEH) catchments and LiDAR data. Not all of the Gloucester boundary has been included in these catchments (as seen in Figure 7-1) as some parts of the City are not part of the WFD catchments as they drain towards the tidally influenced River Severn, where any development is unlikely to have a significant impact on downstream flows on such a large river. The following catchments were used:
    - Dimore Brook
    - Whaddon Brook
    - Wotton Brook
    - River Twyver

- Horsebere Brook
- Sud Brook
- Daniels Brook
- River Severn (eastern channel)
- Tuffley and Podsmead
- Unnamed watercourse in Quedgeley

- The number of flooding hotspots from the North, Central and South Gloucester SWMPs in each catchment were determined. The flood hotspots are areas which are at risk from local sources of flooding, or where flooding sources are integrated (e.g. Main River and surface water). Note that GIS shapefiles were not provided for the SWMP hotspots, and those used in this assessment have been derived from broad scale mapping and reporting in the SWMPs.
- The number of historic flooding incidences as recorded by the LLFA in each catchment were determined.
- The number of historic sewer flooding incidences as recorded by Severn Trent Water in each catchment were determined.
- The percentage of proposed development (using City Plan sites from Gloucester City and sites from neighbouring Stroud District and Tewkesbury Borough) in each catchment was determined.
- The results were ranked for each assessment and combined to give overall rankings of the highest risk catchments.

The assumptions and limitations of the assessment are shown in Table 7-1.

Table 7-1 Assumptions and limitations of the assessment

Assessment aspect	Assumption made	Details of limitation in method	Justification of method used
Development scenarios	Inclusion of all City Plan Sites received from Gloucester City Council and all sites provided by Tewkesbury Borough Council and Stroud District Council.	The study assessed the potential impact of all sites received during the Local Plan process. This included sites which may not be suitable for allocation, as well as more strategic development areas which are often developed in phases. As a result, it presents a 'worst case' assessment of growth which is likely to overestimate the risk within each catchment.	Although the method was a very conservative estimate, it identified settlements and catchments with the greatest potential for growth.
	Assumption of housing density and impermeable areas	As potential development densities were not known for all of the sites, it was assumed that the entire area of the site would contribute surface water runoff to the wider catchment. In reality, landscaping requirements for SuDS within sites lessen the impacts of new development.	The assessment considered the 'worst case; development scenario, if surface water runoff was not controlled from new developments. With housing densities and proportions of undeveloped areas not known, the approach was conservative.
	Current site use	The current use of the sites (e.g. greenfield/brownfield) was undefined. Brownfield sites are unlikely to have a significant impact on flood risk as they have previously been developed,	The assessment considered the 'worst case development scenario'.

		therefore in absence of this information, a 'worst case' assessment is produced which may overestimate the risk within each catchment.	
SWMP hotspots	Location/size/ shape of the SWMP hotspots	The GIS shapefiles of the SWMP hotspots were not provided, therefore they have been estimated using mapping and information from the SWMP reports.	This was the best available data at the time of writing. The size and shape of the SWMP hotspots is unlikely to change the results of the assessments as the hotspots are likely to fall in the same catchments.

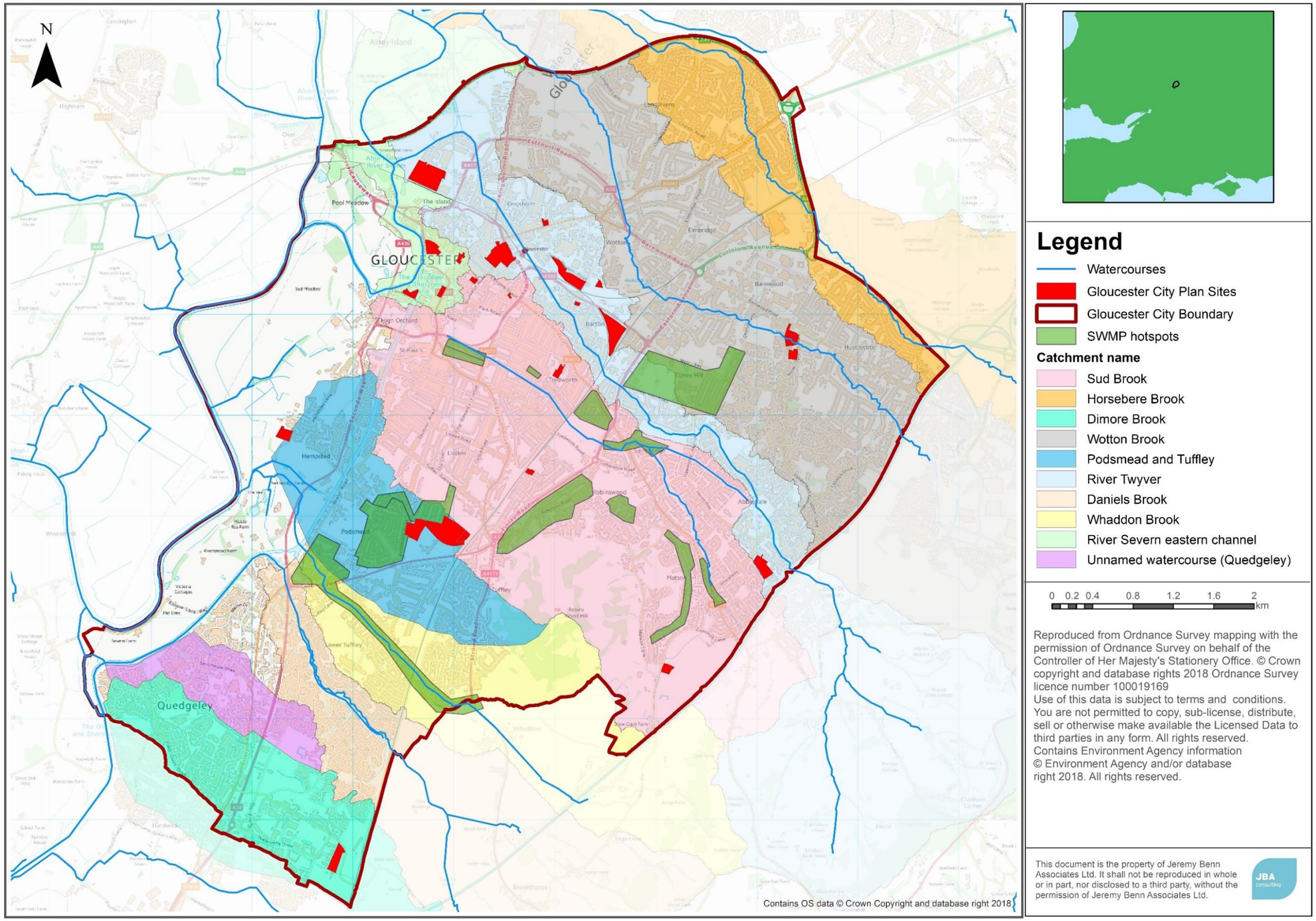
7.3.2 Results

Results of the assessment are shown in Table 7-2 and map showing the catchments in Gloucester are shown in Figure 7-1.

Table 7-2 Results of the cumulative impact assessment

Catchment	% proposed development	Number of SWMP hotspots	Number of LLFA historic flooding incidents	Number of STW historic flooding incidents	Final ranking
Sud Brook	4.03%	10	12	87	1
Horsebere Brook	6.82%	1	3	28	2
Dimore Brook	4.63%	0	4	10	=3
Wotton Brook	3.94%	1	3	27	=3
Podsmead and Tuffley	3.37%	3	4	10	5
River Twyver	2.60%	1	4	24	=6
Daniels Brook	13.94%	0	0	3	=6
Whaddon Brook	3.27%	1	1	5	8
River Severn (eastern channel)	1.50%	0	0	1	=9
Unnamed watercourse (Quedgeley)	0%	0	0	3	=9

Figure 7-1 Map of catchments in Gloucester City



7.3.3 Policy recommendations

Relevant to all developments in the City

- Incorporate SuDS and provide details of adoption, ongoing maintenance and management. Proposals will be required to provide reasoned justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in the City where practicable.
- Gloucestershire County Council as LLFA require all developments on greenfield sites to retain greenfield surface water discharge and all developments on brownfield sites to achieve at least a 40% reduction in surface water discharge.
- It is recommended that an 8m easement from top of bank on all main rivers and ordinary watercourses should kept free of development to help manage flood risk and for maintenance and ecology purposes.
- Gloucester has been designated as a nationally significant 'Flood Risk Area' in the 2018 Environment Agency Preliminary Flood Risk Assessment. Developers should therefore seek to reduce flood risk in the wider area which may include making a developer contribution towards wider flood alleviation works, as appropriate.

Policy that particularly focuses on the high-risk urban catchments: Sud Brook, Horsbere Brook, Wotton Brook and Dimore Brook

All new development in this catchment should:

- Seek to provide wider betterment in addition to that required city wide by demonstrating in site-specific Flood Risk Assessments and Surface Water Drainage Strategies what measures can be put in place to contribute to a reduction in flood risk downstream. This may either be by provision of additional storage on site e.g. through oversized SuDS, natural flood management techniques, green infrastructure and green-blue corridors and/or by providing a Partnership Funding contribution towards a wider community scheme. Consultation on the site-specific requirements should be undertaken with the LPA at the earliest opportunity.
- A Surface Water Drainage Strategy will be required for all developments in this catchment, regardless of development size.
- Gloucestershire County Council as LLFA and Gloucester City Council as LPA will review Surface Water Drainage Strategies in accordance with their local requirements for major developments. These should take into account all sources of flooding to ensure that future development is resilient to flood risk and does not increase flood risk elsewhere.
- The Environment Agency, in consultation with the LPA and GCC, should consider whether to formally designate the catchment as a

Critical Drainage area. This would mean that a detailed Flood Risk Assessment would be required for all developments that are proposed, regardless of their size.

Policy that particularly focuses on the catchments with a SWMP hotspot: Sud Brook, Wotton Brook, Whaddon Brook, River Twyver, Horsbere Brook and Tuffley and Podsmead and City Plan sites located near a SWMP hotspot (SA06 and SA16, Blackbridge)

- Consider short-term measures to managing flood risk
    - Developers should consider property level protection flood resilience measures for new development, e.g. raised thresholds, self-sealing UPVC doors, non-return valves and air brick covers.
    - Construction of online and offline storage areas on upstream catchments to alleviate flooding downstream (e.g. the Horsbere Brook flood storage area, opened in 2011)
- Consider long-term measures to managing flood risk
    - Manage fluvial flood risk by restoring river corridors. Sections of heavily modified watercourse could be naturalised. This is especially relevant to the Sud Brook and Whaddon Brook, where Gloucester City Council are currently and have future plans for naturalising, sections of these watercourses. Watercourses could also be reconnected to the natural floodplain through de-culverting.
    - Managing surface water through green infrastructure e.g. encouraging the use of permeable surfacing in gardens and use measures to optimise drainage and reduce runoff, considering opportunities for water conservation through rainwater harvesting and water butts where appropriate for new and existing development and implementing green roofs.

7.4 Flood alleviation schemes

More information on pipeline and completed schemes in Gloucester can be found on the **programme of FCERM schemes**, and more details on the improvement of the River Twyver and Sud Brook can be found **here**.

7.4.1 Property Flood Resilience

A number of Property Flood Resilience (PFR) schemes are currently being undertaken/ have been completed in Gloucester, including at Dinglewell where PFR has better protected 27 homes from flooding.

7.4.2 River restoration

Gloucester City Council are currently naturalising concrete-lined sections of the Sud Brook (upstream of Heron Way). The Council plan to naturalise further sections of the Sud Brook and the Whaddon Brook upstream of Tuffley Lane over the next 3 years.

7.4.3 Blackbridge SuDS Concept Plan

A SuDS strategy consisting of detention basins, permeable paving, permeable bunding, leaky dams and widened/ enhanced ditches has been proposed around Blackbridge playing fields to reduce flood risk to properties downstream of the playing fields.

7.4.4 River Twyver Natural flood management (NFM)

Gloucester City Council has secured funding to deliver NFM measures upstream of Gloucester City on the Sud Brook and River Twyver in the Upper Twyver catchment. There are 1084 properties at risk of flooding in the Upper Twyver catchment.

The aims of the project are to:

- Reduce flood risk to communities in Gloucester by slowing and reducing flows and attenuating water on the Sud Brook and River Twyver;
- Improve water quality, ecology and morphology of the Sud Brook and River Twyver by reducing sediment entering the catchment;
- Habitat creation and increased biodiversity; and
- Engage the community in understanding and improving the local river environment.

7.4.5 European Regional Development Fund (ERDF) Green Infrastructure Strategy

The ERDF project aims to deliver the ambitions of the Green Infrastructure Strategy (GI Strategy) as part of the JCS. The project aims to create and improve multifunctional green spaces to connect habitat and wildlife, increase biodiversity and manage water sustainably. The project consists of 13 green infrastructure sub-projects (10 of which are in Gloucester, including along the Horsbere Brook, Wotton Brook, Daniels Brook, Sud Brook, River Twyver and Whaddon Brook) that are set to deliver the following relating to flood risk:

- Creation of swales, scrapes, ponds, meadows, reed beds, wetlands and orchards to maximise ecological benefit; and
- River restoration, removing culverts and hard barriers to restore the natural behaviour of watercourses and improve habitats.

7.5 Strategic solutions

7.5.1 Introduction

Strategic flood risk solutions may offer a potential opportunity to reduce flood risk in the City. As described in Chapter 2, Gloucester City is covered by "Policy Option 5 – Areas of moderate to high flood risk where we can generally take further action to reduce flood risk" in the **Severn Tidal Tributaries CFMP** and **River Severn CFMP**.

The following sections outline different options which could be considered for strategic flood risk solutions.

7.5.2 Flood storage schemes

Flood storage schemes aim to reduce the flows passed downriver to mitigate downstream flooding. Development increases the impermeable area within a catchment, creating additional and faster runoff into watercourses. Flood storage schemes aim to detain this additional runoff, releasing it downstream at a slower rate, to avoid any increase in flood depths and/or frequency downstream. Methods to provide these schemes include:

- enlarging the river channel;
- raising the riverbanks; and/or
- constructing flood banks set back from the river.

Flood storage schemes have the advantage that they generally benefit areas downstream, not just the local area.

The construction of new upstream storage schemes as part of upstream catchment-based approaches within Gloucester City (particularly north-east

Gloucester) could provide one potential strategic solution to flood risk. Watercourses which are rural in their upper reaches but have high levels of flood risk to urban areas in the downstream reaches are potential candidates, as the open land in the upper reaches can potentially provide the space for an attenuation area, providing benefit to the urban area downstream.

7.5.3 Promotion of SuDS

Surface water flood risk is present in Gloucester. By considering SuDS at an early stage in the development of a site, the risk from surface water can be mitigated to a certain extent within the site as well as reduce the risk that the site poses to third party land. Regionally, SuDS should be promoted on all new developments to ensure the quantity and quality of surface water is dealt with sustainably to reduce flood risk. Given the detailed policies and guidance produced by Gloucestershire County Council (summarised in Chapter 6), this should actively promote developers to use this information to produce technically proficient and sustainable drainage solutions.

7.5.4 Catchment and floodplain restoration

Compared to flood defences and flood storage, floodplain restoration represents the most sustainable form of strategic flood risk solution, by allowing watercourses to return to a more naturalised state, and by creating space for naturally functioning floodplains working with natural processes.

Although the restoration of floodplain is difficult in previously developed areas where development cannot be rolled back, the following measures should be adopted:

- Promoting existing and future brownfield sites that are adjacent to watercourses to naturalise banks as much as possible. Buffer areas around watercourses provide an opportunity to restore parts of the floodplain
- Removal of redundant structures to reconnect the river and the floodplain. There are a number of culverted sections of watercourse located throughout the City which if returned to a more natural state would potentially reduce flood risk to the local area
- Apply the Sequential Approach to avoid new development within currently undefended floodplain.

For those sites considered within the Local Plan and / or put forward by developers, that also have watercourses flowing through or past them, the sequential approach should be used to locate development away from these watercourses. This will ensure the watercourses retain their connectivity to the floodplain. Loss of floodplain connectivity in rural upper reaches of tributaries which flow through urban areas in the City, could potentially increase flooding within the urban areas. This will also negate any need to build flood defences within the sites. It is acknowledged that sites located in urban areas within the City are likely to have limited opportunity to restore floodplain in previously developed areas.

7.5.5 Upstream natural catchment management

Essentially, opportunities to work with natural processes to reduce flood and erosion risk, benefit the natural environment and reduce costs of schemes should be sought, requiring integrated catchment management and involving those who use and shape the land. It also requires partnership working with neighbouring authorities, organisations and water management bodies.

Conventional flood prevention schemes listed above will likely still be preferred, but consideration of 're-wilding' the more rural reaches of the tributaries upstream in the Cotswolds could provide cost efficiencies as well as considering multiple sources of flood risk; for example, reducing peak flows

upstream such as through felling trees into streams or building earth banks to capture runoff, could be cheaper and smaller-scale measures than implementing flood walls for example. With flood prevention schemes, consideration needs to be given to the impact that flood prevention has on the WFD status of watercourses. It is important that any potential schemes do not have a negative impact on the ecological and chemical status of waterbodies.

Upstream NFM is currently being implemented on the River Twyver catchment using slow the flow measures and reducing sediment entering the catchment.

7.5.6 Structure Removal and / or modification (e.g. weirs)

Structures, both within watercourses and adjacent to them can have significant impacts upon rivers including, alterations to the geomorphology and hydraulics of the channel through water impoundment and altering sediment transfer regime, which over time can significantly impact the channel profile including bed and bank levels, alterations to flow regime and interruption of biological connectivity, including the passage of fish and invertebrates.

Many artificial in-channel structures (examples include weirs and culverts) are often redundant and / or serve little purpose and opportunities exist to remove them where feasible. The need to do this is heightened by climate change, for which restoring natural river processes, habitats and connectivity are vital adaptation measures. However, it also must be recognised that some artificial structures may have important functions or historical/cultural associations, which need to be considered carefully when planning and designing restoration work.

In the case of weirs, whilst weir removal should be investigated in the first instance, in some cases it may be necessary to modify a weir rather than remove it. For example, by lowering the weir crest level or adding a fish pass. This will allow more natural water level variations upstream of the weir and remove a barrier to fish migration.

Further information is provided in the **'Trash and Security Screen Guide 2009'**, published by the Environment Agency/ Defra, which should be used as evidence for any culvert assessment, improvement or structure retention.

7.5.7 Bank Stabilisation

It is generally recommended that bank erosion is avoided where possible and encourage all landowners to avoid using machinery and vehicles close to or within the watercourse.

There are a number of techniques that can be employed to restrict the erosion of the banks of a watercourse. In an area where bankside erosion is particularly bad and/or vegetation is unable to properly establish, ecologically sensitive bank stabilisation techniques, such as willow spiling, can be particularly effective. Live willow stakes thrive in the moist environment and protect the soils from further erosion allowing other vegetation to establish and protect the soils.

7.5.8 Bank removal, set back and / or increased easement

The removal or realignment of flood embankments and walls can allow the natural interrelationship between the river channel and the floodplain to be reinstated. This can be achieved at a small scale within urban areas providing pockets of attractive green spaces along rivers, whilst also improving floodplain storage within confined urban environments at times of flooding.

A detailed assessment would need to be undertaken to gain a greater understanding of the response to the channel modification, including flood risk analysis to investigate flood risk impacts.

All formal defences have a role in reducing flood risk, and therefore opportunities for bank removal, set back and / or increased easement will be limited. However, there may be informal artificial structures (embankments, walls) or defences within the City which are now redundant.

7.5.9 Re-naturalisation

There is potential to re-naturalise a watercourse by re-profiling the channel, removing hard defences, re-connecting the channel with its floodplain and introducing a more natural morphology (particularly in instances where a watercourse has historically been modified through hard bed modification). Detailed assessments and planning would need to be undertaken to gain a greater understanding of the response to any proposed channel modification. These measures are currently being implemented throughout Gloucester City as part of the ERDF GI Strategy project.

8 Sources of information used in preparing the L2 SFRA

8.1 Data used to inform the SFRA

Table 8-1 provides an overview of the supplied data, used to inform the appraisal of flood risk for Gloucester.

Table 8-1 Overview of supplied data for Gloucester City L2 SFRA

Source of flood risk	Data used to inform the assessment	Data supplied by
Historic (all sources)	Historic Flood Map and Recorded Outlines Hydraulic Modelling Reports, where provided	Environment Agency
	2008/ 2011 SFRA 2017 L2 Data Review	Gloucester City Council Atkins
	Historic flood incidents/records	Gloucestershire County Council Gloucester City Council Canals and River Trust
Fluvial (including climate change)	• River Twyver – 2006 – ISIS and TUFLOW models • River Severn (tidal) – 2007 – ISIS model • Wotton Brook – 2007 – ISIS-TUFLOW model • Daniels Brook – 2009 – ESTRY-TUFLOW model • Dimore Brook – 2009 - ESTRY-TUFLOW model • Sud Brook – 2009 – ISIS-TUFLOW model • Whaddon Brook – 2009 – ESTRY-TUFLOW model	Environment Agency
Surface Water	Risk of Flooding from Surface Water dataset	Environment Agency
Groundwater	Areas Susceptible to Groundwater Flooding dataset Bedrock geology/superficial deposits dataset	Environment Agency
Sewer	At Risk Register Historic flooding records	Severn Trent Water
Reservoir	National Inundation Reservoir Mapping	Environment Agency
Canal	Description of flood incidences	Canal and River Trust

8.2 Flood Zones

The data used to prepare the fluvial mapping for this study is based on the results from hydraulic models, either provided by the Environment Agency or prepared for the purposes of this SFRA.

8.2.1 Flood Zones 2 and 3a

Flood Zones 2 and 3a have been taken from the Environment Agency's Flood Map for Planning, with the exception of the Dimore Brook where the outputs of the hydraulic model (100-year and 1,000-year undefended outputs) were used to represent Flood Zone 3a and Flood Zone 2 respectively.

8.2.2 Flood Zone 3b

Flood Zone 3b has been identified as land which would flood with an annual probability of 1 in 20 years (5% AEP). It has been derived from the 20-year defended modelled flood extent (or 25-year in the absence of 20-year), where detailed Environment Agency hydraulic models exist, and where no detailed models exist, Flood Zone 3a should be used as an indication of Flood Zone 3b.

Note on the Environment Agency Flood Map for Planning

Where outlines are not informed by detailed hydraulic modelling, the Flood Map for Planning is based on generalised modelling to provide an indication of flood risk. Whilst the generalised modelling is generally accurate on a large scale, they are not provided for specific sites or for land where the catchment of the watercourse falls below 3km^2. For this reason, the Flood Map for Planning is not of a resolution to be used as application evidence to provide the details of possible flooding for individual properties or sites and for any sites with watercourses on, or adjacent to the site. Accordingly, for site-specific assessments it will be necessary to perform more detailed studies in circumstances where flood risk is an issue. Where the Flood Map for Planning is based on generalised modelling, developers should undertake a more detailed analysis and assessment of the flood risk at the planning application stage.

8.3 Climate change

Three climate change allowances were modelled by re-running the Environment Agency's detailed models, upscaling the 100-year flow event by the relevant climate change factor. These runs represented the Central (100-year +25%), Higher Central (100-year +35%) and Upper End (100-year +70%) climate change allowances for the 2080s epoch, as agreed with the Environment Agency. For the Dimore Brook, the detailed models could not be re-run due to missing files, therefore the 2D generalised modelling was used to represent climate change along this watercourse.

The River Twyver model did not produce reliable results for climate change and therefore Flood Zone 2 has been shown as a conservative indication in this area. Updated modelling which will supersede the current model was being undertaken by another consultant at the time of writing this SFRA. Developers should contact Gloucester City Council for the latest updates on this modelling.

The mapping provides a strategic assessment of climate change risk; developers should undertake detailed modelling of climate change allowances as part of a site-specific FRA, following the **climate change guidance** set out by the Environment Agency.

8.4 Surface Water

Mapping of surface water flood risk in Gloucester has been taken from the Environment Agency's Risk of Flooding from Surface Water (RoFfSW) mapping, which is a slightly more detailed resolution than that published online by the Environment Agency. Surface water flood risk is subdivided into the following four categories:

- **High**: An area has a chance of flooding greater than 1 in 30 (3.3%) each year.
- **Medium**: An area has a chance of flooding between 1 in 100 (0.1%) and 1 in 30 (3.3%) each year.
- **Low**: An area has a chance of flooding between 1 in 1,000 (0.1%) and 1 in 100 (1%) each year.
- **Very Low**: An area has a chance of flooding of less than 1 in 1,000 (0.1%) each year.

The results should be used for high level assessments such as SFRAs for local authorities. If a particular site is indicated in the Environment Agency mapping to be at risk from surface water flooding, a more detailed assessment should be required to more accurately illustrate the flood risk at a site-specific scale. Such an assessment will use the RoFSW in partnership with other sources of local flooding information to confirm the presence of a surface water risk at that particular location.

8.5 Groundwater

Mapping of groundwater flood risk has been based on the Areas Susceptible to Groundwater (AStGWF) dataset. The AStGWF dataset is a strategic-scale map showing groundwater flood areas on a 1km square grid. It shows the proportion of each 1km grid square, where geological and hydrogeological conditions indicate that groundwater might emerge. It does not show the likelihood of groundwater flooding occurring and does not take account of the chance of flooding from groundwater rebound. This dataset covers a large area of land, and only isolated locations within the overall susceptible area are actually likely to suffer the consequences of groundwater flooding.

The AStGWF data is indicative and should only be used in combination with other information, for example local data or historical data. It should not be used as sole evidence for any specific flood risk management, land use planning or other decisions at any scale. However, the data can help to identify areas for assessment at a local scale where finer resolution datasets exist.

8.6 River networks

Main Rivers are represented by the Environment Agency's Statutory Main River layer. Ordinary Watercourses are represented by the Environment Agency's Detailed River Network Layer. Caution should be taken when using these layers to identify culverted watercourses which may appear as straight lines but in reality, are not. Developers should be aware of the need to identify the route of, and flood risk associated with culverts and model these/use CCTV where necessary.

8.7 Flood warning

Flood Warning Areas are represented by the Environment Agency's Flood Warning Area GIS dataset.

8.8 Reservoirs

The risk of inundation as a result of reservoir breach or failure of a number of reservoirs within the area has been identified from the Environment Agency's **Long Term Flood Risk Information website**.

8.9 Sewer flooding

Historical incidents of flooding are detailed by Severn Trent Water through their sewer flooding register. The sewer flooding register records incidents of flooding relating to public foul, combined or surface water sewers and displays which properties suffered flooding. This data was requested and is used to describe any sewer flooding in the Level 2 summary tables. Due to licencing and confidentiality restrictions, sewer flooding data has not been represented on the mapping.

8.10 Historic flooding

Historic flooding was assessed using the Environment Agency's Historic Flood Map, as well as any incidents picked up in the historic flooding register provided by Gloucestershire County Council as LLFA.

8.11 Flood defences

Flood defences are represented by Environment Agency's Asset Information Management System (AIMS) Spatial Defences data set. Their current condition and standard of protection are based on those recorded in the tabulated shapefile data. None of the sites being assessed are formally protected by a flood defence.

8.12 Residual risk

The residual flood risk to sites is identified as where potential blockages or overtopping / breach of defences could result in the inundation of a site.

Potential culvert blockages that may affect a site were identified by querying the Environment Agency's Detailed River Network Layer and using background mapping to determine where watercourses flow into culverts or through structures (i.e. bridges) in the vicinity of the site. These may need to be considered by the developer as part of a site-specific Flood Risk Assessment.

8.13 Depth, velocity and hazard to people

The Level 2 assessment seeks to map the probable depth and velocity of flooding as well as the hazard to people during the defended fluvial 100-year event. The 100-year flood event has been investigated in further detail because the Level 2 assessment helps inform the Exception Test and usually flood mitigation measures and access/ egress requirements focus on flood events lower than the 1,000-year event (e.g. the 100-year or 100-year plus climate change events). As part of a site-specific FRA, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood depth, velocity and hazard based on the relevant 100-year plus climate change event as part of a site-specific FRA, using the relevant climate change allowance based on the type of development and its associated vulnerability classification. Not all of this information is known at the strategic scale.

For 1D-only hydraulic models, these results are not available from the modelled outputs.

The depth, hazard and velocity of the 100-year surface water flood event has also been mapped and considered in this assessment. Hazard to people has been calculated using the below formula as suggested in Defra's FD2321/TR2 "Flood Risk to People". The different hazard categories are shown in Table 8-2.

Table 8-2 Defra's FD2321/TR2 "Flood Risks to People" classifications

Description of Flood Hazard Rating	Flood Hazard Rating	Classification Explanation
Very Low Hazard	< 0.75	Flood zone with shallow flowing water or deep standing water"
Danger for some (i.e. children)	0.75 - 1.25	"Danger: flood zone with deep or fast flowing water"
Danger for most	1.25 - 2.00	Danger: flood zone with deep fast flowing water"
Danger for all	>2.00	"Extreme danger: flood zone with deep fast flowing water"

8.14 Use of SFRA data and future updates

It is important to recognise that the SFRA has been developed using the best available information at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

The SFRA should be a 'living document', and as a result should be updated when new information on flood risk, flood warning or new planning guidance or legislation becomes available. New information on flood risk may be provided by Gloucester City Council, Gloucestershire County Council, the Highways Authority, Canal and River Trust, Severn Trent Water and the Environment Agency. Such information may be in the form of:

- New hydraulic modelling results
- Flood event information following a future flood event
- Policy/ legislation updates
- Environment Agency flood map updates
- New flood defence schemes etc.

The Environment Agency regularly reviews their flood risk mapping, and it is important that they are approached to determine whether updated (more accurate) information is available prior to commencing a detailed Flood Risk Assessment. It is recommended that the SFRA is reviewed in line with the Environment Agency's Flood Zone map updates to ensure latest data is still represented in the SFRA, allowing a cycle of review and a review of any updated data by checking with the above bodies for any new information.

This page is intentionally left blank.

9 Screening of site options

9.1 Introduction

A number of site options were provided by Gloucester City Council; 24 sites in total, which were screened against a suite of available flood risk information and spatial data to provide a summary of risk to each site. Sites were screened to provide a summary of flood risk to each site, including:

- The proportion of the site in each Flood Zone
- Whether the site is shown to be at risk in the RoFfSW and, if so, the lowest return period from which the site is at surface water flood risk
- Whether the site is within, or partially within, the Environment Agency's Historic Flood Map.

The screening was undertaken using JBA in-house software called "FRISM". FRISM is an internal JBA GIS package that computes a range of flood risk metrics based on flood and receptor datasets, giving a clear spatial picture of flood risk. The site boundaries were queried using FRISM against the flood risk information including Flood Zones, surface water and historic flood map.

The results of the screening provide a quick and efficient way of identifying sites that are likely to require a Level 2 Assessment, assisting Gloucester City Council with Sequential Test decision-making so that flood risk is taken into account when considering allocation options.

The screening also provides an opportunity to identify sites which have an ordinary watercourse flowing through or adjacent to them but for which no Flood Zone information is currently available. Note: although there are no Flood Zone maps available for these watercourses, it does not mean the watercourse does not pose a risk, it just means no modelling has yet been undertaken to identify the risk. The Flood Zones are not provided for specific sites or land where the catchment of the watercourse falls below 3km^2. For this reason, the Flood Zones are not of a resolution to be used as application evidence to provide the details of possible flooding for individual properties or sites and for any sites with watercourses on, or adjacent to the site. Additional modelling of ordinary watercourses in these instances may be required to fully understand the level of risk to the site. By undertaking this screening, it will determine where additional modelling may be required as part of a Level 2 SFRA to enable identification of the fluvial flood risk from these watercourses to the sites and will allow application of the Exception Test, if required.

9.2 Site screening

Table 9-1 summarises the flood risk to the 24 sites for consideration.

Where sites are shown to be in Flood Zone 1, these were then checked against OS mapping for any drains or ordinary watercourses which may pose a risk, as well as the surface water mapping for further consideration.

Table 9-1 Site screening against flood risk datasets

Site code	Location	Area (ha)	Flood Zones			Risk of flooding from surface water (Total %s)			Historic flood map	Area of site outside of Flood Zones
			FZ3a	FZ2	FZ1	30yr	100yr	1,000yr		(ha)
SA01	Land at the Wheatridge	2.28	0%	0%	100%	0%	0%	0%	0%	2.28
SA02	Barnwood Manor	1.95	9%	14%	86%	4%	6%	16%	13%	1.67
SA03	67-69 London Road - Prospect House	0.35	0%	0%	100%	0%	0%	0%	0%	0.35
SA04	Wessex House, Great Western Road	0.25	0%	0%	100%	13%	18%	36%	0%	0.25
SA05	Great Western Road Sidings	3.19	0%	0%	100%	0%	1%	18%	0%	3.19
SA06	Blackbridge Sports Hub	9.69	0%	0%	100%	<1%	1%	2%	0%	9.69
SA07	Lynton Fields - Land East of Waterwells	2.23	1%	1%	99%	<1%	1%	3%	0%	2.23
SA08	King's Quarter	4.45	11%	29%	71%	1%	6%	17%	0%	3.16
SA09	Former Quayside House - Greater Blackfriars	1.59	63%	97%	3%	3%	6%	15%	26%	0.05
SA10	Fleece Hotel and Longsmith Street Carpark	0.47	0%	0%	100%	0%	0%	<1%	0%	0.47
SA11	Southgate Moorings Car Park	0.53	0%	0%	100%	0%	0%	0%	0%	0.53
SA12	Land Adjacent to Eastgate Shopping Centre	0.32	0%	0%	100%	0%	0%	<1%	0%	0.32
SA13	Land at St Oswalds	6.47	5%	100%	0%	<1%	1%	5%	100%	0.00
SA14	Land at Rea Lane	1.47	0%	0%	100%	0%	0%	1%	0%	1.47
SA15	Former Colwell Youth & Community Centre	0.18	0%	0%	100%	0%	6%	11%	0%	0.18
SA16	Land at Blackbridge	0.77	0%	0%	100%	0%	0%	0%	0%	0.77
SA17	Land East of Sneedhams Road	0.85	0%	0%	100%	0%	0%	12%	0%	0.85
SA18	Land off Eastgate Street	0.12	<1%	17%	83%	0%	0%	2%	0%	0.10
SA19	Southern Railway Triangle (Employment)	4.23	0%	0%	100%	1%	2%	5%	0%	4.23
SA20	Jordan's Brook House	0.86	0%	0%	100%	0%	0%	3%	0%	0.86
SA21	Land off Myers Road	0.35	0%	0%	100%	0%	0%	0%	0%	0.35
SA22	Glevum Works	0.74	0%	0%	100%	0%	8%	23%	0%	0.74
SA23	White City Replacement Community Facility	0.37	0%	0%	100%	0%	1%	27%	0%	0.37
SA24	Part of West Quay, the Docks	0.84	1%	100%	0%	0%	0%	10%	99%	0.00

9.3 Conclusions of site screening

The 24 sites were screened against a range of flood risk datasets. Of those sites, 6 were shown to be at fluvial flood risk and carried forward to the Level 2 assessment.

Some sites are shown not to be located in the Flood Zones (because their catchments may be <3km^2 and hence not represented in the Flood Map for Planning). However, there may be small drains or ordinary watercourses located near to or within these sites; OS mapping was therefore checked, along with LIDAR, to confirm whether there could still be a flood risk posed. In these cases, a further 3 sites were flagged for consideration. A Level 2 assessment was therefore undertaken for SA07 – Lynton Fields – Land East of Waterwells, due to its proximity to a drain along the site's southern boundary. It is not deemed a Level 2 assessment is required at the remaining 2 sites,

but there is surface water risk which may need to be considered at a site-specific level. These sites are:

- SA04 – Wessex House, Great Western Road
- SA17 – Land East of Sneedhams Road

Where Flood Zones do exist but there is no detailed EA hydraulic model, the Flood Zones are suitable for providing an indication of flood risk for decision-making purposes at a strategic scale; however, it is recommended that developers construct detailed hydraulic models at these sites using channel and structure topographic survey, to confirm flood risk at a site. Where necessary, blockages of nearby culverts may need to be simulated to confirm residual risk to the site.

As well as confirming fluvial flood risk, the risk to these sites from surface water should be considered. Surface water flood risk at these sites should be considered further as part of a detailed site-specific FRA and Surface Water Drainage Strategy.

A further site at Secunda Way was brought forward for consideration of a Level 2 assessment. The site is partially located in Flood Zones 2 and 3; however, an assessment for this site had already been conducted by Atkins in the 2017 study. Since the previous assessment, the proposed land use of the site has changed from residential to employment, which is a 'less vulnerable' use of land, therefore it was deemed unnecessary to reproduce a Level 2 assessment for the Secunda Way site, and the assessment from Atkins in 2017 should be considered.

This page is intentionally left blank.

10 Level 2 assessment methodology

10.1 Introduction

Site options have been provided by the Council for assessment. Following the screening assessment of the 24 sites, 7 were brought forward to undergo the Level 2 assessment. This is based on fluvial flood risk posed to the sites. These sites are:

Table 10-1 Sites carried forward to a Level 2 assessment

Site code	Site name	Development type
SA02	Barnwood Manor	Residential
SA07	Lynton Fields – Land East of Waterwells	Employment
SA08	King's Quarter	Mixed Use
SA09	Former Quayside House – Greater Blackfriars	Residential/ student accommodation
SA13	Land at St Oswalds	Residential
SA18	Land off Eastgate Street	Residential
SA24	Part of West Quay, the Docks	Parking

This Level 2 SFRA assessment helps to determine variations in flood risk across the site options, identifying site-specific FRA requirements and helping guide local policies to provide sustainable developments, as well as reducing flood risk to existing communities.

10.2 Site summary tables

As part of the Level 2 SFRA, detailed site summary tables have been produced for the sites listed above in Table 10-1. The summary tables can be found in Appendix A.

Where available, the results from existing detailed Environment Agency hydraulic models were used in the assessment to provide depth, velocity and hazard information.

Using the model information combined with the Flood Zones, climate change and Risk of Flooding from Surface Water (RoFfSW) extents, detailed site summary tables have been produced for the site options (see Appendix A). Each table sets out the following information:

- Basic site information
- Area, type of site, current land use (greenfield/ brownfield), proposed site use
- Sources of flood risk
    - Existing drainage features
    - Fluvial – proportion of site at risk including description from mapping/ modelling
    - Surface Water – proportion of site at risk including description from RoFfSW mapping
    - Reservoir
    - Canal
- Flood History
- Flood risk management infrastructure

    - Defences – type, Standard of Protection and condition (if known), and description
    - Description of residual risk (blockage scenarios)
- Emergency Planning
    - Flood Warning Areas
    - Access and egress
- Climate change
    - Summary of climate change allowances and increase in flood extent compared to Flood Zones
    - Description of implications to the site
- Requirements for drainage control and impact mitigation
    - Broadscale assessment of possible SuDS to provide indicative surface water drainage advice for each site assessed for the Level 2 SFRA.
    - Groundwater Source Protection Zone
    - Historic Landfill Site
- NPPF Planning implications
    - Exception Test requirements
- Requirements and guidance for site-specific FRA (including consideration of opportunities for strategic flood risk solutions to reduce flood risk)
- Mapping information – description of data sources for the following mapped outputs:
    - Flood Zones
    - Climate change
    - Surface water
    - Fluvial depth, velocity and hazard mapping
    - Surface water depth velocity and hazard mapping

10.2.1 Interactive Geo-PDF mapping

To accompany each site summary table, there is an Interactive Geo-PDF map, with all the mapped flood risk outputs per site. This is displayed centrally, with easy-to-use 'tick box' layers down the right-hand side and bottom of the mapping, to allow navigation of the data.

Flood risk information in the Geo-PDFs include:

- Site boundary and Council boundary
- Title bar showing area, grid reference, site name, proposed development use (e.g. residential/ employment) and percentage Flood Zone coverage
- Flood Zones 2, 3a and 3b (functional floodplain) and indicative FZ3b
- Modelled 100-year fluvial depth, velocity and hazard rating
- Surface water 100-year depth, velocity and hazard rating (depth, hazard and velocity were available for the Dimore Brook, Sud Brook and Wotton Brook. Only depth was available for the River Twyver)
- Climate change extents – Central, Higher Central and Upper End allowances and Indicative climate change extents
- Flood risk from surface water dataset (30-years, 100-years and 1,000-years)
- Areas Susceptible to Groundwater Flooding

- Flood Warning and Flood Alert Areas
- Historic Landfill
- Defences (embankment and wall)
- Main Rivers/ Ordinary watercourses

10.2.2 Important note on datasets used for the summary table maps

It is important to recognise that for the SFRA, several different sets of data have been used to inform the extent, depth, hazard and velocity for each site.

Flood Zones

The extent of flooding, which determines the proportions of the site falling into the different Flood Zones, were determined from several sources:

- Flood Zone 2: based on the Environment Agency's Flood Map for Planning Flood Zone 2, and the 1,000-year flood extent from the 2009 Dimore Brook ESTRY-TUFLOW model (as no Flood Zones were available).
- Flood Zone 3a: based on the Environment Agency's Flood Map for Planning Flood Zone 3a, and the 100-year undefended flood extent from the 2009 Dimore Brook ESTRY-TUFLOW model (as no Flood Zones were available).
- Flood Zone 3b: based on the defended 20-year flood extent from the Environment Agency's detailed hydraulic models (or 25-year in the absence 20-year, e.g. Wotton Brook and River Twyver), where present. Flood Zone 3a can be used as an indication of Flood Zone 3b where detailed modelling is not available.

Depth, velocity and hazard

Depth, velocity and hazard mapping for the 1 in 100-year event (Flood Zone 3a) have been taken from the Environment Agency's detailed defended hydraulic models, where models are present.

For 1D-only models, velocity and hazard data were unable to be presented as these are not available outputs from 1D-only models. Depth outputs are available; however, due to updates to LIDAR since the previous studies, the flood mapping would yield a slightly different extent to the original flood extents provided, and therefore to prevent confusion, these have not been presented. Developers should consider improving or upgrading these models to 1D-2D where deemed appropriate, to derive the level of detail required at a site-specific FRA level.

The Environment Agency's 1 in 100-year surface water depth, speed (velocity) and hazard mapping has been shown in the Geo-PDFs mapping to provide further detail and also to serve as an indication of risk in the absence of modelled fluvial depth, velocity and hazard data. Further information on the depth and velocity from surface water is available on the **long term flood risk map**.

Climate change

Climate change extents are derived by upscaling the 100-year defended event from existing detailed hydraulic models for the relevant climate change allowance for the 2080s epoch and using 2D generalised modelling of the Dimore Brook. The River Twyver model did not produce reliable results for climate change and therefore Flood Zone 2 has been shown as a conservative indication in this area. Updated modelling which will supersede the current model was being undertaken by another consultant at the time of writing this SFRA. Developers should contact Gloucester City Council for the latest updates on this modelling.

10.3 Note on SuDS suitability

The hydraulic and geological characteristics of each site option were assessed to determine the constraining factors for surface water management. This assessment is designed to inform the early-stage site planning process and is not intended to replace site-specific detailed drainage assessments.

The assessment is based on catchment characteristics and additional datasets such as the AStGWF map and British Geological Survey (BGS) Soil maps of England and Wales which allow for a basic assessment of the soil characteristics on a site by site basis. LIDAR data was used as a basis for determining the topography and average slope across each development site. Other datasets were used to determine other influencing factors on potential SuDS. These datasets include the following:

- Historic landfill sites
- Groundwater Source Protection Zones
- Detailed River Network
- Flood Zones derived as part of this L2 SFRA

This data was then collated to provide an indication of particular groups of SuDS systems which might be suitable at a site. SuDS techniques were categorised into five main groups, as shown in Table 10-2. This assessment should not be used as a definitive guide as to which SuDS would be suitable but used as an indicative guide of general suitability. Further site-specific investigation should be conducted to determine what SuDS techniques could be utilised on a particular development.

Table 10-2 Summary of SuDS Categories

SuDS Type	Technique
Source Controls	Green Roof, Rainwater Harvesting, Pervious Pavements, Rain Gardens
Infiltration	Infiltration Trench, Infiltration Basin, Soakaway
Detention	Pond, Wetland, Subsurface Storage, Shallow Wetland, Extended Detention Wetland, Pocket Wetland, Submerged Gravel Wetland, Wetland Channel, Detention Basin
Filtration	Surface Sand filter, Sub-Surface Sand Filter, Perimeter Sand Filter, Bioretention, Filter Strip, Filter Trench
Conveyance	Dry Swale, Underdrained Swale, Wet Swale

The suitability of each SuDS type for the site options has been described in the summary tables, where applicable. The assessment of suitability is broadscale and indicative only; more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. The LLFA should be consulted at an early stage to ensure SuDS are implemented and designed in response to site characteristics and policy factors.

11 Summary of Level 2 assessment

11.1 Assessment methods

As part of the Level 2 SFRA, detailed site summary tables have been produced for 7 of the original 24 considered; these sites are shown to be at risk of fluvial flood risk from watercourses running either through or adjacent to the site as a result of the site screening process against flood risk information.

The summary tables set out the flood risk to each site, including Flood Zone coverage, maps of extent, depth and velocity of flooding as well as hazard mapping for the 100-year defended event. Climate change mapping has also been produced for each site to indicate the impact which different climate change allowances may have on the site. Each table also sets out the NPPF requirements for the site as well as guidance for site-specific FRAs. A broadscale assessment of suitable SuDS options has been provided giving an indication where there may be constraints to certain sets of SuDS techniques. This assessment is indicative and more detailed assessments should be carried out during the site planning stage to confirm the feasibility of different types of SuDS. It may be possible that those SuDS techniques highlighted as possibly not being suitable can be designed to overcome identified constraints. Where deemed required, culvert blockages were also presented to assess residual risk to sites.

It is important to recognise that a number of different sets of data have been used to represent the Flood Zones. Mapping shown in the detailed site summary tables shown in Appendix A as part of the Level 2 assessment may differ to the Environment Agency Flood Zones and 'Flood Map for Planning', as the flood risk from ordinary watercourses flowing through site options has been included in the summary table mapping. It was also agreed with the Environment Agency that where there are detailed models present, the Flood Zones should be derived from these models.

All the sites taken forward to Level 2 will require the application of the Sequential Test. The application of Exception Test will depend on the proposed site layout and the type of development proposed (i.e. the vulnerability classification and in which parts of the site at risk the development is proposed). Table 11-1 below shows an overview of the type of development that is appropriate by Flood Zone.

Table 11-1 Flood risk vulnerability and Flood Zone 'compatibility' from NPPF

Vulnerability Classification		Essential infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zones	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test	✓	✓
	Zone 3a	Exception Test	✓	×	Exception Test	✓
	Zone 3b	Exception Test	✓	×	×	×
Source: Table 3, NPPF Guidance - Flood risk and coastal change						

11.2 Summary of key site issues

- All seven sites taken forward for a Level 2 assessment are covered by detailed Environment Agency hydraulic models: SA07 is covered by the Dimore Brook 2009 ESTRY-TUFLOW model, SA02 is covered by the Wotton Brook 2007 ISIS-TUFLOW model, SA08 and SA18 are covered by the River Twyver 2006 2D TUFLOW model and SA09, SA13 and SA24 are covered by the River Severn tidal model.
- All sites with a detailed Level 2 summary table are at fluvial flood risk. The degree of flood risk varies, with some sites being only marginally affected along their boundaries, and other sites being more significantly affected, which will require more detailed investigations on sequential site layouts, SuDS possibilities, safe access and egress etc.
- The majority of sites are at risk from surface water flooding, with more areas of ponding in the higher return period events. Surface water tends to follow topographic flow routes, for example along the watercourses or isolated pockets of ponding where there are topographic depressions. Surface water should be considered when assessing safe access and egress to and from the site.
- Climate change mapping indicates that flood extents will increase. As a result, the depths, velocities and hazard of flooding may also increase. The significance of the increase tends to depend on the topography of site and the percentage allowance used. The Council and the Environment Agency require the 100-year plus 35% and 100-year plus 70% climate change scenarios to be considered in future developments.
- Blockage locations were determined by visual inspection of the OS mapping and LIDAR in the vicinity of the site, to determine whether a structure upstream, downstream, or within the site could have an impact on the site. These may need to be considered as part of a site-specific assessment.
- No sites are located in a Groundwater Source Protection Zone or a Nitrate Vulnerable Zone.
- Site SA13 – Land at St Oswalds is the only site which has areas within it designated by the Environment Agency as being a historic landfill site. For this, site ground investigation will be required to determine the extent of the contamination and the impact this may have on SuDS. Pre-application discussions with the Environment Agency should be undertaken for this site in particular, as there are specific requirements for drainage due to the contamination and land movement from historic landfill.
- A strategic assessment was conducted of SuDS options using regional datasets. A detailed site-specific assessment of suitable SuDS techniques would need to be undertaken at site-specific level to understand which SuDS option would be best.
- For a number of sites, there is the potential for safe access and egress to be impacted by fluvial or surface water flooding. Consideration should be made to these sites as to how safe access and egress can be provided during flood events, both to people and emergency vehicles.

12 Recommendations

A review of national and local policies has been conducted against the information collated on flood risk in this SFRA. Following this, several recommendations have been made for the Council to consider as part of their planning policy and flood risk management. These have been summarised below.

It is recommended that the outputs from this study are used as an evidence base for the allocation of potential development areas, directing new development to areas of lowest risk.

The Council should use the information provided within this SFRA for their Sequential Test decision-making, following which, if land outside Flood Zones 2 and 3 cannot appropriately accommodate all the necessary development, the Exception Test will need to be applied. This is where the Level 2 SFRA supports, as it considers the detailed nature of the flood characteristics within a Flood Zone and assessment of other sources of flooding. Where a site allocation is shown to be in either Flood Zone 2 and/or 3, and/ or has an ordinary watercourse running through or adjacent to it, the flood risk to the sites is to be taken forward to the Level 2 assessment.

This Level 2 assessment seeks to identify the probable extent, depth and velocity of flooding as well as the hazard posed to people, safe access and egress to help inform the Exception Test and provide more detailed guidance for site-specific FRAs. The Level 2 SFRA also includes a broadscale assessment of suitable SuDS options, providing an indication where there may be constraints to certain sets of SuDS techniques.

12.1 Assessing flood risk and developments

- The NPPF supports a risk-based and sequential approach to development and flood risk in England, so that development is located in the lowest flood risk areas where possible; it is recommended that this approach is adopted for all future developments within Gloucester.
- A site-specific FRA is required for all developments over 1ha in Flood Zone 1; for developments less than 1 ha in Flood Zone 1 where there is a change to vulnerability classification or where the development could be affected by sources of flooding; and for all developments located in an area which has been highlighted as having critical drainage problems. The FRA should be proportionate to the degree of flood risk, as well as the scale, nature and location of the development
- It is recommended that the impact of climate change to a site option is considered in a FRA and that the percentage increases which relate to the proposed lifetime of the development and the vulnerability classification of the development is accounted for. The Environment Agency and LLFA should be consulted to confirm a suitable approach to climate change in light of the latest guidance and requirements of Gloucester City. Developers should be made aware that whilst most watercourses in the City are fluvial, there are tidal influences and as such, climate change guidance in relation to sea level increases and tidal flood risk may need to be considered.
- At a site-specific level, for any developments shown to be at residual flood risk, for example from a breach or overtopping (e.g. reservoir, canal, perched watercourse), it is recommended that a detailed hydraulic modelling study is carried out using Environment Agency guidance to assess the residual risk. For development applications located in the vicinity of a canal or navigation channel or reservoir, it is recommended that overtopping and/

or breach of the structure is considered as part of a site-specific FRA to establish the residual risk to the development.

- Opportunities to reduce flood risk to wider communities should be sought through the regeneration of Brownfield sites, through reductions in the amount of surface water runoff generated on a site. The functional floodplain should be protected from development and returned to greenfield status (where possible).
- The LPA, the Environment Agency and LLFA should be consulted to confirm the level of assessment required and to provide any information on any known local issues.
- When assessing sites not identified in the City Plan (windfall sites), developers should use evidence provided in this SFRA to apply the Sequential Test, as well as provide evidence to show that they have adequately considered other reasonably available sites.
- To demonstrate the Exception Test has been passed, flood resilience design and emergency planning must be accounted for including:
    - The development will remain safe and operational under flood conditions;
    - A strategy for safe evacuation and / or safely remaining in the building under flood conditions;
    - Key services will continue to be provided under flood conditions; and
    - Buildings are designed for a quick recovery following a flood.

- The Environment Agency may require developers to consider the impacts of more extreme events in the appraisal of flood resilience design and emergency planning, i.e. the 100-year plus 70% climate change event for More Vulnerable developments in the Severn River Basin District.
- For any development (both major and minor), that results in built volume below the design flood level (100-year plus climate change flood level), mitigation shall be required for loss in floodplain storage volume.
- FRAs should demonstrate that developments do not increase the likelihood or intensity of flood risk to third party development. Where possible, proposals should seek to maximise opportunities to reduce flood risk at the site and to communities immediately downstream of the site.
- FRAs should follow the approach recommended by the NPPF (and associated guidance) and guidance provided by the Environment Agency and Gloucester City Council. Guidance and advice for developers on the preparation of site-specific FRAs include:
    - **Flood Risk Assessment for Planning Applications** (Environment Agency)
    - **Site-specific Flood Risk Assessment: CHECKLIST** (NPPF PPG, Defra)
    - **Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG)** (Gloucester City Council)

12.1.1 Future Developments

Development must seek opportunities to reduce the overall level of flood risk at the site, for example by:

- Reducing volume and rate of surface water runoff based on local planning policy and LLFA Guidance
- Locating development to areas with lower flood risk

- Leaving an 8m easement from top of bank to development to manage flood risk
- Creating space for flooding
- Integrating green infrastructure into mitigation measures for surface water runoff from potential development and consider using Flood Zones 2 and 3 as public open space.

The Local Planning Authority should consult the National Planning Practice Guidance and Environment Agency's 'Flood Risk Standing Advice (FRSA) for Local Planning Authorities', published in March 2014, when reviewing planning applications for proposed developments at risk of flooding.

At the planning application stage, developers may need to undertake more detailed hydrological and hydraulic assessments of the watercourses to verify flood extent (including latest climate change allowances, published by the Environment Agency in February 2016), inform development zoning within the site and prove, if required, whether the Exception Test can be passed.

The Sustainable Drainage SPG contains local requirements and guidance, some of which may differ from national guidance. This SPG will contain guidance relating to site-specific FRAs as well as drainage strategies.

It is recommended that as part of the early discussions relating to development proposals, developers discuss requirements relating to site-specific FRAs and drainage strategies, to identify any potential issues that may arise from the development proposals. The Council may seek technical advice and views from other Flood Risk Management Authorities; however, the Council's pre-planning application advice service is separate to similar pre-application consultation services provided by other Risk Management Authorities (e.g. the EA) and the Council would expect developers to obtain pre-application advice from the relevant Risk Management Authority on a separate basis.

12.1.2 Promotion of SuDS

Planners should be aware of the conditions set by the LLFA for surface water management and ensure development proposals and applications are compliant with the Council's policy. It is recommended that these policies should also be incorporated into the City Plan.

- Wherever possible, SuDS should be promoted.
- It is essential that developers consider sustainable drainage at an early stage of the development process – ideally at the master-planning stage. This will assist with the delivery of well designed, appropriate and effective SuDS.
- A detailed site-specific assessment of SuDS would be needed to incorporate SuDS successfully into the development proposals. New or re-development should adopt source control SuDS techniques to reduce the risk of frequent low impact flooding due to post-development runoff.
- Development should aim to achieve Greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible.
- Where possible developments must utilise the most sustainable form of drainage systems, in accordance with the SuDS hierarchy.
- For proposed developments, it is imperative that a site-specific infiltration test is conducted early on as part of the design of the development, to confirm whether the water table is low enough and if soils have adequate permeability to allow for SuDS techniques that are designed to encourage infiltration.

- Where sites lie within or close to Groundwater SPZs or aquifers, there may be a requirement for a form of pre-treatment prior to infiltration. Further guidance can be found in the CIRIA SuDS manual on the level of water quality treatment required for drainage via infiltration. Further restrictions may still be applicable, and guidance should be sought from the LLFA.
- Developers need to ensure that new development does not increase the surface water runoff rate from the site and should therefore contact the LLFA and other key stakeholders at an early stage to ensure surface water management is undertaken and that SuDS are promoted and implemented, designed to overcome site-specific constraints.
- The LPA will need to consider drainage schemes for major and minor applications, as well as review of SuDS on both types of application. It is advised that developers utilise the LLFA's policies and guidance to develop their drainage schemes for applications.
- Where SuDS are provided as part of a development, applicants should detail how it will be maintained in the long term.
- Drainage design requirements are set out in the Sustainable Drainage (A Design and Adoption Guide) Supplementary Planning Guide (SPG). The SPG states that Gloucester City Council will require the developed rate of runoff to be no greater than the greenfield runoff rate for a range of annual flow rate probabilities, up to and including the 6 hour 1 per cent AEP event (1 in 100-year) with an allowance for climate change (allowance should be agreed with the Council and the EA).
- The surface water discharge rate from brownfield sites should ideally be reduced to replicate greenfield rates. As a minimum, the surface water discharge rate on brownfield sites should be reduced by 40%, or the level set out in the latest Gloucester City/Gloucestershire County Council guidance, whichever is greater.
- Gloucester City Council require developments to meet the CIRIA C753 water quality recommendations. All watercourses in Gloucester are currently classed as 'failing' and a requirement of the WFD is for these watercourses to achieve a 'good' status.

12.1.3 Infrastructure and Access

- Any developments located within an area protected by flood defences, where the condition of those defences is 'fair' or 'poor', and where the standard of protection is not of the required standard should be identified and the use of developer contributions considered to fund improvements. None of the sites assessed in this Level 2 assessments are protected by formal flood defences, though this should be a consideration for any future windfall sites which may be located near to flood defences.
- Safe access and egress for residents and emergency and service vehicles will need to be demonstrated at all development sites.

12.1.4 Cumulative impact assessment

The following policy recommendations have been made following the cumulative impact assessment.

Relevant to all developments in the City

- Incorporate SuDS and provide details of adoption, ongoing maintenance and management. Proposals will be required to provide reasoned

justification for not using SuDS techniques, where ground conditions and other key factors show them to be technically feasible. Preference will be given to systems that contribute to the conservation and enhancement of biodiversity and green infrastructure in the City where practicable.

- Gloucestershire County Council as LLFA require all developments on greenfield sites to retain greenfield surface water discharge and all developments on brownfield sites to achieve at least a 40% reduction in surface water discharge.
- It is recommended that an 8m easement from top of bank on all main rivers and ordinary watercourses should kept free of development to help manage flood risk and for maintenance and ecology purposes.
- Gloucester has been designated as a nationally significant 'Flood Risk Area' in the 2018 Environment Agency Preliminary Flood Risk Assessment. Developers should therefore seek to reduce flood risk in the wider area which may include making a developer contribution towards wider flood alleviation works, as appropriate.

Policy that particularly focuses on the high-risk urban catchments: Sud Brook, Horsbere Brook, Wotton Brook and Dimore Brook

All new development in these catchments should:

- Seek to provide wider betterment in addition to that required city wide by demonstrating in site-specific Flood Risk Assessments and Surface Water Drainage Strategies what measures can be put in place to contribute to a reduction in flood risk downstream. This may either be by provision of additional storage on site e.g. through oversized SuDS, natural flood management techniques, green infrastructure and green-blue corridors and/or by providing a Partnership Funding contribution towards a wider community scheme. Consultation on the site-specific requirements should be undertaken with the LPA at the earliest opportunity.
- A Surface Water Drainage Strategy will be required for all developments in this catchment, regardless of development size.
- Gloucestershire County Council as LLFA and Gloucester City Council as LPA will review Surface Water Drainage Strategies in accordance with their local requirements for major developments. These should take into account all sources of flooding to ensure that future development is resilient to flood risk and does not increase flood risk elsewhere.
- The Environment Agency, in consultation with the LPA and GCC, should consider whether to formally designate the catchment as a Critical Drainage area. This would mean that a detailed Flood Risk Assessment would be required for all developments that are proposed, regardless of their size.

Policy that particularly focuses on the catchments with a SWMP hotspot: Sud Brook, Wotton Brook, Whaddon Brook, River Twyver, Horsbere Brook and Tuffley and Podsmead and City Plan sites located near a SWMP hotspot (SA06 and SA16, Blackbridge)

- Consider short-term measures to managing flood risk:
    - Developers should consider property level protection flood resilience measures for new development, e.g. raised thresholds, self-sealing UPVC doors, non-return valves and air brick covers.
    - Construction of online and offline storage areas on upstream catchments to alleviate flooding downstream (e.g. the Horsbere Brook flood storage area, opened in 2011).
- Consider long-term measures to managing flood risk:
    - Manage fluvial flood risk by restoring river corridors. Sections of heavily modified watercourse could be naturalised. This is especially relevant to the Sud Brook and Whaddon Brook, where Gloucester City Council are currently and have future plans for naturalising, sections of these watercourses. Watercourses could also be reconnected to the natural floodplain through de-culverting.
    - Managing surface water through green infrastructure e.g. encouraging the use of permeable surfacing in gardens and use measures to optimise drainage and reduce runoff, considering opportunities for water conservation through rainwater harvesting and water butts where appropriate for new and existing development and implementing green roofs.

12.2 Use of SFRA data and future updates

It is important to recognise that the SFRA has been developed using the best available information at the time of preparation. This relates both to the current risk of flooding from rivers, and the potential impacts of future climate change.

The SFRA should be a 'living document', and as a result should be updated when new information on flood risk, flood warning or new planning guidance or legislation becomes available. New information on flood risk may be provided by Gloucester City Council, Gloucestershire County Council, the Highways Authority, Canal and River Trust, Severn Trent Water and the Environment Agency. Such information may be in the form of:

- New hydraulic modelling results
- Flood event information following a future flood event
- Policy/ legislation updates
- Environment Agency flood map updates
- New flood defence schemes etc.

The Environment Agency regularly reviews their flood risk mapping, and it is important that they are approached to determine whether updated (more accurate) information is available prior to commencing a detailed Flood Risk Assessment. It is recommended that the SFRA is reviewed in line with the Environment Agency's Flood Zone map updates to ensure latest data is still represented in the SFRA, allowing a cycle of review and a review of any updated data by checking with the above bodies for any new information.

Appendices

A Level 2 Assessment

A.1 Site summary tables

A.2 Geo-PDF mapping

Offices at

Coleshill
Doncaster
Dublin
Edinburgh
Exeter
Glasgow
Haywards Heath
Isle of Man
Limerick
Newcastle upon Tyne
Newport
Peterborough
Saltaire
Skipton
Tadcaster
Thirsk
Wallingford
Warrington

Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

+44(0)1756 799919
info@jbaconsulting.com
www.jbaconsulting.com
Follow us:

Jeremy Benn Associates Limited

Registered in England 3246693

JBA Group Ltd is certified to:
ISO 9001:2015
ISO 14001:2015
OHSAS 18001:2007