Bradford Level 1 Strategic Flood Risk Assessment

Final Report

July 2019

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Revision history

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Final V1.0 / July 2019	CBMDC final comments	Alex Bartle Edward Norfolk

Contract

This report describes work commissioned by Alex Bartle, on behalf of City of Bradford Metropolitan District Council, by a letter dated 12 September 2018. City of Bradford Metropolitan District Council's representative for the contract was Alex Bartle. Hannah Bishop and Mike Williamson of JBA Consulting carried out this work.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to the client.

Acknowledgements

JBA would like to thank representatives of City of Bradford Metropolitan District Council, the Environment Agency and Yorkshire Water for information provided to inform this assessment.

Carbon footprint

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Executive summary

This Level 1 Strategic Flood Risk Assessment (SFRA) is an update to the 2008 and 2014 draft Level 1 SFRA using up-to-date flood risk information together with the most current flood risk and planning policy available from the National Planning Policy Framework[1] (NPPF) (2019) and Flood Risk and Coastal Change Planning Practice Guidance[2] (FRCC-PPG).

The Level 1 SFRA is focused on collecting readily available flood risk information from a number of stakeholders, the aim being to help identify the number and spatial distribution of flood risk sources present throughout the City of Bradford Metropolitan District Council's (CBMDC) authority area to inform the application of the Sequential Test.

CBMDC requires this Level 1 SFRA to initiate the sequential risk-based approach to the allocation of land for development and to identify whether application of the Exception Test is likely to be necessary. This will help to inform and provide the evidence base for the Local Planning Authority's (LPA) emerging Local Plan.

The LPA provided its latest Strategic Housing Land Availability Assessment (SHLAA) dataset. An assessment of flood risk to all SHLAA sites is carried out as part of this Level 1 SFRA to assist the LPA in its decision-making process for which sites to take forward to allocation as part of the Local Plan, and the strategic distribution of planned housing and economic growth across the District through the Core Strategy.

A number of CBMDC's SHLAA sites are shown to be at varying risk from fluvial, surface water and residual risk. Development consideration assessments for all assessed SHLAA sites are summarised through a number of strategic recommendations within this report and the development sites assessment spreadsheet in Appendix B. The strategic recommendations broadly entail the following:

- Strategic Recommendation A – consider withdrawal based on significant level of fluvial or surface water flood risk (if development cannot be directed away from areas of risk);
- Strategic Recommendation B – Exception Test required;
- Strategic Recommendation C – consider site layout and design;
- Strategic Recommendation D – development could be permitted subject to FRA; and
- Strategic Recommendation E – development could be allocated on flood risk grounds subject to consultation with LPA / LLFA.

SHLAA sites

Of the 1,353 SHLAA sites assessed, 123 are recommended as being potentially unsuitable for development, 33 of which are due to their location within the functional floodplain, updated as part of this Level 1 SFRA. The other 90 sites are seen to be at significant surface water flood risk.

There are 27 SHLAA sites to which Strategic Recommendation B applies, which, if allocated as residential or mixed use (more vulnerable proposed use) would be required to pass the Exception Test. Overall there are 53 assessed SHLAA sites to which Strategic Recommendation C applies. 36 of these sites have over 90% of their footprint within Flood Zone 1, meaning surface water is what needs to be mitigated at these sites. For these sites, the developer should consider site layout and design with a view

[1] https://www.gov.uk/government/publications/national-planning-policy-framework--2
[2] https://www.gov.uk/guidance/flood-risk-and-coastal-change

to incorporating the risk (i.e. the high and medium risk surface water flood zones) into the site design through suitable SuDS.

Recommendation D applies to 870 assessed SHLAA sites, 830 of which are wholly within Flood Zone 1.

Included within this Level 1 SFRA, along with this main report, are:

- The planning framework and flood risk policy information – Appendix A;
- Detailed interactive GeoPDF maps showing all available flood risk information together with the assessed SHLAA sites – Appendix B;
- Development site assessment spreadsheet detailing the risk to each site with strategic recommendations on development – Appendix C;
- A note on the delineation of the functional floodplain following discussion and agreement between the Council and the EA – Appendix D.

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Abbreviations

AAP	Area Action Plans
ABD	Areas Benefitting from Defences
ACDP	Area with Critical Drainage Problems
AEP	Annual Exceedance Probability
ART	Aire Rivers Trust
BCCAAP	Bradford City Centre Area Action Plan
BGS	British Geological Society
CaBA	Catchment Based Approach
CBMDC	City of Bradford Metropolitan District Council
CC	Climate change
CDA	Critical Drainage Area
CFMP	Catchment Flood Management Plan
DCLG	Department for Communities and Local Government
DPD	Development Plan Documents
DTM	Digital Terrain Model
EA	Environment Agency
FAA	Flood Alert Area
FAS	Flood Alleviation Scheme
FCDPAG	Flood and Coastal Defence Project Appraisal Guidance
FCERM	Flood and Coastal Erosion Risk Management Network
FCRMS	Flood and Coastal Risk Management Strategy
FDGiA	Flood Defence Grant in Aid
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FRCC-PPG	Flood Risk and Coastal Change Planning Practice Guidance
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FRMS	Flood Risk Management Strategy
FRR	Flood Risk Regulations
FSA	Flood Storage Area
FWA	Flood Warning Area
FWMA	Flood and Water Management Act
GI	Green Infrastructure
GIS	Geographical Information Systems
HFM	Historic Flood Map
IDB	Internal Drainage Board
LA	Local Authority
LASOO	Local Authority SuDS Officer Organisation
LDF	Local Development Framework
LFRMS	Local Flood Risk Management Strategy
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
LRF	Local Resilience Forum

MAFRP	Multi-Agency Flood Response Plan
MDC	Metropolitan District Council
MHCLG	Ministry of Housing, Communities and Local Government
NCR	National Cycle Route
NFM	Natural Flood Management
NGO	Non-Governmental Organisation
NPPF	National Planning Policy Framework
NPPG	Planning Practice Guidance
PCPA	Planning and Compulsory Purchase Act
PFRA	Preliminary Flood Risk Assessment
PFR	Property Flood Resilience
RBD	River Basin District
RBMP	River Basin Management Plan
RFO	Recorded Flood Outlines
RFCC	Regional Flood and Coastal Committee
RoFSW	Risk of Flooding from Surface Water map
RMA	Risk Management Authority
RoFRS	Risk of Flooding from Rivers and the Sea Map
RUDP	Replacement Unitary Development Plan
SA	Sustainability Appraisal
SCRC	Shipley and Canal Road Corridor
SEA	Strategic Environmental Assessment
SFRA	Strategic Flood Risk Assessment
SHLAA	Strategic Housing Land Availability Assessment
SoP	Standard of Protection
SPD	Supplementary Planning Documents
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
UDP	Unitary Development Plan
UKCIP02	UK Climate Projections 2002
UKCP09	UK Climate Projections 2009
UKCP18	UK Climate Projections 2018
WCS	Water Cycle Study
WFD	Water Framework Directive
WwNP	Working with Natural Processes
WYFRMP	West Yorkshire Flood Risk Management Partnership
YRFCC	Yorkshire Regional Flood and Coastal Committee
YW	Yorkshire Water

1 Introduction

1.1 Commission

City of Bradford Metropolitan District Council (CBMDC) commissioned JBA Consulting by a letter dated 12th September 2018 for the undertaking of a Level 1 Strategic Flood Risk Assessment (SFRA) to update the existing Level 1 SFRA previously updated in 2014. CBMDC requires this updated Level 1 SFRA to screen and assess flood risk to potential Local Plan development site allocations and to provide the evidence to inform the Sequential Test and, where necessary, the Exception Test. This will provide the evidence to support strategic flood risk policies and strategic distribution of planned growth in the Core Strategy, and site allocations in the Local Plan.

1.2 Bradford level 1 SFRA

This SFRA has been carried out in accordance with Government's latest development planning guidance including the revised National Planning Policy Framework (NPPF) (2019) and flood risk and planning policy guidance, the Flood Risk and Coastal Change Planning Practice Guidance (FRCC-PPG) (last updated March 2014, at the time of writing). The latest guidance is available online via:

http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change

An updated version of the NPPF was published on 19 February 2019 and sets out the Government's planning policies for England and how these are expected to be applied. This revised Framework replaces the previous NPPF published in March 2012. The online searchable version of the revised NPPF is not available at the time of writing, however a pdf version can be downloaded via:

https://www.gov.uk/government/publications/national-planning-policy-framework--2

This SFRA assesses the spatial distribution of flood risk across the local authority area and provides the discussion and guidance required to put this information into practice when taking account of flood risk in development plans and the level of detail required to carry out site specific Flood Risk Assessments (FRAs).

This SFRA makes use of the most up-to-date flood risk datasets, available at the time of submission, to assess the extent of risk, at a strategic level, to potential development allocation sites identified by CBMDC which acts as the Local Planning Authority (LPA) and the Lead Local Flood Authority (LLFA). The SFRA appendices contain interactive GeoPDF maps (Appendix B) showing the potential development sites overlaid with the latest, readily available, gathered flood risk information along with a Development Site Assessment spreadsheet (Appendix C) indicating the level of flood risk to each site following a strategic assessment of risk. This information will allow the LPA to identify the strategic development options that may be applicable to each site and to inform the application of the Sequential Test.

1.3 Aims and objectives

The aims and objectives of this Level 1 SFRA, as advised by the NPPF (2019) and FRCC-PPG and more specifically included in the Council's Brief, are to:

- Update on the previous 2014 SFRA using new or updated flood risk information including climate change allowances, where available.
- Produce an independent SFRA Level 1 Report to the Council including an executive summary in plain English.
- Investigate and identify the extent and severity of flood risk from all sources, both presently and in the future, using available data. This assessment will

enable the LPA to steer development away from those areas where flood risk is considered greatest, ensuring that areas allocated for development can be developed in a safe, cost effective and sustainable manner.

- Inform the Sustainability Appraisal (SA) of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies, including policies for flood risk management to ensure that flood risk is not increased.
- Apply the Sequential Test when determining land use allocations; safeguarding land from development that has potential for use in current and future flood risk management.
- Use opportunities offered by new development to reduce the causes and impacts of flooding.
- Identify the requirements for site-specific FRAs in particular locations, including those at risk from sources other than flooding from watercourses.
- Review and update the district's flood zone maps including; the functional floodplain, latest climate change allowances, mapping for flood zones 1/2/3a, surface/groundwater risk and modelled flood outlines.
- Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, using Sustainable Drainage Systems (SuDS), provision for conveyance and storage of floodwater. To present a thorough and updated understanding of all flood risk, based on up-to-date EA modelling.
- Reflect current national policy and legislation including the NPPF and FRCC-PPG to enable the LPA to meet their statutory obligations in relation to flood risk.
- Identify any cross-boundary flooding issues and work collaboratively with all relevant Risk Management Authorities (RMA).
- Adopt a catchment-based approach to flood risk assessment and management to help inform potential catchment-wide approaches and solutions to flood risk management.
- Take into account any specific requirements of the LPA and LLFA.
- Identify land required for current and future flood management that should be safeguarded as set out in the NPPF.
- Assist the Council in identifying specific areas where further and more detailed flood risk data and assessment work may be required whilst also taking into account the surface water management plans and other assessments already undertaken.
- Provide guidance for developers and local authority planning officers on planning requirements in relation to flood risk.
- Provide a reference document (this report) to which all parties involved in development planning and flood risk can reliably turn to for initial advice and guidance.
- Provide a suite of interactive GeoPDF flood risk maps illustrating the interaction between flood risk and potential development sites.
- Ensure any conclusions and recommendations are fully justified and robust, in accordance with the NPPF and NPPG requirements and best practice.

1.4 SFRA future proofing

This SFRA has been developed using the most up-to-date data and information available at the time of submission. The SFRA has been future proofed as far as possible though the reader should always confirm with the source organisation (CBMDC) that the latest information is being used when decisions concerning development and flood risk are being considered. The FRCC-PPG, alongside the NPPF, is referred to throughout this SFRA, being the current primary development and flood risk guidance information available at the time of the finalisation of this SFRA.

The EA would usually recommend updating an SFRA when there is a significant flood affecting the area, updated modelling or a change in policy such as the NPPF (2019). Where possible, the SFRA should be kept as a 'live' entity and continually updated when new information becomes available.

This SFRA uses the EA's Flood Map for Planning version issued in February 2019 to assess fluvial risk to potential development sites. The Flood Map for Planning is updated at quarterly intervals by the EA, as and when new modelling data becomes available. The reader should therefore refer to the online version of the Flood Map for Planning to check whether the flood zones may have been updated since February 2019, via the following link:

https://flood-map-for-planning.service.gov.uk/

2 Study area

The study area for this SFRA is defined by the administrative boundary of City of Bradford MDC located in West Yorkshire. Bradford is a major metropolitan authority and sixth largest district (in terms of population) in England covering an area of approximately 370km^2 stretching across Airedale Valley, Wharfedale Valley and the Worth Valley.

CBMDC is located within the River Aire & Calder and River Wharfe & Lower Ouse catchments. Flood processes and flood risk issues across the Council area are intricately linked by the Rivers Aire, Worth and Wharfe plus their many tributaries. 24km^2 of Bradford District drains to the River Calder which includes the M606 motorway and major employment sites[3].

Over 70% of the district is green open space and the population is estimated at 534,800 (Office for National Statistics (ONS), 2018[4]). The main urban area within the district is the City of Bradford. Other built up communities in the district include Keighley, Ilkley, Bingley, Shipley and Silsden with a number of smaller settlements also located in the more rural parts of the district.

The area has a history of wool spinning and cloth weaving industries with an estimated two-thirds of the UK's wool production being processed in Bradford in the late 19th Century. Industrial growth led to rapid expansion of the city with Bradford being granted city status in 1897 and became a metropolitan district council in 1974. Although the textile industry has declined in recent years, the local economy has diversified so the area now boasts industries entailing engineering, chemical, financial, printing and packaging, banking and export industries.

Flood risk across the Bradford District is varied but caused in the main by overland flow following short, high intensity, or heavy, prolonged rainfall events and/or overtopping rivers and watercourses. There is potential flood risk from fluvial, surface water, groundwater, sewers, and residual risk from canals and reservoirs. In some instances, sites may suffer from a combination of more than one source of flooding.

Historically, flooding has significantly affected parts of Bradford with a number of large scale, damaging flood events having occurred (See Section 5.6). Due to the increasing effects of climate change, awareness of and preparedness for flooding, both at a local and national scale, is vital in reducing flood risk to local authority areas.

The study area falls within the Humber River Basin District (RBD) and is served by Yorkshire Water (YW), the primary local water and sewerage operator.

[3] Bradford District: Local Flood Risk Management Strategy. December 2016
[4] https://datamillnorth.org/dataset/bradford-council-populations

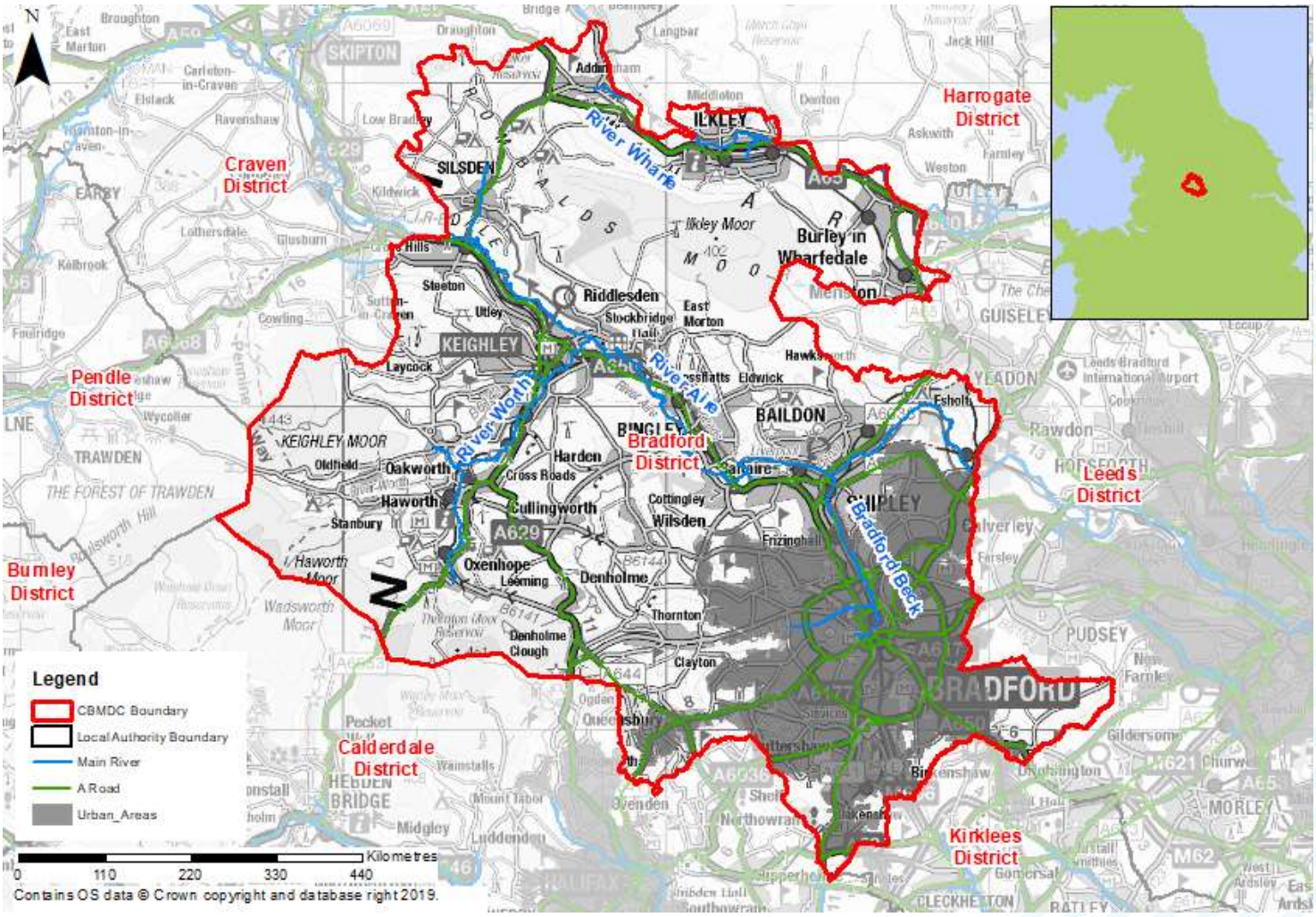

Figure 2-1: Study Area

2.1 Main rivers

Main rivers are usually larger rivers and streams. The Environment Agency carries out maintenance, improvement or construction work on main rivers to manage flood risk and therefore they are designated as the EA's responsibility. The Bradford district contains approximately 277 kilometres of designated Main River including the Rivers Aire, Worth and Wharfe.

2.1.1 River Aire

The River Aire flows for 148 kilometres rising to a height of around 350m above sea level from its source in the Yorkshire Dales near Malham where it flows downstream to its confluence with the River Ouse near Goole. The urban nature of the middle reaches of the Aire results in significant restrictions to the natural floodplain due to dense development.

2.1.2 River Worth

The River Worth is 6.67 kilometres in length. It flows from its source near Oxenhope through Haworth to Keighley where it joins the River Aire; it is one of the larger contributing catchments. The catchment area is generally urban to the east and rural in the uplands although some development has taken place within the upland valley which confines the floodplain. This situation is repeated within the urban low lands of

the River Worth in Keighley. There are a number of tributaries of the River Worth including three 'Main Rivers', North Beck, Bridgehouse Beck, and Providence Lane covering a length of 13.3km and 31km of 'Non-Main River'.

2.1.3 River Wharfe

The River Wharfe is a main river and part of the Ouse catchment area. The River Wharfe rises north of Hubberholme and flows in a south-easterly direction where it confluences with the River Ouse north of Cawood. The gently sloping valley sides lead down to the urbanised areas in the floor of the valley. The River Wharfe is a fast reacting river with flood flow rapidly passed downstream.

There are numerous smaller streams and becks descending from the moors that can be a source of flood risk in extreme rainfall events. Tributaries of the River Wharfe within Bradford MDC area include Backstone Beck in Ilkley and Town Beck. Town Beck has a restricted capacity.

2.2 Ordinary watercourses

Ordinary watercourses are those that are not designated as Main River and therefore come under the control of the LLFA, who have Permissive Powers to carry out works when necessary.

A number of the ordinary watercourses within Bradford MDC area were previously designated by the Environment Agency as 'Critical Ordinary Watercourses' (COWs). This designation reflected a known issue with respect to flooding and is generally associated with, for example, limited channel capacity, channel constrictions and/or a poor maintenance regime. In 2006/7 the EA reclassified all remaining COWs and took over responsibility for their maintenance and management. All the previous COWs are now defined as 'Main Rivers'.

2.3 Cross boundary issues

According to the revised NPPF, the LPA should work with neighbouring authorities to consider strategic cross boundary issues and infrastructure requirements. Local authorities also have a duty to cooperate whereby councils work together on strategic matters and produce effective and deliverable policies on strategic cross boundary matters.

The neighbouring LLFAs of North Yorkshire County Council, Calderdale Council, Kirklees Council, Leeds City Council and Wakefield Council adopt a partnership approach and co-operate in knowledge sharing and the delivery of FRM responsibilities through the West Yorkshire Flood Risk Management Partnership (WYFRMP) and LLFA meetings.

2.3.1 Hydrological linkages

A number of watercourses within Bradford originate outside the Council's administrative boundary. Although it is likely that small land use changes within Bradford will only have localised impact on river flows, major land use changes in the upstream catchments of the River Aire and River Wharfe could have a significant impact on their flow regime and, therefore, flood risk.

Figure 2-2 illustrates fluvial hydraulic linkages for the catchments in and around Bradford. Bradford receives from the Rivers Aire and Wharfe. Upstream land use changes in Craven district or Pendle district authority areas could have an effect on fluvial flood risk along these two watercourses. Bradford will also be a contributing catchment to those districts downstream e.g. Leeds.

The main potential adverse impacts that future development may have on downstream areas are twofold resulting in a potential:

- Reduction in upstream floodplain storage capacity; and

- Reduction in rainfall infiltration and increased runoff.

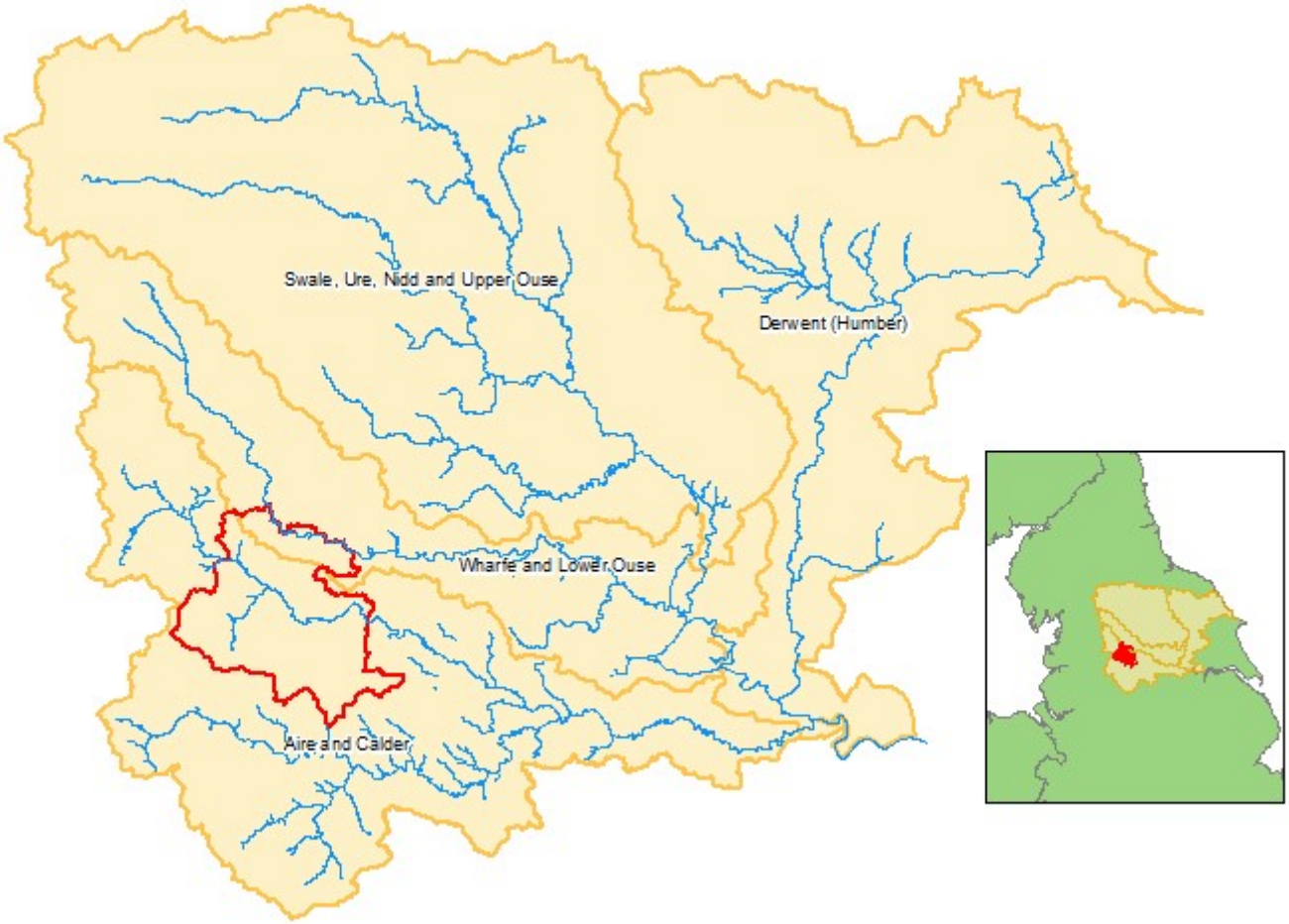

Figure 2-2: Fluvial hydraulic linkages for catchments in and around Bradford

These issues highlight the importance of the WYFRMP and to work together with the Environment Agency on flood risk management, particularly where actions could exacerbate flooding in downstream communities. The need for consistent regional development policies controlling runoff or development in floodplains within contributing districts is therefore crucial as this would have wider benefits for West Yorkshire authorities as a whole as well as Bradford. This should be carried out by the successful implementation of the Sequential Test. Appropriate flood risk management policies will also be required in the Local Plan.

3 Understanding flood risk

3.1 Sources of flooding

Flooding is a natural process and can happen at any time in a wide variety of locations, as discussed below. It constitutes a temporary covering of land not normally covered by water and presents a risk when human or environmental assets are present in the area that floods. Assets at risk from flooding can include housing, transport and public service infrastructure, commercial and industrial enterprises, agricultural land and environmental and cultural heritage. Flooding can occur from many different and combined sources and in many different ways. Major sources of flooding (also see Figure 3-1) include:

- **Fluvial** (main rivers and ordinary watercourses) – inundation of floodplains from rivers and watercourses; inundation of areas outside the floodplain due to influence of bridges, embankments and other features that artificially raise water levels; overtopping or breaching of defences; blockages of culverts; blockages of flood channels/corridors.
- **Tidal** – sea; estuary; overtopping of defences; breaching of defences; other flows (e.g. fluvial surface water) that could pond due to tide locking; wave action (not applicable to Bradford District).
- **Surface water** – surface water flooding covers two main sources including direct run-off from adjacent land (pluvial) and surcharging of piped drainage systems (public sewers, highways drains, etc.)
- **Groundwater** – water table rising after prolonged rainfall to emerge above ground level remote from a watercourse; most likely to occur in low-lying areas underlain by permeable rock (aquifers);
- **Infrastructure failure** – reservoirs; canals; industrial processes; burst water mains; blocked sewers or failed pumping stations.

Different types and forms of flooding present a range of different risks and the flood hazards of speed of inundation, depth and duration of flooding can vary greatly. With climate change, the frequency, pattern and severity of flooding are expected to change and become more damaging.

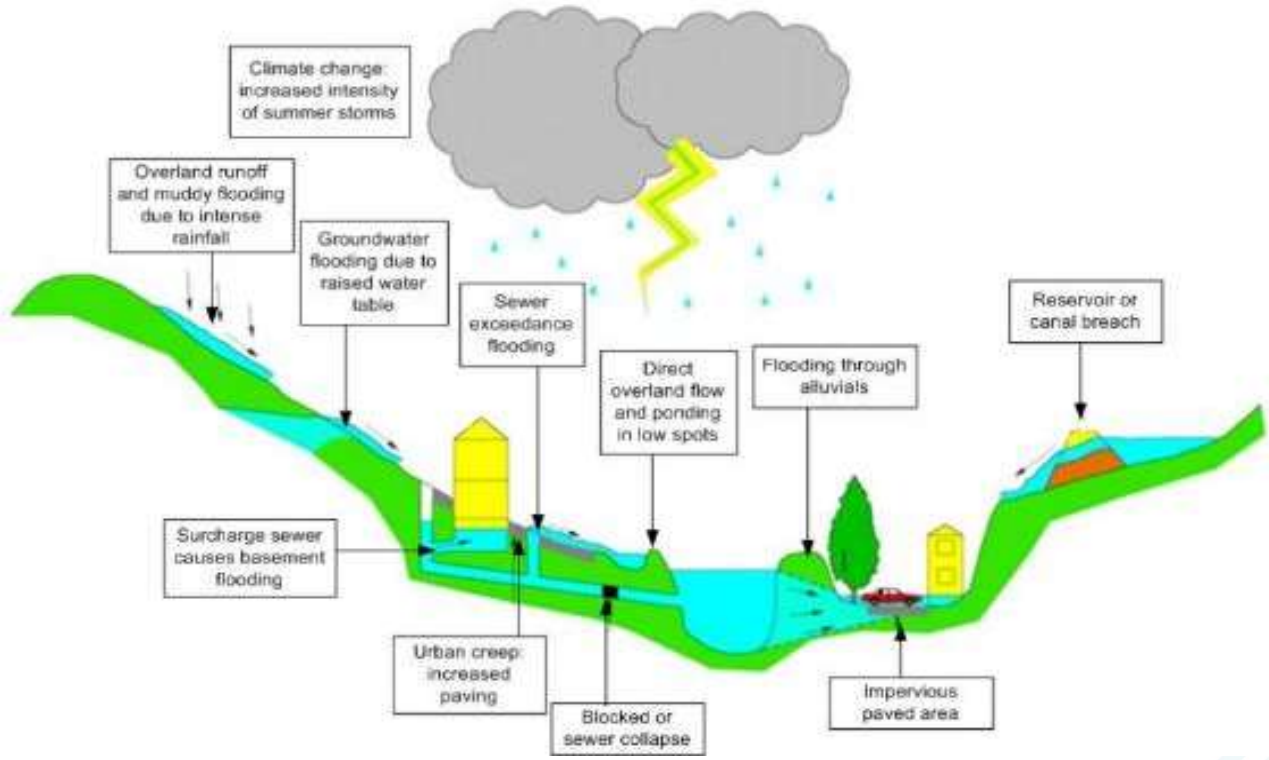

Figure 3-1: Flooding from all sources

3.2 Likelihood and consequence

Flood risk is a combination of the likelihood of flooding and the potential consequences arising. It is assessed using the source – pathway – receptor model as shown in Figure 3-2 below. This is a standard environmental risk model common to many hazards and should be the starting point of any assessment of flood risk. However, it should be remembered that flooding could occur from many different sources and pathways, and not simply those shown in the illustration below.

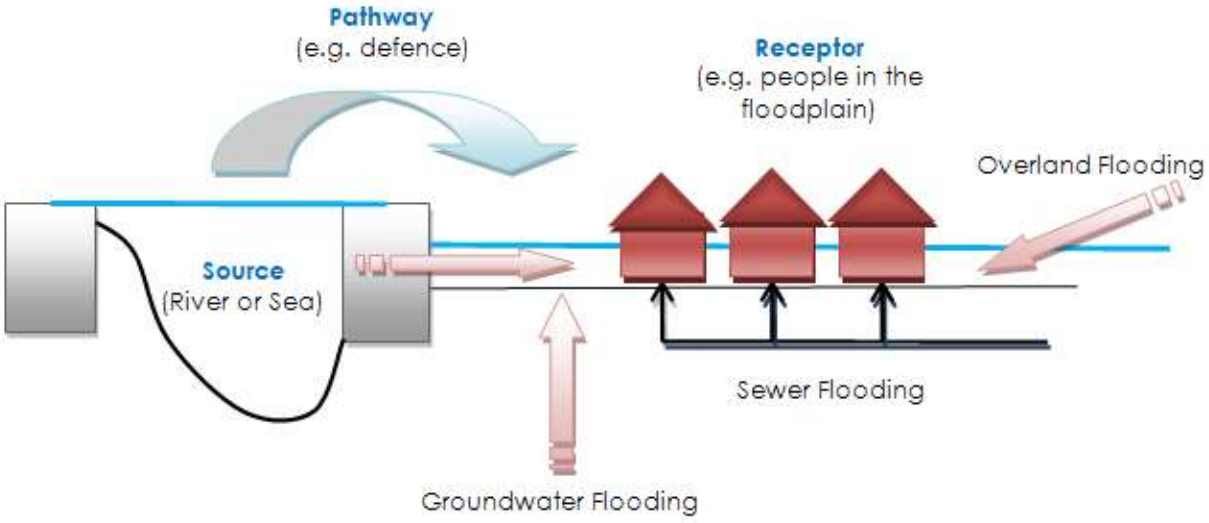

Figure 3-2: Source-Pathway-Receptor Model

The principal sources are rainfall or higher than normal sea levels (though not in Bradford District), the most common pathways are rivers, drains, sewers, overland flow and river and coastal floodplains and their defence assets and the receptors can include people, their property and the environment. All three elements must be present for flood risk to arise. Mitigation measures have little or no effect on sources of flooding, but they can block or impede pathways or remove receptors.

The planning process is primarily concerned with the location of receptors, taking appropriate account of potential sources and pathways that might put those receptors at risk. It is therefore important to define the components of flood risk in order to apply this guidance in a consistent manner.

3.2.1 Likelihood

Likelihood of flooding is expressed as the percentage probability based on the average frequency measured or extrapolated from records over a large number of years. A 1 in 100 AEP (Annual Exceedance Probability) event indicates the flood level that is expected to be reached on average once in a hundred years, i.e. it has a 1 in 100 AEP chance of occurring in any one year, not that it will occur once in every one hundred years. Table 3-1 provides an example of the flood probabilities used to describe the fluvial and tidal flood zones as defined in the FRCC-PPG and as used by the EA in their Flood Map for Planning (Rivers and Sea).

Note that the flood zones shown on the Flood Map for Planning do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding. The Flood Map for Planning can be accessed via:

https://flood-map-for-planning.service.gov.uk/

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea. flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	**This zone comprises land where water has to flow or be stored in times of flood.** Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone3a on the Flood Map)

Table 3-1: NPPF flood zones[5]

[5] Table 1: Flood Zones, Paragraph 065 of the Flood Risk and Coastal Change Planning Practice Guidance

3.2.2 Consequence

The consequences of flooding include fatalities, property damage, disruption to lives and businesses, with severe implications for people (e.g. financial loss, emotional distress, health problems). Consequences of flooding depend on the hazards caused by flooding (depth of water, speed of flow, rate of onset, duration, wave-action effects, water quality) and the vulnerability of receptors (type of development, nature, e.g. age-structure, of the population, presence and reliability of mitigation measures etc.). Flood risk is then expressed in terms of the following relationship:

Flood risk = Probability of flooding x Consequences of flooding

3.3 Risk

Flood risk is not static; it cannot be described simply as a fixed water level that will occur if a river overtops its banks or from a high spring tide that coincides with a storm surge. It is therefore important to consider the continuum of risk carefully. Risk varies depending on the severity of the event, the source of the water, the pathways of flooding (such as the condition of flood defences) and the vulnerability of receptors as mentioned above.

3.3.1 Actual risk

This is the risk 'as is' taking into account any flood defences that are in place for extreme flood events (typically these provide a minimum Standard of Protection (SoP)). Hence, if a settlement lies behind a fluvial flood defence that provides a 1 in 100-year SoP then the actual risk of flooding from the river in a 1 in 100-year event is generally low. However, the residual risk may be high in that the impact of flood defence failure would likely have a major impact.

Actual risk describes the primary, or prime, risk from a known and understood source managed to a known SoP. However, it is important to recognise that risk comes from many different sources and that the SoP provided will vary within a river catchment. Hence, the actual risk of flooding from the river may be low to a settlement behind the defence but moderate from surface water, which may pond behind the defence in low spots and is unable to discharge into the river during high water levels.

3.3.2 Residual risk

Defended areas, located behind EA, CBMDC and private organisation flood defences, remain at residual risk as there is a risk of overtopping or defence breach during significant flood events. Whilst the potential risk of failure may be reduced, consideration of inundation and the impact on development needs to be considered.

Paragraph 041 of the FRCC-PPG defines residual risk as:

"…those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- *The failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;*
- *failure of a reservoir, or;*
- *a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.*

Areas behind flood defences are at particular risk from rapid onset of fast-flowing and deep-water flooding, with little or no warning if defences are overtopped or breached."

Even when flood defences are in place, there is always a likelihood that these could be overtopped in an extreme event or that they could fail or breach. Where there is a

consequence to that occurrence, this risk is known as residual risk. Defence failure can lead to rapid inundation of fast flowing and deep floodwaters, with significant consequences to people, property and the local environment behind the defence. Whilst the actual risk of flooding to a settlement that lies behind a fluvial flood defence that provides a 1 in 100-year SoP may be low, there will always be a residual risk from flooding if these defences overtopped or failed that must be taken into account. Because of this, it is never appropriate to use the term "flood free".

Developers must be able to demonstrate that development will be safe for the lifespan of the development. To that end, Paragraph 042 of the FRCC-PPG states:

"Where residual risk is relatively uniform, such as within a large area protected by embanked flood defences, the Strategic Flood Risk Assessment should indicate the nature and severity of the risk remaining, and provide guidance for residual risk issues to be covered in site-specific flood risk assessments. Where necessary, local planning authorities should use information on identified residual risk to state in Local Plan policies their preferred mitigation strategy in relation to urban form, risk management and where flood mitigation measures are likely to have wider sustainable design implications".

4 The planning framework and flood risk policy

4.1 Introduction

The main purpose of this section of the SFRA is to provide an overview of the key planning and flood risk policy documents that have shaped the current planning framework. This section also provides an overview and context of the LLFA's and LPA's responsibilities and duties in respect to managing local flood risk including but not exclusive to the delivery of the requirements of the Flood Risk Regulations (FRR) 2009 and the Flood and Water Management Act (FWMA) 2010.

Figure 4-1 illustrates the links between legislation, national policy, statutory documents and assessment of flood risk. The figure shows that whilst the key pieces of legislation and policy are separate, they are closely related, and their implementation should aim to provide a comprehensive and planned approach to asset record keeping and improving flood risk management within communities.

It is intended that the non-statutory Surface Water Management Plans (SWMPs) and SFRAs can provide much of the base data required to support the delivery of the LLFA's statutory flood risk management tasks as well supporting local authorities in developing capacity, effective working arrangements and informing Local Flood Risk Management Strategies (LFRMS) and Local Plans, which in turn help deliver flood risk management infrastructure and sustainable new development at a local level. This SFRA should be used to support the LPA's emerging Local Plan and to help inform planning decisions.

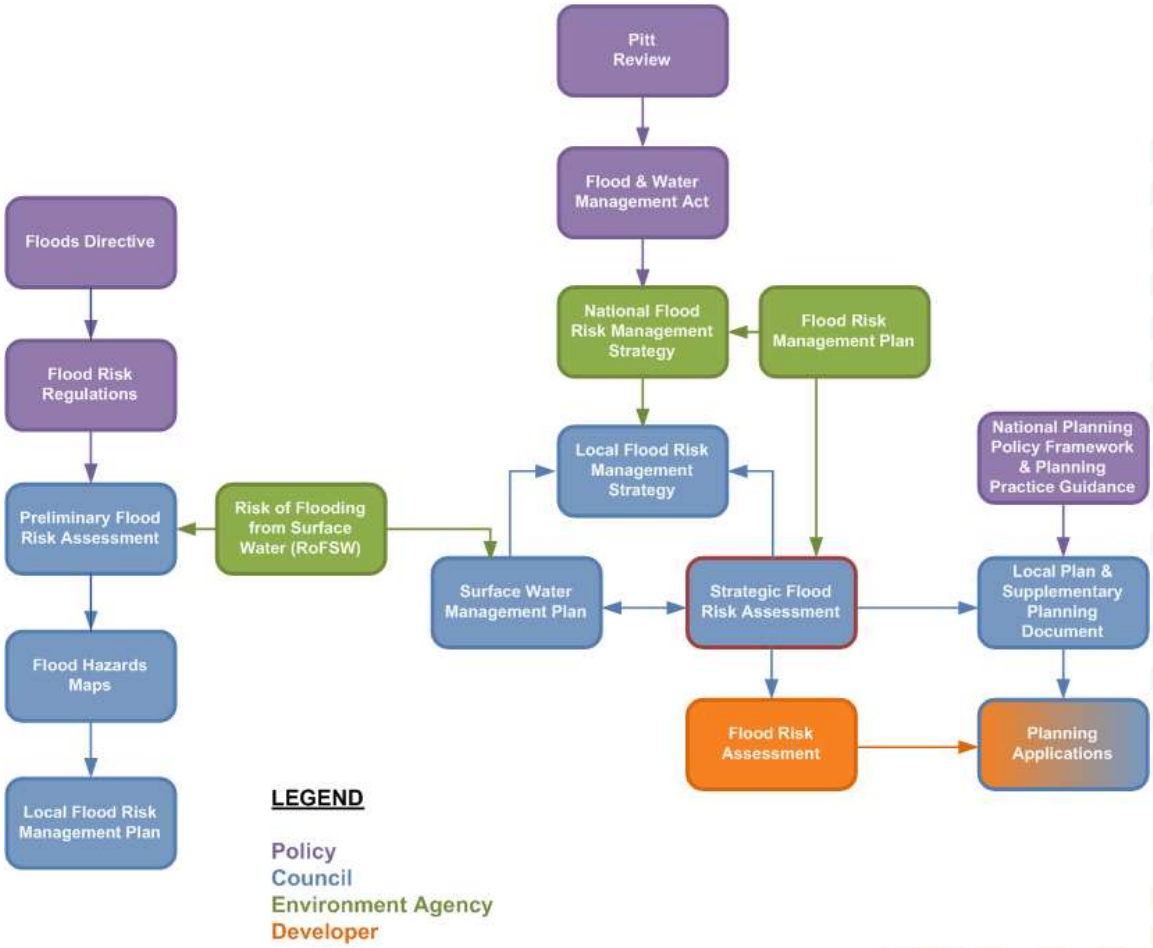

Figure 4-1: Key documents and strategic planning links with flood risk

The remaining flood risk policy information relating to CBMDC is located in Appendix A.

5 Flood risk across Bradford district

5.1 Flood risk datasets

This section of the SFRA provides a strategic overview of flood risk from all sources within the Bradford district. The information contained is the best available at the time of publication and is intended to provide CBMDC with an overview of risk. Table 5-1 provides a summary of the key datasets used in this SFRA according to the source of flooding.

Flood Source	Datasets / Studies
Fluvial	EA Flood Map for Planning (Rivers and Sea) (February 2019 version)
	EA Risk of Flooding from Rivers and Sea map
	Modelled Flood Outlines (MFO) from latest available EA Flood Risk Mapping Studies
	EA Historic Flood Map (HFM) (February 2019)
	EA Recorded Flood Outlines (RFO) (November 2018)
	EA Areas Benefitting from Flood Defences (ABD) (November 2018)
	EA Flood Warning Areas (February 2019)
Pluvial (surface water runoff)	EA Risk of Flooding from Surface Water (RoFSW)
	CBMDC Preliminary Flood Risk Assessment 2011 and update 2017 (Significant FRA identified in Bradford City Centre)
Sewer	Yorkshire Water Historical Flood Incident Data
Groundwater	JBA 5m Resolution Groundwater Flood Map
Reservoir	EA Reservoir Flood Maps (available online)
All sources	Humber Flood Risk Management Plan 2015 to 2021
	Humber River Basin Management Plan (June 2018)
	Aire Catchment Flood Management Plan (2009)
	Ouse Catchment Flood Management Plan (2009)
	Bradford District Local Flood Risk Management Strategy (December 2016)
	CBMDC Historic Flood Records
	CBMDC Level 1 SFRA 2008 (last updated 2014)
	CBMDC Level 2 SFRA AAP 2014
Flood risk management infrastructure	EA Spatial Flood Defence data (November 2018)
	LLFA FRM asset register

Table 5-1: Flood source and key datasets

5.2 Fluvial flooding

Fluvial flooding is associated with the exceedance of channel capacity during higher flows or as a result of blockage. The process of flooding from watercourses depends on a number of characteristics associated with the catchment including geographical location and variation in rainfall; steepness of the channel and surrounding floodplain; and infiltration and rate of runoff associated with urban and rural catchments.

The SFRA Maps in Appendix B present the EA's Flood Map for Planning which shows the fluvial coverage of flood zones 2 and 3 across the CBMDC area.

5.2.1 Main river

The EA decides which watercourses are Main Rivers. It consults with other risk management authorities and the public before making these decisions.

The EA describes Main Rivers as usually being larger rivers and streams with other rivers known as ordinary watercourses. The EA carries out maintenance, improvement or construction work on Main Rivers to manage flood risk and will carry out flood defence work to Main Rivers only.

As noted in Section 2, CBMDC area contains the Main Rivers of the Rivers Aire, Worth and Wharfe. The mechanisms of flooding along these watercourses and their tributaries can be described as fluvial in nature. The Flood Map for Planning is used to assess fluvial risk to CBMDC's potential development sites.

The Flood Map for Planning indicates that the majority of fluvial risk within the CBMDC boundary comes from the River Aire that runs through the centre of the district. The River Wharfe can also be described as posing significant risk towards the north-east of the district.

5.2.2 Ordinary watercourses

Ordinary watercourses are any watercourse not designated as Main River. These watercourses can vary in size considerably and can include rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows.

LLFAs, district councils and internal drainage boards have statutory permissive powers to carry out flood risk management work on ordinary watercourses.

5.2.3 EA Flood Map for Planning (Rivers and Sea)

The EA's Flood Map for Planning is the main dataset used by planners for predicting the location and extent of fluvial and tidal flooding (tidal flooding does not apply to Bradford). This is supported by the CFMPs and FRMPs along with a number of detailed hydraulic river modelling reports which provide further detail on flooding mechanisms.

The Flood Map for Planning provides flood extents for the 1 in 100 AEP fluvial event (Flood Zone 3) and the 1 in 1000 AEP fluvial flood events (Flood Zone 2). Flood zones were originally prepared by the EA using a methodology based on the national digital terrain model (NextMap), derived river flows from the Flood Estimation Handbook (FEH) and two-dimensional flood routing. Since their initial release, the EA has regularly updated its flood zones with detailed hydraulic model outputs as part of their national flood risk mapping programme.

The Flood Map for Planning is precautionary in that it does not take account of flood defence infrastructure (which can be breached, overtopped or may not be in existence for the lifetime of the development) and, therefore, represents a worst-case scenario of flooding. The flood zones do not consider sources of flooding other than fluvial and tidal (although tidal does not apply to Bradford), and do not take account of climate change. As directed by the FRCC-PPG, this SFRA subdivides Flood Zone 3 into Flood Zone 3a and Flood Zone 3b (functional floodplain – see Section 5.2.4).

The EA also provides a 'Risk of Flooding from Rivers and Sea Map'. This map shows the EA's assessment of the likelihood of flooding from rivers and the sea, at any location, and is based on the presence and effect of all flood defences, predicted flood levels and ground levels. This dataset is not used in the assessment of flood risk for planning applications but is a useful source of information to show the presence and effects of flood risk management infrastructure.

This SFRA uses the Flood Map for Planning issued in February 2019 to assess fluvial risk to assessed sites, as per the NPPF and the accompanying FRCC-PPG. The Flood

Map for Planning is updated at quarterly intervals by the EA, as and when new modelling data becomes available. The reader should therefore refer to the online version of the Flood Map for Planning to check whether the flood zones may have been updated since February 2019:

https://flood-map-for-planning.service.gov.uk/

5.2.4 Functional floodplain (Flood zone 3b)

The functional floodplain forms a very important planning tool in making space for flood waters when flooding occurs. Development should be directed away from these areas.

Table 1, Paragraph 065 of the FRCC-PPG defines Flood Zone 3b as:

"…land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency."

Paragraph 015 of the FRCC-PPG explains that:

"…the identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. However, land which would naturally flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood (such as a flood attenuation scheme) in an extreme (0.1% annual probability) flood, should provide a starting point to help identify the functional floodplain.

The area identified as functional floodplain should take into account the presence and effect of all flood risk management infrastructure including defences. Areas which would naturally flood, but which are prevented from doing so by existing defences and infrastructure or solid buildings, will not normally be identified as functional floodplain. If an area is intended to flood, e.g. an upstream flood storage area designed to protect communities further downstream, then this should be safeguarded from development and identified as functional floodplain, even though it might not flood very often."

The EA's most up-to-date Historic Flood Map (HFM), Areas Benefitting from Defences (ABD), Recorded Flood Outlines (RFO) and Flood Storage Areas (FSA) datasets were assessed with regards to assisting with the update of the functional floodplain, where appropriate. A technical note is provided in Appendix D which explains the methodology used in creating the functional floodplain outline

The River Wharfe Tribs Model (Burley Beck 2002, Backstone Beck 2003 and Town Beck 2003 outlines), River Worth 2007, Upper Aire 2008, and the River Wharfe 2014 modelled outlines were also used to update the functional floodplain. Flood Zone 3 and the previous functional floodplain were also used in this instance with Flood Zone 3 being used in areas where the functional floodplain exceeded Flood Zone 3 outlines.

The functional floodplain outline was assessed and agreed upon by the LPA, the LLFA and the EA, based on their knowledge.

5.3 Surface water flooding

Surface water flood risk should be afforded equal standing in importance and consideration as fluvial flood risk, given the increase in rainfall intensities due to climate change and the increase in impermeable land use due to development.

Surface water flooding, in the context of this SFRA, includes:

- **Surface water runoff (also known as pluvial flooding); and**
- **Sewer flooding**

There are certain locations, generally within urban areas, where the probability and consequence of pluvial and sewer flooding are more prominent due to the complex hydraulic interactions that exist in the urban environment. Urban watercourse

connectivity, sewer capacity, and the location and condition of highway gullies all have a major role to play in surface water flood risk.

Paragraph 013 of the FRCC-PPG states that SFRAs should address surface water flooding issues by identifying areas of surface water flooding and areas where there may be drainage issues that can cause surface water flooding. The EA's Risk of Flooding from Surface Water (RoFSW) map along with information within the LFRMS (see Appendix A, Section A.7.4) should assist with this and various mitigative measures, i.e. SuDS, should be identified. Sections 6.12 and 6.14 provide guidance on mitigation options and SuDS for developers.

It should be acknowledged that once an area is flooded during a large rainfall event, it is often difficult to identify the route, cause and ultimately the source of flooding without undertaking further site-specific and detailed investigations.

According to the 2011 PFRA, for a rainfall event with a 1 in 200 chance of occurring, it is estimated that approximately 7,250 properties (approximately 80% are residential properties) are at risk from surface water flooding to a depth of 0.3m within the Bradford district.

At the time of writing, the Council are carrying out surface water modelling in Silsden, parts of Keighley and Burley-in-Wharfedale. Modelling outputs should be available in late 2019 / early 2020.

5.3.1 Pluvial flooding

Pluvial flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours. In these instances, the volume of water from rural land can exceed infiltration rates in a short amount of time, resulting in the flow of water over land. Within urban areas, this intensity can be too great for the urban drainage network resulting in excess water flowing along roads, through properties and ponding in natural depressions. Areas at risk of pluvial flooding can, therefore, lie outside of the fluvial flood zones.

Pluvial flooding within urban areas across the country will typically be associated with events greater than the 1 in 30 AEP design standard of new sewer systems. Some older sewer and highway drainage networks will have a lower capacity than what is required to mitigate for the 1 in 30 AEP event. There is also residual risk associated with these networks due to possible network failures, blockages or collapses.

Risk of Flooding from Surface Water dataset

The Risk of Flooding from Surface Water (RoFSW), formally referred to as the updated Flood Map for Surface Water (uFMfSW) is the third-generation national surface water flood map, produced by the EA, aimed at helping to identify areas where localised, flash flooding can cause problems even if the Main Rivers are not overflowing. The RoFSW, used in this SFRA to assess risk from surface water, has proved extremely useful in supplementing the EA Flood Map for Planning by identifying areas in Flood Zone 1, which may have critical drainage problems. However, any sites identified to be at risk from surface water flooding should be assessed in more detail, following this SFRA, as the RoFSW is a national-scale dataset and could therefore over-represent the specific risk to the district.

The RoFSW includes surface water flood outlines, depths, velocities and hazards for the following events:

- 1 in 30 AEP event (3.33%) – high risk
- 1 in 100 AEP event (1%) – medium risk
- 1 in 1000 AEP event (0.1%) – low risk

The RoFSW is much more refined than the second-generation map in that:

- More detailed hydrological modelling has been carried out using several design rainfall events rather than one for the second-generation,
- A higher resolution Digital Terrain Model (DTM) has been used – 2m, compared to 5m for the second-generation,
- Manual edits of DTM to improve flow routes at over 91,000 locations compared to 40,000 for the second-generation,
- DTM edited to better represent road network as a possible flow pathway, this was not done for the second-generation,
- 'Manning's n roughness' (used to represent the resistance of a surface to flood flows in channels and floodplains) values varied using MasterMap Topography layer compared to blanket values for urban and rural land use applied in the second-generation surface water flood map.

The aim of the RoFSW map is to identify areas where localised, flash flooding can cause problems even if the Main Rivers are not overflowing. The RoFSW has proved extremely useful in supplementing the Flood Map for Planning, by identifying areas in Flood Zone 1 which may have critical drainage problems.

The National Modelling and Mapping Method Statement, May 2013 details the methodology applied in producing the map. The RoFSW is displayed on the SFRA maps.

5.3.2 Sewer flooding

Combined sewers spread extensively across urban areas serving residential homes, business and highways, conveying waste and surface water to treatment works. Combined Sewer Overflows (CSOs), provide an EA consented overflow release from the drainage system into local watercourses or large surface water systems during times of high flows. Some areas may also be served by separate waste and surface water sewers which convey waste water to treatment works and surface water into local watercourses.

Flooding from the sewer network mainly occurs when flow entering the system, such as an urban storm water drainage system, exceeds its available discharge capacity, the system becomes blocked or it cannot discharge due to a high water level in the receiving watercourse. Pinch points and failures within the drainage network may also restrict flows. Water then begins to back up through the sewers and surcharge through manholes, potentially flooding highways and properties. It must be noted that sewer flooding in 'dry weather' resulting from blockage, collapse or pumping station mechanical failure (for example), is the sole concern of the drainage undertaker.

Yorkshire Water is the water company responsible for the management of the majority of the drainage networks across the district.

5.3.3 Areas with Critical Drainage Problems and Critical Drainage Areas

The EA can designate Areas with Critical Drainage Problems (ACDPs). ACDPs may be designated where the EA is aware that development within a certain catchment / drainage area could have detrimental impacts on fluvial flood risk downstream, and / or where the EA has identified existing fluvial flood risk issues that could be exacerbated by upstream activities. In these instances, the EA would work with the LLFA and LPA to ensure that adequate surface water management measures are incorporated into new development to help mitigate fluvial flood risk.

EA guidance on carrying out Flood Risk Assessments[6] states that a FRA should be carried out for sites in Flood Zone 1 that are…

[6] https://www.gov.uk/guidance/flood-risk-assessment-in-flood-zone-1-and-critical-drainage-areas

"…in an area with critical drainage problems as notified by the Environment Agency."

This statement refers to sites within an ACDP, not a CDA. At the time of writing there are no ACDPs or CDAs in CBMDC.

CDAs can be designated by LPAs or LLFAs for their own purposes. The EA do not have to be consulted on sites that are within a CDA if such sites are in Flood Zone 1.

5.3.4 Locally agreed surface water information

EA guidance, from within the Flood and Water Management Act (FWMA) (2010)[7], on using surface water flood risk information recommends that CBMDC, as a LLFA, should:

"…review, discuss, agree and record, with the Environment Agency, Water Companies, Internal Drainage Boards and other interested parties, what surface water flood data best represents their local conditions. This will then be known as locally agreed surface water information".

Following on from the LLFA consultation on the RoFSW in 2013 before its release, the EA stated that the Flood Map for Surface Water (2010) and the Areas Susceptible to Surface Water Flooding (2008) maps do not meet the requirements of the Flood Risk Regulations and are not compatible with the 2013 RoFSW mapping. Consequently, these datasets cannot be used as 'locally agreed surface water information'.

Locally agreed surface water information either consists of:

- The RoFSW map, or
- Compatible local mapping if it exists i.e. from a SWMP, or
- A combination of both these datasets for defined locations in the LLFA area.

CBMDC should consider the RoFSW to be its locally agreed surface water flood information as this is the latest, most robust surface water flood map available for the district, at the time of writing. The aforementioned surface water modelling outputs for Silsden, parts of Keighley and Burley-in-Wharfedale may be used as the best available surface water information for these areas, once complete.

5.4 Groundwater flooding

Groundwater flooding is caused by the emergence of water from beneath the ground, either at point or diffuse locations. The occurrence of groundwater flooding is usually local and unlike flooding from rivers and the sea, does not generally pose a significant risk to life due to the slow rate at which the water level rises. However, groundwater flooding can cause significant damage to property, especially in urban areas, and can pose further risks to the environment and ground stability.

There are several mechanisms that increase the risk of groundwater flooding including prolonged rainfall, high in-bank river levels, artificial structures, groundwater rebound and mine water rebound. Properties with basements or cellars or properties that are located within areas deemed to be susceptible to groundwater flooding are at particular risk. Development within areas that are susceptible to groundwater flooding will generally not be suited to SuDS; however, this is dependent on detailed site investigation and risk assessment at the FRA stage.

This SFRA uses groundwater data in the form of JBA's 5m groundwater map, which provides a general broad-scale assessment of the groundwater flood hazard. The map is categorised by grid code where each code is explained in Table 5-2.

[7] https://www.legislation.gov.uk/ukpga/2010/29/pdfs/ukpga_20100029_en.pdf

Groundwater head difference (m)*	Grid Code	Class label
0 to 0.025	4	Groundwater levels are either at very near (within 0.025m of) the ground surface in the 100-year return period flood event. Within this zone there is a risk of groundwater flooding to both surface and subsurface assets. Groundwater may emerge at significant rates and has the capacity to flow overland and/or pond within any topographic low spots.
0.025 to 0.5	3	Groundwater levels are between 0.025m and 0.5m below the ground surface in the 100-year return period flood event. Within this zone there is a risk of groundwater flooding to surface and subsurface assets. There is the possibility of groundwater emerging at the surface locally.
0.5 to 5	2	Groundwater levels are between 0.5m and 5m below the ground surface in the 100-year return period flood event. There is a risk of flooding to subsurface assets but surface manifestation of groundwater is unlikely.
>5	1	Groundwater levels are at least 5m below the ground surface in the 100-year return period flood event. Flooding from groundwater is not likely.
N/A	0	No risk. This zone is deemed as having a negligible risk from groundwater flooding due to the nature of the local geological deposits.

*Difference is defined as ground surface in mAOD minus modelled groundwater table in mAOD.

Table 5-2: Groundwater flood hazard classification of JBA groundwater map

This dataset shows that the areas with the highest levels of groundwater vulnerability are located at Keighley, Keighley Moor, Menston, Birkenshaw, East Morton, Cullingworth, south of Oxenhope, and to the west of Bradford City Centre. A high proportion of Bradford District is categorised as very little or no risk of flooding from groundwater.

It is important to ensure that future development is not placed at unnecessary risk therefore groundwater flood risk should be considered on a site by site basis in development planning.

Groundwater flood risk should be considered particularly when determining the acceptability of SuDS schemes as a way of managing surface water drainage. Developers should consult with the LPA, the LLFA and the EA at an early stage of the assessment.

The groundwater vulnerability dataset is shown on the SFRA Maps in Appendix B.

This SFRA uses groundwater data in the form of JBA's 5m groundwater map, which provides a general broad-scale assessment of the groundwater flood hazard. Where development is shown to lie within areas that are susceptible to groundwater flooding detailed site hydrogeological investigation and risk

assessment should be carried out at the Flood Risk Assessment stage to fully understand the risk from this source.

5.5 Canal and reservoir flood risk

5.5.1 Canals

Non-natural or artificial sources of flooding can include canals where water is retained above natural ground level. The risk of flooding along a canal is considered to be residual and is dependent on a number of factors. As canals are manmade systems that are heavily controlled, it is unlikely they will respond in the same way as a natural watercourse during a storm event. Flooding is more likely to be associated with residual risks, similar to those associated with river defences, such as overtopping of canal banks, breaching of embanked reaches or asset (gate) failure as highlighted in Table 5-3. Canals can also have a significant interaction with other sources, such as watercourses that feed them and minor watercourses or drains that cross underneath.

Potential Mechanism	Significant Factors
Leakage causing erosion and rupture of canal lining leading to breach	Embankments Sidelong ground Culverts Aqueduct approaches
Collapse of structures carrying the canal above natural ground level	Aqueducts Large diameter culverts Structural deterioration or accidental damage
Overtopping of canal banks	Low freeboard Waste weirs
Blockage or collapse of conduits	Culverts

Table 5-3: Canal flooding

The risks associated with these events are also dependent on their potential failure location with the consequence of flooding higher where floodwater could cause the greatest harm due to the presence of local highways and adjacent property.

The Leeds and Liverpool canal runs through the Bradford District and is managed by the Canal and River Trust. Flooding has been recorded when the River Aire overtops into the canal causing increased flood risk to communities located close to the canal network (see Section 5.6). Shipley has been identified as an area at risk[8].

5.5.2 Reservoirs

A reservoir can usually be described as an artificial lake where water is stored for use. Some reservoirs supply water for household and industrial use, others serve other purposes, for example, as fishing lakes or leisure facilities. Like canals, the risk of flooding associated with reservoirs is residual and is associated with failure of reservoir outfalls or breaching. This risk is reduced through regular maintenance by the operating authority. Reservoirs in the UK have an extremely good safety record with no incidents resulting in the loss of life since 1925.

The EA is the enforcement authority for the Reservoirs Act 1975 in England and Wales, with the Flood and Water Management Act (2010) amending this Act. All large reservoirs must be regularly inspected and supervised by reservoir panel engineers.

[8] Humber RBD Flood Risk Management Plan 2015-2021 Part A: Background and River Basin District wide information

LAs are responsible for coordinating emergency plans for reservoir flooding and ensuring communities are well prepared. The LPAs should work with other members of the West Yorkshire Resilience Forum to develop these plans. See Section 7.1.1 for more information on the West Yorkshire Resilience Forum.

Paragraph 014 of the FRCC-PPG states that, in relation to development planning and reservoir dam failure, *"the local planning authority will need to evaluate the potential damage to buildings or loss of life in the event of a dam failure, compared to other risks, when considering development downstream of a reservoir. Local planning authorities will also need to evaluate in Strategic Flood Risk Assessments (and when applying the Sequential Test) how an impounding reservoir will modify existing flood risk in the event of a flood in the catchment it is located within, and/or whether emergency draw-down of the reservoir will add to the extent of flooding."*

5.5.3 Reservoir Flood Map (RFM)

The EA has produced Reservoir Flood Maps (RFM) for all large reservoirs that they regulated under the Reservoirs Act 1975 (reservoirs that hold over 25,000 cubic metres of water). The FWMA updated the Reservoirs Act and targeted a reduction in the capacity at which reservoirs should be regulated from 25,000m^3 to 10,000m^3. This reduction is, at the time of writing, yet to be confirmed meaning the requirements of the Reservoirs Act 1975 should still be adhered to.

The maps show the largest area that might be flooded if a reservoir were to fail and release the water it holds, including information about the depth and speed of the flood waters. In September 2016, the EA produced a RFM guide 'Explanatory Note on Reservoir Flood Maps for Local Resilience Forums – Version 5[9]' which provides information on how the maps were produced and what they contain.

The RFM can be viewed on the GeoPDF maps in Appendix B for the Bradford authority area, or nationally online at:

https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=SurfaceWater#Reservoirs_3-ROFR

The RFM shows that there are four reservoirs within the CBMDC boundary. These may have an adverse effect on locations within the boundary in the unlikely event of a breach.

5.6 Historic flooding

As LLFA, CBMDC is required, under the FWMA, to maintain and update its historic flood incidents database as and when any flood incidents occur. The LLFA has a statutory responsibility to investigate and report upon any 'significant' flood events.

The flood risk across the Bradford District is varied but caused in the main by overland flow following short, high intensity, or heavy, prolonged rainfall events and/or overtopping watercourses. According to the LFRMS (2016), flooding has been caused by a combination of high river levels, excessive surface water runoff, saturated ground, groundwater fluctuations and exceeded capacity in sewer and highway drainage systems. Historically, records for more localised events have not always been captured leading to limited understanding of interactions between the different sources of flooding.

The Bradford Beck Flood Alleviation Scheme was constructed in the early 1990s; it is a diversion tunnel designed to allow storm flows to bypass the City Centre and prevent flooding for up to a 1 in 50 annual probability event (national standard at that time). The risk of flooding from Bradford Beck has been significantly reduced by the diversion

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/558441/LIT_6882.pdf

tunnel, and CBMDC have confirmed that no flooding has been reported in the city centre since the works were undertaken (at the time the LFRMS was produced, 2016).

Flood risk from groundwater sources has been difficult to confirm for some historical events; due to the geology of the area (clay stratum) and the lack of records of confirmed cases, groundwater has not historically been identified as a major problem.

The LFRMS (2016) identified major flood events (river and combined river and surface water) within the Bradford District as being:

- October-November 2000
- February 2002
- July-August 2002
- August 2004
- July 2005
- September 2008, and
- November-December 2015

Figure 5-1 shows CBMDC's historic flood incidents/records, which includes multiple sources of flooding. There is visible clustering of incidents around the urban areas such as; Bradford, Ilkley, Keighley and Shipley.

The historic (compiled) dataset that was provided did not state the date or source of the event meaning conclusions are very limited. CBMDC also provided data regarding historic and recent drainage incidents ranging from January 2000 - March 2018, with one additional record being dated May 1980. The recorded flood incidents include flooding of property, gardens to property, highways and footpaths.

CBMDC also provided more sensitive historic flooding records, with 2,449 incidents recorded from 2008 - 2018 and largely attributed to surface water / drainage issues or blockages. Many of these incidents are at the property level and as such are considered as sensitive information and have therefore not been included on the detailed large scale SFRA maps in Appendix B. They are however shown at the smaller scale of the whole authority within Figure 5-1. The incidents are clustered around the Main Rivers that run through Bradford District and Bradford City Centre.

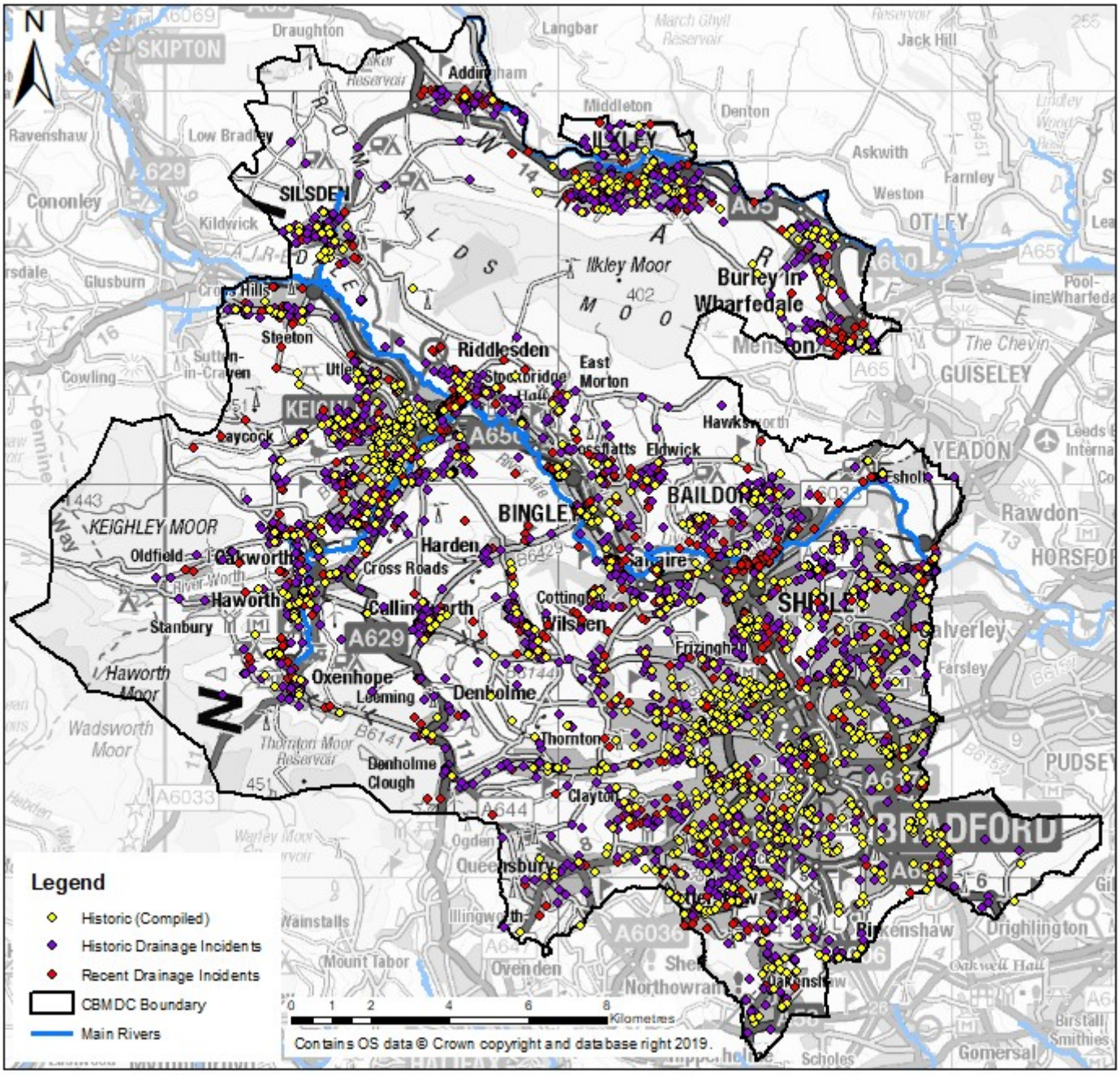

Figure 5-1: CBMDC historic flood records

5.6.1 Historic surface water flooding

Sewer flooding is often caused by excess surface water entering the drainage network. The DG5 Register from Yorkshire Water was analysed to investigate the occurrence of sewer flooding incidents across the CBMDC area. The DG5 Register is used to record flood risk attributable to water company-controlled sewer networks, whether that be from foul and / or surface water sewers.

It was found that there were several sewer flooding events that have been recorded by the water company over the past decade relating to both internal and external flooding to property. However, these events have not been georeferenced, so no comments can be made about their spatial extent and distribution. Also, the DG5 data

did not include any dates so it is difficult to determine if the events were recent or historic.

5.6.2 Historic pluvial/fluvial flooding – notable incidents

October – November 2000 floods

The Aire catchment was already fully saturated following a sustained summer of wet weather. This led to high river levels caused by the widespread and heavy rainfall across the whole catchment. The events were triggered by abnormally high rainfall sustained over a period of hours in the upper part of the main Aire valley. The high rainfall led to flows and levels in the upper Aire that were higher than any on record with return periods in excess of 100-years.

Flooding from the River Aire and Silsden Beck saw 370 properties flood and people evacuated in Stockbridge, 7 at Shipley, 58 at Bingley and 6 at Apperley Bridge. As well as residential and commercial properties being flooded, roads were significantly affected in the upper and middle Aire valley and in Bradford. The East Coast mainline was severely disrupted and damaged, with the main line to Keighley and Skipton being flooded for several days.

July – August 2002 floods

The flooding of late July / early August was caused by intense and localised rainfall generated by a series of convective rainfall events. The first storms caused relatively limited flooding problems but critically, saturated the upland parts of a number of catchments. During the second period of storms, a number of locations experienced the equivalent of two months average rainfall in two days. Due to the intensity of rainfall the result was rapid runoff that caused flooding in the upper reaches of some catchments.

A further two periods of rainfall occurred on the 7 and 10 August, when flooding was caused by surface water. Within the Aire catchment a number of properties were flooded. However, the main impact of this event was on roads and railways. Several roads were closed due to surface water flooding.

November – December 2015 floods

The floods of December 2015, caused by Storm Desmond, inundated over 1,000 homes and businesses across a wide swathe of Bradford District and adversely affected the lives of many hundreds of local people. Due to prolonged periods of heavy rainfall from a succession of Atlantic storms, all four large main rivers (Aire, Wharfe, Worth and Silsden Beck) surcharged simultaneously[10]. Flooding occurred from a number of additional sources in combination.

Roads were closed and there was significant damage to properties and infrastructure in a wide number of areas across Bradford District. The cost of the damage to residential and commercial property is estimated to have been around £34 million[11] (£18 million to residential properties and £15.5 million to businesses). The personal impact on residents and communities such as; long-term health impacts and disruption is difficult to quantify.

5.6.3 EA Historic Flood Map (HFM)

The Historic Flood Map (HFM) is a spatial dataset showing the maximum extent of all recorded historic flood outlines from river, sea and groundwater, and shows areas of land that have previously been flooded across England. Records began in 1946 when predecessor bodies to the EA started collecting information about flooding incidents.

[10] Bradford Local Flood Risk Management Strategy (LFRMS) (2016)
[11] https://bradford.moderngov.co.uk/documents/s14894/Env2MayDocAMAppendixDraft%20Report%20-%20Water%20Management%20Scrutiny%20Review%20KW.pdf

The HFM accounts for the presence of defences, structures, and other infrastructure where such existed at the time of flooding. It includes flood extents that may have been affected by overtopping, breaches or blockages. It is also possible that historic flood extents may have changed and that some areas would not flood at present i.e. if a flood defence has been built.

The HFM does not contain any information regarding the specific flood source, return period or date of flooding, nor does the absence of the HFM in an area mean that the area has never flooded, only that records of historic flooding do not exist. The Recorded Flood Outlines (RFO) dataset however does include details of flood events. The difference between the two datasets is that the HFM only contains flood outlines that are 'considered and accepted' by the EA following adequate verification using certain criteria.

The HFM shows areas of flooding being centred along the River Aire near urban areas of Keighley, Bingley and Shipley. There is also flooding associated with the River Wharfe impacting the town of Ilkley.

The HFM dataset is shown on the SFRA maps in Appendix B.

5.7 Flood risk management

The aim of this section of the SFRA is to identify existing Flood Risk Management (FRM) assets and previous / proposed FRM schemes. The location, condition and design standard of existing assets will have a significant impact on actual flood risk mechanisms. Whilst future schemes in high flood risk areas carry the possibility of reducing the probability of flood events and reducing the overall level of risk. Both existing assets and future schemes will have a further impact on the type, form and location of new development or regeneration.

5.7.1 EA inspected assets (Spatial Flood Defences)

The EA maintain a spatial dataset called the Spatial Flood Defences dataset. This national dataset contains such information as:

- Asset type (flood wall, embankment, high ground, demountable defence, bridge abutment);
- Flood source (fluvial, tidal, fluvial and tidal) (tidal does not apply to CBMDC);
- Design standard (SoP);
- Asset length;
- Asset age;
- Asset location; and
- Asset condition.

See Table 5-4 for condition assessment grades using the EA's Condition Assessment Manual[12] (CAM).

[12] Environment Agency. (2012). Visual Inspection Condition Grades. In: EA Condition Assessment Manual. Bristol: Environment Agency. p9.

Grade	Rating	Description
1	Very Good	Cosmetic defects that will have no impact on performance
2	Good	Minor defects that will not reduce the overall performance of the asset
3	Fair	Defects that could reduce the performance of the asset
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed.
5	Very Poor	Severe defects resulting in complete performance failure.

Table 5-4: EA flood defence condition assessment grades

Defence Location	Asset Type	Flood Source	Watercourse	Design Standard	Condition
Along the A629 by Steeton and Low Utley, to the south of Silsden	11 Embankments	Fluvial	River Aire	0 (3) 50 (2) 80 (6)	3 (9) 4 (2)
River confluence by Keighley	23 Floodwalls 2 Embankments	Fluvial	Rivers Aire and Worth	0 (15) 50 (6) 80 (4)	1 (2) 2 (11) 3 (11) 4 (1)
Bingley by B6429	1 Floodwall	Fluvial	River Aire	50 (1)	2 (1)
Greystone Manor Farm by Ilkley Road	1 Embankment	Fluvial	River Wharfe	0 (1)	5 (1)
Low Mill Lane near Addingham	5 Floodwalls	Fluvial	River Wharfe	0 (5)	3 (5)
Near Otley Road by Shipley	2 Floodwalls	Fluvial	River Aire	50 (2)	2 (2)
Number in brackets = number of assets					

Table 5-5: Major flood defences in Bradford district

In total, there are 63 flood defence assets within Bradford District, according to the EA's spatial flood defence dataset. Table 5-5 highlights the main locations within the district that have significant FRM assets, the majority of which are located on the River Aire near Keighley and continuing upstream.

Of the 63 constructed fluvial flood defence assets within Bradford, 49 are floodwalls and 14 are flood embankments. The floodwalls aim to prevent the flooding of residential and commercial properties and infrastructure. The embankments located by Silsden and Steeton have levels of design standard that vary between 0, 50 and 80 with the condition also falling as 3 or 4 meaning the condition is rated as 'Fair/Poor' according to the EA's Condition Assessment Manual (as discussed in Table 5-4). These embankments will have defects that could reduce the performance of the asset, partially or significantly.

Along the majority of the Main Rivers within Bradford District, there are areas of high ground, offering protection from fluvial flooding. The condition grade of the majority of these defences is stated as 2/3, which means 'Good/Fair', as per the EA's Condition Assessment Manual meaning there could be defects that could reduce the performance of the asset or the defects are only minor and would not compromise performance.

As well as the ownership and maintenance of a network of formal defence structures, the EA carries out a number of other flood risk management activities that help to reduce the probability of flooding, whilst also addressing the consequences of flooding. These include:

- Maintaining and improving the existing flood defences, structures and watercourses.
- Enforcement and maintenance where riparian owners unknowingly carry out work that may be detrimental to flood risk.
- Identifying and promoting new flood alleviation schemes (FAS) where appropriate.
- Working with local authorities to influence the location, layout and design of new and redeveloped property and ensuring that only appropriate development is permitted relative to the scale of flood risk.
- Operation of Floodline Warnings Direct and warning services for areas within designated Flood Warning Areas (FWA) or Flood Alert Areas (FAA). EA FWAs are shown on the SFRA Maps in Appendix B.
- Promoting awareness of flooding so that organisations, communities and individuals are aware of the risk and therefore sufficiently prepared in the event of flooding.
- Promoting resilience and resistance measures for existing properties that are currently at flood risk or may be in the future as a result of climate change.

5.7.2 CBMDC assets

The LLFA owns and maintains a number of assets throughout the district which includes culverts, bridge structures, gullies, weirs and trash screens. The majority of these assets will lie along ordinary watercourses within smaller urban areas where watercourses may have been culverted or diverted, or within rural areas. All these assets can have flood risk management functions as well as an effect on flood risk if they become blocked or fail. In most cases responsibility lies with the riparian / land owner.

Bradford Council (as the LLFA), under the provisions of the FWMA, has a duty to maintain a register of structures or features that have a significant effect on flood risk, including details of ownership and condition as a minimum. The Asset Register should include those features relevant to flood risk management function including feature type, description of principal materials, location, measurements (height, length, width, diameter) and condition grade. The Act places no duty on the LLFA to maintain any third-party features, only those for which the authority has responsibility as land/asset owner.

5.7.3 Water company assets

The sewerage infrastructure within Bradford District is likely to be based on Victorian sewers from which there may be a risk of localised flooding associated with the existing drainage capacity and sewer system. Yorkshire Water are responsible for the management of the adopted sewerage system for their areas. This includes surface water and foul sewerage. There may however be some private surface water sewers in the district as only those connected to the public sewer network that were transferred

to the water companies under the Private Sewer Transfer in 2011 are likely to have been constructed since this transfer date. Surface water sewers discharging to watercourses were not part of this transfer and would therefore not be under the ownership of YW, unless adopted under a Section 104 adoption agreement.

Water company assets include Wastewater Treatment Works, Combined Sewer Overflows, pumping stations, detention tanks, sewer networks and manholes.

5.7.4 Natural Flood Management / Working with Natural Processes

Natural flood management (NFM) or Working with Natural Processes (WwNP) is a type of flood risk management used to protect, restore and re-naturalise the function of catchments and rivers to reduce flood and coastal erosion risk. WwNP has the potential to provide environmentally sensitive approaches to reduce flood risk in areas where hard flood defences are not feasible and to increase the lifespan of existing flood defences. NFM and WwNP are used interchangeably in the UK though the term WwNP will be used throughout this report.

CBMDC work closely with the Aire Rivers Trust (ART) and the Wharfe Flood Partnership to deliver NFM across the Bradford district. A wide range of techniques can be used that aim to reduce flooding by working with natural features and processes in order to store or slow down flood waters before they can damage flood risk receptors (e.g. people, property, infrastructure, etc.). WwNP involves taking action to manage flood and coastal erosion risk (although coastal erosion is not applicable to CBMDC) by protecting, restoring and emulating the natural regulating functions of catchments, rivers, floodplains and coasts (not applicable).

Both the European Commission and UK Government are actively encouraging the implementation of WwNP measures within catchments and coastal areas in order to assist in the delivery of the requirements of various EC Directives relating to broader environmental protection and national policies. It is fully expected that the sustained interest in WwNP implementation across the UK will continue in the post-Brexit era as a fundamental component of the flood risk management tool kit.

Evidence base for WwNP to reduce flood risk

There has been much research on WwNP, but it has never been synthesised into one location. This has meant that it has been hard for flood risk managers to access up-to-date information on WwNP measures and to understand their potential benefits. The EA has now produced the WwNP evidence base which includes three interlinked projects:

- Evidence directory
- Mapping the potential for WwNP
- Research gaps

The evidence base can be accessed via:

https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk

The evidence base can be used by those planning projects which include WwNP measures to help understand:

- Their potential FCRM benefits and multiple benefits
- Any gaps in knowledge
- Where it has been done before and any lessons learnt
- Where in a catchment they might not be most effective

The evidence directory presents the evidence base, setting out the scientific evidence underpinning it. Its purpose is to help flood risk management practitioners and other

responsible bodies access information which explains what is known and what is not about the effectiveness of the measures from a flood risk perspective. There is also a guidance document which sits alongside the evidence directory and the maps which explains how to use them to help make the case for implementing WwNP when developing business cases.

Mapping the potential for WwNP

JBA Consulting has been working with the EA and Lancaster Environment Centre (LEC) to update national maps of Potential for Working with Natural Processes. LEC has developed a new spatial model of slowly permeable soils to identify areas where shrub or tree-planting could increase hydrological losses and slow the flow based on British Geological Survey (BGS) 1:50k maps, who have also agreed to an open government license for the maps. The new national maps for England make use of different mapping datasets and highlight potential areas for tree-planting (for three different types of planting), runoff attenuation storage, gully blocking, and floodplain reconnection. The maps can be used to signpost areas of potential, but do not take into account issues such as land-ownership and drainage infrastructure, however they may well help start the conversation and give indicative estimates of, for example, additional distributed storage in upstream catchments.

Interactive mapping showing the potential for WwNP is available for all river basin districts, including the Humber via:

http://wwnp.jbahosting.com/

These maps are intended to be used alongside the evidence directory to help practitioners think about the types of measure that may work in a catchment and the best places in which to locate them. There are limitations with the maps, however it is a useful tool to help start dialogue with key partners. The maps are provided as spatial data for use in GIS and also interactive GeoPDF format, supported by a user guide and a detailed technical guide.

WWNP Type	Open data licence details
Floodplain reconnection	• Risk of Flooding from Rivers and Seas (April 2017) • Data derived from the Detailed River Network, which is not displayed, rescinding the licence requirements for displaying the dataset (to be superseded by OS Water Network but not available for project in time). • Constraints data
Run-off attenuation features	• Data derived from Risk of Flooding from Surface Water (Depth 1 percent annual chance and Depth 3.3 percent annual chance) (October 2013). The original data is not displayed, due to licensing restrictions.[2] • Constraints data • Gully blocking potential (a subset of run-off attenuation features on steeper ground) • Data derived from OS Terrain 50 (2016) to classify each run-off attenuation feature based on median slope.
Tree planting (3 categories)	• Floodplain: Flood Zone 2 from Flood Map for Planning (April 2016) and new constraints layer • Riparian: 50m buffer OS water features from Section 2.2.3 with constraints layer • Wider catchment woodland: - Based on slowly permeable soils. - BGS Geology 50,000 Superficial and Bedrock layers (both V8, 2017). Used with new science to derive new 100m gridded open data. This new layer can be used to signpost areas of SLOWLY PERMEABLE SOILS and can be checked in more detail on the BGS portal. - To the north of the line of Anglian glaciation, the presence of till-diamicton has been shown to be a strong predictor of slowly permeable soils. - To the south of this line, particular bedrock geologies have shown a similarly strong spatial relationship to the presence of slowly permeable soils.

Table 5-6: WwNP measures and data[13]

The WwNP datasets are included on the SFRA Maps in Appendix B and should be used to highlight any sites or areas where the potential for WwNP should be investigated further as a means of flood mitigation:

- Floodplain Reconnection:
  - Floodplain Reconnection Potential – areas of low or very low probability based on the Risk of Flooding from Rivers and Sea dataset, which are in close proximity to a watercourse and that do not contain properties, are

[13]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/677592/Working_with_natural_processes_mapping_technical_report.pdf

possible locations for floodplain reconnection. It may be that higher risk areas can be merged, depending on the local circumstances.

- Runoff Attenuation Features (Run-off attenuation features are based on the premise that areas of high flow accumulation in the RoFSW maps are areas where the runoff hydrograph may be influenced by temporary storage if designed correctly):
  - Runoff Attenuation Features 1% AEP
  - Runoff Attenuation Features 3.3% AEP
- Tree Planting:
  - Floodplain Woodland Potential and Riparian Woodland Potential – woodland provides enhanced floodplain roughness that can dissipate the energy and momentum of a flood wave if planted to obstruct significant flow pathways. Riparian and floodplain tree planting are likely to be most effective if close to the watercourse in the floodplain, which is taken to be the 0.1% AEP flood extent (Flood Zone 2), and within a buffer of 50 metres of smaller watercourses where there is no flood mapping available. There is a constraints dataset that includes existing woodland.
  - Wider Catchment Woodland Potential – slowly permeable soils have a higher probability of generating 'infiltration-excess overland flow' and 'saturation overland flow'. These are best characterised by gleyed soils, so tree planting can open up the soil and lead to higher infiltration and reduction of overland flow production.

Limitations

The effectiveness of WwNP measures is site-specific and depends on many factors, including the location and scale at which they are used. It may not always be possible to guarantee that these measures alone will deliver a specified standard of defence. Consequently, flood risk management measures should be chosen from a number of options ranging from traditional forms of engineering through to more natural systems. The research gaps that need to be addressed to move WwNP into the mainstream are identified in the evidence directory.

WwNP in CBMDC[14]

Harden Moor NFM pilot project

Leeds City Council and the EA, in partnership with CBMDC are undertaking a NFM project on Harden Moor as part of the Leeds Flood Alleviation Scheme phase 2. Harden Moor was identified as one of five pilot NFM projects being implemented throughout the River Aire catchment, funded by Leeds City Council. The design was developed by Bradford Council through the White Rose Forest and includes interventions aimed at 'slowing the flow' of water into Harden Beck, which is a major tributary to the River Aire. The natural methods that are proposed for this project are:

- Blocking drainage features and leaky dams to reduce water run-off and re-wet land;
- Woodland creation and sphagnum planting to increase water absorption;
- Land management to maximise woodland cover through natural regeneration and re-wetting of heathland where feasible, so that the runoff is reduced, and the landscape can hold more water in times of flood.

[14] https://www.bradford.gov.uk/media/3511/kyi-december-2018-final.pdf

- Existing habitats will be kept, and minor amendments will be made to reduce surface water runoff and erosion and improve water absorption in the area.

Backstone Beck NFM project

An NFM project on Backstone Beck in Ilkley will begin in 2019 led by the Environment Agency and in conjunction with Bradford Council. It has secured £167,000 of Defra funding. The approaches that are looking to be implemented on the moor (slowing the flow, drainage reversal, sphagnum translocation, increasing tree cover and additional environmental benefits of increased biodiversity, active blanket bog management and re-wetting areas of the moor) are all replicable on other catchments within the district.

6 Development and flood risk

6.1 Introduction

This section of the SFRA provides a strategic assessment of the suitability, relative to flood risk, of the Strategic Housing Land Availability Assessment (SHLAA) sites to be considered for allocation in the Local Plan.

The information and guidance provided in this chapter (also supported by the SFRA maps in Appendix B and the development site assessment spreadsheet in Appendix C) can be used by the LPA to inform its Local Plan and provide the basis from which to apply the Sequential Approach in the development allocation and development management process.

6.2 The Sequential Approach

The FRCC-PPG provides the basis for the Sequential Approach. It is this approach, integrated into all stages of the development planning process, which provides the opportunities to reduce flood risk to people, property, infrastructure and the environment to acceptable levels.

The approach is based around the FRM hierarchy, in which actions to avoid, substitute, control and mitigate flood risk is central. For example, it is important to assess the level of risk to an appropriate scale during the decision-making process, (starting with this Level 1 SFRA). Once this evidence has been provided, positive planning decisions can be made and effective FRM opportunities identified.

Figure 6-1 illustrates the FRM hierarchy with an example of how these may translate into each authorities' management decisions and actions.

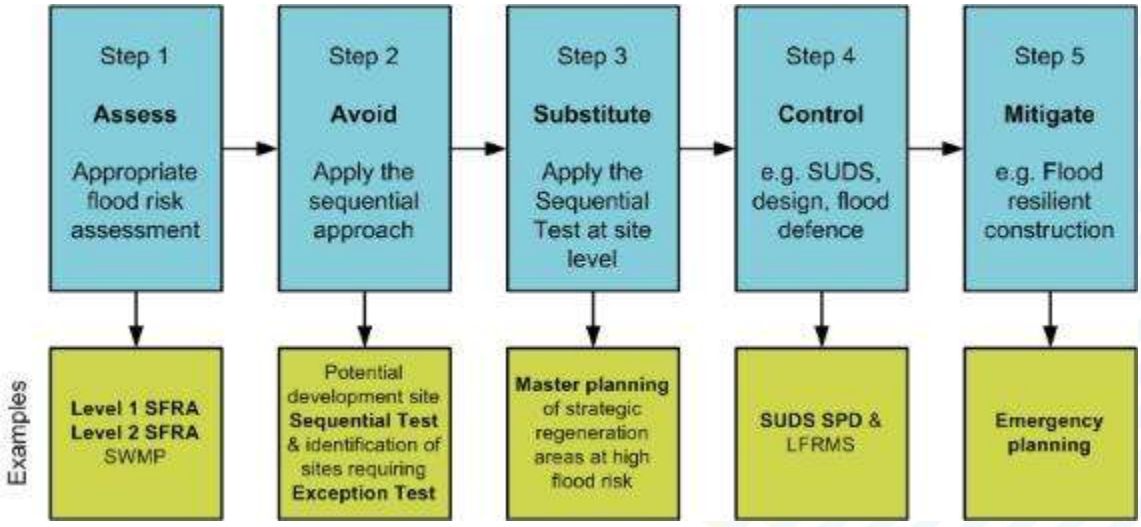

Figure 6-1: Flood risk management hierarchy

Using the EA's Flood Map for Planning, the overall aim of the Sequential Approach should be to steer new development to low risk Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, the flood risk vulnerability of land uses and reasonably available sites in Flood Zone 2 should be considered, applying the Exception Test if required.

Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in higher risk Flood Zone 3, be considered. This should take into account the flood risk vulnerability of land uses and the likelihood of meeting the requirements of the Exception Test if required.

There are two different aims in carrying out the Sequential Approach depending on what stage of the planning system is being carried out i.e. LPAs allocating land in Local Plans or determining planning applications for development. This SFRA does not remove the need for a site-specific Flood Risk Assessment at a development management stage.

The following sections provide a guided discussion on why and how the Sequential Approach should be applied, including the specific requirements for undertaking Sequential and Exception Testing.

6.3 Local Plan Sequential & Exception tests

The LPA should seek to avoid inappropriate development in areas at risk of flooding by directing development away from areas at highest risk and ensuring that all development does not increase risk and where possible can help reduce risk from flooding to existing communities and development.

At a strategic level, this should be carried out as part of the LPA's Local Plan. This should be done broadly by:

1. Applying the Sequential Test and if the Sequential Test is passed, applying and passing the Exception Test, if required;
2. Safeguarding land from development that is required for current and future flood management (i.e. using potential for WwNP data);
3. Using opportunities offered by new development to reduce the causes and impacts of flooding;
4. Identifying where flood risk is expected to increase with climate change so that existing development may not be sustainable in the long term; and
5. Seeking opportunities to facilitate the relocation of development including housing to more sustainable locations.

Figure 6-2 illustrates the Sequential and Exception Tests as a process flow diagram using the information contained in this SFRA to assess sites put forward in the Local Plan against the EA's Flood Map for Planning flood zones and development vulnerability compatibilities.

This is a stepwise process, but a challenging one, as a number of the criteria used are qualitative and based on experienced judgement. The process must be documented, and evidence used to support decisions recorded.

This can be done using the development site assessment spreadsheet in Appendix C. This spreadsheet will help show that the LPA, through the SFRA, has applied the Sequential Test for sites at fluvial risk and also considered surface water flood risk in equal standing and thus considered development viability options for each SHLAA site.

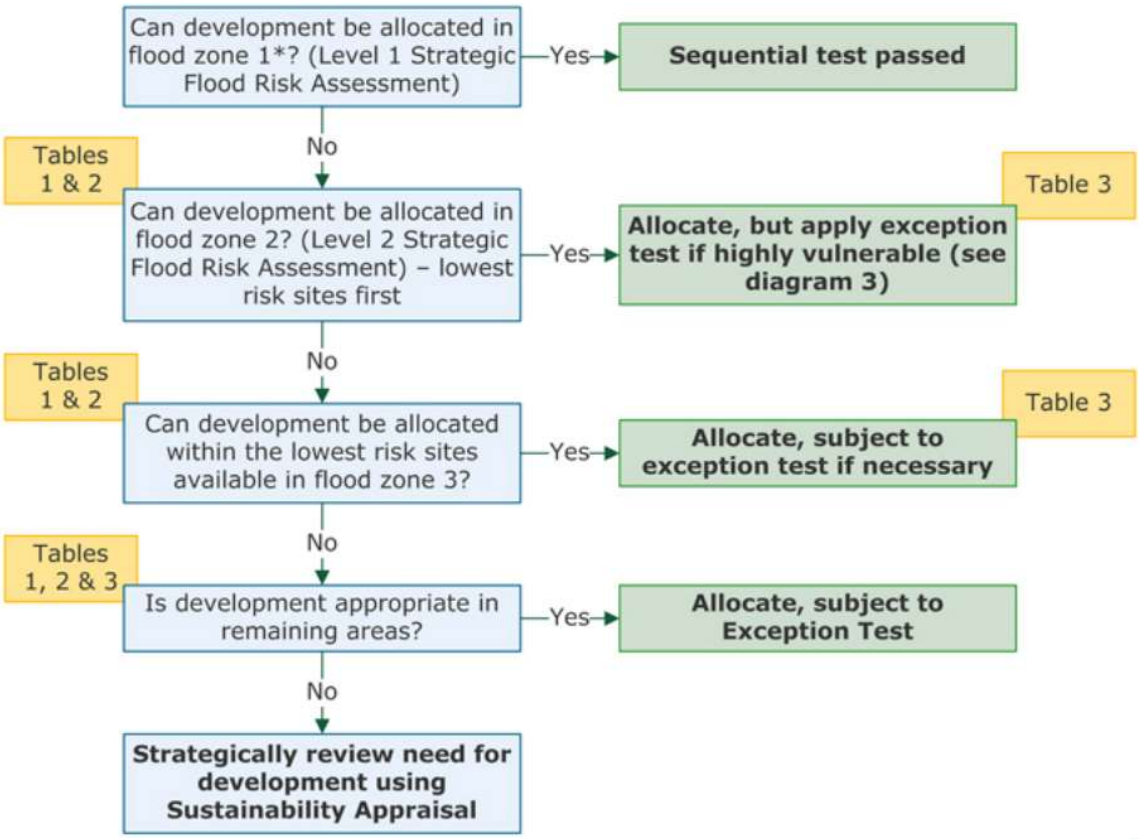

Figure 6-2: Local Plan sequential approach to site allocation[15]

*Other sources of flooding also need to be considered

(Tables 1, 2, 3 refer to the Flood Zone and flood risk tables of the FRCC-PPG Paragraphs 065-067).

The approach shown in Figure 6-2 provides an open demonstration of the Sequential Test being applied in line with the NPPF and the FRCC-PPG. The EA works with local authorities to agree locally specific approaches to the application of the Sequential Test and any local information or consultations with the LLFA should be taken into account.

This SFRA provides the main evidence required to carry out this process. The process also enables those sites that have passed the Sequential Test, and may require the Exception Test, to be identified. Following application of the Sequential Test the LPA and developers should refer to 'Table 3: Flood risk vulnerability and flood zone 'compatibility'' of the FRCC-PPG (Paragraph 067) when deciding whether a development may be suitable or not.

The NPPF para 160 states:

"The application of the exception test should be informed by a strategic or site-specific flood risk assessment, depending on whether it is being applied during plan production or at the application stage. For the exception test to be passed it should be demonstrated that:

a. *the development would provide wider sustainability benefits to the community that outweigh the flood risk; and*
b. *the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

[15] https://www.gov.uk/guidance/flood-risk-and-coastal-change#Sequential-Test-to-Local-Plan

Both elements of the exception test should be satisfied for development to be allocated or permitted." (para 161).

Although passing the Exception Test will require the completion of a site-specific FRA, the LPAs should be able to assess the likelihood of passing the test at the Local Plan level by using the information contained in this SFRA to answer the following questions:

a. Can development within higher risk areas be avoided or substituted?
b. Is flood risk associated with possible development sites considered too high; and will this mean that the criteria for Exception Testing are unachievable?
c. Can risk be sustainably managed through appropriate development techniques (resilience and resistance) and incorporate Sustainable Drainage Systems without compromising the viability of the development?
d. Can the site, and any residual risks to the site, be safely managed to ensure that its occupiers remain safe during times of flood if developed?

To fully answer questions b to d, further, more detailed assessment may be required through a Level 2 SFRA.

Where it is found to be unlikely that the Exception Test can be passed due to few wider sustainability benefits, the risk of flooding being too great, or the viability of the site being compromised by the level of flood risk management work required, then the LPA should consider avoiding the site altogether.

Once this process has been completed, the LPA should then be able to allocate appropriate development sites through its Local Plan as well as prepare flood risk policy including the requirement to prepare site-specific FRAs for all allocated sites that remain at risk of flooding or that are greater than one hectare in area.

6.4 Local Plan sites assessment

CBMDC provided a GIS layer of possible 1,353 SHLAA sites with potential to be included as site allocations in the new Local Plan. All sites have been assessed with the FRCC-PPG vulnerability classification of 'more vulnerable', as each site may have a residential element included.

In order to inform the Sequential Approach to the allocation of development through the Local Plan (as illustrated in Figure 6-2), this review entails a high-level GIS screening exercise overlaying the SHLAA sites against Flood Zones 1, 2, 3a and 3b and calculating the area of each site at risk. Flood Zones 1, 2 and 3a are sourced from the EA's Flood Map for Planning (Rivers and Sea) and Flood Zone 3b (functional floodplain) has been delineated as part of this Level 1 SFRA. Surface water risk to assessed SHLAA sites is analysed by way of the EA's Risk of Flooding from Surface Water (RoFSW) dataset. The outcomes of the sites assessment are presented in the Sites Assessment spreadsheet in Appendix C.

It is important to consider that each individual site will require further investigation, following this review as local circumstances may dictate the outcome of the recommendation. Such local circumstances are discussed in the following section.

For this SFRA, surface water flood risk is afforded the equivalent level of importance as fluvial risk in terms of strategic recommendations assigned to each potential development site.

6.5 Screening of SHLAA sites

This section of the report draws together the results included in the Sites Assessment spreadsheet (Appendix C), produced from the GIS screening exercise. The LPA should use the spreadsheet to identify which sites are sequentially preferable. Where wider strategic objectives require development in areas already at risk of flooding, then the LPA should consider the compatibility of vulnerability classifications and Flood Zones (refer to FRCC-PPG) and whether or not the Exception Test will be required before finalising sites.

The decision-making process on site suitability should be transparent and information from this SFRA should be used to justify decisions to allocate land in areas at risk of flooding.

The Sites Assessment spreadsheet provides a breakdown of each SHLAA site and the area (in hectares) and percentage coverage of each fluvial flood zone and each surface water flood zone. Fluvial Flood Zones 3b, 3a, 2 and 1 are considered in isolation. Any area of a site within the higher risk Flood Zone 3b that is also within Flood Zone 3a is excluded from Flood Zone 3a and any within Flood Zone 3a is excluded from Flood Zone 2. This allows for the sequential assessment of risk at each site by addressing those sites at higher risk first. The surface water flood zones are assessed cumulatively rather than in isolation. Table 6-1 shows the number of sites within each fluvial flood zone and Table 6-2 shows the number of sites within each surface water flood zone.

Proposed use	**Number of sites within…**			
	Flood Zone 1*	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Residential	1165	175	139	64
***Sites with 100% area within Flood Zone 1**				

Table 6-1: Number of SHLAA sites at risk from fluvial flooding

Proposed use	**Number of sites within RoFSW flood zone…**		
	Low risk (1 in 1000)	Medium risk (1 in 100)	High risk (1 in 30)
Residential	995	653	457

Table 6-2: Number of SHLAA sites at risk from surface water flooding

Strategic recommendations are based on Tables 1, 2 and 3 of the flood risk and vulnerability tables[16] of the FRCC-PPG (Paragraphs 065 - 067). The strategic recommendations are intended to assist the LPA in carrying out the Sequential Test and to highlight those sites at greatest flood risk. Table 6-3 shows the number of sites each strategic recommendation applies to:

- Strategic Recommendation A – consider withdrawal based on significant level of fluvial or surface water flood risk; **(if development cannot be directed away from risk areas, the site may be unsuitable for development)**
- Strategic Recommendation B – Exception Test required, if site passes Sequential Test;

[16] https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables

- Strategic Recommendation C – consider site layout and design around the identified flood risk if site passes Sequential Test i.e. redrawing of development boundaries to remove risk or incorporation of risk through appropriate mitigation techniques;
- Strategic Recommendation D – site-specific FRA required as a minimum; and
- Strategic Recommendation E – site could be allocated or permitted for development on flood risk grounds due to little perceived risk, subject to consultation with the LPA and LLFA.

Indicative land use	Number of sites...				
	A	B	C	D	E
Residential	123*	27	53	870	280
*33 due to Flood Zone 3b					

Table 6-3: Number of SHLAA sites per strategic recommendation

It is important to note that each individual site will require further investigation before development is allocated or permitted, as local circumstances may dictate the outcome of the strategic recommendation. Such local circumstances may include the following:

- Flood depths and hazards will differ locally to each at risk site therefore modelled depth, hazard and velocity data should be assessed for the relevant flood event outlines, including climate change (using the EA's February 2016 allowances at the time of writing, however using the EA's UKCP18 allowances once published), as part of a site-specific FRA or Level 2 SFRA.
- Current surface water drainage infrastructure and applicability of SuDS techniques are likely to differ at each site considered to be at risk from surface water flooding. Further investigation would therefore be required for any site at surface water flood risk. The LLFA requires that all planning applications must be accompanied by an appropriate drainage strategy, independent of the requirement for a site-specific FRA.
- If sites have planning permission but construction has not started, the SFRA will only be able to influence the design of the development e.g. finished flood levels. New, more extensive flood extents (from new models) cannot be used to reject development where planning permission has already been granted.
- It may be possible at some sites to develop around the flood risk. Planners are best placed to make this judgement i.e. will the site still be deliverable if part of it needs to be retained to make space for flood water?
- Surrounding infrastructure may influence scope for layout redesign/removal of site footprints from risk.
- Safe access and egress must exist at all times during a flood event for emergency response and evacuation.
- Current land use. A number of sites included in the assessment are likely to be brownfield, thus the existing development structure could be taken into account as further development may not lead to increased flood risk.
- Existing planning permissions may exist on some sites where the EA may have already passed comment and/or agreed to appropriate remedial works concerning flood risk. Previous flood risk investigations/FRAs may already have been carried out at some sites.

- Cumulative effects. New development may result in increased risk to other potential or existing sites. This should be assessed through a Level 2 SFRA/site specific FRA or drainage strategy, if required.

6.5.1 Strategic Recommendation A – consider withdrawal based on significant level of fluvial or surface water flood risk (if development cannot be directed away from areas at risk)

This strategic recommendation DOES NOT take into account local circumstances, only that part of a site area falls within a flood zone.

Strategic Recommendation A applies to any site where one or more of the following criteria is true:

- A significant proportion of the site area is within Flood Zone 3b. The FRCC-PPG flood risk vulnerability classification states that only water-compatible uses and essential infrastructure should be permitted in Flood Zone 3b, though any essential infrastructure must pass the Exception Test and water-compatible uses must be designed and constructed to remain operational and safe for users in times of flood; must result in no net loss of floodplain storage; and not impede water flows and not increase flood risk elsewhere. Development should not be allocated or permitted for sites within the highly, more or less vulnerable categories (when allocated) that fall within Flood Zone 3b. If the developer can avoid 3b however, then part of the site could still be delivered.
- A significant proportion of the site area of any site type is within the high risk surface water flood outline, and therefore at high surface water flood risk.

It is important to state that it may still be possible to deliver a site that has been recommended for withdrawal from allocation upon more detailed investigation through a Level 2 SFRA.

Depending on local circumstances, if it is not possible to adjust the site boundary to remove the developable area from Flood Zone 3b to a lower risk zone then development should not be allocated or permitted.

Strategic Recommendation A applies to 123 sites, of which 33 have a significant proportion of their areas within the functional floodplain (listed in Table 6-4). 12 of these 33 sites, namely sites AD/017, BI/056, BI/058, CR/020, CR/044, IL/017, IL/031, KY/044, KY/144, NE/069, SH/018, ST/011, are extremely unlikely to be suitable for allocation due to the considerably large areas located within the functional floodplain (over 50%). The Council should carry out a more detailed review of all 33 sites to confirm viability.

The remaining 90 of the 123 sites recommended for withdrawal are subject to significant surface water flood risk (listed in Appendix E). Significant surface water risk refers to a site with a significant proportion of its area within the 3.33% or 1% AEP event outlines. Site OA/009 is at particularly significant risk from surface water with over 77% of its area within the 3.33% AEP event. With a total area of 0.89 ha in size, this site is highly unlikely to be able to accommodate surface water on site. Similarly, site CR/046 is small in size at 0.13 ha with 48% of its area within the 1 in 30 AEP event and 64% within the 1 in 100 AEP event.

Any area within Flood Zone 3b must be left as open green space or the site boundary amended to remove the developable area from the risk area. For the smaller sites, this approach is unlikely to be achievable compared to larger sites where there may be enough space to limit the impact through effective

SuDS. If this is not possible, the site should be withdrawn. The EA supports recommendations for withdrawing sites within Flood Zone 3b.

Site ID	Site area (ha)	% area in FZ3b
AD/006	1.91	10.62
AD/016	2.03	18.09
AD/017	5.72	95.63
BI/056	0.72	50.45
BI/058	1.47	80.39
CC/023	0.52	20.52
CC/028	1.20	39.81
CR/019	1.81	17.13
CR/020	0.54	82.19
CR/024A	5.02	11.89
CR/044	0.38	57.83
IL/005	1.04	39.01
IL/013	1.28	11.44
IL/014	25.65	38.61
IL/016	23.85	42.61
IL/017	1.72	69.80
IL/031	6.50	75.74
KY/034	1.33	25.85
KY/044	7.67	67.34
KY/050	1.49	46.43
KY/142	9.80	31.58
KY/144	0.88	87.35
KY/160	0.47	14.36
NE/069	18.90	52.21
SH/018	0.50	78.04
SI/015	11.44	20.54
ST/001	7.72	18.35
ST/009	14.95	29.98
ST/011	1.48	85.52
SW/035A	4.37	13.55
SW/039	2.70	15.10
SW/057	1.63	15.83
SW/139	1.34	39.91

Table 6-4: SHLAA sites potentially unsuitable for development based on fluvial flood risk (if development cannot be directed away from risk areas, the site will be unsuitable for development)

6.5.2 Strategic Recommendation B – Exception Test required

This strategic recommendation DOES NOT take account of local circumstances, only that part of a site area falls within a flood zone.

Strategic Recommendation B applies to sites where it is likely the Exception Test would be required, assuming the Sequential Test has been passed in the first instance. This does not include any recommendation on the likelihood of a site passing the Exception Test. A more in-depth investigation such as a Level 2 SFRA would be required to assess this. The developer / LPA should always attempt to avoid the risk area where possible.

> Strategic Recommendation B applies to sites where the following criteria is true:
>
> - A significant proportion of a more vulnerable site (residential and mixed use) is within Flood Zone 3a. Less vulnerable (employment) uses of land do not require the Exception Test.
>
> NOTE: All development proposals in Flood Zone 3a must be accompanied by a flood risk assessment.

Strategic Recommendation B applies to 27 assessed SHLAA sites shown in Table 6-5. All sites must pass both parts of the Exception Test in order to proceed (see Section 6.3 for information on the Exception Test). Out of the 27 sites to which Strategic Recommendation B applies, 4 sites (CC/089, KY/065A, KY/088 and IL/001) have a significant area (over 80%) within Flood Zone 3a, which will consequently be more difficult to pass the second part of the Exception Test.

Site Reference	Site Name	Site area (ha)	% area in FZ3a
SI/007	Keighley Road, Belton Road	6.72	10.78
SE/044	Huddersfield Road, Wyke	7.35	10.97
SI/013	Sykes Lane	5.52	11.10
OX/014	Cross Lane, Oxenhope	0.79	11.20
ME/016	Bradford Road	0.19	12.98
BU/004	Hag Farm Road, Burley in Wharfedale	2.68	13.09
BU/011	Greenholme Mills, Great Pasture Lane	2.89	13.10
NE/148	Land at Harrogate Road, Apperley Bridge	1.23	13.12
EM/008	Green End Road	1.35	14.14
BI/005	Coolgardie, Keighley Road	2.99	14.30
KY/067	Woodhouse Road	4.31	14.93
KY/033	Brewery Street	0.90	18.93
KY/064	The Walk	1.69	23.34
BI/039	Former Bingley Auction Mart, Keighley Road	1.76	25.61
OX/001	Denholme Road	0.98	29.37
EM/013	Land North of Morton Lane	3.22	29.99
OX/005	Crossfield Road	0.38	30.92
SI/018	Weaving Shed – Waterloo Mills	0.07	34.34

Site Reference	Site Name	Site area (ha)	% area in FZ3a
HR/009	Goit Stock Lane	0.24	46.75
BA/012	Cliffe Avenue / Otley Road	0.15	48.06
SH/052	Shipley Tax Office, Shipley	4.73	50.62
KY/035	Harclo Road	1.74	65.58
CR/021	Dockfield Road, South, Shipley	0.68	68.76
KY/065A	Marriner Road	1.21	87.87
IL/001	Leeds Road	2.12	89.42
CC/089	Arndale House, Charles Street	0.21	100.00
KY/088	Florist Street, Stockbridge	0.11	100.00

Table 6-5: Sites which Strategic Recommendation B applies to

6.5.3 Strategic Recommendation C – consider site layout and design

This strategic recommendation DOES NOT take account of local circumstances, only that part of a site area falls within a Flood Zone.

Strategic Recommendation C applies to sites where one or more of the following criteria is true:

- A small proportion of any site type is within Flood Zone 3b.
- A small proportion of any residential or mixed use (more vulnerable) site is within Flood Zone 3a.
- A small proportion of any more vulnerable site is within the high or medium risk surface water flood zone.

Overall there are 53 potential SHLAA sites to which Strategic Recommendation C applies. 36 of these sites have over 90% within Flood Zone 1, meaning surface water risk is what needs to be mitigated at these sites.

Strategic Recommendation C applies in instances where, due to only a small proportion of a site being at risk, from a high-level strategic viewpoint, there is a greater possibility that a detailed review of site layout and design around the flood risk, as part of a detailed FRA at the development planning stage, may enable the site to be allocated. Or it may be possible to incorporate suitable SuDS into the site layout to mitigate surface water risk on-site, following a detailed FRA or drainage strategy. Similarly, in line with the daylighting policy and where there may be opportunities to do so, there could be potential to remove culverts and restore watercourses to a more natural condition. In many cases, opening culverts can reduce flood risk when combined with SuDS. A Level 2 SFRA and/or detailed site-specific FRA would be required to help inform on site layout and design.

Where Strategic Recommendation C applies to a potential site, the developer should consider the site layout with a view to excluding the developable area from the flood extent that is obstructing development. If this is not possible then the alternative would be to investigate the incorporation of on-site storage of water into the site design. Depending on local circumstances, if it is not possible to adjust the site boundary to confine the developable area to a lower risk zone then this part of the development should not be permitted (for any site in Flood Zone 3b), or the Exception

Test should be undertaken and passed as part of a site-specific FRA for the more vulnerable sites within Flood Zone 3a.

Development planning should always be aware of the requirement to not develop within 8 metres of any watercourse, flood defence structure or culvert, or within 16 metres on a tidal river which is likely to be a regulated flood risk activity under Schedule 25 of the Environmental Permitting (England and Wales) Regulations 2016. Site layout and design will have to take this into consideration for development proposals. The 8 metre buffer is recommended by the EA to allow ease of access to watercourses for maintenance works. Any site redesign, where Flood Zones 3b and 3a, are included within the site footprint, should allow water to flow naturally or be stored in times of flood through application of suitable SuDS.

6.5.4 Strategic Recommendation D – development could be allocated subject to FRA

This strategic recommendation DOES NOT take account of local circumstances, only that part of a site area falls within a flood zone.

This recommends that development could be allocated due to low flood risk perceived from the EA flood maps, assuming a site-specific FRA shows the site can be safe for its lifetime and it is demonstrated that the site is sequentially preferable. A site within Flood Zone 2 could still be rejected if the conclusions of the FRA decide development is unsafe or inappropriate.

Strategic Recommendation D applies to sites where one or more of the following criteria is true:

- Any site within Flood Zone 2 that does not have any part of its footprint within Flood Zone 3a, with the exception of highly vulnerable development which would be subject to, and have to pass, the Exception Test.
- Less vulnerable and water compatible sites within Flood Zone 3a. No part of the site can be within Flood Zone 3b.
- Less vulnerable sites which are 100% within Flood Zone 1 where surface water flood risk is apparent but not considered significant.
- Any site which is 100% within Flood Zone 1 that is greater than or equal to 1 hectare in area.

Strategic Recommendation D applies to 870 sites, 830 of which are 100% within Flood Zone 1. The surface water risk at these 830 sites will be nominal although will still require appropriate assessment through an FRA or drainage strategy. The other 40 sites are at some risk from Flood Zone 2 and must therefore be subject to an FRA at planning application stage by a developer. Each site-specific FRA should investigate the risk and mitigate accordingly, including consideration of plans for site access and egress during a possible flood event.

6.5.5 Strategic Recommendation E – development could be allocated on flood risk grounds subject to consultation with the LPA / LLFA

This strategic recommendation DOES NOT take account of local circumstances, only that part of a site area falls within a flood zone.

This recommends that development could be allocated on flood risk grounds, based on the evidence provided within this SFRA. Further investigation (i.e. FRA) may be required by the developer at planning application stage if any further or new information becomes available since the publication of this SFRA. Recommendation E applies to 280 SHLAA sites.

Strategic Recommendation E applies to any site with 100% of its area within Flood Zone 1 and not within any surface water flood zone.

6.5.6 Assessment of climate change

Modelled flood outlines accounting for fluvial climate change were not available for this SFRA. A precautionary approach to assessing future flood risk is therefore adopted whereby, the assumption is that the current day Flood Zone 2 will become Flood Zone 3a in the 2080s or longer term and Flood Zone 3a could become functional floodplain. This is within the 100-year assumed lifetime for residential development specified in the FRCC-PPG.

This precautionary approach to estimating the effects of climate change is considered to be the most pragmatic methodology available and is also consistent with other SFRAs and professional modelling experience. As such, for any site within Flood Zone 2, the possibility of these sites being within Flood Zone 3a in the 2080s or longer term should be considered. It is also important to consider that the sites that are partially within Flood Zone 3a and are also additionally at risk from Flood Zone 2 will have larger areas at risk from Flood Zone 3a in the future. For example, a site that may have 10% of its area currently within Flood Zone 3a and a further 60% within Flood Zone 2, may have 70% of its area within Flood Zone 3a in the 2080s or longer term. This would impact on the more vulnerable sites (once allocated) in particular with potentially further, more detailed mitigation techniques required to satisfy the second part of the Exception Test.

Predicting the future expansion of the functional floodplain would be more difficult due to the criteria used to define the functional floodplain outline.

It should however be noted that changes in flood zone extents in well-defined floodplains will be more negligible compared to very flat floodplains. However, changes in flood depth within the more well-defined floodplains will be greater. The expected increase in flood extents and depths as a result of climate change will have implications for the type of development that is considered appropriate according to its vulnerability.

The same approach should also be applied to the surface water flood zones whereby the 1 in 100 AEP event outline (currently medium risk outline) may increase in the future to cover the extent of the 1 in 1000 AEP event outline (currently the low risk outline).

The sites assessment spreadsheet (Appendix C) alongside the SFRA maps (Appendix B) should be consulted to ascertain which sites may be at increased risk in the future based on the approach outlined above.

A more detailed assessment of the impacts of climate change on flooding from the land and rivers, and the coast if applicable, should be carried out as part of any Level 2 SFRA before allocation or FRA after allocation carried out by a developer. This should be carried out using the EA's allowances (see Section 6.13.2).

6.6 Summary of sites assessment outcomes

There are several consequential development considerations which could come out of the site assessment sequential testing process. Each outcome is discussed below. The LPA should refer to Section 6.4 of this report, and Appendix C, for details on the site assessments carried out for this SFRA.

6.6.1 Rejection of site

A site which fails to pass the Sequential Test and / or the Exception Test should be rejected and development should not be permitted or allocated. Rejection would also

apply to any more (residential, mixed use inclusive of residential) or less vulnerable (employment) sites within Flood Zone 3b where development should not be permitted or allocated. The FRCC-PPG flood risk vulnerability classification states that only water-compatible uses and essential infrastructure should be permitted in Flood Zone 3b, though any essential infrastructure must pass the Exception Test and clearly demonstrate that it does not increase or exacerbate flood risk elsewhere. If the developer is able to avoid Flood Zone 3b, part of the site could still be delivered. However, depending on local circumstances, if it is not possible to adjust the site boundary to remove the site footprint from Flood Zone 3b to a lower risk zone then development should not be permitted.

In terms of surface water flood risk, if risk is considered significant, based on AEP or development vulnerability, or where the size of the site does not allow for on-site storage or application or appropriate SuDS then such sites could be rejected.

6.6.2 Exception Test required

Applies to those sites that, according to the FRCC-PPG vulnerability tables, would require the Exception Test. Only water-compatible and less vulnerable land uses would not require the Exception Test in Flood Zone 3a. More vulnerable uses, including residential, and essential infrastructure are only permitted if the Exception Test is passed and all development proposals in Flood Zone 3a must be accompanied by a Flood Risk Assessment. To avoid having to apply the Exception Test, the developer / LPA should attempt to avoid the risk area altogether by altering the site boundary.

6.6.3 Consideration of site layout and design

Site layout and site design is important at the site planning stage where flood risk exists. The site area would have to be large enough to enable any alteration of the developable area of the site to remove development from the functional floodplain, or to leave space for on-site storage of flood water. Careful layout and design at the site planning stage may apply to such sites where it is considered viable based on the level of risk. Surface water risk and opportunities for SuDS should also be assessed during the planning stage.

Depending on local circumstances, if it is not possible to adjust the site boundary to remove the site footprint from Flood Zone 3b to a lower risk zone then development should not be allocated or permitted. If it is not possible to adjust the developable area of a site to remove the indicative development from Flood Zone 3a to a lower risk zone or to incorporate the on-site storage of water within site design, then the Exception Test would have to be passed as part of a site-specific Flood Risk Assessment. Highly vulnerable sites should be rejected.

Any development within 8m of any flood defence structure or culvert on a Main River is likely to be regulated flood risk activity under Schedule 25 of the Environment Permitting (England and Wales) Regulations 2016. Any site redesign, where Flood Zone 3a is included within the site footprint, should allow water to flow naturally or be stored in times of flood through application of appropriate SuDS techniques (see Section 6.14). Similarly, any change or alteration to an ordinary watercourse within the site would need consent from the LLFA under the Land Drainage Act 1991[17].

6.6.4 Site-specific flood risk assessment

According to the FRCC-PPG (Para 030), a site-specific FRA is:

"…carried out by (or on behalf of) a developer to assess the flood risk to and from a development site. Where necessary (see footnote 50 in the National Planning Policy

[17] https://www.legislation.gov.uk/ukpga/1991/59/contents

Framework), the assessment should accompany a planning application submitted to the local planning authority. The assessment should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users (see Table 2 – Flood Risk Vulnerability of FRCC-PPG)."

The objectives of a site-specific FRA are to establish:

Whether an indicative development is likely to be affected by current or future flooding (including effects of climate change) from any source. This should include referencing this SFRA to establish sources of flooding. Further analysis should be performed to improve understanding of flood risk including agreement with the LPA and LLFA on areas of functional floodplain that have not been specified within this SFRA. Key objectives:

- Whether the development will increase flood risk elsewhere;
- Whether the measures proposed to deal with these effects and risks are appropriate;
- The evidence for the local planning authority to apply (if necessary) the Sequential Test;
- Whether the development will be safe for its lifetime and pass the Exception Test, if applicable; and
- That an appropriate Emergency Plan is in place that accounts for the possibility of a flood event and shows the availability of safe access and egress points accessible during times of flood.

When is a Site-Specific FRA Required?

According to the NPPF (2019) footnote 50, a site-specific FRA should be prepared when the application site is:

- Situated in Flood Zone 2 and 3; for all proposals for new development (including minor development and change of use);
- 1 hectare or greater in size and located in Flood Zone 1;
- Located in Flood Zone 1 on land which has been identified by the EA as having critical drainage problems (i.e. within a ACDP);
- Land identified in the SFRA as being at increased flood risk in future (i.e. based on RoFSW mapping; sites within Flood Zone 2 that may be within Flood Zone 3 in the longer term (in the absence of modelled climate change outputs));
- At risk of flooding from other sources of flooding, such as those identified in this SFRA; or
- Subject to a change of use to a higher vulnerability classification which may be subject to other sources of flooding.

Optionally, the LPA may also like to consider further options for stipulating FRA requirements, such as:

- Situated in an area currently benefitting from defences;
- At residual risk from reservoirs or canals;
- Within a council designated CDA; or
- Situated over a culverted watercourse or where development will require controlling the flow of any river or stream or the development could potentially change structures known to influence flood flow.

These further options should be considered during the preparation and development of the Local Plan.

Paragraph 031 of the FRCC-PPG contains information regarding the level of detail required in the FRAs and indicates that it should always be proportionate to the degree of flood risk whilst making use of existing information, including this SFRA. Paragraph 068 of the FRCC-PPG contains an easy to follow FRA checklist for developers to follow.

Together with the information in the FRCC-PPG, there is further detail and support provided for the LPA and developers in the EA's FRA guidance[18] and also the EA guidance for FRAs for planning applications[19]. CIRIA's report 'C624 Development and Flood Risk[20]' also provides useful guidance for developers and the construction industry. Section 6.12 of this report provides further guidance on FRAs for developers.

6.6.5 Sites passing the Sequential and Exception Tests

Development sites can be allocated or granted planning permission where the Sequential Test and the Exception Test (if required) are passed. In addition, a site is likely to be allocated without the need to assess flood risk where the indicative use is for open space. Assuming the site is not to include any development and is to be left open then the allocation is likely to be acceptable from a flood risk point of view.

[18] https://www.gov.uk/flood-risk-assessment-local-planning-authorities
[19] https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications
[20] CIRIA C624 Development and Flood Risk - guidance for the construction industry. 2004

However, for sites where there is potential for flood storage, options should be explored as part of an FRA.

In terms of opportunities for reducing flood risk overall as a requirement of the Exception Test, the FRCC-PPG states:

"Local authorities and developers should seek opportunities to reduce the overall level of flood risk in the area and beyond. This can be achieved, for instance, through the layout and form of development, including green infrastructure and the appropriate application of sustainable drainage systems, through safeguarding land for flood risk management, or where appropriate, through designing off-site works required to protect and support development in ways that benefit the area more generally." (Paragraph 50).

6.6.6 Surface water risk to assessed sites

For sites at surface water flood risk the following should be considered:

- Possible withdrawal, redesign or relocation for those sites considered to be at significant risk. This applies to the sites listed in Appendix E;
- A detailed site-specific FRA incorporating surface water flood risk management;
- Detailed surface water modelling to ascertain flow routes, particularly for the larger sites which may influence sites elsewhere;
- Ensuring future maintenance of surface water and sustainable drainage assets through s106 agreements;
- The size of development and the possibility of increased surface water flood risk caused by development on current greenfield land (where applicable), and cumulative impacts of this within specific areas;
- Management and re-use of surface water on-site, assuming the site is large enough to facilitate this and achieve effective mitigation. Effective surface water management should ensure risks on and off site are controlled;
- Larger sites could leave surface water flood-prone areas as open greenspace, incorporating social and environmental benefits;
- SuDS should be used where possible. Appropriate SuDS may offer opportunities to control runoff to greenfield rates or better. Restrictions on surface water runoff from new development should be incorporated into the development planning stage. The LLFA agree that for brownfield sites, where current infrastructure may be staying in place, then runoff should attempt to mimic that of greenfield rates, unless it can be demonstrated that this is unachievable or hydraulically impractical. Developers should refer to the national 'non-statutory technical standards for sustainable drainage systems' and other guidance documents cited in Sections 6.12 and 6.14 of this report;
- Runoff up to and including the 1 in 100 AEP event (1%) should be managed on site where possible;
- Measures of source control should be required for development sites;
- Developers should be required to set part of their site aside for surface water management, to contribute to flood risk management in the wider area and supplement green infrastructure networks;
- Developers should be required to maximise permeable surfaces;
- Flow routes on new development where the sewerage system surcharges as a consequence of exceedance of the 1 in 30 AEP design event should be retained; and

- Whether the delineation of CDAs may be appropriate for areas particularly prone to surface water flooding. Detailed analysis and consultation with the LLFA, Yorkshire Water and any relevant Internal Drainage Board would be required. It may then be beneficial to carry out a local SWMP or drainage strategy for targeted locations with any such critical drainage problems. Investigation into the capacity of existing sewer systems would be required in order to identify critical parts of the system i.e. pinch points. Drainage model outputs could be obtained from Yorkshire Water to confirm the critical parts of the drainage network and subsequent recommendations could then be made for future development i.e. strategic SuDS sites, parts of the drainage system where any new connections should be avoided, and parts of the system that may have any additional capacity and recommended runoff rates.

6.7 Site-specific constraints to development

It is important to note that each individual site will require further investigation before development is allocated or permitted, as local circumstances may dictate the outcome of any strategic recommendation. Such local circumstances may include the following:

- Flood depths and hazards will differ locally to each at risk site therefore modelled depth, hazard and velocity data should be assessed for the relevant flood event outlines, including climate change (using the EA's February 2016 allowances), as part of a site-specific FRA or Level 2 SFRA.
- Current surface water drainage infrastructure and applicability of SuDS techniques are likely to differ at each site considered to be at risk from surface water flooding. Further investigation would therefore be required for any site at surface water flood risk. The LLFA requires that all planning applications must be accompanied by an appropriate drainage strategy, independent of the requirement for a site-specific FRA.
- If sites have planning permission but construction has not started, the SFRA will only be able to influence the design of the development e.g. finished flood levels. New, more extensive flood extents (from new models) cannot be used to reject development where planning permission has already been granted.
- It may be possible at some sites to develop around the flood risk. Planners are best placed to make this judgement i.e. will the site still be deliverable if part of it needs to be retained to make space for flood water?
- Surrounding infrastructure may influence scope for layout redesign/removal of site footprints from risk.
- Safe access and egress must exist at all times during a flood event for emergency response and evacuation.
- Current land use. A number of sites included in the assessment are likely to be brownfield, thus the existing development structure could be taken into account as further development may not lead to increased flood risk.
- Existing planning permissions may exist on some sites where the EA may have already passed comment and/or agreed to appropriate remedial works concerning flood risk. Previous flood risk investigations/FRAs may already have been carried out at some sites.
- Cumulative effects. New development may result in increased risk to other potential or existing sites. This should be assessed through a Level 2 SFRA/site specific FRA or drainage strategy, if required.

6.8 Sustainability Appraisal (SA) and flood risk

The Sustainability Appraisal should help to ensure that flood risk is taken into account at all stages of the planning process with a view to directing development away from areas at flood risk, now and in the future, by following the sequential approach to site allocation, as shown in Figure 6-2.

By avoiding sites identified in this SFRA as being at significant risk, the Council would be demonstrating a sustainable approach to development.

In terms of surface water, the same approach should be followed whereby those sites at highest risk should be avoided or site layout should be tailored to ensure sustainable development. This should involve investigation into appropriate SuDS techniques (see Section 6.14).

Surface water flood risk should be considered with the same importance as fluvial flood risk.

Once the LPA has decided on a final list of sites following application of the Sequential Test and, where required, the Exception Test following a site-specific FRA, a phased approach to development should be carried out to avoid any cumulative impacts that multiple developments may have on flood risk. For example, for any site where it is required, following the Sequential Test, to develop in Flood Zone 3, detailed modelling would be required to ascertain where displaced water, due to development, may flow and to calculate subsequent increases in downstream flood volumes. The modelling should investigate scenarios based on compensatory storage techniques to ensure that downstream or nearby sites are not adversely affected by development on other sites.

6.9 Safeguarded land for flood storage

Where possible, the LPA may look to allocate land designed for flood storage functions. Such land can be explored through the site allocation process whereby an assessment is made, using this SFRA, of the flood risk at assessed SHLAA sites and Green Belt land parcels and what benefit could be gained by leaving the site undeveloped. In some instances, the storage of flood water can help to alleviate flooding elsewhere, such as downstream developments. Where there is a large area of a site at risk that is considered large enough to hinder development, it may be appropriate to safeguard this land for the storage of flood water.

Section 14 Paragraph 157 of the revised NPPF states that, to avoid where possible, flood risk to people and property they should manage any residual risk by,

'safeguarding land from development that is required, or likely to be required, for current or future flood management'

A strategic assessment has been made of the assessed SHLAA sites and Green Belt land parcels and their applicability for flood storage. Applicable sites include any current greenfield sites:

- That are considered to be large enough (>1 hectare) to store flood water to achieve effective mitigation,
- With large areas of their footprint at high or medium surface water flood risk (based on the RoFSW),
- That is within the functional floodplain (Flood Zone 3b),
- With large areas of their footprint at risk from Flood Zone 3a, and
- That are large enough and within a suitable distance to receive flood water from a nearby development site using appropriate SuDS techniques which may involve pumping, piping or swales / drains.

Brownfield sites could also be considered though this would entail site clearance of existing buildings and conversion to greenspace.

By using the sequential approach to site layout, the LPA and developers should be able to avoid the areas at risk and leave clear for potential flood storage. See the SFRA Maps in Appendix B to spatially assess the areas of the sites at risk.

6.10 Phasing of development

Flood risk should be taken into account at all stages of the planning process with a view to directing development away from areas at flood risk, now and in the future, by following the sequential approach to site allocation, as shown in Figure 6-2.

By avoiding sites identified in this SFRA as being at significant flood risk, or by considering how changes in site layout can help to avoid those parts of a site at flood risk, the Council would be demonstrating a sustainable approach to development. In terms of surface water, for those sites at highest risk, more detailed and site-specific modelling of the risk will be required to determine the viability of development. For all sites at risk from surface water, site design and layout should be tailored to ensure sustainable development. This should involve investigation into appropriate SuDS techniques (see Section 6.14).

Using a phased approach to development, based on modelling results of floodwater storage options, should ensure that any sites at risk of causing flooding to other sites are developed first in order to ensure flood storage measures are in place before other sites are developed, thus ensuring a sustainable approach to site development. Also, it may be possible that flood mitigation measures put in place at sites upstream could alleviate flooding at downstream or nearby sites. Large strategic multiple development sites should also carry out development phasing within the overall site boundary so as to avoid cumulative impacts within the site, as well as off the site (see Section 5.7.4 for information on Natural Flood Management and Working with Natural Processes).

6.11 Cumulative impacts

The NPPF (2019) states that strategic policies…

"…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". (para 156)

Previous policies have relied on the assumption that if each individual development does not increase the risk of flooding, the cumulative impact will also be minimal. However, if there is a lot of development occurring within one catchment, particularly where there is flood risk to existing properties or where there are few opportunities for mitigation, the cumulative impact may be to change the flood response of the catchment.

This SFRA considers cumulative impacts of new development through much of the generic advice provided on mitigation throughout Section 6 of this report. Consideration is given to the following:

- The importance of phasing of development, as discussed in Section 6.10;
- Cross boundary impacts i.e. there should be dialogue between CBMDC and neighbouring authorities upstream and downstream of Bradford, namely; Leeds and within North Yorkshire County Council. Decisions on flood risk management practices and development in these authorities should involve discussion with CBMDC given the possible downstream impacts of development on flood risk;

- Leaving space for floodwater, utilising greenspace for flood storage and slowing the flow; and
- SuDS and containment of surface water on-site as opposed to directing elsewhere (see Section 6.14).

6.12 Guidance for developers

This SFRA provides the evidence base for developers to assess flood risk at a strategic level and to determine the requirements of an appropriate site-specific FRA. Before carrying out an FRA, developers should check with the LPA whether the Sequential Test has been carried out. If not, the developer must apply the Sequential Test as part of their FRA by comparing their indicative development site with other available sites to ascertain which site has the lowest flood risk. The EA provides advice on this via: https://www.gov.uk/guidance/flood-risk-assessment-the-sequential-test-for-applicants

When initially considering the development options for a site, developers should use this SFRA, the NPPF and the FRCC-PPG to:

- ***Identify whether the site is***
  - *A windfall development, allocated development, within a regeneration area, single property or subject to a change of use to identify if the Sequential and Exception Tests are required.*
- ***Check whether the Sequential Test and / or the Exception Test have already been applied***
  - *Request information from the LPA on whether the Sequential Test, or the likelihood of the site passing the Exception Test, have been assessed;*
  - *If not, provide evidence to the LPA that the site passes the Sequential Test and will pass the Exception Test.*
- ***Consult with the LPA, the LLFA and the EA and the wider group of flood risk consultees, where appropriate, to scope an appropriate FRA if required***
  - *Guidance on FRAs provided in Section 6.6.4 of this SFRA;*
  - *Also, refer to the EA Standing Advice, CIRIA Report C624, the NPPF and the FRCC-PPG;*
  - *Consult the LLFA.*
- ***Submit FRA to the LPA and the EA for approval, where necessary***

Table 6-6 identifies, for developers, when the Sequential and Exception Tests are required for certain types of development and who is responsible for providing the evidence and those who should apply the tests if required.

Development	Sequential Test Required?	Who Applies the Sequential Test?	Exception Test Required?	Who Applies the Exception Test?
Allocated Sites	No (assuming the development type is the same as that submitted via the allocations process)	LPA should have already carried out the test during the allocation of development sites	Dependent on land use vulnerability	LPA to advise on the likelihood of test being passed. The developer must also provide evidence that the test can be passed by providing planning justification and producing a detailed FRA
Windfall Sites	Yes	Developer provides evidence, to the LPA that the test can be passed. An area of search will be defined by local circumstances relating to the catchment and for the type of development being proposed	Dependent on land use vulnerability	Developer must provide evidence that the test can be passed by providing planning justification and producing a detailed FRA
Regeneration Sites Identified Within Local Plan	No	-	Dependent on land use vulnerability	LPA to advise on the likelihood of test being passed. The developer must also provide evidence that the test can be passed by providing planning justification and producing a detailed FRA
Redevelopment of Existing Single Properties	No	-	Dependent on land use vulnerability	Developer must provide evidence that the test can be passed by providing planning justification and producing a detailed FRA
Changes of Use	No (except for any proposal involving changes of use to land	Developer provides evidence to the LPA that the test can be passed	Dependent on land use vulnerability	Developer must provide evidence that the test can be passed by providing planning justification and

Development	Sequential Test Required?	Who Applies the Sequential Test?	Exception Test Required?	Who Applies the Exception Test?
	involving a caravan, camping or chalet site)			producing a detailed FRA

Table 6-6: Development types and application of Sequential and Exception Tests for developers

Figure 6-3 shows what developers should do with regards to applying the Sequential Test if the LPA has not already done so.

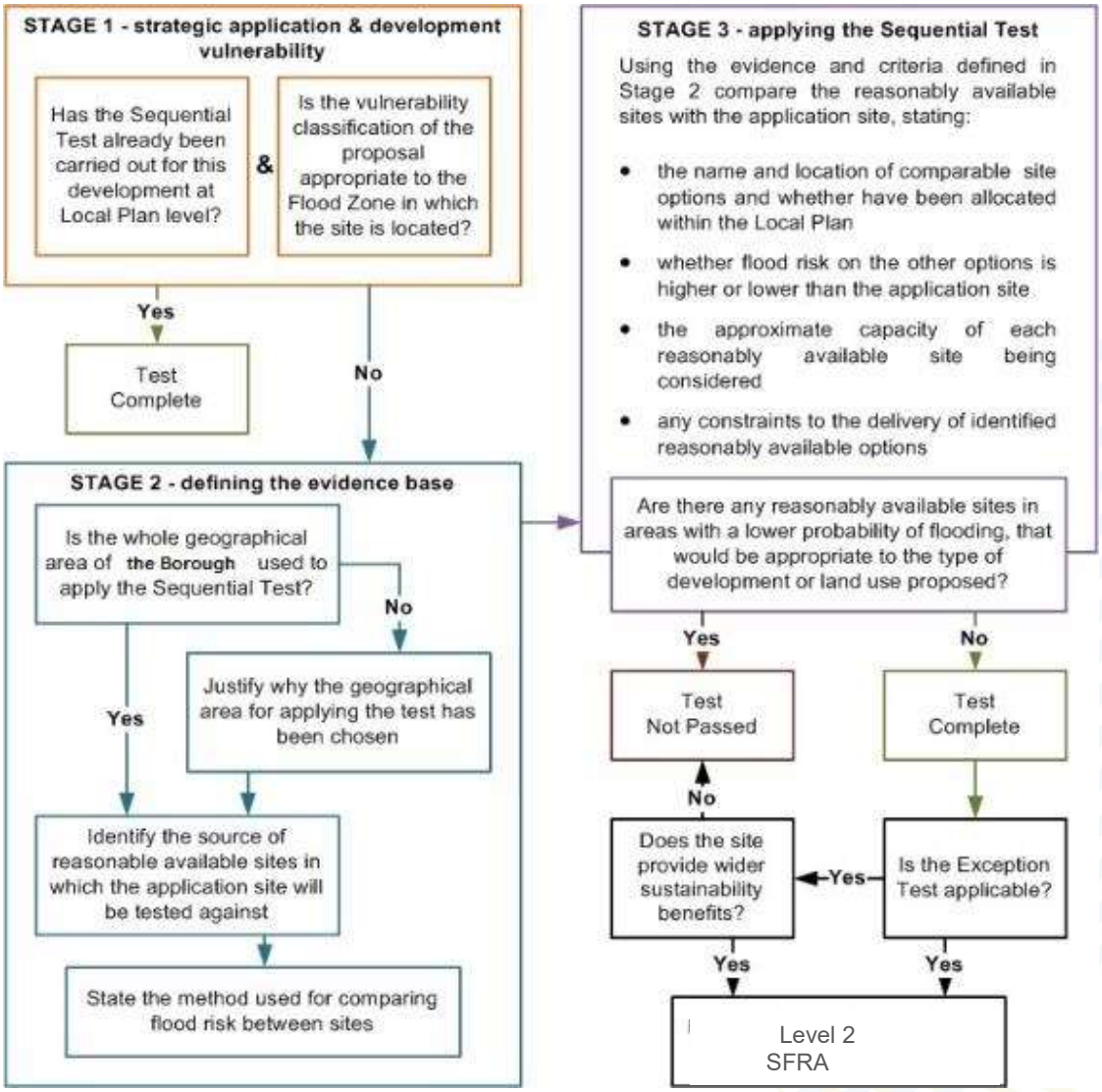

Figure 6-3: Development management Sequential Test process

The Sequential Test does not apply to change of use applications unless it is for change of land use to a caravan, camping or chalet site, or to a mobile home site or park home

site. The Sequential Test can also be considered adequately demonstrated if both of the following criteria are met:

- The Sequential Test has already been carried out for the site (for the same development type) at the strategic level (Local Plan); and
- The development vulnerability is appropriate to the Flood Zone (see Table 3 of the FRCC-PPG).

If both these criteria are met, reference should be provided for the site allocation of the Local Plan document and the vulnerability of the development should be clearly stated.

When applying the Sequential Test, the following should also be considered:

- **The geographic area in which the Test is to be applied;**
- **The source of reasonable available sites in which the application site will be tested against; and**
- **The evidence and method used to compare flood risk between sites.**

Sites should be compared in relation to flood risk; Local Plan status; capacity; and constraints to delivery including availability, policy restrictions, physical problems or limitations, potential impacts of the development on the local area, and future environmental conditions that would be experienced by the inhabitants of the development.

The test should conclude if there are any reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use that has been put forward in the Local Plan.

The LPA should now have sufficient information to be able to assess whether or not the indicative site has passed the Sequential Test. If the Test has been passed, then the developer should apply the Exception Test in the circumstances set out by tables 1 and 3 of the FRCC-PPG.

In all circumstances, where the site is within areas at risk of flooding and where a site-specific FRA has not already been carried out, a site-specific FRA should be completed in line with the NPPF and the FRCC-PPG.

In addition to the formal Sequential Test, the NPPF sets out the requirement for developers to apply the sequential approach to locating development within the site. As part of their application and masterplanning discussions with applicants, LPAs should seek whether or not:

- Flood risk can be avoided by substituting less vulnerable uses or by amending the site layout;
- Less vulnerable uses for the site have been considered; or
- Density can be varied to reduce the number or the vulnerability of units located in higher risk parts of the site.

6.13 Accounting for climate change

Climate change will increase flood risk over the lifetime of a development. This SFRA has considered a precautionary approach to climate change as modelled climate change outputs are not available for this study. It is often the case that modelled 1 in 1000 AEP event outlines are similar to modelled climate change scenarios for the 1 in 100 AEP event. Therefore, Flood Zones 2 and 3 of the EA's Flood Map for Planning have been used as a climate change proxy to provide an indication of risk to sites in the future.

For this SFRA therefore, the assumption should be that the current day Flood Zone 2 will become Flood Zone 3a in the 2080s or longer term and Flood Zone 3a could become

the Flood Zone 3b. Predicting future expansion of the functional floodplain is however more difficult as the functional floodplain extent is based on a number of different criteria, as discussed in Section 5.2.4.

This approach to climate change is precautionary though is considered to be the most pragmatic methodology available. This approach is also consistent with other SFRAs and professional modelling experience. As such, for any sites within Flood Zone 2, the possibility of these sites being within Flood Zone 3a within in the 2080s or longer term should be considered.

A more detailed assessment of the impacts of climate change on flooding from the land and rivers should be carried out as part of any Level 2 SFRA or FRA. This should be carried out using the sensitivity ranges presented in this section which will provide an appropriately robust response to the uncertainty about climate change impacts on rainfall intensities, river flows and sea level rise.

Considering the impacts of climate change within a FRA / Level 2 SFRA will have implications for both the type of development that is appropriate according to its vulnerability to flooding and design standards for any SuDS or mitigation schemes proposed. For example, through very flat floodplains, using the +35 per cent from 2070 to 2115 allowance for peak river flows, could see an area currently within lower risk zones (Flood Zone 2), in future be re-classified as lying within a higher risk zone (Flood Zone 3a). Therefore, residential development may not be appropriate without suitable flood mitigation measures or flood resilient or resistant houses. In well-defined floodplains, the same climate change allowance could have significant impacts on flood depths influencing building type and design (e.g. finished floor levels).

6.13.1 Planning for climate change (NPPF, 2019)

In relation to flood risk and climate change in the planning system, the revised NPPF states:

"All plans should apply a sequential, risk-based approach to the location of development – taking into account the current and future impacts of climate change – so as to avoid, where possible, flood risk to people and property." (para 157).

Local plans should do this by safeguarding land from development that is required, or likely to be required, for current or future flood management; and to seek opportunities for the relocation of development, including housing, to more sustainable locations from areas where climate change is expected to increase flood risk.

6.13.2 EA climate change allowances

The EA revised the climate change allowances in 2016, for use in FRAs and SFRAs and will use these revised allowances when providing advice:

https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

The revised climate change allowances are predictions of anticipated change for:

- Peak river flow by River Basin District;
- Peak rainfall intensity;
- Sea level rise; and
- Offshore wind speed and extreme wave height.

Deciding on which of the peak river flow allowances to use is based on the flood zone the development is within and the associated vulnerability classification (see Table 2 of the FRCC-PPG). Climate change allowances for river flows are based on which River Basin District the river is located within. As discussed, CBMDC is within the Humber RBD.

RBD	Allowance Category	Total Potential Change Anticipated for...		
		2020s (2015-2039)	2050s (2040-2069)	2080s (2070-2115)
Humber	Upper end	+20%	+30%	+50%
	Higher central	+15%	+20%	+30%
	Central	+10%	+15%	+20%

Table 6-7: Recommended peak river flow allowances for the Humber RBD

The peak rainfall intensity allowance applies to the whole of England. SFRAs and FRAs should assess both the central and upper end allowances to gauge the range of impacts.

Allowance Category	Total Potential Change Anticipated for...		
	2015-2039	2040-2069	2070-2115
Upper end	+10%	+20%	+40%
Central	+5%	+10%	+20%

Table 6-8: Peak rainfall intensity allowances in small and urban catchments for England

The EA will also require consideration, if appropriate, of the 'high++ allowances' for peak river flows and mean sea level rise (although sea level rise does not apply to CBMDC) where a development is considered to be very sensitive to flood risk and with lifetimes beyond the end of the century. This could include infrastructure projects or developments that significantly change existing settlement patterns. The high++ allowances can be found in the EA's *Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities*[21], which uses science from UKCP09. This guidance is based on the Government's policy for climate change adaptation and is specifically intended for projects or strategies seeking Government FDGiA funding. However, RMAs in England may also find it useful in developing plans and making FCERM investment decisions even if there is no intention of applying for central government funding. This is important for any future large-scale infrastructure used to support the delivery of strategic sites such as flood defence schemes.

Although, it is anticipated that increases in river flows will lie somewhere within the range of the central to upper end estimates of the February 2016 allowances, more extreme change cannot be discounted. The high++ allowances can be used to represent more severe climate change impacts and help to identify the options that would be required.

UKCP18

In November 2018 Defra released a new set of UK Climate Projections (UKCP18). These projections replace the UKCP09 projections which have been used for the past ten years. In terms of applying climate change to SFRAs and FRAs, the EA's February 2016 allowances are, at the time of writing, still the best representation of how climate change is likely to affect flood risk for peak river flows and peak rainfall intensities. Research that is due to be published in Spring 2019 may result in changes to these allowances.

As discussed, modelled climate change outputs, using the February 2016 allowances, are not available at the time of writing for this Level 1 SFRA.

21 Environment Agency Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities

However, any Level 2 assessment, following on from this Level 1, could involve the modelling of appropriate climate change events, where fully functioning EA hydraulic models are available.

6.14 Sustainable drainage systems (SuDS)

Development has the potential to cause an increase in impermeable area, an associated increase in surface water runoff rates and volumes, and consequently a potential increase in downstream flood risk due to overloading of sewers, watercourses, culverts and other drainage infrastructure. Managing surface water discharges from new development is therefore crucial in managing and reducing flood risk to new and existing development downstream. Carefully planned development can also play a role in reducing the amount of properties that are directly at risk from surface water flooding.

The Department for Communities and Local Government (DCLG) (now MHCLG) announced, in December 2014, that the local planning authority, in consultation with the LLFA, should be responsible for delivering SuDS[22] through the planning system. Changes to planning legislation gave provisions for major applications of ten or more residential units or equivalent commercial development to require sustainable drainage within the development proposals in accordance with the 'non-statutory technical standards for sustainable drainage systems'[23], published in March 2015. A Practice Guidance[24] document has also been developed by the Local Authority SuDS Officer Organisation (LASOO) to assist in the application of the non-statutory technical standards.

Bradford Sustainable Drainage[25]

In order to manage flood risk, all development, regardless of development type, flood zone and development size, must give priority use to SuDS. Particularly for major developments, there is a requirement to assess and include SuDS for managing surface water at the development unless it is demonstrated during the assessment that it is inappropriate for the site.

In order to satisfy the NPPF and its accompanying PPG, applicants must demonstrate that priority has been given to the use of sustainable drainage systems (SuDS) in their development proposals. SuDS should be provided by default unless demonstrated to be inappropriate. Where priority use of SuDS cannot be achieved, applicants must justify this by submitting robust and acceptable evidence.

Policy EN7 has been extracted from the CBMDC Core Strategy (see below) and it states the ways the Council will manage flood risk proactively within the District in terms of assessing development proposals. Relating specifically to SuDS, point A.9 of Policy EN7 refers to the need for developers to assess how advantageous it would be to implement and maintain SuDS on a site that remains integral to site design and achieves high water quality standards.

22 http://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Commons/2014-12-18/HCWS161/
23 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf
24 http://www.susdrain.org/files/resources/other-guidance/lasoo_non_statutory_suds_technical_standards_guidance_2016_.pdf
25 https://www.bradford.gov.uk/media/3042/sdgsupportingdocuments.pdf

Core Strategy Policy EN7: Flood Risk

A. The Council will manage flood risk pro-actively and in assessing proposals for development will:

1. Integrate sequential testing into all levels of plan-making
2. Require space for the storage of flood water within Flood Zones 2 and 3a
3. Ensure that any new development in areas of flood risk is appropriately resilient and resistant
4. Safeguard potential to increase flood storage provision and improve defences within the Rivers Air and Wharfe corridors
5. Manage and reduce the impacts of flooding within the beck corridors, in a manner that enhances their value for wildlife
6. Adopt a holistic approach to flood risk in the Bradford Beck corridor in order to deliver sustainable regeneration in LDDs and in master planning work
7. Require that all sources of flooding are addressed, that development proposals will only be acceptable where they do not increase flood risk elsewhere and that any need for improvements in drainage infrastructure is taken into account
8. Seek to minimise run-off from new development; for Greenfield sites run off should be no greater than the existing Greenfield overall rates
9. Require developers to assess the feasibility of implementing and maintaining SuDS in a manner that is integral to site design, achieves high water quality standards and maximises habitat value
10. Use flood risk data to inform decisions made about Green Infrastructure

Only support the use of culverting for ordinary watercourses, and additional flood defence works that could have adverse impacts on the environment, in exceptional circumstances.

B. The Council will not permit development in areas shown as functional floodplain in the Bradford SFRA, with the exception of water compatible uses and essential infrastructure.

This policy is currently being updated as part of the Core Strategy Partial Review.

6.14.1 SuDS and the revised NPPF, 2019

The Revised NPPF (2019), para 165, states:

"Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

a. take account of advice from the lead local flood authority;

b. have appropriate proposed minimum operational standards;

*c. **have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development;** and*

d. *where possible, provide multifunctional benefits*".

As since 2014, the NPPF still states only 'major' developments should incorporate SuDS. However, all developments, both major and minor, can include some kind of SuDS, providing multiple benefits that contribute to many other NPPF policies, including climate change. Where site conditions may be more challenging, the types of SuDS may need to be adapted to the site's opportunities and constraints. At a strategic level, this should mean identifying SuDS opportunities according to geology, soil type, topography, groundwater / minewater conditions, their potential impact on site allocation, and setting out local SuDS guidance and opportunities for adoption and maintenance.

In terms of what kind of evidence would show SuDS to be inappropriate for a certain site, it is possible that clarity on what evidence is required may be subsequently set out in the revised FRCC-PPG, and that these circumstances would be exceptional.

Maintenance options must clearly identify who will be responsible for SuDS maintenance and funding for maintenance should be fair for householders and premises occupiers; and, set out a minimum standard to which the sustainable drainage systems must be maintained.

Sustainable drainage should form part of an integrated design methodology secured by detailed planning conditions to ensure that the SuDS to be constructed is maintained to a minimum level of effectiveness.

6.14.2 SuDS hierarchy

The runoff destination should always be the first consideration when considering design criteria for SuDS including the following possible destinations in order of preference:

1 To ground;
2 To surface water body;
3 To surface water sewer;
4 To combined sewer.

Effects on water quality should also be investigated when considering runoff destination in terms of the potential hazards arising from development and the sensitivity of the runoff destination. Developers should also establish that proposed outfalls are hydraulically capable of accepting the runoff from SuDS through consultation with the LLFA, EA and Yorkshire Water as appropriate.

The non-statutory technical standards for sustainable drainage systems (March 2015) sets out appropriate design criteria based on the following:

1 Flood risk outside the development;
2 Peak flow control;
3 Volume control;
4 Flood risk within the development;
5 Structural integrity;
6 Designing for maintenance considerations;
7 Construction.

Many different SuDS techniques can be implemented. As a result, there is no one standard correct drainage solution for a site. In most cases, using the Management Train principle (see Figure 6-4), will be required, where source control is the primary aim.

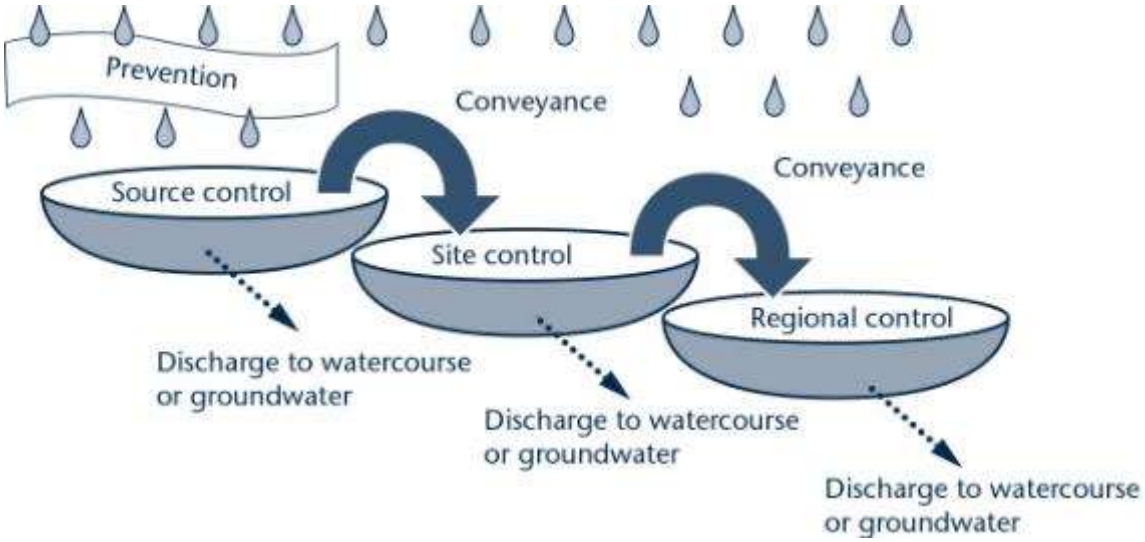

Figure 6-4: SuDS management train principle[26]

The effectiveness of a flow management scheme within a single site is heavily limited by land use and site characteristics including (but not limited to) topography; geology and soil (permeability); and available area. Potential ground contamination associated with urban and former industrial sites should be investigated with concern being placed on the depth of the local water table and potential contamination risks that will affect water quality. The design, construction and ongoing maintenance regime of any SuDS scheme must be carefully defined as part of a site-specific FRA. A clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential for successful SuDS implementation.

In addition to the national standards, the LPA may set local requirements for planning permission that include more rigorous obligations than the non-statutory technical standards. More stringent requirements should be considered where current Greenfield sites lie upstream of high risk areas. This could include improvements on Greenfield runoff rates.The LPA should always be contacted with regards to its local requirements at the earliest opportunity in development planning.

The CIRIA SuDS Manual[27] 2015 should also be consulted by the LPA and developers. The SuDS manual (C753) is highly regarded and incorporates the latest research, industry practice, technical advice and adaptable processes to assist in the planning, design, construction, management and maintenance of good SuDS. The SuDS Manual complements the non-statutory technical standards and goes further to support the cost-effective delivery of multiple benefits.

6.15 Drainage for new developments

Development has the potential to cause an increase in impermeable area, an associated increase in surface water runoff rates and volumes, and a consequent potential increase in downstream flood risk due to overloading of sewers, watercourses, culverts and other drainage infrastructure.

Managing surface water discharges from new development is crucial in managing and reducing flood risk to new and existing development.

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[26] CIRIA (2008) Sustainable Drainage Systems: promoting good practice – a CIRIA initiative

27 https://www.ciria.org/Memberships/The_SuDs_Manual_C753_Chapters.aspx

Carefully planned development can also play a role in reducing the amount of properties that are directly at risk from surface water flooding. The Planning System has a key role to play in setting standards for sustainable drainage from new developments and ensuring that developments are designed to take account of the risk from surface water flooding. Sustainable drainage plays an important part in reducing flows in the sewer network and in meeting environmental targets, alongside investment in maintenance by the water companies on their assets. Water companies plan their investment on a five year rolling cycle, in consultation with key partners, including the EA and local authorities.

6.15.1 Overland flow paths

Underground drainage systems have a finite capacity and regard should always be given to larger events when the capacity of the network will be exceeded. Hence there is a need to design new developments with exceedance in mind. This should be considered alongside any surface water flows likely to enter a development site from the surrounding area.

Master planning should ensure that existing overland flow paths are retained within the development. As a minimum, the developer should investigate, as part of a site-specific FRA, the likely extents, depths and associated hazards of surface water flooding on a development site, as shown by the RoFSW dataset. This is considered to be an appropriate approach to reduce the risk of flooding to new developments. Green infrastructure should be used wherever possible to accommodate such flow paths. **Floor levels should always be set a minimum of 300 mm above adjacent roads** to reduce the consequences of any localised flooding.

The effectiveness of a flow management scheme within a single site is heavily limited by site constraints including (but not limited to) topography; geology and soil (permeability); development density; existing drainage networks both on-site and in the surrounding area; adoption issues; and available area. The design, construction and ongoing maintenance regime of such a scheme must be carefully defined at an early stage and a clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential.

6.16 Property Flood Resilience (PFR)

The NPPF (2019) states that, where development must be located in an area of flood risk, following application and passing of the Sequential and Exception Tests (if applicable), the development must be appropriately flood resistant and resilient (para 163b).

Flood resilience and resistance measures are designed to mitigate flood risk and reduce damage and adverse consequences to existing property. Resistance and resilience measures may aim to help residents and businesses recover more quickly following a flood event.

It should be noted that it is not possible to completely prevent flooding to all communities and businesses.

Research carried out by the then DCLG (now the MHCLG) and the EA has recommended that the use of resistance measures should generally be limited to a nominal protection height of 600 mm above ground level, the lowest point of ground abutting the external property walls. This is because the structural integrity of the property may be compromised above this level.

It should be noted that PFR measures would not be expected to cause an increase in flood risk to other properties or other parts of the local community. They will help mitigate against flood risk but, as with any flood alleviation scheme, flood risk cannot

be removed completely. Emergency plans should, therefore, be in place that describe the installation of measures and residual risks.

As the flood risk posed to a property cannot be removed completely, it is recommended that PFR products are deployed in conjunction with pumps of a sufficient capacity. Pumps will help manage residual flood risks not addressed by resistance measures alone such as rising groundwater.

6.16.1 Definitions

Flood resilience measures aim to reduce the damage caused by floodwater entering a property. Flood resilience measures are based on an understanding that internal flooding may occur again and when considering this eventuality, homes and businesses are encouraged to plan for flooding with an aim of rapid recovery and the return of the property to a habitable state.

For example, tiled floors are easier to clean than carpets, raised electricity sockets and high-level wall fixings for TVs / computers may mean that that power supply remains unaffected. Raising kitchen or storage units may also prevent damage that may not require replacement after a flood. There is a lot of information available about what items get damaged by floodwater and features that are considered to provide effective resilience measures that can be installed at a property.

Flood resistance measures aim to reduce the amount of floodwater entering the property. Obvious inflow routes, such as through doors and airbricks may be managed, for example, by installing bespoke flood doors, door flood barriers and automatic closing airbricks. However, the property's condition and construction are also key to understanding how floodwater may enter and move between buildings. For example, flood water can also flow between properties through connecting cavity walls, cellars, beneath suspended floors and through internal walls. Flood resistance measure alone may not keep floodwater out. Building condition is a critical component of any flood mitigation study.

6.16.2 Property mitigation surveys

To define the scale and type of resistance or resilience measures required, a survey will need to be undertaken to pick up property threshold levels, air brick levels, doorways, historic flood levels and a number of ground spot levels required to better understand the flood mechanisms for flood water arriving at the property (e.g. along road, pavements, etc.). The depth of flooding at each property will help guide the selection of resistance measures proposed. Surveys will need to include consideration of issues such as:

- Detailed property information
- An assessment of flood risk, including property (cross) threshold levels
- Routes of water ingress (fluvial, ground and surface water flooding)
- An assessment of impact of flood waters
- A schedule of measures to reduce risk (resistance and resilience)
- Details of recommendations (including indicative costs)
- Advice on future maintenance of measures
- Advice on flood preparedness

All sources of flooding will need to be considered, including a comprehensive survey of openings (doors, windows and air bricks), as well as potential seepage routes through walls and floors, ingress through service cables, pipes, drains and identify possible weaknesses in any deteriorating brickwork or mortar.

7 Emergency Planning

The provisions for emergency planning for local authorities as Category 1 responders are set out by the Civil Contingencies Act, 2004 and the National Flood Emergency Framework for England, December 2014[28]. This framework is a resource for all involved in emergency planning and response to flooding from the sea, rivers, surface water, groundwater and reservoirs. The Framework sets out Government's strategic approach to:

- Ensuring all delivery bodies understand their respective roles and responsibilities when planning for and responding to flood related emergencies;
- Giving all players in an emergency flooding situation a common point of reference which includes key information, guidance and key policies;
- Establishing clear thresholds for emergency response arrangements;
- Placing proper emphasis on the multi-agency approach to managing flooding events;
- Providing clarity on the means of improving resilience and minimising the impact of flooding events;
- Providing a basis for individual responders to develop and review their own plans; and
- Being a long-term asset that will provide the basis for continuous improvement in flood emergency management.

Along with the EA flood warning systems, there are a range of flood plans at a sub-regional and local level, outlining the major risk of flooding and the strategic and tactical response framework for key responders.

This SFRA contains useful data to allow emergency planning processes to be tailored to the needs of the area and be specific to the flood risks faced. The SFRA Maps in Appendix B and accompanying GIS layers should be made available for consultation by emergency planners during an event and throughout the planning process.

7.1 Civil Contingencies Act

Under the Civil Contingencies Act (CCA, 2004)[29], the LLFA and LPAs are classified as Category 1 responders and thus have duties to assess the risk of emergencies occurring, and use this to:

- Inform contingency planning;
- Put in place emergency plans;
- Put in place business continuity management arrangements;
- Put in place arrangements to make information available to the public about civil protection matters;
- Maintain arrangements to warn, inform and advise the public in the event of an emergency;
- Share information with other local responders to enhance coordination; and
- Cooperate with other local responders to enhance coordination and efficiency and to provide advice and assistance to businesses and voluntary organisations about business continuity management.

[28] https://www.gov.uk/government/publications/the-national-flood-emergency-framework-for-england
[29] https://www.gov.uk/preparation-and-planning-for-emergencies-responsibilities-of-responder-agencies-and-others#the-civil-contingencies-act

During an emergency, such as a flood event, the local authority must also co-operate with other Category 1 responders (such as the emergency services and the EA) to provide the core response.

7.1.1 West Yorkshire Local Resilience Forum

The role of the West Yorkshire Local Resilience Forum (LRF) is to co-ordinate the actions and arrangements between responding services in the area to provide the most effective and efficient response to civil emergencies when they occur.

7.1.2 West Yorkshire Community Risk Register[30]

As a strategic decision-making organisation, the LRF prepared a Community Risk Register (CRR), which considers the likelihood and consequences of the most significant risks and hazards the area faces, including fluvial, coastal, surface water and urban flooding. This SFRA can help to inform this. The CRR is considered as the first step in the emergency planning process and is designed to reassure the local community that measures and plans are in place to the potential hazards listed within the CRR.

7.1.3 Community Emergency Plan

Communities may need to rely on their own resources to minimise the impact of an emergency, including a flood, before the emergency services arrive. Many communities already help each other in times of need, but experience shows that those who are prepared cope better during an emergency. Communities with local knowledge, enthusiasm and information are a great asset and a Community Emergency Plan can help. Details on how to produce a community emergency plan, including a toolkit and template, are available from the Government's website[31]. CBMDC have created an emergency management plan on how to protect the community, which offers a range of advice before, during and after an emergency, which is available from:

https://www.bradford.gov.uk/media/4302/final-emp-ver-12k-july-2017-public.pdf

7.1.4 Local flood plans

This SFRA provides a number of flood risk data sources that should be used when producing or updating flood plans. The LPA will be unable to write their own specific flood plans for new developments at flood risk. Developers should write their own. Generally, owners with individual properties at risk should write their own individual flood plans, however larger developments or regeneration areas, such as retail parks, hotels and leisure complexes, should consider writing one collective plan for the assets within an area.

This SFRA can help to:

- Update these flood plans if appropriate;
- Inform emergency planners in understanding the possibility, likelihood and spatial distribution of all sources of flooding (emergency planners may however have access to more detailed information, such as for Reservoir Inundation Maps, which have not been made available for this SFRA);
- Identify safe evacuation routes and access routes for emergency services;

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[30] https://www.westyorkshire.police.uk/advice/emergency-plans/reports-community-risk-register/reports-community-risk-register

[31] https://www.gov.uk/guidance/resilience-in-society-infrastructure-communities-and-businesses#community-resilience

- Identify key strategic locations to be protected in flooding emergencies, and the locations of refuge areas which are capable of remaining operational during flood events;
- Provide information on risks in relation to key infrastructure, and any risk management activities, plans or business continuity arrangements;
- Raise awareness and engage local communities;
- Support emergency responders in planning for and delivering a proportionate, scalable and flexible response to the level of risk; and
- Provide flood risk evidence for further studies.

7.2 Flood warning and evacuation plans

Developments that include areas that are designed to flood (e.g. ground floor car parking and amenity areas) or have a residual risk associated with them, will need to provide appropriate flood warning and instructions so users and residents are safe in a flood. This will include both physical warning signs and written flood warning and evacuation plans. Those using the new development should be made aware of any evacuation plans.

In relation to new development it is up to the LPA to determine whether the flood warning and evacuation plans, or equivalent procedures, are sufficient or not. If the LPA is not satisfied, taking into account all relevant considerations, that an indicative development can be considered safe without the provision of safe access and exit, then planning permission should be refused.

Whilst there is no statutory requirement on the EA or the emergency services to approve evacuation plans, LPAs are accountable under their Civil Contingencies duties, via planning condition or agreement, to ensure that plans are suitable. This should be done in consultation with development management officers. Given the cross-cutting nature of flooding, it is recommended that further discussions are held internally to the LPA between emergency planners and policy planners / development management officers, the LLFA, drainage engineers and also to external stakeholders such as the emergency services, the EA, YW, Internal Drainage Boards and Canal & River Trust (if applicable).

It may be useful for both the LLFA and spatial planners to consider whether, as a condition of planning approval, flood evacuation plans should be provided by the developer which aim to safely evacuate people out of flood risk areas, using as few emergency service resources as possible. West Yorkshire Local Resilience Forum are essential to establish the feasibility / effectiveness of such an approach, prior to it being progressed. It may also be useful to consider how key parts of agreed flood evacuation plans could be incorporated within local development documents, including in terms of protecting evacuation routes and assembly areas from inappropriate development.

Once the development goes ahead, it will be the requirement of the plan owner (developer) to make sure the plan is put in place, and to liaise with the LPA and LLFA regarding maintenance and updating of the plan.

At the time of writing there are 24 flood warning areas within the CBMDC region located along the Rivers Aire, Wharfe and Worth, and their tributaries.

7.2.1 What should the Plan include?

Flood warning and evacuation plans should include the information stated in Table 7-1. Advice and guidance on plans are accessible from the EA website and there are templates available for businesses and local communities.

Consideration	Purpose
Availability of existing flood warning system	The EA offers a flood warning service that currently covers designated Flood Warning Areas in England and Wales. In these areas, they are able to provide a full Flood Warning Service.
Rate of onset of flooding	The rate of onset is how quickly the water arrives and the speed at which it rises which, in turn, will govern the opportunity for people to effectively prepare for and respond to a flood. This is an important factor within Emergency Planning in assessing the response time available to the emergency services.
How flood warning is given and occupants awareness of the likely frequency and duration of flood events.	Everyone eligible to receive flood warning should be signed up to the EA flood warning service. Where applicable, the display of flood warning signs should be considered. In particular sites that will be visited by members of the public on a daily basis such as sports complexes, car parks, retail stores. It is envisaged that the responsibility should fall upon the developers and should be a condition of the planning permission. Information should be provided to new occupants of houses concerning the level of risk and subsequent procedures if a flood occurs.
The availability of staff / occupants / users to respond to a flood warning and the time taken to respond to a flood warning	The plan should identify roles and responsibilities of all responders. The use of community flood wardens should also be considered.
Designing and locating safe access routes, preparing evacuation routes and the identification of safe locations for evacuees	Dry routes will be critical for people to evacuate as well as emergency services entering the site. The extent, depth and flood hazard rating, including allowance for climate change, should be considered when identifying these routes.
Vulnerability of occupants	Vulnerability classifications associated with development as outlined in the FRCC-PPG. This is closely linked to its occupiers.
How easily damaged items will be relocated, and the expected time taken to re-establish normal use following an event	The impact of flooding can be long lasting well after the event has taken place affecting both the property which has been flooded and the lives that have been disrupted. The resilience of the community to get back to normal will be important including time taken to repair / replace damages.

Table 7-1: Flood warning and evacuation plans

7.2.2 EA Flood Warning Areas (FWA) and flood awareness

The EA monitor river levels within the main rivers affecting the authority area and based upon weather predictions provided by The Met Office, making an assessment of the anticipated maximum water level that is likely to be reached within the proceeding hours (and/or days). Where these predicted water levels are expected to result in inundation of a populated area, the EA will issue a series of flood warnings within defined Flood Warning Areas (FWA), encouraging residents to take action to avoid damage to property in the first instance.

More information on flood warnings is provided by the EA via:

https://www.gov.uk/government/publications/flood-warnings-what-they-are-and-what-to-do

There are 24 Flood Warning Areas (FWA) in operation across CBMDC. Two of the FWA are large scale and are located on the River Aire close to the town of Shipley. The FWA's are located on the River Aire or the River Wharfe to protect the properties and businesses within the CBMDC boundary. FWAs are shown on the SFRA maps in Appendix B.

Live information on flood warning and flood alerts is available via:

https://flood-warning-information.service.gov.uk/

Emergency planners may also use the outputs from this SFRA to raise awareness within local communities. This should include raising awareness of flood risk, roles and responsibilities and measures that people can take to make their homes more resilient to flooding from all sources whilst also encouraging all those at fluvial flood risk to sign up to the EA's Flood Warning service[32].

It is also recommended that Category 1 responders are provided with appropriate flood response training to help prepare them for the possibility of a major flood with an increased number of people living within flood risk areas, to ensure that adequate pre-planning response and recovery arrangements are in place.

[32] https://www.gov.uk/sign-up-for-flood-warnings

8 Conclusions and Recommendations

8.1 Conclusions

This SFRA provides a single repository planning tool relating to flood risk and development in the metropolitan district of Bradford. Key flood risk stakeholders namely the EA, LPA, LLFA and YW were consulted to collate all available and relevant flood risk information on all sources into one comprehensive assessment. Together with this report, this SFRA also provides a suite of interactive GeoPDF flood risk maps (Appendix B) and a development site assessment spreadsheet (Appendix C) illustrating the level of risk to potential Local Plan development sites.

The flood risk information, assessment, guidance and recommendations of the SFRA will provide the LPA with the evidence base required to apply the Sequential Test, as required under the NPPF, and demonstrate that a risk-based, sequential approach has been applied in the preparation of its new Local Plan.

Whilst the aim of the sequential approach is the avoidance of high flood risk areas, in some locations where the council is looking for continued growth and/or regeneration, this will not always be possible. This SFRA therefore provides the necessary links between spatial development, wider flood risk management policies, local strategies and plans and on the ground works by combining all available flood risk information together into one single repository. As this is a strategic study, detailed local information on flood risk is not fully accounted for. For a more detailed assessment of specific areas or sites, a Level 2 SFRA may be carried out following on from the completion of a Level 1 assessment, if required.

The data and information used throughout the SFRA process is the most up-to-date data available at the time. Once new, updated or further information becomes available, the LPA should look to update this SFRA. The Level 1 SFRA should be considered to be, and maintained as, a live assessment which is updated as and when required (when new modelling or flood risk information becomes available). The LPA and LLFA can decide to update the SFRA, and the EA as a statutory consultee can also advise the LPA to update the SFRA.

8.2 Planning policy and flood risk recommendations

The following planning policy recommendations relating to flood risk are designed to enable the LPA to use the information provided in this Level 1 SFRA to inform policy direction:

Recommendation 1: No development within Flood Zone 3b…

…as per the NPPF (2019) and FRCC-PPG, unless in exceptional circumstances such as for essential infrastructure, which must still pass the Exception Test, or where development is water compatible.

Development must not impede the flow of water within Flood Zone 3b nor should it reduce the volume available for the storage of floodwater. Sites within Flood Zone 3b may still be developable if the site boundary can be removed from the floodplain or the site can accommodate the risk on site and keep the area free from development.

Refer to tables 1 to 3 of the FRCC-PPG.

Recommendation 2: Consider surface water flood risk…

…with equal importance alongside fluvial risk including possible withdrawal, redesign or relocation for sites at significant surface water risk.

SuDS on all new development must adhere to industry standards and to the applicable runoff discharge rate and storage volume allowances stated by the LLFA.

Site specific FRAs should always consider surface water flood risk management and options for on-site flood storage through appropriate SuDS. The LPA and LLFA must always be consulted during this process, as should YW and the EA, if required.

Recommendation 3: Sequential approach to site allocation and site layout…

…must be followed by the LPA to ensure sustainable development when either allocating land in Local Plans or determining planning applications for development.

The overall aim of the Sequential Approach should be to steer new development to low risk Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, the flood risk vulnerability of land uses and reasonably available sites in Flood Zone 2 should be considered, applying the Exception Test if required.

Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in higher risk Flood Zone 3a, be considered. This should take into account the flood risk vulnerability of land uses, residual surface water and/or groundwater flood risk and the likelihood of meeting the requirements of the Exception Test, if required.

This SFRA, the NPPF and FRCC-PPG must be consulted throughout this process along with the LPA, LLFA, EA and YW.

Recommendation 4: Requirement for a site-specific Flood Risk Assessment…

…from a developer when a site is: (NPPF, 2019)

- Sites of 1 hectare or more
- Land which has been identified by the EA as having critical drainage problems
- Land identified as being at increased flood risk in future
- At risk of flooding from other sources of flooding or at residual risk

Additional to the requirements of the NPPF:

- Within Flood Zone 1 where any part of the site is identified by the RofSW flooding maps as being at risk of surface water flooding.
- Situated over or within 8 metres of a culverted watercourse or where development will be required to control or influence the flow of any watercourse
- Subject to a change of use to a higher vulnerability classification which may be subject to other sources of flooding
- Situated in an area currently benefitting from defences
- Within a council designated CDA or
- Situated over a culverted watercourse or where development will require controlling the flow of any river or stream or the development could potentially change structures known to influence flood flow.

Before deciding on the scope of the FRA, this SFRA should be consulted along with the LPA, LLFA and YW. The FRA should be submitted to and be approved by the LPA including suitable consultation with the LLFA and the EA and any other applicable parties.

Recommendation 5: Use of appropriately sourced SuDS…

…required for all major developments of 10 or more residential units or equivalent commercial development. This is in accordance with Para 165 of the NPPF (2019). (Major development defined as, for housing, development where 10 or more homes will be provided, or the site has an area of 0.5 hectares or more. For non-residential development it means additional floorspace of 1,000m2 or more, or a site of 1 hectare or more, or as otherwise provided in the Town and Country Planning (Development Management Procedure) (England) Order 2015).

As per the NPPF (2019), in terms of SuDS, development in areas at flood risk should only be permitted where SuDS are incorporated into the design, unless clear evidence suggests demonstrates this would be inappropriate.

SuDS scoping and design, as part of a site-specific FRA, must be included within the early stages of the site design in order to incorporate appropriate SuDS within the development.

The LPA, LLFA, and YW and IDB (if appropriate) must be consulted during the site design stage and the FRA must be submitted to and approved by the LPA, considering all consultation with key stakeholders.

All SuDS must be designed to meet industry standards, as specified below, including any replacement standards/documents which update or are in addition to those listed:

- Technical Standards for SuDS (Defra)
- C753 The SuDS Manual
- Sewers for Adoption 8

Appropriate guidance should always be followed, as referenced within this SFRA.

Recommendation 6: Natural Flood Management techniques…

…must be considered, where possible, to aid with flood alleviation and implementation of suitable SuDS, depending on the location.

A Green Infrastructure Strategy (once completed) and the national WwNP mapping (included in this SFRA) should be consulted in the first instance, followed by local investigation into whether such techniques are appropriate and whether the benefits are proportionate to the work required to carry out the identified WwNP approaches.

Recommendation 7: Phasing of development…

…must be carried out by the LPA on a site by site basis and also within sites by the developer to avoid any cumulative impacts of flood risk (reinforced by the revised NPPF (2019)).

Using a phased approach to development, should ensure that any sites at risk of causing flooding to other sites are developed first to ensure that flood storage measures are in place and operational before other sites are developed, thus contributing to a sustainable approach to site development during all phases of construction. It may be possible that flood mitigation measures put in place at sites upstream could alleviate flooding at downstream or nearby sites.

Development phasing within large strategic sites of multiple developments should also be considered where parts of such sites are at flood risk.

Recommendation 8: Planning permission for at risk sites…

…can only be granted by the LPA where a site-specific FRA shows that:

- The NPPF and FRCC-PPG have been referenced together with appropriate consultation with the LLFA, the EA, and YW, where applicable
- The effects of climate change have been taken into account using the latest allowances developed by the EA
- There is no loss in floodplain storage resulting from the development
- The development will not increase flood risk elsewhere
- For previously developed sites, the development will offer a minimum betterment of 30% reduction in discharge rate, achieved through providing SuDS as appropriate or through the use of appropriate flow and volume control devices
- There is no adverse effect on the operational functions of any existing flood defence infrastructure
- Proposed resistance / resilience measures designed to deal with current and future risks are appropriate
- Appropriate SuDS techniques have been considered and are to be incorporated into the design of the site, where applicable
- Whether the development will be safe for its lifetime and has passed the Exception Test, if applicable
- An appropriate Emergency Plan is included that accounts for the possibility of a flood event and shows the availability of safe access and egress routes accessible during times of flood.

8.2.1 Recommendations for further work

The SFRA process has developed into more than just a planning tool. Sitting alongside the SA, LFRMS and FRMP, it can be used to provide a much broader and inclusive vehicle for integrated, strategic and local flood risk management and delivery.

There are a number of plans and assessments listed in Table 8-1 that may be of benefit to the LPA, in developing their flood risk evidence base to support the delivery of the Local Plan, or to the LLFA to help fill critical gaps in flood risk information.

Type	Study	Reason	Timeframe
Understanding of local flood risk	Level 1 SFRA update	Assigning proposed use to the sites provided to determine vulnerabilities and therefore produce more specific recommendations.	Short term
		As and when new sites to be assessed, flood risk information or policy becomes available.	As required
	Level 1 SFRA update; Level 2 SFRA; site-specific FRA	Reviewing of EA flood zones in those areas not covered by existing detailed hydraulic models i.e. the Flood Map for Planning does not cover every watercourse such as those <3km^2 in catchment area or Ordinary Watercourses. If a watercourse or drain is present on OS mapping but is not covered by the Flood Map for Planning, this does not mean there is no potential flood risk. A model may therefore be required to ascertain the flood risk, if any, to any nearby sites.	Short term
	Level 2 SFRA	Further, more detailed assessment of flood risk to high risk sites, as notified by this Level 1 SFRA.	Short term
	Local Flood Risk Management Strategy Review	It is recommended that the LFRMS is updated in 2020 to ensure it remains consistent with the National Flood and Coastal Erosion Risk Management Strategy that, at the time of writing, is currently being revised (see Appendix A, Section A.6.3).	Short term
	SWMP / drainage strategy	CBMDC has not developed a SWMP for the district, nor for any areas or communities within Bradford. It is recommended that the LLFA uses information from this SFRA to ascertain whether certain locations at high surface water flood risk may benefit from a SWMP.	Short to Medium term
	Requirements for Flood Risk Area (FRA)	Due to designation of significant FRA (through 2017 PFRA) in Bradford City Centre, flood hazard mapping (by December 2019) would need to be undertaken by the LLFA to inform the Flood Risk Management Plan by December 2021.	December 2019 / December 2021

	Water Cycle Study	CBMDC has not developed a WCS for the district, nor for any areas or communities within Bradford. If the Local Plan highlights large growth and urban expansion, the LLFA should produce a WCS to look at capabilities of water and sewerage providers.	Short to Medium term
	Climate change assessment for Level 1 update or Level 2 SFRA (and FRAs)	Modelling of climate change, using EA's most up-to-date allowances. February 2016 allowances for updated EA models are currently used, however post UKCP18 allowances will need to be used when figures are published.	Short term
	Possible CDA delineation	Whether the delineation of CDAs may be appropriate for areas particularly prone to surface water flooding. Detailed analysis and consultation with the LLFA, YW and any relevant Internal Drainage Board would be required. It may then be beneficial to carry out a local SWMP or drainage strategy for targeted locations with any such critical drainage problems.	Long term
Flood storage and attenuation	Community Infrastructure Levy (CIL) / Working with Natural Processes	For new developments, GI assets can be secured from a landowner's 'land value uplift' and as part of development agreements. The LPA could include capital for the purchase, design, planning and maintenance of GI within its CIL programme. Further assess WwNP options in upper catchments to gauge possible areas for Natural Flood Management.	Short term
	Natural Flood Management	Promote creation of floodplain and riparian woodland, floodplain reconnection and runoff attenuation features where the research indicates that it would be beneficial in Bradford.	Ongoing
Data collection	Flood Incident data	CBMDC, as LLFA, has a duty to investigate and record details of significant flood events within their area. General data collected for each incident, should include date, location, weather, flood source (if apparent without an investigation), impacts (properties flooded or number of people affected) and response by any RMA.	Short term
	FRM Asset Register	CBMDC should update and maintain a register of structures and features, which are considered to have an effect on flood risk.	Ongoing
Risk Assessment	Asset Register Risk Assessment	CBMDC, as LLFA, should carry out a strategic flood risk assessment of structures and features on the Asset Register to inform capital programme and prioritise maintenance programme.	Short Term / Ongoing

Capacity	SuDS review / guidance	The LLFA should clearly identify its requirements of developers for SuDS in new developments. Internal capacity, within CBMDC should be in place to deal with SuDS applications, set local specification and set policy for adoption and future maintenance of SuDS.	Short Term / Long Term
Partnership	Yorkshire Water	The LLFA should continue to collaborate with YW on sewer and surface water projects. The LPA should be kept informed and carry out an assessment of water company assets to ensure they are operational and resilient at all times across the catchment.	Ongoing
	EA	CBMDC should continue to work with the EA on fluvial flood risk management projects. Potential opportunities for joint schemes to tackle flooding from all sources should be identified.	Ongoing
	Community	Continued involvement with the community through CBMDC's existing flood risk partnerships.	Ongoing

Table 8-1: Recommended further work for CBMDC or developers

8.2.2 Level 2 SFRA

Following the proposed sites being allocated with a proposed use and the Level 1 SFRA being updated accordingly. The LPA should review the sites where they expect the main housing numbers and employment sites to be delivered, using Section 6.4 of this report, the SFRA maps in Appendix B and the development site assessment spreadsheet in Appendix C. A Level 2 SFRA will be required if a large site, or group of sites, are within Flood Zone 3 and have strategic planning objectives, which means they cannot be relocated or avoided. A Level 2 SFRA may also be required if the majority of sites are within Flood Zone 2 or are at significant risk of surface water flooding. Residual flood risk should also be taken account of when considering options for future work.

A Level 2 SFRA should build on the source information provided in this Level 1 assessment and should show that a site will not increase risk to others and will be safe for its lifetime, once developed, and whether it will pass the Exception Test, if required, at the FRA stage.

As discussed in Section 6.13, a Level 2 assessment can be used to model the February 2016 climate change allowances, where current EA models are available. A Level 2 study may also further assess locations and options, in more detail, for the implementation of open space, or Green Infrastructure, to help manage flood risk in key areas.

The LPA will need to provide evidence in their Local Plan to show that housing numbers, economic needs and other sites can be delivered. The Local Plan may be rejected if a large number of sites require the Exception Test to be passed but with no evidence that this will be possible.

Once all sites within this Level 1 assessment have been review by the LPA then further advice or guidance should be sought to discuss possible next steps.

Appendices

A Planning Framework and Flood Risk Policy

Following the introduction to the planning framework and flood risk policy located in Section 4, the remainder of the policy information is located within Appendix A and gives background into the policy documents that are relevant to CBMDC.

B SFRA maps

Interactive GeoPDF maps

The SFRA Maps consist of all flood risk information used within the SFRA, by way of interactive GeoPDFs. Open the Overview Map in Adobe Acrobat (2018s1210_CBMDC_SFRA_Index.pdf). The Index map contains a set of index squares covering the authority area at a scale of 1:10,000. Clicking on one of these index squares will open up a more detailed map of that area (scale = 1:10,000) by way of a hyperlink.

Within the detailed maps, use the zoom tools and the hand tool to zoom in/out and pan around the open detailed map. In the legend on the right-hand side of the detailed maps, layers can be switched on and off when required by way of a dropdown arrow. The potential development site reference labels can also be switched on and off if, for example, smaller sites are obscured by labels.

C Development site assessment spreadsheet

Excel spreadsheet containing an assessment of flood risk to the potential development sites based on Flood Zones 1, 2, 3a and 3b, as delineated through this SFRA, and also the Risk of Flooding from Surface Water dataset (RoFSW).

D Functional floodplain delineation

Technical note explaining the methodology behind the delineation of the functional floodplain (Flood Zone 3b) for this SFRA.

E SHLAA sites at significant risk from surface water

SHLAA sites that are potentially unsuitable for development based on surface water risk (if development cannot be directed away from risk areas or the risk incorporated within the site design, the site may be unsuitable for development).

Site ID	Site area (ha)	% area at medium risk (1 in 100 AEP event)	% area at high risk (1 in 30 AEP event)
AD/008	4.59	12.94	8.84
AD/009	0.83	11.06	9.52
AD/011A	0.47	11.45	8.55
AD/014	0.55	36.33	31.92
BA/014	0.42	12.04	3.12
BI/028	0.21	16.54	4.13
BI/047	1.05	16.19	1.20
BU/012	0.22	13.44	9.94
CC/005	0.58	70.92	48.73
CC/007	1.05	25.02	8.65
CC/022	0.95	27.90	2.62
CC/024	1.66	18.00	4.58
CC/039	1.19	49.07	23.30
CC/044	1.45	31.65	2.46
CC/045	3.16	69.36	27.62
CC/063	0.12	44.79	0.86
CR/003	1.80	59.21	8.37
CR/024B	1.67	10.11	5.30
CR/034	0.76	11.97	8.96
CR/036	0.83	11.36	3.17
CR/037	0.60	12.96	8.56
CR/046	0.14	64.40	47.77
CU/004	1.17	41.26	37.62
CU/008	0.58	10.35	4.06
DH/002	2.53	22.87	14.50
DH/011	0.73	15.22	11.54
DH/012	0.69	39.05	24.37
EM/001	0.67	38.02	13.90
HA/009	4.29	17.06	7.83
HA/012	1.94	10.14	6.53
IL/007	1.20	23.72	20.70
IL/010	0.37	10.24	3.12
IL/030	0.27	12.45	10.36
KY/018	0.97	10.69	5.48

Site ID	Site area (ha)	% area at medium risk (1 in 100 AEP event)	% area at high risk (1 in 30 AEP event)
KY/028	0.44	12.40	3.57
KY/030	0.38	14.52	2.97
KY/072	0.51	14.81	10.30
KY/074	3.94	23.38	11.22
KY/083	0.57	33.72	23.67
KY/118	0.22	16.74	5.06
KY/139	1.35	11.28	10.27
ME/001A	0.99	21.85	17.75
ME/018	1.59	17.60	9.89
ME/019	0.71	17.98	11.40
NE/015A	0.25	17.18	4.84
NE/015B	0.29	46.82	31.37
NE/025B	1.63	10.53	3.40
NE/036	2.16	18.29	5.20
NE/053	6.20	30.84	22.23
NE/057	0.70	12.91	5.80
NE/063	0.45	10.27	2.27
NE/066	1.14	60.51	4.88
NE/067	0.57	13.93	7.44
NW/010	0.21	29.50	12.60
NW/034	0.70	12.03	4.07
NW/066	0.26	60.06	33.72
NW/072	4.58	21.72	5.64
NW/082	1.07	16.68	2.43
NW/088	0.17	41.82	28.93
OA/003	1.41	10.35	9.05
OA/009	0.89	78.06	77.49
OA/012	0.11	19.85	0.00
OA/022	1.73	11.20	8.78
OX/002	0.51	27.42	17.30
OX/003	0.84	16.34	8.56
OX/010	0.18	11.21	3.46
SE/028	0.59	36.22	21.63
SE/045	1.09	21.60	11.75
SE/098	3.56	13.84	7.36
SE/111	0.26	13.78	0.00
SE/130	0.21	15.79	14.81
SE/144	0.69	17.42	4.98
SE/151	1.17	19.14	5.01

Site ID	Site area (ha)	% area at medium risk (1 in 100 AEP event)	% area at high risk (1 in 30 AEP event)
SE/161	0.48	44.82	28.22
SH/011	1.79	18.71	12.86
SH/014	0.36	10.76	0.00
SH/017	0.22	45.87	29.60
SH/041	1.79	16.09	12.37
SH/050	0.37	14.02	0.21
SI/020	4.51	10.20	1.43
SI/024	0.52	16.36	9.45
SI/025	0.19	47.93	27.21
ST/014	0.35	44.25	33.66
SW/074	0.18	31.47	0.00
SW/084	0.12	73.06	11.14
SW/090	0.18	24.71	9.96
SW/131	0.09	13.84	0.00
SW/148	0.45	10.56	5.48
SW/149	0.20	24.13	6.84
TH/023	1.54	12.81	6.38

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