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Leeds City Council SFRA Update 2022

Strategic Flood Risk Assessment

FINAL

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Quality information

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Executive Summary

Leeds City Council declared a climate emergency in March 2019 with an ambition to work towards carbon neutrality by 2030. The priority for the Local Plan Update 2021 is to update and improve existing policies and create new policies, where deemed relevant, to address climate change, and the climate emergency declaration to achieve net zero emissions by 2030.

Leeds City Council are planning for the long term to be ready for the impacts of climate change. Leeds already has a significant level of development in the pipeline, which is anticipated to last until 2028 and beyond. If not built to higher standards, taking into consideration the potential increased flood risk with climate change, these developments may serve to exacerbate the challenge in the future.

Leeds City Council recognise that flooding will increase as the global and local climate changes. Increased risk of flooding is one of the impacts of climate change. This update to the Strategic Flood Risk Assessment (SFRA) identifies flood risk now and in the future including the impacts of climate change and the actions that can be taken to reduce this risk. This includes identifying areas for sustainable development, green and blue infrastructure, sustainable drainage and flood mitigation.

Leeds District is dominated by the valleys of the River Aire, River Wharfe and their tributaries. A very large proportion of the local communities are situated adjacent to, or near, these rivers and/or their tributaries. The south-eastern boundary of the District is adjacent to the River Calder and parts of Leeds District also experience flooding from the Calder. Leeds Flood Alleviation Scheme Phase 1 completed in 2017, reduces risk of river flooding to Leeds City Centre - the economic and commercial heart of the wider region. Leeds Flood Alleviation Scheme Phase 2 Step 1 and Step 2 are both currently under construction with Step 1 due to be completed in 2022 and Step 2 completed in 2023.

In addition to fluvial flood risk, parts of the Leeds District area are also at risk of flooding from surface water runoff and surcharging of sewers during particularly heavy and/or prolonged rainfall. Future development can exacerbate problems of this nature if not carefully designed, blocking flow paths and increasing the magnitude and speed of runoff from the site.

This update to the Leeds SFRA has been carried out to deliver the following key outcomes:

- To collate all known sources of flooding, including river, surface water (local drainage), sewers and groundwater, reservoir and overland flooding that may affect existing and/or future development within Leeds District;
- To take into account the impacts of Climate Change;
- To delineate areas that have a ‘low’, ‘medium’ or ‘high’ probability of flooding within the District, defined in accordance with the National Planning Policy Framework (NPPF)[1]; including delineating areas benefiting from flood defence across all flood zones;
- To review existing flood risk planning policies to ensure they are resilient in respect to the impacts of climate change and the use of SuDS. To consider the cumulative risk of flooding to existing development, taking due consideration of the likely depth and speed of the flow, assessing the likely consequence that this may pose to life and property within Leeds District;
- In accordance with the NPPF Sequential Test direct development away from areas at flood risk and where this cannot be achieved, to areas of lowest flood risk first;
- Where flood risk has been identified as a potential constraint to future development, recommend possible flood mitigation solutions including the use of SuDS and Green/Blue Infrastructure that may be integrated into the design (by the developer) to minimise the risk to property and life should a flood occur (in accordance with the NPPF Exception Test);
- To identify opportunities to reduce the risk of flooding, including the requirement to prepare emergency plans in site specific FRAs;
- Define the scope of site specific Flood Risk Assessments in relation to new development;
- A GIS based mapping system to allow for future updates as and when required and to provide a more accessible means of demonstrating the current extent and nature of flood risk across the Leeds District.

[1] National Planning Policy Framework, Ministry of Housing, Communities and Local Government, July 2021

Flood Risk within the Leeds District

The first phase of the Leeds Flood Alleviation Scheme (LFAS1) and the second phase of Leeds Flood Alleviation Scheme (LFAS2, currently under construction) reduce the risk of river flooding from the River Aire to Leeds City Centre. There are also flood defence structures reducing the risk to other towns and communities within the Leeds District. These structures may increase the standard of protection provided to properties situated behind them, but there is always a residual risk that these structures may be overtopped in more extreme flood events or suffer failures such as breaching. It is important, therefore, that future development takes careful consideration of the standard of protection provided by these structures, the maintenance arrangements and any possible risk to life in the event of defence failure. This underlines the NPPF requirement that development should only be located within areas shown to be at medium and high flood risk on the Flood Map for Planning where the flood risk Sequential Test and, as necessary, the Exception Test have been passed.

Smaller watercourses and local drainage paths are far more susceptible than the larger river systems to flashier flood flow responses due to localised intense rainfall. Flooding of this nature can often occur unexpectedly and involve rapid increase in water levels. With a changing climate it is expected that storms of this nature will become increasingly common, potentially increasing the risk posed to properties situated in close proximity to local watercourses.

In addition to river flooding, there is also a risk to properties posed as a result of localised flooding issues including groundwater flooding, surface water runoff and/or surcharging of the underground sewer system. Many developed areas of Leeds rely upon ageing underground networks to capture and convey local runoff. These networks may have insufficient capacity to cater for increasing urban development within the Leeds District. There is an opportunity to address surface water flooding within Leeds District whilst also responding to climate change adaptation and mitigation through the use of sustainable drainage and multi-benefit blue-green infrastructure.

Why carry out a Strategic Flood Risk Assessment (SFRA)?

Flooding can result not only in costly damage to property but can also pose a risk to life and livelihood. It is essential that future development is planned carefully, steering it away from areas that are most at risk from flooding, and ensuring that it does not exacerbate existing flood risk.

The NPPF requires local planning authorities to review the variation in flood risk across their area and to steer development towards areas of lowest risk. The SFRA helps to do this by mapping the variations in river flooding and by indicating where there are other known sources of flooding.

In allocating land for development, it is essential that the Local Planning Authority (LPA) applies the principles of the Sequential Test at the earliest stage in the planning process. The Sequential Test requires that land for future development must first be sought within lower flood risk areas. Only if it can be demonstrated that, for sound planning reasons, there are no suitable sites within this area, can sites elsewhere within the Council area be considered.

Where the Sequential Test has been applied, and the LPA considers that there are sound reasons to allocate a site within Flood Zone 2, Flood Zone 3 or at risk from other sources of flooding on planning grounds, then the NPPF requires the Council to demonstrate that there are sustainable mitigation solutions available that will ensure that the risk to property and life is minimised (throughout the lifetime of the development) should flooding occur. This is through the application of the Exception Test which is informed by a site-specific Flood Risk Assessment and Sustainability Appraisal.

The SFRA provides information and an evidence base upon which the Council's Planning and Development Control decisions can be made. The NPPF was last updated in July 2021 and forms the basis for guiding planning decisions within flood affected areas.

Planning Policy Guidance Flood risk and coastal change – August 2022 update

The Planning Policy Guidance (PPG) Flood risk and coastal change guidance document, which has informed the Leeds SFRA, was recently updated on 25 August 2022. This SFRA document was substantially complete and in the final stages of review when the update to the PPG was published.

An important update to the PPG document has modified part of the definition of Flood Zone 3b The Functional Floodplain as follows:

> *land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively;*

The previous guidance, and consequently the basis of this SFRA document and associated mapping, defined Flood Zone 3b as land with a 5% or greater annual probability of flooding (1:20 year return period), or land where water has to flow and/or be stored in times of flood. Given the extremely advanced status of the SFRA, we are unfortunately unable to revise the whole SFRA document and associated mapping to reflect the updated guidance. Where already available from existing modelling studies, we will update and use the 3.3% annual probability (1:30 year return period) flood extent to delineate the starting point for the extent of Functional Flood Plain. However, it is acknowledged that there is currently not available complete mapping of the 3.3% annual probability flood extent across the Leeds administrative catchment area. To avoid ambiguity or confusion, all references to Functional Flood Plain and/or Flood Zone 3b within the text of this SFRA, should be read as set out in latest update to the PPG *as land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively.*

Where the current day flood risk 3.3% annual probability flood extent is unavailable, developers will need to demonstrate that their site(s) is not within the updated definition of Zone 3b. The 5% annual probability (1 in 20 year return period) plus climate change modelled flood extents presented in the SFRA provide an indication / starting point to define the 1 in 30 year, or 3.3% annual probability, flood extent. provide an indication / starting point to define the 1 in 30 year, or 3.3% annual probability, flood extent.

Application of the Leeds SFRA

The NPPF requires that the Sequential Test is applied at all stages of the planning process, including both the allocation of land for future development (i.e. by the Council) and at the planning application stage (i.e. by the developer). The Leeds SFRA informs the application of the Sequential Test. Where the Sequential Test cannot be satisfied the application should be refused. Where the sequential test has been passed it may then be necessary to carry out the Exception Test. The SFRA provides guidance as to the minimum design considerations that will be required to ensure that the proposed development is sustainable throughout its design life and assist in completion of site specific Flood Risk Assessments.

This SFRA has identified land at risk of flooding, as follows:

- **Main River fluvial flooding:** Flood Zones 1, 2, 3 and 3b, as defined under the NPPF, have been identified based on modelled Environment Agency flood outlines. These correspond to land:
  - With less than a 1 in 1000 years annual probability (0.1% AEP) of fluvial flooding (Flood Zone 1);
  - Between a 1 in 100 (1% AEP) to 1 in 1000 years annual probability (0.1% AEP) of fluvial flooding (Flood Zone 2);
  - More than a 1 in 100 years annual probability (1% AEP) of fluvial flooding (Flood Zone 3).
  - Where water has to flow or be stored in times of flood, land having a 1 in 20 or greater annual probability (5% AEP) of fluvial flooding (Flood Zone 3b).

- The NPPF flood zones are defined using undefended flood zones, i.e. ignoring the presence of flood defences. The Environment Agency Flood Map for Planning flood outlines have been used to denote the full extent of Flood Zones 2 and 3, although it should be noted that these are sometimes based on broad scale flood modelling and may be subject to future revision following detailed modelling. The Flood Map for Planning also does not consider the risk of flooding from most Ordinary Watercourses unless specifically recorded for an area. The location of named ordinary watercourses is shown in Figure A.2 in Appendix A and Figure A.9 (surface water flooding) provides an indication of flow paths. Fluvial flooding has occurred on a number of occasions within Leeds, so mapping of historical main river fluvial flood extents has been carried out separately.
- **The Functional Floodplain** (Flood Zone 3b, defined as land with a 1 in 20 years annual probability (5% AEP) of flooding, or land where water has to flow and/or be stored in times of flood) has been mapped where this flood outline is available. The Functional Floodplain is mapped with consideration to the presence of flood defences.

  Within the Leeds District the Functional Floodplain (Flood Zone 3b) includes the following categories:

  – Functional Floodplain (undeveloped areas) - Areas of Functional Floodplain that do not have existing development and will continue to be Functional Floodplain in the future.

  – Functional Floodplain (existing development) - Developed areas within the functional floodplain where only the footprint of existing development is acceptable for re-development (providing all other policy requirements are met).

  – Functional Floodplain (future defended) – Areas of existing Functional Floodplain that are expected to be removed from the functional floodplain by future defences that are currently being delivered by LCC, for example LFAS2.
- **Surface Water Flooding:** Areas at high, medium and low risk of surface water flooding (33%, 1% and 0.1% annual probability) have been mapped based on the “Risk of Surface Water Flooding” dataset, along with the locations of historical surface water flooding.
- There are no designated Critical Drainage Areas within the Leeds District.
- **Groundwater Flooding:** Areas susceptible to groundwater flooding have been mapped based on British Geological Survey data. This map shows the estimated probability of groundwater emergence at the surface (clearwater flooding), floodwater emergence from within superficial deposits, or a combination of both. The extent of historical groundwater flooding has also been mapped to inform this assessment.
- **Sewer Flooding and flooding from drainage systems:** the risk of sewer flooding is limited to a postcode level analysis of the number of internal and external sewer flooding incidents within the last five years. This has been supplemented with mapped information on flooding from other drainage systems (e.g. highways flooding).
- **Flooding from artificial sources:** flood risk from artificial sources, i.e. Canals and Reservoirs) has been assessed by mapping the extent of the Environment Agency Flood Risk from Reservoirs flood outlines, and the locations of any known breach or near failures of canal embankments, as provided by the Canal and River Trust.
- **Ordinary Watercourse flooding:** flood risk from Ordinary Watercourse is not always quantified in the available datasets, particularly for smaller watercourses. The risk from Ordinary Watercourses will need to be assessed for development sites on a case by case basis, although some datasets can assist with this determination, including the Risk of Surface Water Flooding map which identifies flow paths in local topography. Historical flood mapping can also show where Ordinary Watercourse flooding has previously occurred. However, site specific flood risk assessments for sites adjoining Ordinary Watercourses may need to be informed by detailed hydrological and hydraulic modelling. This is outside the scope of this SFRA.

Flood Risk Constraints upon Emerging Future Development within Leeds

The SFRA will inform the application of the Sequential Test and, where necessary, the Exception Test in the allocation of future development sites, as required by the NPPF[4], taking into account all sources of flooding. AECOM has prepared the SFRA in such a way that it will provide relevant and easily accessible information to assist applicants preparing site specific flood risk assessments.

The primary objective of the Leeds SFRA is to inform the revision of flooding policies, including the allocation of land for future development. Furthermore, the SFRA has a broader purpose and in providing a robust depiction of flood risk across the district it can:

- Inform the development of Council policy that will underpin decision making within the District, particularly within areas that are affected by (and/or may adversely impact upon) flooding;
- Assist the development control process by providing a more informed response to development proposals affected by flooding, influencing the design of future development within the District;
- Help to identify and implement strategic solutions to flood risk, providing the basis for possible future flood attenuation works;
- Support and inform the Council's emergency planning response to flooding.

A Living Document

The SFRA has been developed building heavily upon existing knowledge and model data with respect to the existing flood risk within the Leeds District.

With the completion of major flood alleviation schemes and following any major flood events, it is anticipated this SFRA should be updated to provide an updated evidence base of flood risk within the Leeds District.

Abbreviations and Glossary of Terms

AEP	Annual Exceedance Probability e.g. 1% AEP is equivalent to 1% probability of occurring (or being exceeded) in any one year
Core Strategy	The Core Strategy is the main strategic document within the Local Plan for Leeds and sets out the strategic policy framework for the district to 2028 and a housing requirement to 2033.
MHCLG	Ministry of Housing, Communities and Local Government (Department for Levelling Up, Housing and Communities)
Defra	Department of Environment, Food and Rural Affairs
Development	The carrying out of building, engineering, mining or other operations, in, on, over or under land, or the making of any material change in the use of a building or other land.
Development Plan Document (DPD)	A spatial planning document within the Council's Local Development Framework which set out policies for development and the use of land. They are subject to independent examination.
EA	Environment Agency
Flood Zone Map	Nationally consistent delineation of 'high' and 'medium' flood risk, published on a quarterly basis by the Environment Agency
Flood Zone 1 Low Probability	NPPF Flood Zone, Land having a less than 1 in 1,000 annual probability (0.1% AEP) of river or sea flooding.
Flood Zone 2 Medium Probability	NPPF Flood Zone, Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding;
Flood Zone 3a High Probability	NPPF Flood Zone, Land having a 1 in 100 or greater annual probability (1% AEP) of river flooding.
Flood Zone 3b Functional Floodplain	NPPF Flood Zone, this zone comprises land where water has to flow or be stored in times of flood. Land having a 1 in 20 or greater annual probability (5% AEP) of river flooding. Local planning authorities identify in their Strategic Flood Risk Assessments areas of Functional Floodplain and its boundaries accordingly, in agreement with the Environment Agency.
Formal Flood Defence	A structure built and maintained specifically for flood defence purposes
Freeboard	An allowance for uncertainty in design water level and any other physical processes that may affect the ability of an asset to withstand the design criteria
Green-Blue Infrastructure	A network of multi-functional green and blue spaces and other natural features, urban and rural, which is capable of delivering a wide range of environmental, economic, health and wellbeing benefits for nature, climate, local and wider communities and prosperity.
Habitable Room	A room used as living accommodation within a dwelling but excludes bathrooms, toilets, halls, landings or rooms that are only capable of being used for storage. All other rooms, such as kitchens, living rooms, bedrooms, utility rooms and studies are counted.
Informal Flood Defence	A structure that provides a flood defence function but has not been built and/or maintained for this purpose (e.g. boundary wall)

LCC	Leeds City Council
Lead Local Flood Authority (LLFA)	Local government authority (county council or and unitary authority) who lead in managing local flood risks (including risk of flooding from surface water, ground water and ordinary watercourses). LLFAs have duties under the Flood and Water Management Act 2010.
Local Development Scheme	Consists of a number of documents which together form the spatial strategy for development and the use of land
LPA	Local Planning Authority
Main River	All watercourses designated as Main River by the Environment Agency and Defra. Main Rivers are usually larger rivers and streams. The Environment Agency has powers to carry out maintenance, improvement or construction work on Main Rivers to manage flood risk.
Mitigation Measures	Measures to mitigate the risk of flooding by taking actions to reduce or remove the impact of flooding. Often approaches as a hierarchical approach to mitigation: 1. Locate development and infrastructure outside areas of high risk; 2. Adapt the design to reduce the risk of flooding; 3. Engineering measures to reduce flood risk, such as flood walls or flood storage (Control); 4. Use of flood resilient design (property level protection)
Ordinary Watercourse	The Environment Agency carries out maintenance, improvement or construction work on Main Rivers to manage flood risk. All other rivers are called 'ordinary watercourses'. Lead local flood authorities, district councils and internal drainage boards have powers to carry out flood risk management work on ordinary watercourses.
Previously Developed (Brownfield) Land	Land which is or was occupied by a building (excluding those used for agriculture and forestry). It also includes land within the curtilage of the building, for example a house and its garden would be considered to be previously developed land.
Rapid Inundation Zone	The area near to flood defences where a breach or the source of flooding could create a significant flood hazard i.e. due to high velocity floodwaters and significant depth.
Residual Risk	A measure of the outstanding flood risks and uncertainties that have not been explicitly quantified and/or accounted for as part of the review process. Examples of residual flood risk includes: • the failure of flood management infrastructure; • a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defences; • an intense rainfall event which exceeds the drainage system capacity.
Sustainability Appraisal (SA)	The purpose of the sustainability appraisal process is to appraise the social, environmental and economic effects of a plan from the outset. In doing so it will help ensure that decisions are made that contribute to achieving sustainable development.
Site Allocation Plan (SAP)	The Site Allocations Plan (SAP) is a key document in the Local Plan for Leeds. The SAP identifies sites for housing, employment, retail and greenspace to ensure that enough land is available in appropriate locations to meet the growth targets set out in the Core Strategy.
SuDS	Sustainable Drainage System
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The World Commission on Environment and Development, 1987).

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Figures

Tables

1. User Guide

It is anticipated that this SFRA will have a number of end users with slightly different requirements; this Section describes how to use the SFRA and how to navigate the report and mapping deliverables. The SFRA Report is set out as follows:

- Section 2 Introduction
- Section 3 SFRA Study Area
- Section 4 Consultation
- Section 5 National, Regional and Local Flood Risk Policy
- Section 6 Plans and Strategies
- Section 7 Data Collection
- Section 8 SFRA Methodology
- Section 9 Flood Risk in Leeds
- Section 10 Flood Risk with Climate Change
- Section 11 Residual Flood Risk
- Section 12 Sequential Test and Site Allocations
- Section 13 Applying the Exception Test – Assessment of Site Allocations
- Section 14 Guidance for Site Specific Flood Risk Assessment
- Section 15 Sustainable Drainage Developer Guidance
- Appendix A- Flood Maps

1.1 Strategic Planning and Policy

The main purpose of the SFRA for Leeds City Council (LCC), as explained in the NPPF[4], is to provide a strategic overview of flood risk within the LPA in order to enable effective risk-based strategic planning for the future, through the preparation of the Local Plan. Sections 9, 10 and 11 present the information that should be used by LCC to inform their knowledge of flood risk from all sources throughout their area. The SFRA is then used to inform the application of the Sequential and Exception Tests during the process of allocating development within the LPA Area. The current local plan is being updated in response to the Climate Emergency and does not include site allocations and therefore Exception Tests have not been carried out as part of this SFRA.

1.2 Applying the Sequential Test

The NPPF[4] sets strict tests to protect people and property from flooding which all LPAs are expected to follow. The aim of the Sequential Test, under the NPPF[4], is to steer new development to areas with the lowest probability of flooding. Section 12 provides an overview of how LCC has undertaken the Sequential Test and specific guidance on how the Sequential Test is applied. Section 13 provides specific information on the Exception Test undertaken by LCC and guidance for applying the Exception Test where appropriate.

1.3 Emergency Planning

LCC is a Category One Responder under the Civil Contingencies Act 2004[2] and therefore has a responsibility, along with other organisations, to develop emergency plans to help reduce, control or ease the effects of an emergency. The complex nature of flooding, and its subsequent impacts, often requires a comprehensive and sustained response from a wide range of organisations. West Yorkshire Combined Authority (WYCA) is also a Category One Responder and coordinates the West Yorkshire Local Resilience Forum to allow all Category One and Category Two responding parties to work together to plan and implement the response to emergency events

[2] HSMO (2004) Civil Contingencies Act. Available from: http://www.legislation.gov.uk/ukpga/2004/36/contents

including flooding[3]. The SFRA deliverables should be used by LCC's Emergency Planning team as a useful source of up to date information about flood risk. The SFRA should be reviewed by the team, such that the findings can be incorporated into their understanding of flood risk. Section 14.10 provides detail on Emergency Planning and Flood Warnings within the LPA Area.

1.4 Preparing Site Specific FRAs

The SFRA can provide a useful starting point to the preparation of site specific Flood Risk Assessments (FRAs) for individual development sites as follows;

1. Sections 9, 10 and 11 provides an overview of the key issues within the LPA in relation to flood risk;
2. Section 12 provides guidance on the application of the Sequential Test for sites that have not yet been tested by the LPA, and Section 13 provides details on when the Exception Test is required, and how to apply it;
3. Section 5 provides details of relevant local plans and policies for managing and mitigating flood risk within the study area,
4. Section 14 provides specific guidance for preparing site specific FRAs in accordance with the checklist presented in the National Planning Policy Guidance (PPG)[5].

1.5 Assessing Planning Applications

Flood Risk Management Development Control officers who are reviewing site specific FRAs as part of the planning application process should consult Sections 9 to 11 of the SFRA to provide background for flood risk in the area relating to the planning application. Section 14 can also be used by those assessing applications as a checklist for issues that need to be addressed as part of site specific FRAs.

[3] West Yorkshire Emergency Response Manual (2011) is available here: https://www.calderdale.gov.uk/v2/sites/default/files/emergency-contacts.pdf

2. Introduction

The LCC administrative area extends from Otley in the north west, to Wetherby in the north east, to Allerton Bywater in the south east and to Morley in the south west. LCC encompasses the major population centre of Leeds. A large proportion of Leeds is designated Green Belt, interspersed by a number of suburbs, towns and villages.

The River Aire, River Wharfe and their tributaries are dominant features of Leeds. A large proportion of the local communities are situated adjacent to, or near, these rivers and/or their tributaries. Additionally, the River Calder flows along the south-eastern boundary of the District where it adjoins Wakefield and also poses a risk of flooding in the Leeds area. Flooding represents a risk to both property and life. It is essential therefore that planning decisions are informed and take due consideration of the risk posed to, and by, future development by flooding.

This SFRA for Leeds is being developed in tandem with the detailed preparation of the LCC planning framework. The SFRA has been developed based upon the best available information regarding flood risk within the District and will inform the preparation of climate change policies within the Local Plan. Understanding of flood risk will improve over time and it is important that the SFRA is adopted as a 'living' document and is reviewed regularly in light of emerging policy directives and an improved understanding of flood risk.

2.1 Approach to Flood Risk Management

The NPPF[4] and associated PPG[5] for Flood Risk and Coastal Change emphasise the active role LPAs should take to ensure that flood risk is assessed, avoided, and managed effectively and sustainably throughout all stages of the planning process. The overall approach for the consideration of flood risk set out in Section 1 of the PPG can be summarised as follows:

This has implications for LPAs and developers as described below.

2.1.1 Assess flood risk

The NPPF[4] outlines that Strategic Policies should be informed by a SFRA and should manage flood risk from all sources. Figure 2-1 reproduced from the PPG[5], illustrates how flood risk should be taken into account in the preparation of the Local Plan by LCC. Certain sites will require a site-specific FRA as defined in the NPPF[4]. The FRA process is described in further detail in Section 14.

2.1.2 Avoid flood risk

LCC should apply the sequential approach to site selection so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of current and future impacts of climate change and the vulnerability of future users and property to flood risk.

In plan-making this involves applying the Sequential Test, and where necessary the Exception Test to Local Plans, as described in Figure 2-1. This SFRA update is not to inform a new site allocation plan, it is to update the evidence base identifying flood risk now and in the future including the impacts of climate change.

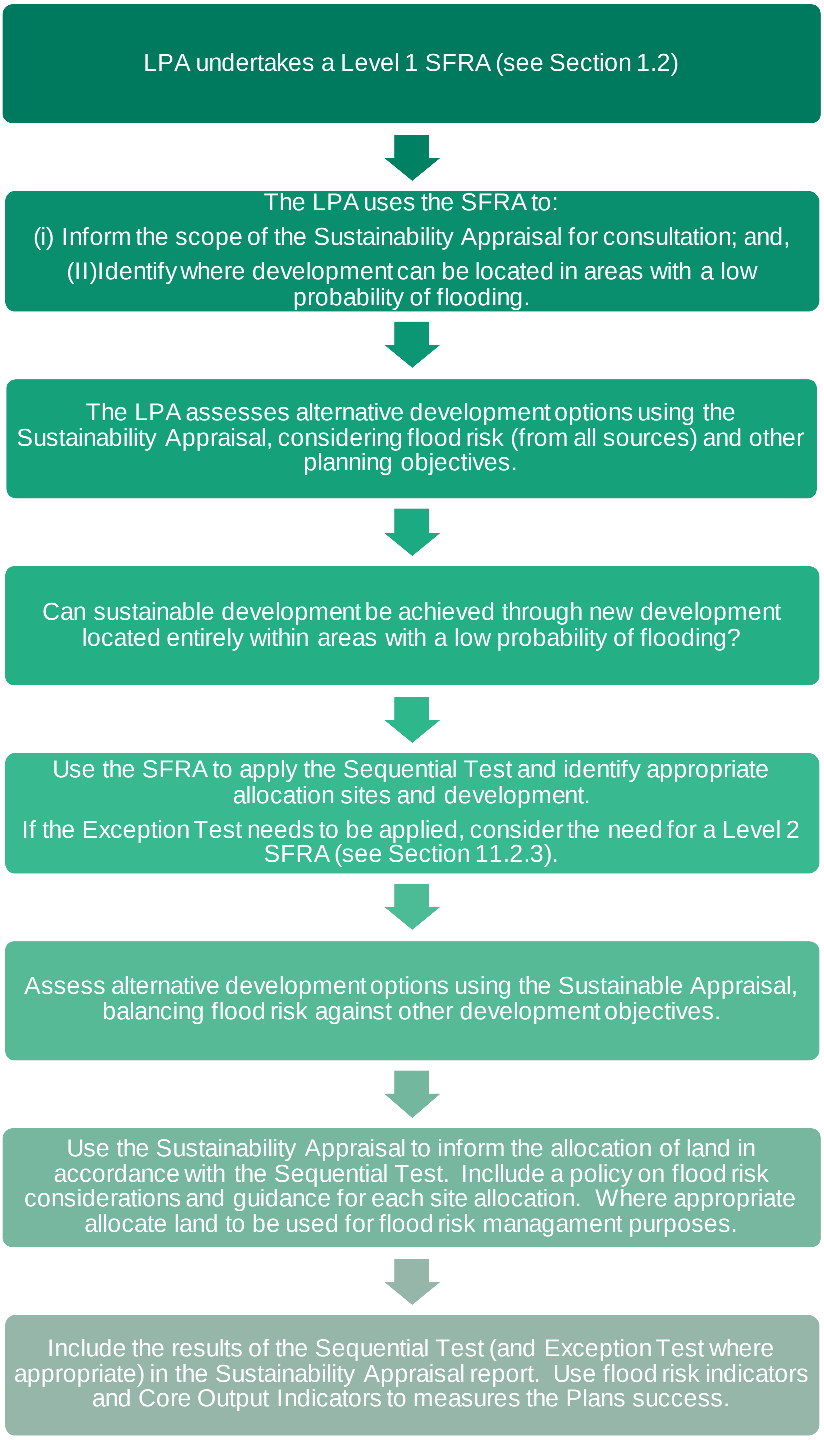
In decision-taking this involves applying the Sequential Test and, if necessary, the Exception Test for specific development proposals.

[4] Ministry of Housing, Communities and Local Government. July 2021. *Revised National Planning Policy Framework*. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2
[5] Communities and Local Government. Planning Practice Guidance: Flood Risk and Coastal Change. Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

2.1.3 Manage and mitigate flood risk

Where alternative sites in areas at lower risk of flooding are not available, it may be necessary to locate development in areas at risk of flooding. In these cases, LCC and developers must ensure that development is appropriately flood resilient and resistant, safe for its users for the lifetime of the development and will not increase flood risk overall. LCC and developers should seek flood risk management opportunities (e.g. safeguarding land), and to reduce the causes and impacts of flooding (e.g. through the use of SuDS, Green-Blue Infrastructure and natural flood management).

Figure 2-1: How flood risk can be taken into account in the preparation of a Local Plan (Planning Practice Guidance for Flood Risk and Coastal Change)



2.2 Purpose of a SFRA

The purpose of the Level 1 SFRA will be to collate and analyse the most up to date flood risk information for use by LCC to inform the strategy for development in the Local Plan, and to further inform site-specific FRAs. The SFRA will assess the risks associated with all types of flooding in accordance with the NPPF[6] and PPG[7] and will assess the risks both now and in the future. The SFRA will build on existing hydraulic modelling and available information.

As the LPA, LCC must demonstrate throughout the site allocation process that a range of possible sites have been considered in conjunction with the flood risk information and that the Sequential Test has been applied. The Sequential Test requires an understanding of all sources of flooding within the District, including the fluvial Flood Zones in the study area and risk and potential sources of surface water flooding, as well as the vulnerability classification of the proposed developments. The NPPF acknowledges that some areas will be at risk of flooding from sources other than fluvial. All sources must be considered when planning for new development including; flooding from land or surface water runoff; groundwater; sewers; and artificial sources (see Section 9).

The primary objective of the Leeds SFRA is to inform the revision of flooding policies in response to the Climate Emergency. Furthermore, the SFRA has a broader purpose and in providing a robust depiction of flood risk across the district it can:

- Inform the development of Council policy that will underpin decision making within the District, particularly within areas that are affected by (and/or may adversely impact upon) flooding;
- Assist the development control process by providing a more informed response to development proposals affected by flooding, influencing the design of future development within the District;
- Help to identify and implement strategic solutions to flood risk, providing the basis for possible future flood attenuation works;
- Support and inform the Council’s emergency planning response to flooding.

A considerable amount of knowledge exists with respect to flood risk within the District, including information relating both to historical flooding and the predicted extent of flooding under extreme weather conditions (i.e. as an outcome of detailed flood risk modelling carried out by the Environment Agency and LCC and Risk of Surface Water flood maps developed by the Environment Agency). The Leeds SFRA has built heavily upon this existing knowledge, underpinning the delineation of the district into ‘high’, ‘medium’ and ‘low’ risk zones, in accordance with the NPPF. These zones have then been used to provide a robust and transparent evidence base for the development of flooding related policy and the allocation of sites for future housing and employment uses.

It is important to recognise that some of the rivers that affect Leeds flow into, or from, adjoining authorities. Future development within the District, if not carefully managed, can influence the risk of flooding posed to residents within neighbouring areas. Conversely, careless planning decisions within adjacent districts can also impact adversely upon flooding within the District.

A number of authorities within the Aire Valley and Wharfe Valley are carrying out similar strategic flood risk investigations at the current time. Whilst the delivery teams and programmes underpinning these studies vary from one District to the next, all are being developed in close liaison with the Environment Agency. Consistency in adopted approach and decision making with respect to the effective management of flood risk throughout the Aire and Wharfe catchment is imperative. Regular discussions with the Environment Agency have been carried out throughout the SFRA process to this end, seeking clarity and consistency where needed.

[6] Ministry of Housing, Communities and Local Government. July 2021. *Revised National Planning Policy Framework*. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2

[7] Communities and Local Government. 6th March 2014. Planning Practice Guidance: Flood Risk and Coastal Change. Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

2.3 Living Document

This SFRA has been developed building heavily upon existing knowledge with respect to flood risk within the LPA Area taking into account cross boundary flood risk issues. The Environment Agency review and update the Flood Map for Planning (Rivers and Sea)[8] on a quarterly basis and a rolling programme of detailed flood risk mapping is underway. The Environment Agency also have a programme to update the risk of flooding from surface water mapping.

New information may influence future development control decisions within these areas, one example being Phase 2 of the Leeds Flood Alleviation Scheme. Therefore, it is important that the SFRA is adopted as a 'living' document and is reviewed and updated regularly in light of emerging policy directives, updated flood risk datasets and an improving understanding of flood risk within the LPA Area.

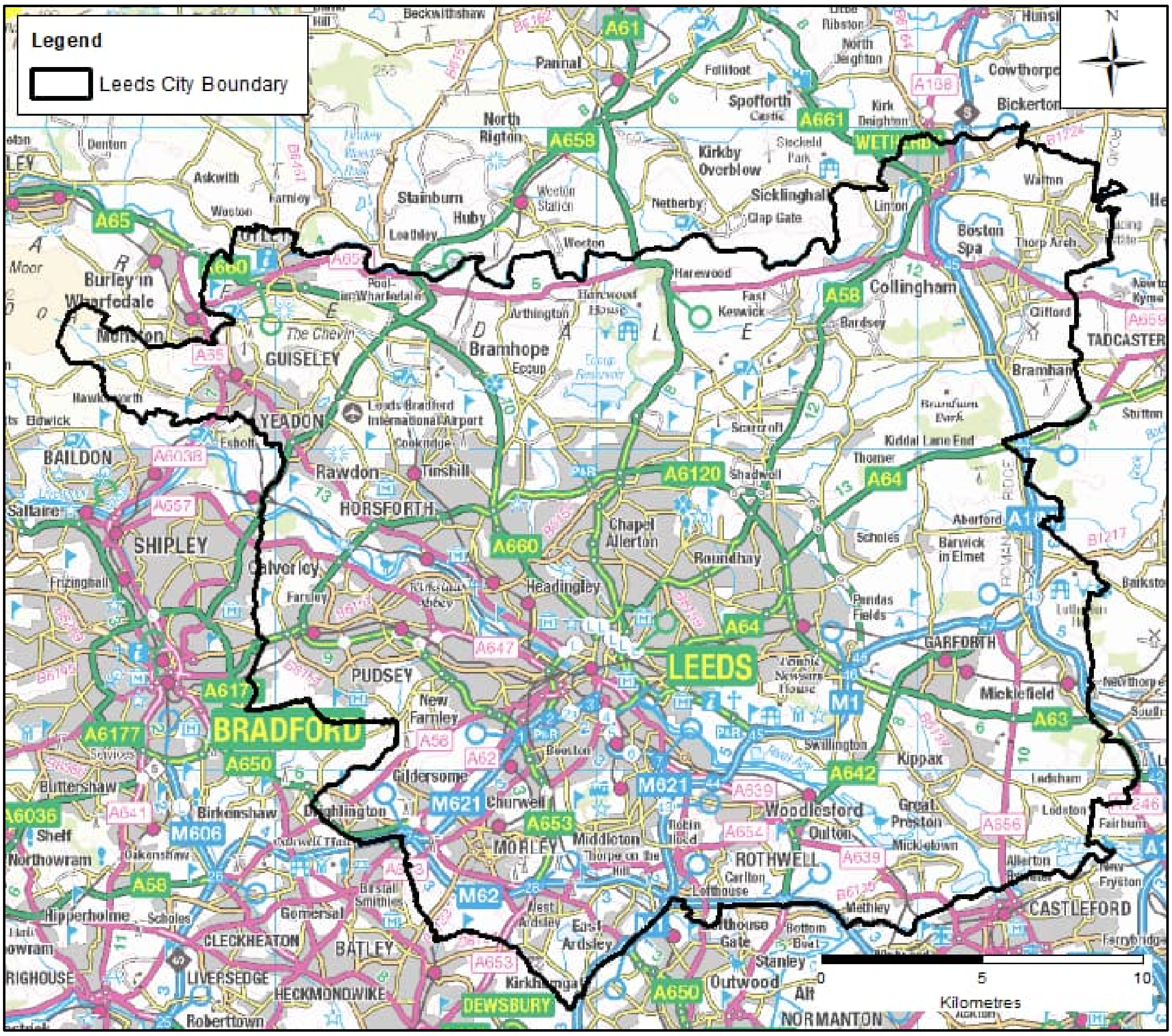
[8] Environment Agency (2018) Flood Map for Planning https://flood-map-for-planning.service.gov.uk/

3. SFRA Study Area

3.1 Leeds District

The study area shown in Figure 3-1 below includes the whole of the LCC Area (Leeds District). Leeds is the second largest metropolitan district in England, with a population of approximately 800,000 and covering an area of 552 square kilometres.

Figure 3-1: Study Area



The Leeds District includes the City of Leeds and a number of towns and settlements including Wetherby, Otley, Guiseley, Yeadon, Horsforth, Bramhope, Roundhay, Garforth, Kippax, Rothwell, Middleton, Pudsey, Boston Spa, Collingham, Thorner, Barwick-in-Elmet and Scholes. At the heart of West Yorkshire, Leeds has excellent transportation, located near to the motorway network (including M1, M62 and A1M) and Leeds Station is a transport hub for Yorkshire and beyond. Transportation within the Leeds District is connected up by rail, bus, canal, road and air (Leeds-Bradford International Airport) links.

3.2 Topography

Ordnance Survey 50m digital topographic data is presented in Figure A.1 in Appendix A. The highest point of the District is approximately 343m Above Ordnance Datum (AOD) in Wharfedale above Guiseley in the West, with the lowest point, <25m AOD, located just north of Castleford as the River Aire flows beyond the District boundary and also near the River Wharfe at Boston Spa. The topography to the East of the Leeds District is generally lower and flatter than in the West.

3.3 Surface Watercourses

The River Aire and the River Wharfe are the two primary catchment areas of the Leeds District. The River Aire flows from the Bradford Council area into the western edge of Leeds District and then through the communities of Horsforth, Kirkstall and the City Centre and south easterly down through Woodlesford and around Mickletown and Allerton Bywater, before leaving the District. Many of the town and villages have been developed along the Aire and the regeneration and reconnection of people with the river and canal is an important focus for development. The River Aire has a number of tributaries that are Main River, including Bagley Beck, Wortley Beck, Farnley Wood Beck, Oulton Beck, Meanwood Beck, Wyke Beck, Cock Beck and Lin Dyke.

The River Wharfe runs along much of the northern boundary of the Leeds District and flows through key towns of Otley and Wetherby. The River Wharfe has a number of tributaries that are main river, including, Hol Beck, Kel Beck, Collingham Beck and Fir Green Beck.

The River Calder makes up parts of the southern boundary of Leeds District and flows through Castleford and Methley. The locations of the principal Main River watercourses are shown in Appendix A Figure A.2, however the study area also includes other Main Rivers as well as numerous Ordinary Watercourses.

3.4 Geology

Datasets have been obtained from the British Geological Survey (BGS) website to provide a high-level identification of the superficial deposits and bedrock geology across the district. This is displayed in Appendix A Figure A.3.

Bedrock is the consolidated rock underlying the ground surface. Superficial deposits refer to the more geologically recent deposits (typically of Quaternary age) that may be present above the bedrock such as floodplain deposits, beach sands and glacial drift. Underlying geology can influence the presence and nature of groundwater in an area, and therefore potential groundwater flood risk. The geology can also impact on the potential for infiltration-based drainage systems.

The bedrock of the study area is mostly comprised of Millstone Grit in the north, Pennine and South West Lower Coal Measures in the central area and Pennine and South West Middle Coal Measures in the south. The Zechstein Group of limestones and dolomites make up the bedrock geology in the east of the study area. The principle superficial deposit is glacial till, found mainly in the north of the study area, with alluvium along the river valleys.

3.5 Hydrogeology

Aquifers are defined as layers of permeable rock or unconsolidated material (sand, gravel, silt etc.) capable of storing and transporting large quantities of water. The understanding of the behaviour and location of aquifers is important as they can provide an indication of the potential for groundwater flooding.

Strata designated as aquifers are limited to the superficial deposits within the study area and are designated as Secondary A and Secondary (undifferentiated) aquifers. The Environment Agency describes these aquifers as:

> ***'Secondary A*** *- permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.*
>
> ***Secondary B*** *- predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.*
>
> ***Secondary Undifferentiated*** *- has been assigned in cases where it has not been possible to attribute either category A or B to a rock type.'*

Further information on groundwater flooding from aquifers is provided within Section 9.

4. Consultation

Under the Localism Act 2011[9], there is now a legal duty on LPAs to co-operate with one another, County Councils and other Prescribed Bodies to maximise the effectiveness within which certain activities are undertaken as far as they relate to a 'strategic matter'.

In complying with the duty to cooperate, Government Guidance recommends that LPAs 'scope' the strategic matters of Local Plan documents at the beginning of the preparation process taking account of each matters 'functional geography' and identify those LPAs and Prescribed Bodies that need to be constructively and actively engaged.

Flood risk is identified as a strategic matter and specific engagement activities are proposed with a number of adjoining LPAs and Prescribed Bodies, both in relation to the preparation of the SFRA and the Local Plan. As part of the SFRA, a number of organisations were contacted, invited to attend an inception meeting, and/or requested to provide data to inform the SFRA. A summary of the roles of each organization, and their involvement through the SFRA project, is provided in Table 4-1.

Table 4-1: SFRA Stakeholder Organisations and Roles

Stakeholder Organisation	Role with respect to LCC SFRA
Leeds City Council (LCC)	As a, LPA, LCC has a responsibility to consider flood risk in their strategic land use planning and the development of their Local Plan. The NPPF requires LPAs to undertake a SFRA and to use their findings, and those of other studies, to inform strategic land use planning including the application of the Sequential Test which seeks to steer development towards areas of lowest flood risk prior to consideration of areas of greater risk. LCC is also required to consider flood risk and, when necessary, apply the Sequential and Exception Tests when assessing applications for development. LCC is also the Lead Local Flood Authority (LLFA) for the study area. As the LLFA, under the Flood and Water Management Act (FWMA) LCC has a duty to take the lead in the coordination of local flood risk management, specifically defined as flooding from surface water, groundwater and Ordinary Watercourses. LCC is also responsible for regulation and enforcement on Ordinary Watercourses and is a statutory consultee for future sustainable drainage systems (SuDS) for major developments in the District, following changes to the Town and Country Planning (Development Management Procedures) (England) Order 2015. LCC is also the Highways Authority and therefore has responsibilities for the effectual drainage of surface water from adopted roads insofar as ensuring that drains, including kerbs, road gullies and ditches and the pipe network which connect to the sewers, are maintained. During the preparation of the SFRA, LCC has provided access to available datasets held by the Council regarding flood risk across the Leeds District. This has included current datasets in relation to the assessment of local sources of flooding (surface water, groundwater and ordinary watercourses). The SFRA will be used by the LCC's Emergency Planning team to ensure that the findings are incorporated into their understanding of flood risk and the preparation of their Multi-Agency Flood Plan (MAFP).
Environment Agency	The Environment Agency is responsible for taking a strategic overview of the management of all sources of flooding and coastal erosion. This includes, for example, setting the direction for managing the risks through strategic plans; providing evidence and advice to inform Government policy and support others; working collaboratively to support the development of risk management skills and capacity; and providing a framework to support local delivery. The Agency also has operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea, as well as being a coastal erosion risk management authority. As part of its strategic overview role, the Environment Agency has published a National Flood and Coastal Risk Management Strategy for England. The strategy provides a lot more information designed to ensure that the roles of all those involved in managing risk are clearly defined and understood. The Environment Agency undertakes systematic modelling and mapping of fluvial flood risk associated with all Main Rivers in the study area, as well as supporting LLFAs with the management of surface water flooding by mapping surface water flood risk across England. The Environment Agency has supplied available datasets for use within the SFRA.
Yorkshire Water	Yorkshire Water is responsible for surface water drainage from development via adopted sewers and for maintaining public sewers into which much of the highway drainage connects. In relation to the SFRA, the main role that Yorkshire Water has played is providing data regarding past sewer flooding.
West Yorkshire Combined Authority (WYCA)	WYCA comprises LCC and adjacent Councils within the West Yorkshire Region. The West Yorkshire Combined Authority takes a strategic view of flooding across the region and coordinates regional strategy. Among other actions, WYCA has produced detailed guidance on integrating Sustainable Drainage Systems into development.

[9] HMSO (2011) Localism Act Available from: http://www.legislation.gov.uk/ukpga/2011/20/contents/enacted

Stakeholder Organisation	Role with respect to LCC SFRA
Canal and River Trust	The Canal and River Trust have provided information to LCC on the locations of Canal structures and recorded breach overtopping events within the study area. Canal and River Trust were contacted as part of the consultation process to obtain information on historic flood information.
Ainsty Internal Drainage Board	Ainsty Internal Drainage Board is responsible for maintaining and operating watercourses draining a small area of mainly rural land in the northeast of the study area. Ainsty Internal Drainage Board was contacted as part of the consultation process to obtain information on their current and future expectations for providing flood management within the area.

5. National, Regional and Local Flood Risk Policy

There is an established body of policy and guidance documents which are of particular importance when considering development and flood risk. These are identified in Table 5-1 along with links for where these documents can be found for further detail.

Table 5-1: Flood Risk Policy and Guidance Documents

National Legislative and Policy Documents		
Flood and Water Management Act (2010)	Provides for a more comprehensive management of flood risk, designating roles and responsibilities for different Risk Management Authorities. Designates LCC as the LLFA, with duties and responsibilities for managing local flood risk (defined as flooding from surface water, groundwater and Ordinary Watercourses).	https://www.legislation.gov.uk/ukpga/2010/29/contents
Flood Risk Regulations (2009)	The Flood Risk Regulations transpose the EU Floods Directive into law in England. It aims to provide a consistent approach to flood risk across Europe.	http://www.legislation.gov.uk/uksi/2009/3042/contents/made
Revised National Planning Policy Framework	The NPPF was first published on 27 March 2012 and updated on 24 July 2018, 19 February 2019 and 20 July 2021. This sets out the government's planning policies for England and how these are expected to be applied. This includes Section 14 - *Meeting the challenge of climate change, flooding and coastal change.*	https://www.gov.uk/guidance/national-planning-policy-framework
National Flood and Coastal Erosion Risk Management Strategy for England (2011)	The National FCERM Strategy sets out the long-term objectives for managing flood and coastal erosion risks and the measures proposed to achieve them. It provides a framework for the work of all flood and coastal erosion risk management authorities.	https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2
The Environmental Permitting (England and Wales) Regulations (2016)	In order to complete works on or near a Main River, on or near a flood defence structure, in a floodplain or on or near a sea defence. Guidance on obtaining an environmental permit is available from the Environment Agency.	https://www.gov.uk/guidance/flood-risk-activities-environmental-permits http://www.legislation.gov.uk/uksi/2016/1154/contents/made
Guidance Documents		
Planning Policy Guidance – Flood Risk and Coastal Change	Describes the planning approach to development within areas at risk of flooding from all sources	http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
Environment Agency Standing Advice	Guidance on information to be included within robust site-specific FRAs	https://www.gov.uk/guidance/flood-risk-assessment-standing-advice
Flood and coastal risk projects, schemes and strategies: climate change allowances	Supporting guidance that provides the UK Climate Projections (UKCP18) climate change factors for river flood flows, extreme rainfall, storm surge and wave climate for each river basin district and provides advice on applying climate change projections.	Flood and coastal risk projects, schemes and strategies: climate change allowances - GOV.UK (www.gov.uk)
Regional Flood Risk Policy		
Aire, Calder and Ouse Catchment Flood Management Plans (CFMP)	Role of the CFMP is to establish flood risk management policies which will deliver sustainable flood risk management for the long term (an Environment Agency Document).	https://www.gov.uk/government/collections/catchment-flood-management-plans
Humber River Basin Management Plan	River Basin Management Plans (RBMPs) set out how organisations, stakeholders and communities will work together to improve the water environment.	https://www.gov.uk/government/publications/humber-river-basin-district-river-basin-management-plan
Yorkshire Regional Flood and Coastal Committee	The Regional Flood and Coastal Committee (RFCC) brings together the Environment Agency, LLFAs and expert independent parties to build understanding of flood risk, guide the identification, communication and management of flood risk across catchments, ensuring investment in flood risk management is efficient and targeted while benefitting local communities.	https://www.gov.uk/government/groups/yorkshire-regional-flood-and-coastal-committee

National Legislative and Policy Documents		
Leeds City Region Sustainable Drainage System Guidance	This document outlines the types of sustainable drainage systems, their use in the built environment and requirements their use for future developments.	https://www.gov.uk/government/groups/yorkshire-regional-flood-and-coastal-committee
Local Documents and Strategies		
Leeds Local Flood Risk Management Strategy	The Local Flood Risk Management Strategy is used by risk management authorities in Leeds (LCC, Environment Agency, Yorkshire Water, Ainsty Internal Drainage Board, and Highways England) to manage flood risk from Main Rivers, Ordinary Watercourses, surface water, sewers and groundwater.	https://www.leeds.gov.uk/emergencies/flooding-advice/flood-risk-management-strategy
Leeds Preliminary Flood Risk Assessment	The Preliminary Flood Risk Assessment focusses on non-main river flooding, i.e. the risk of surface water, sewer, Ordinary Watercourse and groundwater flooding.	https://datamillnorth.org/dataset/flooding-grants
LCC Section 19 Flood Investigation Reports	Section 19 Flood Investigation Reports provide analysis of significant flood events, outlining the locations affected and the flood mechanisms. These reports outline where flood mitigation may be targeted in future.	https://datamillnorth.org/dataset/flooding-grants
Minimum Development Control Standards for Flood Risk	This document sets out the minimum requirements for flood risk assessment and drainage design for planning application within LCC area.	https://www.leeds.gov.uk/docs/Minimum%20development%20control%20standards%20for%20flood%20risk.pdf

Within the LCC area there are a number of authorities responsible or involved with flood and/or water management. Table 5-2 below shows who is responsible within the Leeds District.

Table 5-2: Responsibilities and duties for managing flood risk in Leeds District

Key Responsibilities of Different Authorities	Environment Agency	LCC	Yorkshire Water	Highways England	Canal and Rivers Trust	Riparian Owners	Ainsty IBD
Fluvial Flooding from Main Rivers	✓					✓	
Fluvial Flooding from Ordinary Watercourses		✓				✓	✓
Surface Water flooding		✓					
Groundwater Flooding		✓					
Sewer Flooding			✓				
Reservoir Flooding	✓	✓	✓		✓	✓	
Highways flooding		✓		✓		✓	
Canal Flooding					✓		

Further details and guidance of when to use standing advice on site specific flood risk assessment and when to consult the LLFA and the Environment Agency is provided at: https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities

Table 5-3 below shows the organizations that are statutory and non-statutory planning consultees for flood risk issues within the Leeds District. Further details and guidance of when to use standing advice on site-specific flood risk assessments, and when to consult the LLFA and the Environment Agency is provided : https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities

Table 5-3 Planning consultees for flood risk issues

Consultee / Flood Risk Issue	Environment Agency	Leeds City Council (LLFA)	Yorkshire Water	Ainsty IDB
Flood Zones 2 & 3	All development (except minor development and access & egress issues).	For developments that will increase the vulnerability classification. Development access and egress & Minor development.		
Surface water drainage from site	in an area with critical drainage problems, other than minor development	All major developments.	Where development connects to a Yorkshire Water sewer (non-statutory).	Where development discharges to an Internal Drainage Board watercourse/land drain.
Surface Water Indicative Flood Problem Areas		All new buildings/ change of use to dwellings.		
Groundwater Indicative Flood Problem Areas		All new buildings/ change of use to dwellings.		
Ordinary watercourses		Works in Ordinary Watercourses (Non-Statutory).		
Main river	Works within 20m of a designated Main River.			
Sewerage	Major development not using a main sewer.		Where development connects to a Yorkshire Water sewer (non-statutory).	

6. Plans and Strategies

6.1 National and Regional Strategies

The National 2020 Flood and Coastal Erosion Risk Management Strategy[10] includes three long term goals:

- Increasing resilience to flooding and coastal change across the nation, both now and in the face of climate change;
- Making the right investment and planning decisions to secure sustainable growth and environmental improvements as well as infrastructure resilient to flooding and coastal change, and;
- Ensuring local people understand their risk to flooding and coastal change and know their responsibilities and how to take action.

This SFRA assists in delivering these goals by providing information on flood risk from all sources in the LCC area, providing the evidence base for any new Local Plan. The information within the SFRA should be used to guide location of development away from areas at flood risk but where development is necessary in these locations the SFRA should be used to guide site-specific FRAs and mitigation proposals.' .

The regional flood risk management strategies for this area (see Section 5) includes ongoing delivery of flood alleviation and flood risk mitigation measures across the study area. Further details are provided below.

6.2 Flood Management Measures and Defences

Various flood alleviation schemes have recently been completed or will soon be implemented within the study area.

6.2.1 Completed Flood Management measures

The following schemes have been completed:

- Leeds Flood Alleviation Scheme Phase 1 (completed in 2017)
- Wyke Beck Programme (deculverting at Arthurs Rein completed in 2018, flood control structure, ponds and wetlands at Killingbeck Meadows now completed, supplemented with tree planting and NFM at Halton Moor)
- Mickletown Flood Alleviation Scheme (completed January 2021)
- Hawthorn Terrace, Garforth, Flood Alleviation Scheme (completed February 2021)

The presence of these schemes is reflected in the defended flood outlines used in this SFRA where updated model outputs are available (i.e. for Leeds City Centre), however updated defended flood outlines are not available for Wyke Beck, Mickletown and Hawthorn Terrace flood alleviation schemes. A more detailed analysis of the level of protection provided by these schemes may be required if any sites are allocated for future development.

6.2.1.1 Leeds Flood Alleviation Scheme – Phase 1

Phase 1 of the Leeds Flood Alleviation Scheme (LFAS1) reduces flood risk to the area of Leeds downstream of the railway station along the River Aire and Hol Beck. Through a combination of works LFAS1 provided the city centre with a standard of protection of 1 in 100 year annual probability (1% AEP) event with an allowance for climate change to 2039. The key feature of the scheme is the use of two moveable weirs, one at Crown Point in the city centre and the other further downstream at Knostrop Weir. These weirs have been designed to be lowered in advance of a flood event to increase the channel capacity through the City Centre. In doing so, the weirs meant the flood walls through the city could be reduced in height whilst providing the same standard of protection.

6.2.2 Flood Management measures currently being delivered

The following schemes are currently under construction:

- Leeds Flood Alleviation Scheme Phase 2 – Step 1 and Step 2 (currently under construction)
- Otley Flood Alleviation Scheme (substantially complete)

The planned /progressing presence of these schemes is not reflected in the defended modelled flood outlines used in this SFRA (i.e. for Kirkstall Road corridor). Once the construction has been completed and the "as-built" flood

[10] https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2/national-flood-and-coastal-erosion-risk-management-strategy-for-england-executive-summary

defences have been finalised the SFRA and associated definition of defended flood outlines can be updated to reflect the revised flood risk.

6.2.2.1 Leeds Flood Alleviation Scheme – Phase 2 (LFAS2)

Phase 2 of the LFAS has been split into Steps 1 and 2. LFAS2 Step 1 will deliver linear flood defences upstream of Leeds railway station through the Kirkstall corridor as far as Newlay Bridge. These floodwalls and embankments aim to deliver a 1 in 100 annual probability (1% AEP) standard of protection in line with the LFAS1 area downstream of the railway station. LFAS2 Step 2 will deliver a flood storage area at Calverley, upstream of the Step 1 linear defences. This storage area aims to only operate at flows in excess of the 1 in 100 year annual probability (1% AEP) event. The 1 in 100 year annual probability (1% AEP) flow will be allowed to pass downstream and flows up to the 1 in 200 year annual probability (0.5% AEP) event will be stored at Calverley. The storage area aims to raise the standard of protection by both the LFAS2 and LFAS1 flood defences to the 1 in 200 year annual probability (0.5% AEP) event.

The flood risk along the River Aire aims to be significantly reduced from Newlay Bridge, through Leeds City Centre and downstream as a result of the LFAS. The scheme has been designed to ensure the scheme does not transfer the risk of fluvial flooding elsewhere.

The LFAS schemes are focused on reducing fluvial flood risk from the River Aire however, the works have ensured that the defences along the river do not adversely affect the risk of surface water flooding and where the opportunity presents it seeks to also reduce the risk of surface water flooding.

6.2.3 Flood Management measures identified and early stages of development

Additional flood alleviation schemes which are at an earlier stage of development are listed below:

- Potternewton Surface Water Flood Alleviation Scheme
- Guiseley Surface Water Flood Alleviation Scheme
- Wortley Beck Flood Alleviation Scheme
- Farnley Wood Beck Flood Alleviation Scheme
- Lin Dyke Garforth Flood Alleviation Scheme
- Lin Dkye Kippax Flood Alleviation Scheme
- Meanwood Beck Flood Alleviation Scheme
- Gledhow Lake Flood Alleviation Scheme
- Wharfedale Flooded Communities Study
- FRM Coastal and Resilience Fund
- Methley Sluices Replacement
- Collingham Beck Improvements
- Leeds FAS Phase 2 NFM Programme

Land is likely to be needed for flood risk management features and structures proposed under many of these schemes. Potential options include flood storage areas along Meanwood Beck and Wortley Beck, along with de-culverting opportunities on Farnley Wood Beck. Plans for development on land adjoining these watercourses or including culverted sections should be assessed against proposals for future flood alleviation schemes. Opportunities to reduce the causes and impacts of flooding should be identified and taken forward, including de-culverting, retaining and restoring river corridors, attenuating surface runoff and improving the flood resilience of new development.

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7. Data Collection

A large quantity of information and datasets have been made available by the stakeholder organisations and used to inform the assessment of flood risk. Descriptions of the datasets that have been used, along with details of their appropriate use or limitations, are provided below and in the flood risk assessment discussion in Sections 8 to 10.

Table 7-1: Details of Datasets Used within this SFRA

	Dataset Description	Source	Format	Benefits / Limitations
Fluvial	Flood Map for Planning (Rivers and Sea) Flood Zones 2 and 3	Environment Agency Geostore* (*available to the public on the Environment Agency website)	GIS Layer	A quick and easy reference that can be used as an indication of the probability of flooding from Main Rivers. The original Flood Map was broad scale national mapping that is generally thought to have some inaccuracies. This is regularly updated with the result of new modelling studies. For those rivers where there is no updated modelling, the Flood Zones may not provide an accurate representation of probability of flooding. Ordinary watercourses are typically omitted from Environment Agency mapping unless there is a history of flooding affecting a population. Consequently, there will be some locations adjacent to watercourses that on first inspection, suggest there is no flood risk.
Fluvial	Main Rivers	Environment Agency Geostore	GIS Layer	Identification of the Main River network for which the Environment Agency have responsibility to maintain.
Fluvial	Detailed River Network (DRN)	Environment Agency Geostore	GIS Layer	Identification of the river network including Main Rivers and Ordinary Watercourses for which the Environment Agency and LCC have discretionary and regulatory powers.
Fluvial	Modelled flood outlines for Rivers Aire, Wharfe and Calder, as well as Bagley Beck, Oulton Beck, Meanwood Beck, Wyke Beck, Fir Green Beck, Cock Beck, Hol Beck and Wortley Beck	Environment Agency and LCC	GIS Layer	The flood extents for the hydraulic model studies that have been completed for watercourses within Leeds District have been mapped. These provide indication of flooding from these rivers. The Environment Agency applies the outcomes from these detailed modelling studies to update the Flood Map for Planning (Rivers and Sea) on a quarterly basis. For some Main River flood extents with defences and without defences have been mapped. Some watercourses have not been modelled (e.g. some of the tributaries of other the Main Rivers). The flood risk from these is based on broad scale modelling and therefore the flood risk from these cannot be as accurately assessed.
Fluvial	Asset Information Management System (AIMS) for the District	Environment Agency	GIS Layer	Shows where there are existing flood defences and structures, including their heights, type and design standard. However, many fields contain default values.
Surface Water	'Risk of Flooding from Surface Water' dataset	Environment Agency Geostore	GIS Layer	Provides an indication of the broad areas likely to be at risk of surface water flooding, i.e. areas where surface water would be expected to flow or pond. This dataset does not show the susceptibility of individual properties to surface water flooding.
Groundwater	GIS layers of the geology across the District	EHDC	GIS Layer	Illustrates bedrock and superficial geology across Leeds District.
Groundwater	Aquifer Designation Maps for Bedrock and Superficial	Environment Agency Geostore	GIS Layer	A polygon shapefile that shows aquifer designations for bedrock aquifers. The designations identify the potential of the geological strata to provide water that can be abstracted and have been defined through the assessment of the underlying geology.
Groundwater	GIS layer 'Infiltration SuDS Map'	British Geological Survey	GIS Layer	Dataset produced by the BGS of relevance to professionals who make decisions on SuDS design, construction and approval. The maps will help: (1) make preliminary decisions on the suitability of the subsurface for infiltration SuDS; (2) make preliminary decisions on the type of infiltration SuDS that will likely be appropriate; (3) assess SuDS planning applications to determine

	Dataset Description	Source	Format	Benefits / Limitations
				whether the necessary factors have been considered; and (4) determine whether infiltration SuDS could be appropriate where a non-infiltrating SuDS technique has been proposed.
	GIS layer 'Susceptibility to Groundwater Flooding'	British Geological Survey	GIS Layer	Dataset produced by BGS showing areas susceptible to groundwater flooding on the basis of geological and hydrogeological conditions. Suitable for broad scale assessment such as the SFRA.
Sewer	DG5 Register of sewer flooding incidents, by post code area.	Yorkshire Water	MS Excel Spreadsheet	Indicates post code areas that may be prone to flooding as have experienced flooding in the last 10 years due to hydraulic incapacity. However, given that Yorkshire Water target these areas for maintenance and improvements, areas that experienced flooding in the past may no longer be at greatest risk of flooding. It should be noted that these are flooding incidents that have been reported to Yorkshire Water by the homeowners. This will not account for any incidents that don't get reported and therefore do not show on the register. Incidents of sewer flooding can be retrospectively reported to Yorkshire Water via their website – https://www.yorkshirewater.com/your-water/report-a-problem/
Other	LiDAR data (DTM, ASCII)	Environment Agency Geomatics Group	GIS ASCII	Provides a useful basis for understanding local topography and the surface water flood risk in the area. Spatial resolution of 1m. Accuracy of +/- 0.25m. The Environment Agency's LiDAR data archive contains digital elevation data derived from surveys carried out since 1998.
	Ordnance Survey 50m DTM Data	Ordnance Survey	GIS ASCII	Lower resolution digital terrain model – this data is not appropriate for site specific analysis, but national coverage is available.
Artificial Sources	Canal flooding records	Canal and River Trust	GIS Layer	Locations of historical canal breaches and overtopping incidents
	Reservoir Flooding Outline	Environment Agency Geostore	GIS Layer	Extent of potential risk of flooding from reservoirs. Shows the flood extents for all large raised reservoirs in the event that they were to fail and release the water held on a: 1. "dry day" when local rivers are at normal levels. 2. "wet day" when local rivers had already overflowed their banks. It represents a prediction of a credible worst case scenario, however it's unlikely that any actual flood would be this large because the flood outlines are the combined extents from failures of all upstream reservoirs. The data gives no indication of the likelihood or probability of reservoir flooding.
Historic Flooding	Recorded Flood Outlines	Environment Agency Geostore	GIS Layer	A single GIS layer showing the extent of historic flood events from fluvial, surface water, groundwater sources created using best available information at time of publication. However, some of the data is based on circumstantial and subjective evidence. There is not always available metadata, e.g. date of flood event.
	Flood Investigations	LCC	GIS, pdf reports	Detailed flood investigations carried out by LCC.
Emergency Planning	Flood Warning Areas	Environment Agency Geostore	GIS Layer	Indicates which areas are covered by the flood warning system.
Planning	OS Mapping of Leeds District	Ordnance Survey	GIS Layer	Provides background mapping to other GIS layers. Designed for use at 1:50K and 1:10K scales.
	GIS layer of administrative boundary	LCC	GIS Layer	Defines the administrative area of Leeds District for mapping purposes.

Dataset Description	Source	Format	Benefits / Limitations
GIS layer of post code boundaries	LCC	GIS Layer	Delineates post code boundaries for the District. Enables mapping of Yorkshire Water datasets which are provided by post code sector.

8. SFRA Methodology

8.1 SFRA Methodology and Approach

Under Section 14 of the NPPF[4], the risk of flooding from all sources must be considered as part of a SFRA, including flooding from the sea, rivers, land, groundwater, sewers and artificial sources. The study area is not located within an area at risk of tidal flooding, therefore flood risk from this source will not be considered further as part of this SFRA. Section 9 provides a strategic assessment of the flood risk across the LPA Area from each source. Reference should be made to the supporting mapping contained within Appendix A.

Planning Policy Guidance Flood risk and coastal change – August 2022 update

The Planning Policy Guidance (PPG) Flood risk and coastal change guidance document, which has informed the Leeds SFRA, was recently updated on 25 August 2022. This SFRA document was substantially complete and in the final stages of review when the update to the PPG was published.

An important update to the PPG document has modified part of the definition of Flood Zone 3b The Functional Floodplain as follows:

> *land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively;…..*

The previous guidance, and consequently the basis of this SFRA document and associated mapping, defined Flood Zone 3b as land with a 5% or greater annual probability of flooding (1:20 year return period), or land where water has to flow and/or be stored in times of flood. Given the extremely advanced status of the SFRA, we are unfortunately unable to revise the whole SFRA document and associated mapping to reflect the updated guidance. Where already available from existing modelling studies, we will update and use the 3.3% annual probability (1:30 year return period) flood extent to delineate the starting point for the extent of Functional Flood Plain. However, it is acknowledged that there is currently not available complete mapping of the 3.3% annual probability flood extent across the Leeds administrative catchment area. To avoid ambiguity or confusion, all references to Functional Flood Plain and/or Flood Zone 3b within the text of this SFRA, should be read as set out in latest update to the PPG *as land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively.*

Where the current day flood risk 3.3% annual probability flood extent is unavailable, developers will need to demonstrate that their site(s) is not within the updated definition of Zone 3b. The 5% annual probability (1 in 20 year return period) plus climate change modelled flood extents presented in the SFRA provide an indication / starting point to define the 1 in 30 year, or 3.3% annual probability, flood extent.

This SFRA has used the data sources outlined in Section 7 to identify land at risk of flooding, as follows:

- **Main River fluvial flooding:** Flood Zones 1, 2 and 3 and 3b, as defined under NPPF, have been identified based on modelled Environment Agency flood outlines. These correspond to land:
  - With less than a 1 in 1000 years annual probability (0.1% AEP) of fluvial flooding (Flood Zone 1);
  - Between a 1 in 100 (1% AEP) to 1 in 1000 years annual probability (0.1% AEP) of fluvial flooding (Flood Zone 2);
  - More than 1 in 100 years annual probability (1% AEP) of fluvial flooding (Flood Zone 3).
  - Where water has to flow or be stored in times of flood or land having a 1 in 20 or greater annual probability (5% AEP) of fluvial flooding (Flood Zone 3b).
- The NPPF flood zones are defined using undefended flood zones, i.e. ignoring the presence of flood defences. The Environment Agency Flood Map for Planning flood outlines have been used to denote the full extent of Flood Zones 2 and 3, although it should be noted that these are sometimes based on broad scale flood modelling and may be subject to future revision following detailed modelling. The Flood Map for Planning also does not consider the risk of flooding from most Ordinary Watercourses. Fluvial flooding has occurred

on a number of occasions within Leeds, so mapping of historical main river fluvial flood extents has been carried out separately.

- **The Functional Floodplain** (Flood Zone 3b, defined as land with a 1 in 20 years annual probability (5% AEP) of flooding, or land where water has to flow and/or be stored in times of flood) has been mapped where this flood outline is available. The Functional Floodplain is mapped with consideration to the presence of flood defences.
- **Rapid Inundation Zone,** the area near to flood defences where a breach or the source of flooding could create a significant flood hazard i.e. due to high velocity floodwaters and significant depth. Developers will need to demonstrate that their sites are not affected by rapid inundation.
- **Detailed flood modelling** has been carried out for many of the main watercourses within Leeds District. The flood outlines available on the Flood Map for Planning at the time of publication of this report are included within Appendix A. Flood maps based on detailed flood modelling are provided in Appendix A and provide additional detail. The SFRA will be updated as and when required.
- **Flood defences** are present along most of the Main Rivers within the study area. However, the type of defence and standard of protection varies. Separate flood maps have been produced which shows the extent of flooding, taking flood defences into account, where this modelling has been carried out. For the purposes of this study, "flood defences" have been defined as purpose-built walls, flood gates and embankments. Natural features such as high ground and temporary demountable flood defences have not been considered. LCC is currently developing flood defences, such as LFAS Phase 2, these defences have not been included as LFAS2 Step 1 is currently under construction and the Step 2 design is being finalised.
- **Surface Water Flooding:** Areas at high, medium and low risk of surface water flooding (33%, 1% and 0.1% annual probability) have been mapped based on the "Risk of Surface Water Flooding" dataset, along with the locations of historical surface water flooding occasions.
- **Groundwater Flooding:** Areas susceptible to groundwater flooding have been mapped based on British Geological Survey data. This map shows the estimated annual probability of groundwater emergence at the surface (clearwater flooding), floodwater emergence from within superficial deposits, or a combination of both. The extent of historical groundwater flooding has also been mapped to inform this assessment.
- **Sewer Flooding and flooding from drainage systems:** the risk of sewer flooding is limited to a postcode level analysis of the number of internal and external sewer flooding incidents within the last five years. This has been supplemented with mapped information on flooding from other drainage systems (e.g. highways flooding).
- **Flooding from artificial sources:** flood risk from artificial sources, i.e. canals and reservoirs) has been assessed by mapping both the extent of the Environment Agency Flood Risk from Reservoirs flood outline, and the locations of any known breach or near failures of canal embankments, as provided by the Canal and River Trust.
- **Ordinary Watercourse flooding:** flood risk from Ordinary Watercourse is not always quantified in the available datasets, particularly for smaller watercourses. The risk from Ordinary Watercourses will need to be assessed for development sites on a case by case basis, although some datasets can assist with this determination, including the risk of surface water flooding map which identifies flow paths in local topography. The historical flood mapping (shown in Appendix A Figure A.14) can also show where Ordinary Watercourse flooding has previously occurred. However, site- specific FRAs (see Section 14) for sites adjoining Ordinary Watercourses may need to be informed by detailed hydrological and hydraulic modelling. The responsibility for this assessment rests with the developer.

8.2 Functional Floodplain (Flood Zone 3b)

The Functional Floodplain is defined in the NPPF as 'land where water has to flow or be stored in times of flood'. The Functional Floodplain (also referred to as Flood Zone 3b), is not separately distinguished from Flood Zone 3a on the Flood Map for Planning. The SFRA is the place where LPAs should identify areas of Functional Floodplain.

The PPG states 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 in a 1 in 20 year annual probability (5% AEP) event or is designed to flood (such as a flood attenuation scheme) in an extreme event (1 in 1000 year annual probability) flood, should provide a starting point for consideration. The guidance goes on to say that 'areas which would naturally flood in a 1 in 20 annual probability (5% AEP) event but are prevented from doing so by existing infrastructure or solid buildings will not normally be defined as Functional Floodplain'.

Within the Leeds District the Functional Floodplain (Flood Zone 3b) includes the following categories:

- Functional Floodplain (undeveloped areas) - Areas of Functional Floodplain that do not have existing development and will continue to be Functional Floodplain in the future.
- Functional Floodplain (existing development) - Developed areas within the functional floodplain where only the footprint of existing development is acceptable for re-development (providing all other policy requirements are met).
- Functional Floodplain (future defended) – Areas of existing Functional Floodplain that are expected to be removed from the functional floodplain by future defences that are currently being delivered by LCC, for example LFAS2.

8.2.1 Functional Floodplain (undeveloped areas)

Areas within the 1 in 20 year annual probability (5% AEP) event flood extents have been delineated. Within this outline, undeveloped areas, where water has to flow or be stored in times of flood, are defined as Functional Floodplain and protected from non-compatible development.

8.2.2 Functional Floodplain (future defended)

As discussed in Section 6.2 LCC is making a significant investment in flood defences including LFAS2 and Otley FAS. These are areas that LCC are expecting to be removed from the Functional Floodplain as flood alleviation schemes are completed.

8.2.3 Functional Floodplain (existing development)

Within Leeds District there are some areas within the 1 in 20 annual probability (5% AEP) event flood extent that are already developed and are prevented from flooding by the presence of existing infrastructure or solid buildings. Whilst these areas will be subject to frequent flooding, it may not be practical to refuse all future redevelopment. In accordance with the PPG, the existing building footprints can be developed, where they can be demonstrated to exclude floodwater and are used for existing or less vulnerable use. The land surrounding these buildings are important flow paths and flood storage areas and properties within these areas will be subject to frequent flooding; therefore, care must be given to the future sustainability of such development and ensuring there is no reduction in any flood storage for all events up to the 1 in 100 year annual probability (1% AEP) flood event with an allowance for climate change.

The planning policy approach to development within these areas recognises the importance of pragmatic planning solutions that will not unnecessarily 'blight' areas of existing development as well as the importance of the undeveloped land surrounding them and the potential opportunities to reinstate areas which can operate as Functional Floodplain through redevelopment to provide space for floodwater and reduce risk to new and existing development.

This primarily includes areas of existing development situated adjacent to the River Aire and the River Wharfe (including Leeds City Centre) and along Wyke Beck and Bagley Beck.

8.3 Climate Change Methodology and Allowances

The currently available flood modelling for watercourses in the study area uses 20%, 30% and 50% allowances for future increase in fluvial flood risk in the study area, based on UKCP09 climate change projections for the Humber River Basin..

Environment Agency guidelines on climate change allowances was updated on 27 July 2021[11], after publication of the modelling used to inform this report. However, the range of revised upper end climate change allowances for river flow in the study area is 22-51%, which is extremely similar to the previous 20-50% range. This means that the current climate change flood outlines can still be used to assess the potential change in risk across the study area as a result of climate change.

These allowances are applied to the 1 in 100 year annual probability (1% AEP) flow and the resulting flood maps are provided in Appendix A. The changes in flood extent are discussed below for each main river watercourse for which this modelling has been carried out.

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances, accessed 5 August 2021. These guidelines are subject to periodic revision and should be checked prior to carrying out site specific flood risk assessments

Climate change allowances of 20%, 30% and 50% have been applied in most of the modelled flood outlines in Appendix A. A full set of climate change allowances has not been modelled for all watercourses, for example the 20% allowance is the only allowance available for Wortley Beck. A review of the geographic extent and scenarios was undertaken as part of the SFRA and the most appropriate model output was chosen to represent flood outlines for key flood events under NPPF. Exact model outputs for each key event are not available for all areas and a suitable proxy has been identified. For example comparing the 1 in 1000 year annual probability (0.1% AEP) flood extent to the 1 in 100 year annual probability (1% AEP) flood extent including a 51% allowance for climate change, where this has been modelled, shows that the differences in the two modelled flood extents are usually small. The 1 in 1000 year annual probability (0.1% AEP) event flood outline can therefore be used as a proxy for the 1 in 100 year annual probability (1% AEP) event with 51% allowance for climate change where required.

9. Flood Risk in Leeds

9.1 Risk from Main Rivers

9.1.1 River Aire

The River Aire flows southeast through Leeds, entering the study area north of the village of Calverley and exiting north of Castleford. The flood outlines in Appendix A are based on a number of modelling studies including:

- Northern Forecasting Package: Lower Aire Model, Final Report v1.0, July 2017, report ref 2016s3877, JBA Consulting on behalf of the Environment Agency;
- Leeds Flood Alleviation Scheme Phase 1.

Defended and undefended modelled flood outlines were provided by the Environment Agency for Leeds City Centre and take account of LFAS1.

These studies show that the River Aire presents a risk of flooding to central Leeds as well as to the suburbs and settlements of Rodley, Newlay, Sandford, Kirkstall, Knowsthorpe, Woodlesford, Lower Mickletown and Allerton Bywater. The floodplain through Leeds is fairly narrow, however towards the downstream reaches the floodplain expands to include large washlands.

Flooding occurred along the entire River Aire through the study area in Autumn 2000 and December 2015, as well as more localised flooding in December 1978 and February 2020. Flooding also occurred within the downstream reaches, north of Castleford, in February 1995, January 1982 and was particularly severe in February 2020.

The LFAS Phase 1 (completed in 2017) reduces flood risk from the River Aire to central Leeds and contains the 1 in 20 year (5% AEP) within the river channel and for all events up to the 1 in 100 year annual probability (1% AEP) flood event with an allowance for climate change to 2039. The LFAS2 will increase this level of protection further as well as providing protection to areas upstream of Leeds City Centre. LFAS2 is currently within the design and construction stage. Note that the impact of the scheme on the 1 in 1000 year annual probability (0.1% AEP) event has not been modelled.

In addition, the Mickletown Flood Alleviation Scheme was completed in January 2021 and reduces the risk of flooding to properties downstream of Leeds, in the Mill Lane and Pit Lane area of north Mickletown from the River Aire up to the 1 in 100 year annual probability (1% AEP) event including an allowance for climate change.

9.1.2 River Wharfe

The River Wharfe flows along much of the northern extent of the study area. The modelled flood outlines in Appendix A.5 and A.6 are based on the 2020 River Wharfe Catchment Study[12] and Otley Flood Alleviation Scheme modelling[13] carried out by WSP for LCC (note there is a gap in the detailed modelling before Castley and the A61). The Wharfe presents a risk of flooding to the settlements of Otley, Collingham, Linton and Wetherby. The Functional Floodplain includes extensive areas of rural land and green space, although some properties within Boston Spa may be located within Flood Zone 3b. Limited flooding occurred along the River Wharfe in February 2020 and December 2015.There are flood defences on the reach of the River Wharfe downstream of the A61, including at Wetherby and Boston Spa, however the standard of protection is low and there is little difference in the undefended and defended flood extents even in the 1 in 20 year annual probability (5% AEP) event. Otley Flood Alleviation Scheme is substantially complete and includes an additional culvert on Kel Beck (see Section 9.1.10), construction of a defence embankment and vegetation management. It will reduce the risk of flooding up to the 1 in 25 year annual probability (4% AEP) event and will therefore reduce the extent of the Functional Floodplain within Otley, although the overall extent of Flood Zone 3 may not significantly be reduced.

[12] Project Number 70036954, report dated October 2020
[13] Otley Flood Alleviation Scheme Flood Risk Assessment, WSP, March 2020, Project Number 70049382

9.1.3 River Calder

The River Calder defines a short section of the southern boundary of the study area, flowing into the River Aire upstream of Castleford. The reach of the Calder near the confluence with the River Aire is included within Northern Forecasting Package: Lower Aire Model. This area is the Lower Aire washlands area and an important designated area of flood storage. The flood risk within this area of the Lower Aire and Calder confluence is complex with interaction across both watercourses.

The reach of the Calder upstream of the Methley Junction is included within 2015 Calder and Canals Model. The modelled flood outlines and Flood Zones show that the River Calder presents a risk of flooding to the villages of Methley Lanes, Methley Junction and Methley. Much of this reach of the Calder is defended, however the standard of protection relies heavily on antecedent conditions. Flooding occurred at the downstream end of the River Calder in February 2020 and December 1978.

9.1.4 Meanwood Beck catchment

Meanwood Beck rises north of Leeds near Bramhope and flows through an extensively urbanised catchment (Figure 9-1), reaching the confluence with the River Aire in central Leeds. The watercourse is extensively culverted with open and closed culverts between Buslingthorpe Lane and Mabgate and culverted from Mabgate to the confluence with the River Aire. Detailed flood modelling is available for this watercourse[14]. There is an Ordinary Watercourse tributary known as Gledhow Beck and Gipton Beck which flows from Lidgett Park to Mabgate and is also mainly in culvert. The model results show that these watercourses present a risk of flooding to a narrow floodplain area, mainly along the more downstream culverted reaches. The Functional Floodplain is often limited to the immediate area of the Beck and its tributary - extensive flooding does not occur in the 1 in 20 year annual probability (5% AEP) event except in localised areas. Hazard mapping shows that areas of "Danger for Most" include developed areas during the 1 in 20 year annual probability (5% AEP) event and for larger events, but areas of "Danger for All" are only seen in the extreme 1 in 1000 year annual probability (0.1% AEP) event. Historical records of flooding on Meanwood Beck are limited to small areas affected in February 2020.

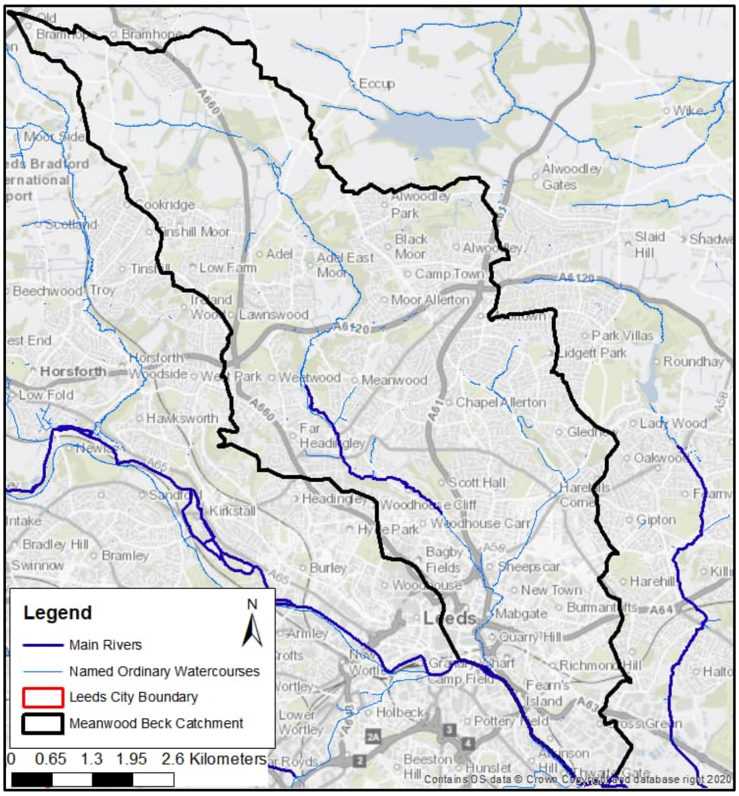


Figure 9-1 Meanwood Beck Catchment

There are currently no flood defences along either Meanwood Beck or its tributary. However, opportunities to reduce flood risk using sites for surface water management were identified as part of a 2020 feasibility study and flood modelling. These proposals are currently being developed further.

[14] Northern Forecasting Package: Meanwood Beck Model Update, Final Report, April 2017, JBA Consulting for Environment Agency, report ref 2016s3878

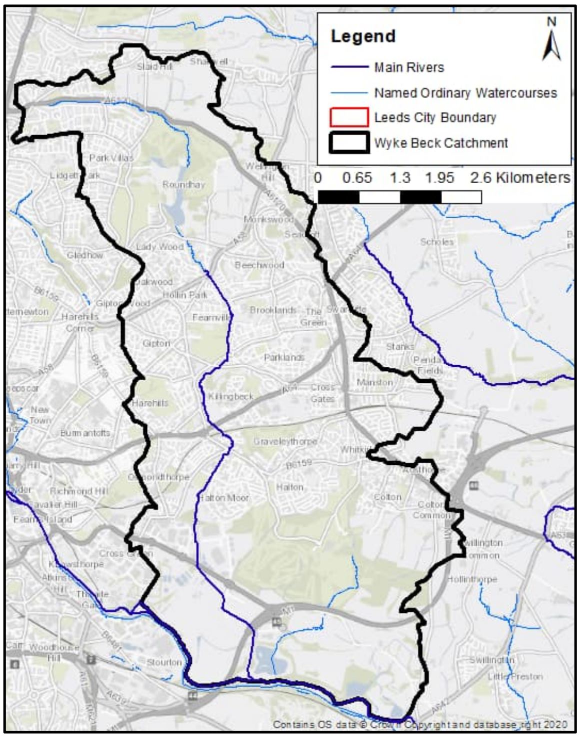


Figure 9-2: Wyke Beck Catchment

9.1.5 Wyke Beck catchment

Wyke Beck flows north from Moor Allerton to the River Aire through the eastern suburbs of Leeds, including alongside Oakwood, Killingbeck and Halton Moor (Figure 9-2). Flood zones are defined for this watercourse from downstream of the A58[15]. The floodplain is narrow but affects roads and properties in the Harehills area. The 1 in 20 year annual probability (5% AEP) event is usually contained within bank and the only areas of mapped Functional Floodplain are within green open space.

There are no historical flood outlines for flood events on Wyke Beck, but frequent flooding and drainage issues are seen on this watercourse. Constructed flood defences are limited to the most downstream section, between the M1 and the River Aire, however flood storage areas have recently been constructed on the Wyke Beck Valley at Arthur's Rein, Killingbeck Meadows and Halton Moor.

9.1.6 Oulton Beck catchment

Oulton Beck is initially named West Beck and rises near Thorpe on the Hill and flows southeast under the M1 (Figure 9-3). It then flows east to where it joins Carlton Beck, flowing north and receiving flows from Haigh Beck before becoming Oulton Beck north of Rothwell where it turns east and flows through Oulton to the River Aire. The Oulton Beck floodplain[16] is narrow and only affects properties and roads in Rothwell and Oulton. Constructed flood defences are limited to a short section upstream of the A654 at Rothwell. Localised flooding was recorded on Oulton Beck in Autumn 2000.

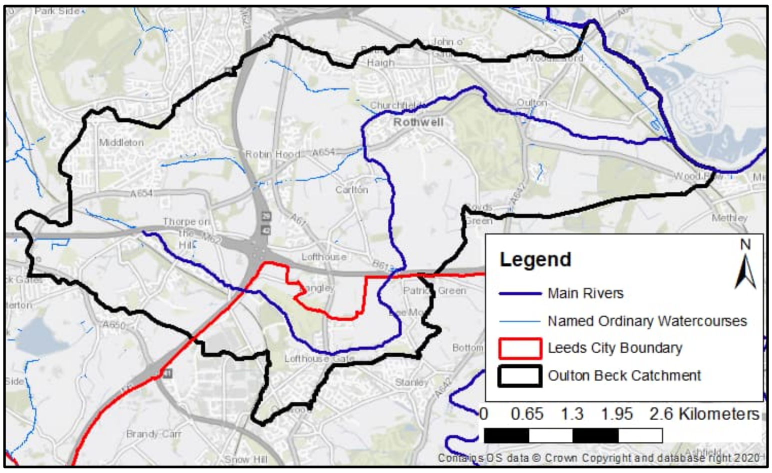


Figure 9-3: Oulton Beck Catchment

[15] Detailed flood modelling updated as part of Wyke Beck Flood Modelling Study, October 2014, JBA Consulting for Environment Agency, report ref 2014s0885

[16] Modelled as part of Upper Aire Tributaries Flood Mapping, October 2020, JBA Consulting for Environment Agency, report ref 2017s5501

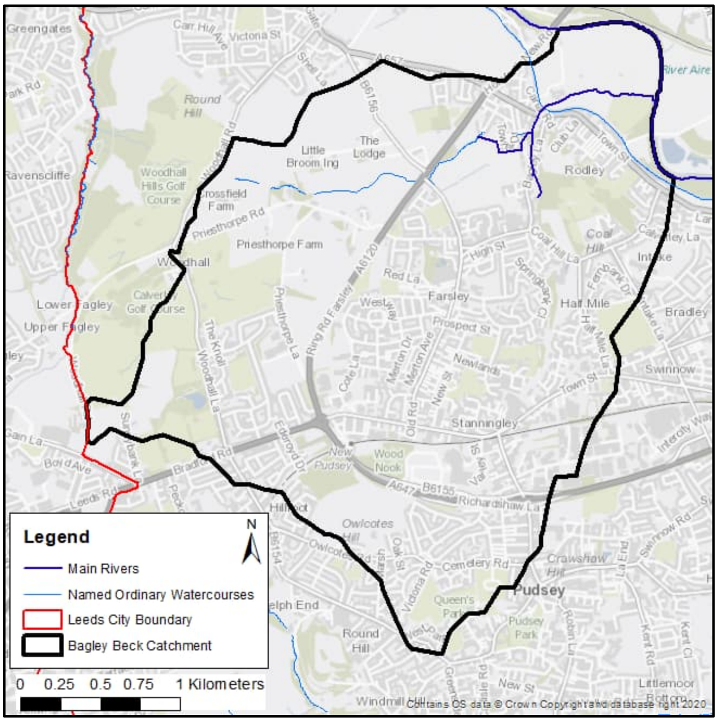


Figure 9-4: Bagley Beck Catchment

9.1.7 Bagley Beck

Bagley Beck rises near Pudsey and flows north to the River Aire (Figure 9-4). Detailed flood mapping has been carried out for the section from Farsley to the River Aire only. The floodplain[17] is generally narrow and limited to areas of public open space, however the extent of the floodplain increases close to the River Aire and some roads and properties in Rodley are at risk of flooding. The Functional Floodplain includes areas of residential development, although flood hazard mapping shows very low hazard over the majority of the flooded area in the 1 in 100 year annual probability (1% AEP) event, with limited areas of Danger for Most and small areas of Danger for All. There are no historical flood outlines for flood events on Bagley Beck.

9.1.8 Cock Beck catchment

Cock Beck (Figure 9-5) is a Main River tributary of the River Wharfe located in the east of the study area. This watercourse drains rural catchments and presents a risk of flooding to properties within the village of Aberford. Detailed flood modelling is available for some reaches of Cock Beck. There are limited flood defences reducing the risk of flooding to small areas in Aberford. No historical flood outlines are available for Cock Beck.

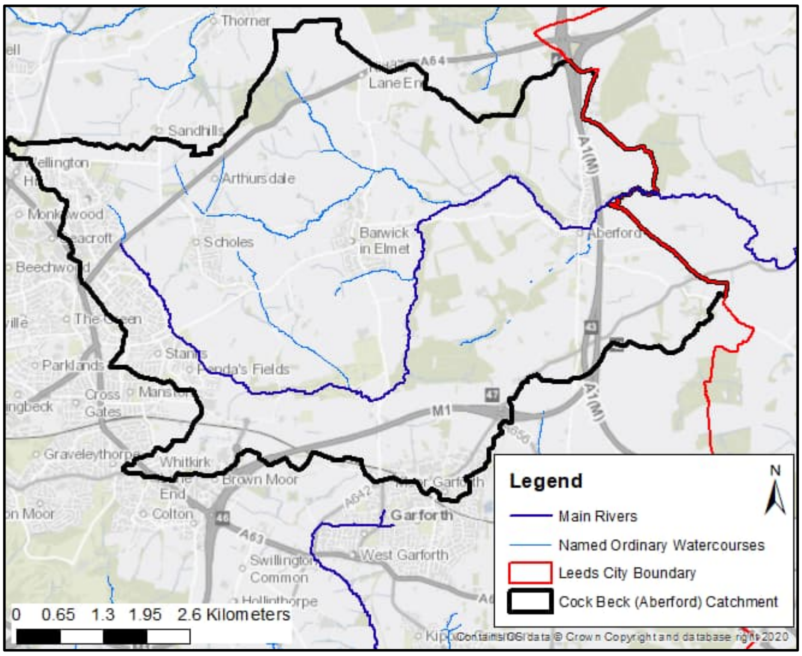


Figure 9-5: Cock Beck Catchment

[17] Modelled as part of Upper Aire Tributaries Flood Mapping, October 2020, JBA Consulting for Environment Agency, report ref 2017s5501

9.1.9 Collingham Beck and Fir Green Beck catchments

Collingham Beck and Fir Green Beck (Figure 9-6) are main river tributaries of the River Wharfe located in the north of the study area near Wetherby. These watercourses drain rural catchments and present a risk of flooding to properties within the villages of Collingham (Collingham Beck) and Thorner, Bramham and Clifford (Fir Green Beck). Detailed flood modelling is available for the lower reaches of Collingham Beck[18] and for reaches of Fir Green Beck which pass through settlements on the edge of Leeds and the villages of Bramham and Clifford.

There are limited flood defences reducing flood risk to small areas in Collingham and Bramham. Collingham Beck flooded the settlement of Collingham and upstream in June 2007, and flooded Collingham in December 2015 and February 2020. Localised flooding occurred on Fir Green Beck in June 2007 and February 2020.

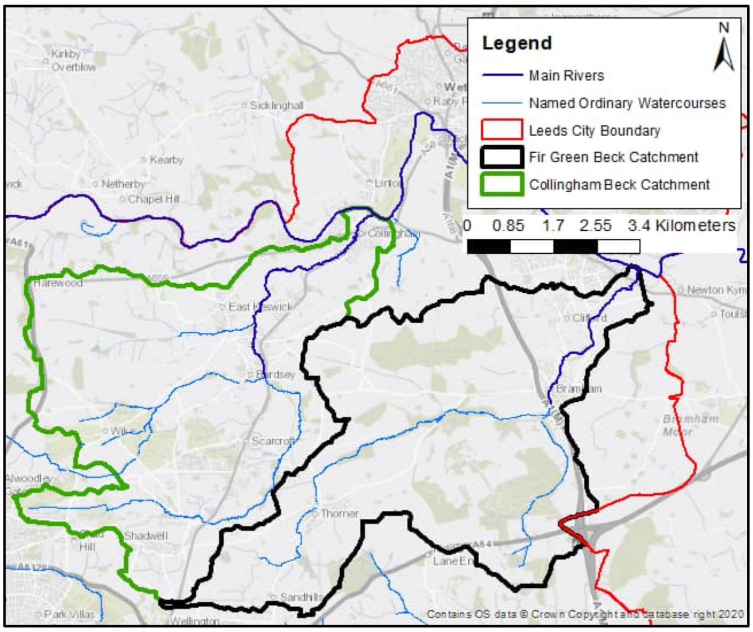


Figure 9-6: Collingham Beck and Fir Green Beck Catchment Areas

9.1.10 Hol Beck and Kel Beck

Hol Beck and Kel Beck are Main River tributaries of the River Wharfe which flow south from the northern edge of the study area, through Otley, to the River Wharfe. Detailed flood outlines are available for Hol Beck, showing a risk of flooding to properties through Otley, but neither detailed flood outlines nor broad scale Flood Zone 2 or 3 outlines are available for Kel Beck. Neither watercourse has constructed flood defences within the study area and Hol Beck and Kel Beck both flooded in Otley in December 2015 and February 2020.

9.1.11 Farnley Wood Beck and Wortley Beck

Wortley Beck (Figure 9-7) rises west of Leeds, on the outskirts of Bradford, near Holme, and flows east into the River Aire within Leeds City Centre. Farnley Wood Beck is a tributary of Wortley Beck which rises near Scott Green before flowing east and then north to meet Wortley Beck. A small section of Farnley Wood Beck and a long section of Wortley Beck are designated main river, however the reach of Wortley Beck from the Farnley Wood Beck confluence to the River Aire is designated Ordinary Watercourse and is culverted.

Detailed modelling of both Wortley Beck and Farnley Wood Beck have been carried out[19]. Neither watercourse has significant flood defences within the study area but most of the Wortley Beck floodplain is contained within open green space,

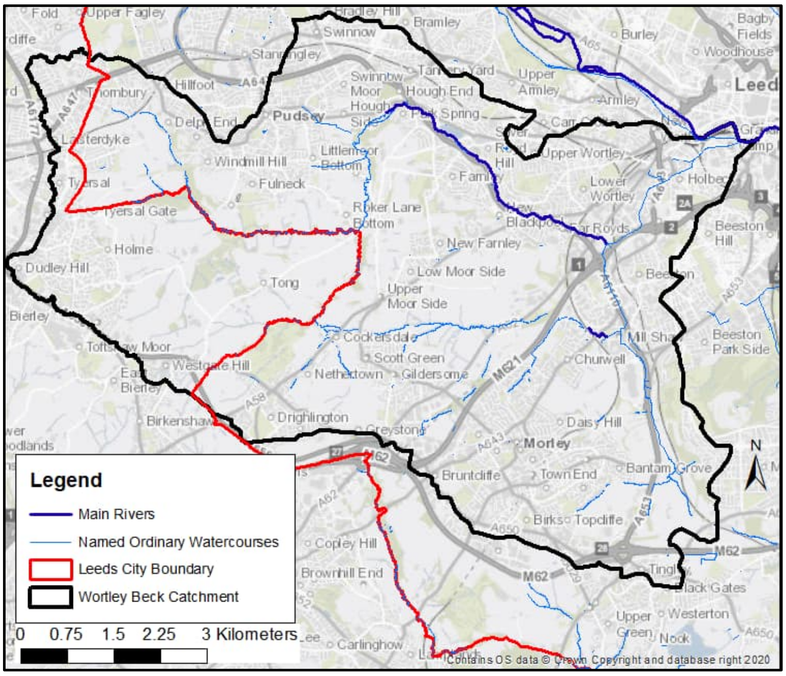


Figure 9-7: Wortley and Farnely Wood Beck Catchment Area

[18] River Wharfe Catchment Study Hydraulic Modelling Report, October 2020, WSP for Leeds City Council, report ref 70036954
[19] Wortley Beck Flood Modelling Study, February 2017, Environment Agency

with properties only at risk in limited areas of Park Spring and New Blackpool. Farnley Wood Beck presents a greater risk of flooding, with commercial and residential development shown to be at risk in the Cottingley area. The Functional Floodplain of Wortley Beck affects development only in localised areas in Park Spring and New Blackpool, and the Farnley Wood Beck Functional Floodplain is very limited in extent and only affects a small developed area in Cottingley. Flood hazard outside the watercourse channel is generally low in the 1 in 20 year annual probability (5% AEP) event, with some areas of Danger for Some in the 1 in 100 year annual probability (1% AEP) event, and localised areas of “Danger for Most” in the extreme 1 in 1000 year annual probability (0.1% AEP) event. Historical flood outlines show localised flooding along Wortley Beck and tributaries in February 2020.

Additional flood alleviation measures are currently under consideration for both Wortley Beck and Farnley Wood Beck. Proposals for flood storage measures on Wortley Beck are being developed as part of a feasibility study, while proposals for Farnley Wood Beck focus on de-culverting and are expected to proceed in 2021-2022.

9.1.12 Lin Dyke

Lin Dyke (Figure 9-8) rises in Garforth and flows mainly south to the River Aire through rural land. No detailed flood modelling is available for this watercourse and Flood Map for Planning outlines have been used in Figure A.5. The Flood Zone 3 outline has been used to define the Functional Floodplain. Lin Dyke only presents a risk of flooding to limited numbers of properties east of Preston Hill and to some areas of farmland downstream. There are no formal constructed flood defences on this watercourse and therefore no detailed flood extent or hazard mapping or historical flood outlines.

Some localised flood alleviation measures have been undertaken within Garforth (e.g. Hawthorn Terrace FAS and Barleyhill recreation ground FAS) which have reduced the flood risk to the downstream sections of Lin Dyke

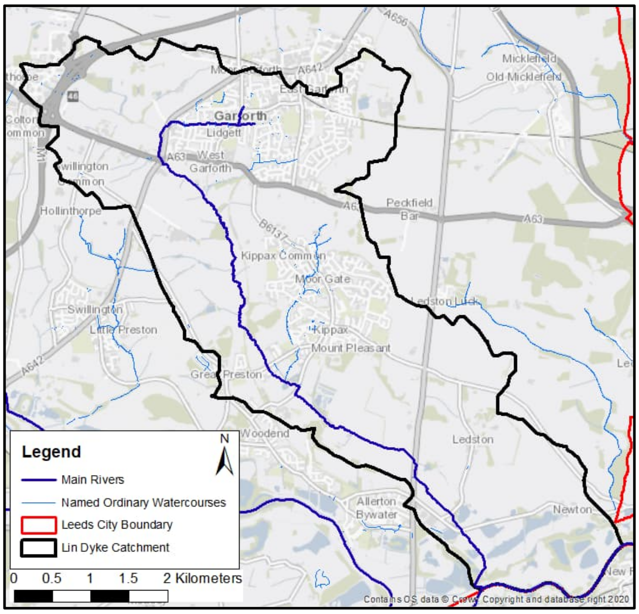


Figure 9-8: Lin Dyke Catchment

9.2 Risk from Ordinary Watercourses

There are numerous small named and unnamed Ordinary Watercourses within the Study area, including the upstream reaches of Meanwood Beck and Wortley Beck, most of Farnley Wood Beck and its tributaries and a number of rural watercourses to the north and east of Leeds. Flood outlines do not currently exist for most of these watercourses, although some (e.g. Farnley Wood Beck) have been modelled as part of Main River fluvial flood risk mapping projects. Flood risk from Ordinary Watercourses will therefore need to be assessed for nearby and adjoining proposed development sites on a case-by-case basis. Resources which can assist with this include the “Risk of Surface Water Flooding map” (see below) which can show major overland flow routes and flooding extents, and maps of historical flooding extents. Historic flood extents in Figure A.14 show flooding along a tributary of Fir Green Beck in June 2007, on tributaries of Wyke Beck in February 2020 and on a tributary of Cock Beck in January 2021. Surface water flooding is discussed in Section 9.3 below.

9.3 Risk from Surface Water & Drainage

The risk of surface water flooding map is presented in Figure A.9. The risk across the study area is generally low outside the topographic river valleys, but there are many isolated areas of higher risk within the Leeds urban area, some of which show where watercourse ditches may have been diverted or culverted. Historical surface water flooding extents are shown in Appendix A Figure A.14 and are greatest in the lower River Aire valley, with smaller extents in other locations.

Recorded instances of surface water flooding from 2014 onwards have been used to create the surface water flooding heat map in Appendix A Figure A.9A. This shows that the principal areas at risk of surface water flooding are central Leeds and the suburbs of Burley and Graveleythorpe as well as the towns of Otley, Guiseley, Collingham, Garforth, Kippax and Allerton Bywater. Although the heat maps identify areas with high frequency of historic flooding, this is a combination of fluvial and surface water flooding and each hot spot should be assessed on a case by case basis with a detailed assessment of the flooding incidents.

9.4 Risk from Groundwater

Areas susceptible to groundwater flooding are mapped in Appendix A Figure A.10. The risk over most of the study area is extremely low, with most of the high-risk areas being focussed along the Aire and Wharfe river valleys. There are only five small locations (one incident in each in Beeston, Pudsey, Yeadon, Guiseley and Otley) across the study area which have records of groundwater flooding, associated with three recent named storms (Ciara and Dennis in February 2020 and Christoph in January 2021).

9.5 Sewer Flooding

Historic sewer flooding records have been obtained from Yorkshire Water and are summarised by postcode area in Appendix A Figure A.12. The area most affected by sewer flooding is east of Leeds, around Garforth and Rothwell, while sewer flooding is less common in central and western Leeds. It is important to note that Yorkshire Water may have implemented, or be planning, capital schemes that address the identified areas at risk of sewer flooding. As part of any FRA or Drainage Strategy prepared to support a planning application for a new development, Yorkshire Water should be consulted to determine the capacity of the receiving network to accommodate any additional flows.

9.6 Risk of Flooding from Reservoirs and Canals

Significant areas of Leeds are at risk of flooding in the event of reservoir failure. Reservoir flood extents were made available in 2021 that provided flood extents for all large raised reservoirs in the event that they were to fail and release the water held on a:

- “dry day” when local rivers are at normal levels.
- “wet day” when local rivers had already overflowed their banks.

These are mapped in Appendix A Figure A.13. The reservoir flood map for the area is complex as there are a large number of reservoirs of varying size and capacity in the upstream catchment, some at considerable distance from the study area, and the reservoir flood map provides the combined flood outline for all structures such that the risk from individual reservoirs is difficult to assess.

Central Leeds is at risk from flooding from reservoirs in the River Aire catchment. There are: Reva Reservoir, Weecher Reservoir, Graincliffe reservoir, Chellow Dean Reservoir, Thornton Moor Reservoir, Leeshaw Water, Lower Laithe Reservoir, Ponden Reservoir, Watersheddles Reservoir, Keighley Moor Reservoir, Silsden Reservoir, Whinny Gil Reservoir, Embsay Reservoir, Elslack Reservoir, Winterburn Reservoir, Coniston Lake and Malham Tarn. These are often small reservoirs located at a significant distance from the study area where water flows along the River Aire to Leeds in the event of reservoir failure. There is also a risk of flooding due to breach of embanked sections of the Leeds and Liverpool Canal (see below).

In addition to the risk to central Leeds, there is an area of reservoir flood risk along the Wortley Beck valley from an impounded lake at Silver Royd Hill. The main area at risk is New Blackpool. There is also an area of flood risk along the Wyke Beck Valley from Waterloo Lake (Roundhay) – the main areas of risk are Hollin Park and Gipton.

There are also a number of reservoirs in the upper River Wharfe valley which pose a risk of flooding in the north of the study area in the event of reservoir failure. Flood risk along the River Wharfe Valley arises from: Thruscross Reservoir, Fewston Reservoir, Swinsty Reservoir, Lindley Wood Reservoir, March Ghyll Reservoir, Chelker

Reservoir, Lower Barden Reservoir, Upper Barden Reservoir and Grimwith Reservoir. These are much larger waterbodies than those in the River Aire catchment and there are therefore more extensive areas of flood risk along the River Wharfe. There is one reservoir within the study area – Eccup Reservoir on Eller Beck, an Ordinary Watercourse tributary of the River Wharfe. Failure of this reservoir would potentially cause flooding to a limited area of rural land downstream of the impounding wall and along the River Wharfe downstream.

Land around Methley, in the south of the study area, is potentially at risk of flooding due to failure of reservoirs within the River Calder catchment. This risk derives from: an unnamed impounded waterbody at Wintersett, Wintersett Reservoir, Cold Hiendley Reservoir, Newmiller Dam, Ardsley Reservoir, Whitley Reservoir, Park Dam, Scammonden Water, Ridgestone Edge Reservoir, Booth Wood Reservoir, Booth Dean Upper Reservoir, Green Withens Reservoir, Baitings Reservoir, Wharley Moor Reservoir, Haigh Cote Dam, Leadbeater Dam, Ogden Reservoir, Walshaw Dean Upper, Middle and Lower Reservoirs, Widdop Reservoir, Gorple Lower Reservoir, Warland Reservoir, Light Hazzles Reservoir, White Holme Reservoir, Withens Clough Reservoir, Ringstone Edge Reservoir, Deanhead Reservoir, Wessenden Head Reservoir, Wessenden Reservoir, Blakeley Reservoir, Swellends Reservoir, Redbrook Reservoir, Butterley Reservoir, March Haigh Reservoir and Compensation Reservoir. As for the River Aire, there is considerable variation in the size and capacity of these reservoirs; some are very large, and some are smaller ornamental lakes. Some structures are maintained for public water supply, and some for water supply to Calder and Hebble and Aire and Calder Navigations.

The Leeds and Liverpool Canal and Aire and Calder Navigation follow the course of the River Aire through the study area. Flooding from canals can occur for three reasons:

1. Where the Canal is used as a major flow path for fluvial floodwater from a local watercourse or surface water runoff and its capacity is exceeded resulting in over-topping;
2. Where the Canal is embanked, and a raised section of bank is breached or the aqueduct fails or;
3. Operational failure, e.g. where lock paddles are improperly left open and flows are not properly controlled.

Details of recorded Canal breach and overtopping incidences within the study area have been provided by the Canals and Rivers Trust and are summarised in Table 9-1.

Table 9-1: Canal Breach and Overtopping Records within Study Area

Date	Canal	Type	Location	Description
15/06/2007	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Flooding on River Aire – Canal is part of River Aire in this reach.
25/06/2007	Leeds and Liverpool Canal	Overtopping	Rodley Marina, Rodley, near Bagley Beck	Field runoff increased canal water level.
25/06/2007	Aire and Calder Navigation	Overtopping	Woodlesford	Flood bank overtopped by adjacent river Aire
25/06/2007	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Flooding on River Aire – Canal is part of River Aire in this reach.
13/01/2015	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Minor overtopping, cause unknown
27/06/2015	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Vandalism with lock paddles left in incorrect position
07/01/2016	Aire and Calder Navigation	Overtopping	Woodlesford	Flood bank overtopped by adjacent river Aire
23/12/2015	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Overtopping due to heavy rain, resolved by opening sluices.
26/12/2015	Leeds and Liverpool Canal	Breach	Leeds City Centre	Lock bywash damaged during works on Leeds Flood Alleviation scheme resulting in breach
02/08/2017	Leeds and Liverpool Canal	Overtopping	Kirkstall Forge	Insufficient capacity in overflow channel.
20/04/2018	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Possible overtopping recorded, possibly caused by vegetation blocking sluices.
12/01/2018	Leeds and Liverpool Canal	Overtopping	Leeds City Centre	Blockage of lock bypass channel

The records in Table 9-1 show that the most common cause of flooding from Canals (5 of 12 occasions) in the study area is overtopping where the Leeds and Liverpool Canal or Aire and Calder Navigation join the River Aire. This allows floodwater to flow into the canalised sections and cause flooding – this flood mechanism is represented in the hydraulic flood modelling of the River Aire and the fluvial flood outlines can be used to assess the risk to proposed development sites. Failure of Canal structures due to vandalism is less common, accounting for only one record of flooding, but failure of canal structures due to blockage or lack of capacity accounts for a further three incidents. Runoff from a natural catchment area draining to the canal caused overtopping on one occasion and on one further occasion the cause of overtopping is unknown. There is only one recorded incidence of breach within the study area, and this was associated with significant engineering works to the canal and adjoining River Aire.

Overall, the risk of flooding from Canals is low across the study area and is associated mainly with fluvial flooding on adjoining watercourses. The recorded overtopping incidents are either localised or associated with major fluvial flood events and the only breach event was caused by local engineering works. Most of the study area will not be at risk of flooding from Canals, however sites adjacent to Canals should assess this risk in more detail.

10. Flood Risk with Climate Change

Climate change is causing more frequent intense rainfall events, in addition to more frequent extreme weather conditions (e.g. extremely wet winters and extremely dry summers). This will increase the risk of flooding in future as the capacity of natural (rivers) and artificial (sewers) drainage systems is exceeded. The risk can be exacerbated by development and land use change which reduce infiltration of rainwater into the soil. This Section provides an assessment of changes in fluvial flood risk in Leeds, based on the currently available information, as well as current allowances to be used in assessment of future fluvial flood risk to sites and rainfall intensity for design of drainage systems.

10.1 Climate Change Allowances for Leeds CC Area

Current climate change allowances for river flow were updated on 27 July 2021 and are available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. The updated climate change allowances are calculated on the scale of individual river management catchment areas, while the previous allowances had been calculated on the scale of regional river basins. The study area includes two river management catchments – the Aire and Calder and the Wharfe and Lower Ouse. The current climate change allowances for these river management catchments are shown in Table 10-1 and Table 10-2 - These allowances are usually used to adjust the 1 in 100 year annual probability (1% AEP) river flow.

Table 10-1: Climate Change Allowances for River Flow Increases in the Aire and Calder River Management Catchment

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	24	31	51
Higher central	15	18	31
Central	11	13	23

Table 10-2: Climate Change Allowances for River Flow Increases in the Wharfe and Lower Ouse River Management Catchment

Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper end	22	29	48
Higher central	14	18	31
Central	11	13	23

The allowance to be applied to a proposed development site depends on the type of development proposed. Development is divided into vulnerability classifications under NPPF[20] and Table 10-3 shows which climate change allowances should be applied to each vulnerability classification in a given Flood Zone. Development vulnerability types are given in Table 12-1.

Table 10-3: Climate Change Allowances to be Applied for Each Development Vulnerability Classification

Flood Zone	Development Vulnerability	Climate Change Allowance
2 and 3a	Essential Infrastructure	Higher Central
	Highly Vulnerable, More Vulnerable, Less Vulnerable and Water Compatible	Central
3b	Essential Infrastructure	Higher Central
	Highly Vulnerable, More Vulnerable and Less Vulnerable	Development should not be permitted
	Water Compatible	Central

[20] https://www.gov.uk/guidance/flood-risk-and-coastal-change#Table-2-Flood-Risk-Vulnerability-Classification, accessed 12 July 2021

The above allowances are applied to the 1 in 100 year annual probability (1% AEP) flow to assess the potential future flood risk to development sites, including sites which are in Flood Zone 1 under the present day scenario but may be in Flood Zones 2 or 3 in future. The central allowance should be used for assessing risk to access and egress routes, escape routes and places of refuge, except for essential infrastructure when the higher central allowance should be used.

Climate change allowances should also be used to design mitigation measures for essential infrastructure or water compatible uses that result in loss of floodplain storage. According to the current Environment Agency guidance, the central allowance should be used unless the affected area includes essential infrastructure, in which case the higher central allowance should be used.

The climate change allowances for peak river flow in relation to SFRA's are set out in the current climate change allowances (July 2021). For SFRAs both the central and higher central allowances should be assessed.

Where the SFRA shows an increased risk of flooding in the future apply the peak river flow allowances to developments and allocations. This includes locations that are currently in Flood Zone 1 but might be in Flood Zone 2 or 3 in the future.

10.2 Functional Floodplain with Climate Change

The Functional Floodplain (Flood Zone 3b) comprises land where water has to flow or be stored in times of flood or land having a 1 in 20 or greater annual probability (5% AEP) of river flooding. The impact of climate change, with higher intensity and more frequent storms, is likely to result in increases in peak river flow levels. The Environment Agency have recently updated the guidance on peak river flow allowances. As an example using the "central allowance" the increase in the peak river flow will be 23% in the 2080's (Aire and Wharfe). Changes to the functional floodplain with climate change are shown in Appendix A Figure A.20.

The SFRA has used existing hydraulic modelling output to estimate the likely changes in the extent of Functional Floodplain with climate change, in many cases these were 20% as proxy for 23%, 30% as a proxy for 31% and 50% as a proxy for 48/51%. This future scenario has also assumed that the LFAS and Otley FAS have been completed and therefore these schemes have been included within the estimate of the future Functional Floodplain.

10.3 Peak Rainfall Intensity Allowance

Development proposals should include drainage designs which will ensure that the proposals do not increase flood risk off-site through increasing the rates and volumes of surface water runoff. Further requirements for drainage systems are discussed in Section 15, however these drainage proposals will need to include appropriate allowances for future increased rainfall intensity during the design event. Very large strategic rural development sites (more than 5km^2) should use the allowances for river flow in Table 10-1 and Table 10-2, however urbanised sites and sites smaller than 5km^2 should apply the allowances in Table 10-4 and Table 10-5. Both the central and upper end allowances based on the lifetime of the development should be considered in the drainage design calculations to understand the potential range of impacts due to climate change. Further details of how these are applied can be found in Environment Agency guidelines 'Flood risk assessments: climate change allowances'[21].

Table 10-4: Climate Change Allowances for Peak Rainfall Intensity in the Aire and Calder Management Catchment

Allowance category	'2050s' (2022 to 2060) 30 year return period	'2050s' (2022 to 2060) 100 year return period	'2070s' (2061 to 2125) 30 year return period	'2070s' (2061 to 2125) 100 year return period
Upper end	35%	40%	40%	45%
Central	20%	25%	25%	30%

[21] Flood risk assessments: climate change allowances https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Table 10-5: Climate Change Allowances for Peak Rainfall Intensity in the Wharfe and Lower Ouse Management Catchment

Allowance category	'2050s' (2022 to 2060) 30 year return period	'2050s' (2022 to 2060) 100 year return period	'2070s' (2061 to 2125) 30 year return period	'2070s' (2061 to 2125) 100 year return period
Upper end	35%	40%	40%	40%
Central	20%	25%	25%	30%

The design of the proposed development should consider overland flow paths in the event that the capacity of the drainage system is exceeded, including assessment of the impacts of climate change. If overland flows are such that the velocity or depth of surface water flow is sufficient to present a hazard to site users then mitigation measures should be provided – the upper end allowance for climate change should be used in this assessment, and there should be no significant flood hazard to site users when the central allowance is applied.

10.4 Climate Change Risk in LCC Area - Main Rivers

The currently available flood modelling for Main Rivers and Ordinary Watercourses in the study area uses 20%, 30% and 50% allowances for future increase in fluvial flood risk in the study area and are based on UKCP09 climate change projections. These allowances are applied to the 1 in 100 year annual probability (1% AEP) flow and the resulting flood maps are provided in Appendix A Figure A.7 and Figure A.8. These climate change allowances provide a good approximation of the 2021 climate change allowances set out in Table 10-1 and Table 10-2 above. The coverage of flood modelling with appropriate climate change allowances for the various watercourses across the Leeds District is complex. Included within Appendix B is an overview of the modelling data and an indication of where proxies have been utilised to define modelled climate change outlines. The changes in flood extent are discussed below for each Main River watercourse for which this modelling has been carried out.

10.4.1 River Aire

The impacts of climate change on flood risk from the River Aire has been assessed taking into account the presence of flood defences. This is because the main impact of climate change will be to reduce the standard of protection provided by the flood defence schemes that have been completed.

The completed LFAS Phase 1 provides a 1 in 100 annual probability (1% AEP) plus climate change protection to 2039. However, the modelling results also show that the extent of flooding in the 1 in 100 year annual probability (1% AEP) event will be significantly increased as a result of climate change. The main area of risk is at the downstream end of Wortley Beck, where this watercourse is known as Hol Beck, and is at risk of flooding in the 1 in 100 year annual probability (1% AEP) event including a 23% allowance for climate change. Areas immediately adjacent to the River Aire are also at risk when a 31% allowance is used. A 51% increase in the 1 in 100 year annual probability (1% AEP) event flow significantly exceeds the capacity of the flood alleviation scheme and presents a risk of flooding to large areas of Leeds City Centre, although the reach of the river downstream to the M1 can generally convey this flow.

No climate change flood outlines are available for the reach of the River Aire between the M1 and the A642 because this section falls between the modelled flood extent from the Phase 1 LFAS and the 2017 Lower Aire study. A provisional assessment of changes in flood risk from climate change has been made in this area using the Flood Zone 2 outline as a proxy for the 1 in 100 year annual probability (1% AEP) plus climate change event. However, it should be noted that this section of watercourse may benefit indirectly from changes in flow due to the LFASs, and that a more detailed analysis will be required if large developments are planned for this area. The Flood Zone 2 outline shows that climate change in this section will increase the flooded area, but mainly in areas of existing green open space such as the River Aire/Leeds and Aire and Calder Navigation corridor.

The extent of flooding downstream of the A642 is expected to increase as a result of climate change, with a 23% and 31% allowance resulting in a similar extent of change and increased flood risk immediately downstream of the A642 and to the Allerton Bywater area. A 51% allowance for climate change produces a flood extent which is extremely similar to the present day 1 in 1000 year annual probability (0.1% AEP) flood extent.

Along much of the River Aire with the LFAS, the Functional Floodplain (1 in 20 year annual probability (5% AEP)) with a climate change allowance (future Functional Floodplain) is contained within the defences. Therefore, the reaches of the Aire that benefit from LFAS1 and LFAS2 are not expected to cause an increase in the extent of the Functional Floodplain. There is increased flooding in the Lower Aire flood storage areas in the 1 in 20 year annual probability (5% AEP) with a climate change allowance (future Functional Floodplain) as more water is stored in these areas.

The Environment Agency are currently reviewing and revising the LFAS1 as-built hydraulic model downstream around Woodlesford and once this information and flood outlines are available, the SFRA web-based mapping will be updated.

10.4.2 River Wharfe

The impacts of climate change on flood risk from the River Wharfe has been assessed taking into account the presence of flood defences. This is because the main impact of climate change will be to reduce the standard of protection provided by flood defence schemes.

The available modelling results show similar increased flood extents on the River Wharfe when 23%, 31% and 48% allowances for climate change are applied to the 1 in 100 year annual probability (1% AEP) flow. The flood extent is similar to the present day defended 1 in 1000 year annual probability (0.1% AEP) flood extent. The main area of increased flood risk is in Collingham, where a small number of additional properties are at risk of flooding.

Within the River Wharfe catchment the Functional Floodplain with climate change (1 in 20 year annual probability (5% AEP) increases in extent within Otley, downstream of Otley and through Wetherby.

10.4.3 River Calder

The model output shows an increase in flood risk with climate change from the River Calder. The extent of flooding increases in the undefended scenario and shows that the extent of flooding in the 1 in 100 year annual probability (1% AEP) event could increase significantly in future. This area of the District includes important areas of both flood storage and areas benefiting from defences (with uncertain standard of protection). The standard of protection to areas of Methley would be expected to decrease with climate change. Development proposals in this area should consider the future risk of flooding from the River Calder.

10.4.4 Meanwood Beck

There are no significant flood defences along Meanwood Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. The 23%, 31% and 51% allowances for climate change give generally similar flood extents, similar to or slightly smaller than the present day 1 in 1000 year annual probability (0.1% AEP) flood extent along Meanwood Beck. The 1 in 100 year annual probability (1% AEP) flood extent is not significantly increased due to climate change along the modelled tributary of Meanwood Beck because the culverted sections have sufficient capacity to convey the increased flow (flooding is expected in the 1 in 1000 year annual probability (0.1% AEP) event on this tributary).

10.4.5 Wyke Beck

There are no significant flood defences along Wyke Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. The current modelling includes a 20% allowance for climate change only and shows no significant increase in the 1 in 100 year annual probability (1% AEP) flood extent using this allowance. Using the current 1 in 1000 year annual probability (0.1% AEP) flood extent as a proxy for the higher climate change allowances shows potential for significant increased flood risk to residential developments along the Wykebeck Valley Road area.

10.4.6 Oulton Beck

There are no significant flood defences along Oulton Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. The 23%, 31% and 51% allowances for climate change give generally similar flood extents, similar to or slightly smaller than the present day 1 in 1000 year annual probability (0.1% AEP) flood extent along Oulton Beck. In the area in and around Rothwell there is increased extent and risk of flooding with climate change especially at the 1 in 100 year annual probability (1% AEP).

10.4.7 Bagley Beck

There are no significant flood defences along Bagley Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. This shows that the 23%, 31% and 51% allowances for climate change generally show similar increased flood extent, generally similar to the extent of flooding currently expected in the 1 in 1000 year annual probability (0.1% AEP) event. However, the majority of the area affected by flooding is also currently at risk in the 1 in 100 year annual probability (1% AEP) event, and the increased flood extent generally affects undeveloped land between the Leeds and Liverpool Canal and the River Aire.

10.4.8 Cock Beck

Detailed flood modelling of climate change scenarios for sections of Cock Beck indicate that flood risk along Cock Beck is not expected to increase significantly as the difference in flood extent with and without the climate change allowance is minimal. However, there may be some increase in risk in Aberford, immediately upstream of the A1(M).

10.4.9 Collingham Beck and Fir Green Beck

There are no significant flood defences along Collingham Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. This shows that the 23%, 31% and 48% allowances for climate change generally show similar increased flood extent, generally similar to the extent of flooding currently expected in the 1 in 1000 year annual probability (0.1% AEP) event. There is also potential increased risk of flooding from Collingham Beck to the A58 and properties at Bardsey, as well as undeveloped land downstream.

Along Fir Green Beck there is potential for increased risk downstream of the A1(M), including to the settlement of Bramham.

10.4.10 Hol Beck and Kel Beck

There are no significant flood defences along Hol Beck and Kel Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. This shows that the 23%, 31% and 48% allowances for climate change generally show increased flood extent, particularly at the 1 in 20 year annual probability (5% AEP) event.

10.4.11 Farnley Wood Beck and Wortley Beck

There are currently no significant flood defences along Farnley Wood Beck or Wortley Beck and the impacts of climate change have therefore been considered with reference to undefended flood outlines. The available flood modelling shows that 21%, 31% and 51% allowances for climate change generally produce similar flood extents, and that these flood extents are similar to the present day 1 in 100 year annual probability (1% AEP) flood extent. The current climate change allowances therefore make minimal impact on the risk of flooding to developments along these watercourses.

10.4.12 Lin Dyke

Detailed flood modelling of climate change scenarios is not available for Lin Dyke. Flood Zones 2 and 3 have therefore been used to identify where climate change may significantly increase the risk of flooding. These flood zones have very similar flood extents along most of Lin Dyke, suggesting that climate change will not significantly increase the extent of flooding in the 1 in 100 year annual probability (1% AEP) event. The main areas where an increase is possible is towards the downstream extent of Lin Dyke, north of Allerton Bywater, however this does not affect developed areas.

10.5 Climate Change Risk in LCC Area - Ordinary Watercourses

Modelled flood outlines do not currently exist for most Ordinary Watercourses within the study area. The risk to sites adjoining Ordinary Watercourses will need to be assessed on a case by case basis, potentially including detailed hydrological and hydraulic modelling studies. These studies should apply the climate change allowances set out in Section 10.1 unless these are superseded.

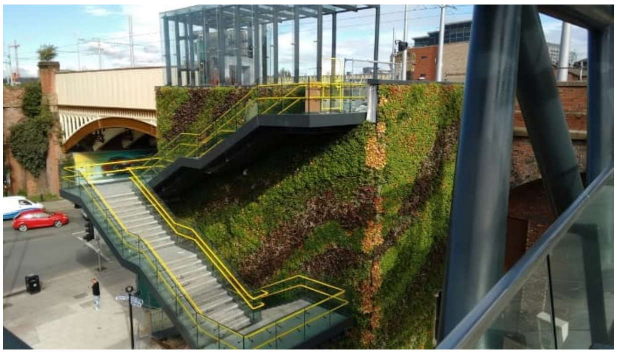
10.6 Climate Change Risk - Surface Water & Drainage

The risk of surface water flooding map does not include a specific scenario to determine the impact of climate change on the risk of surface water flooding. However a range of three annual probability events have been undertaken, 1 in 30 year (3.33% AEP), 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP), and therefore it is possible to use with caution the 1 in 1000 year annual probability (0.1% AEP) outline as a substitute dataset to provide an indication of the implications of climate change in site- specific FRAs. This assessment should include discussion of any local, relevant policies and actions taken under LCC actions to reduce climate change, including aspirations for providing additional bio-diversity and green infrastructure.

10.7 Managing flood risk with Climate Change

Blue-Green Infrastructure, Sustainable Drainage and Water Sensitive Urban Design are all important elements of the sustainable urban design process that can reduce flood risk. By working with and enhancing natural habitats to take advantage of their ability to sequester carbon, nature-based solutions have the potential to tackle climate mitigation and adaptation challenges at relatively low cost while delivering numerous additional benefits for the Leeds District.

Upton Sustainable Drainage



Deansgate, Green Wall

Natural Flood Management

Natural Flood Management (NFM) is a sustainable catchment-based approach to complement sustainable water management in our cities and towns and reduce the risk of flooding.

Swindale Beck re-meandering

The natural landscape plays an important role in managing water. NFM uses natural features, such as tree planting, to store or slow down the flow of water before it reaches communities downstream. NFM can provide multiple benefits to compliment engineered solutions, enhancing the natural environment whilst providing reduced flood risk to the built environment. This includes:

- increased bio-diversity through river restoration
- green networks through riparian vegetation and native species buffer strips
- healthier moorlands through moorland grip blocking
- water supply to farms
- reduced fine sediment loading to rivers.

Within the wider Aire catchment NFM techniques can play a key role in improving resilience to climate change. To compliment the engineering work being developed as part of the LFAS (Phase 2) and Wyke Beck FAS Phase 2 NFM techniques are being implemented (eg. White Rose Forest https://whiteroseforest.org/about/aire-river-catchment-programme/). In other parts of Leeds District similar approaches should be actively considered to identify and implement NFM techniques.

Working with Natural Processes

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

Braid Burn – flood management

Leicester Conveyance improvements

Although the restoration of a floodplain is difficult in previously developed areas where development cannot be rolled back, the following measures are methods that could be implemented to help catchment and floodplain restoration:

- Promoting existing and future brownfield sites that are adjacent to watercourses to naturalise banks as much as possible.
- Buffer areas around watercourses provide an opportunity to restore parts of the floodplain.
- Removal of redundant structures to reconnect the river and the floodplain.
- Avoid placing new development within the floodplain

A review of the mapping outputs from the Environment Agency led research project 'Working with Natural Processes' has been used to identify potential locations for Working with Natural Processes (WWNP) in the District. Four of these layers are included within the Appendix A Figure A.19:

- *WWNP Floodplain Reconnection Potential* – best estimate of locations where it may be possible to establish reconnection between a watercourse and its natural floodplain, especially during high flows. The dataset is designed to support signposting of areas where there is currently poor connectivity such that flood waters are constrained to the channel and flood waves may therefore propagate downstream rapidly.
- *WWNP Floodplain Woodland Potential* – best estimate of locations where tree planting on the floodplain may be possible, and effective to attenuate flooding. The dataset is designed to support signposting of areas of floodplain not already wooded.
- *WWNP Riparian Woodland Potential* – best estimate of locations where tree planting may be possible on smaller floodplains close to flow pathways, and effective to attenuate flooding. The dataset is designed to support signposting of riparian areas not already wooded.
- *WWNP Wider Catchment Woodland Potential* – best estimate of locations where there are slowly permeable soils, where scrub and tree planting may be most effective to increase infiltration and hydrological losses. The dataset is designed to support signposting of areas not already wooded.

Blue-Green Infrastructure

Blue-Green infrastructure, including urban green spaces, such as parks, green walls and green roofs and urban wetlands, provide resilience to climate change. This approach protects, restores, or mimics the natural water cycle and allows a way of managing surface water as close as possible to where it falls.

SuDS at Olympic Park
https://www.susdrain.org/case-studies/case_studies/olympic_park_london.html

In terms of climate resilience woodlands, wetlands, grasslands and marshlands can effectively absorb carbon dioxide and sequester carbon, mitigating emissions as well as providing benefit in terms of quality and quantity of stormwater run-off. There are opportunities for increased green-blue infrastructure that creates a natural system of resilience against the impacts of the climate change including reducing local temperatures, lowering flood risk and defending against storms. It also provides a mechanism to reconnect individuals and local communities with the natural landscape.

Clandeboye Rainwater Garden

SuDS at Clandeboye Primary School, taking inspiration from the natural environment and a child's love of play to design a raingarden consisting of ponds, cascades, bog gardens and duck races.

Those proposing development should actively consider opportunities to undertake river/watercourse restoration and enhancement and implement natural flood management measures as part of a development to make space for water and reduce flood risk. Enhancement opportunities should be sought when renewing assets (e.g. de-culverting, the use of bio-engineered river walls, raising bridge soffits to take into account climate change).

The SusDrain website provides range of case studies of successful implementation of sustainable drainage. https://www.susdrain.org/

11. Residual flood risk

11.1 Overview

It is important to recognise that the risk of flooding in the study area can never be fully mitigated, and there will always be a residual risk of flooding that will remain after measures have been implemented to protect an area or a particular site from flooding. This residual risk is associated with a number of potential risk factors including (but not limited to):

- a flooding event that exceeds that for which the flood risk management measures have been designed e.g. flood levels above the designed finished floor levels,
- the structural deterioration of flood defence structures (including informal structures acting as a flood defence) over time, and/or
- general uncertainties inherent in the prediction of flooding (the modelling of flood flows and flood levels is not an exact science, therefore there are inherent uncertainties in the prediction of flood levels used in the assessment of flood risk. Whilst the NPPF flood zones provide a relatively robust depiction of flood risk for specific conditions, all modelling requires the making of core assumptions and the use of empirical estimations relating to (for example) rainfall distribution and catchment response.)

Steps should be taken to further reduce these residual risks where required, e.g. through the use of flood warning and evacuation procedures, as described in Section 14.

11.2 Residual Risk Within the Study Area

The principal source of residual flood risk within the study area is failure of water management infrastructure. Small scale failures, e.g. localised blockage or exceedance of the capacity of surface water sewers, will need to be considered on a site-by-site basis, however the risk from breaching of flood defences has potential to affect larger areas and multiple sites. The principle areas defended by structures which may breach (embankments and walls) are:

- Leeds City Centre (flood risk reduced by flood walls and infrastructure on the River Aire and Wortley Beck);
- Washlands downstream of the A642 (protected by embankments on the River Aire);
- Collingham (protected by embankments on Collingham Beck and the River Wharfe);
- Wetherby (protected by embankments on the River Wharfe, but to a low standard of protection), and;
- Otley (when Otley FAS is completed) protected by embankments on the River Wharfe.

Note that there are additional flood defences in the study area, including demountable defences and flood gates. These defences have a particularly high level of residual risk because they depend on deployment and operation during flood events which may not occur due to factors such as rapid onset of flooding or lack of access.

The Aire CFMP[22] includes policies to maintain and improve the level of flood protection provided to Leeds City Centre. This will reduce the residual risk to Leeds from breach of raised flood defences.

The River Ouse CFMP[23] includes plans to reduce the risk of flooding to Collingham and Wetherby. This includes maintaining and improving existing flood defences, which will reduce the residual risk in this area due to breach of fluvial flood defences.

[22] Aire Catchment Flood Management Plan Summary Report, Environment Agency, December 2010
[23] River Ouse Catchment Flood Management Plan Summary Report, Environment Agency, December 2010

11.2.1 Residual Risk, Operation and Maintenance of the LFAS

LFAS1 includes the moveable weirs at Crown Point and Knostrop which present a residual risk should they not operate during a flood event. The flood walls alone provide a lesser standard of protection than the moveable weirs and flood walls together. The flood defences also include a number of floodgates, there is also a residual risk that these may not be closed in advance of a flood event.

LFAS2 will include moveable gates at the storage area in Calverley and should they not operate correctly, there is a risk that flows in excess of the 1 in 100 year annual probability (1% AEP) event will pass downstream and could overtop the linear defences.

When completed LFAS2 includes structures which may breach (embankments and walls).

11.2.2 LFAS maintenance

LCCs Flood Risk Management team are responsible for the flood defence assets that have been, and will be delivered, by the LFAS. The delivery of the scheme has included detailed input with LCC's Flood Risk Management team to ensure that they understand, appreciate and are able to develop the operation and maintenance requirements. The LCC Flood Risk Management team undertakes a regular schedule of maintenance for the flood defence assets ensuring that they are in good working order and operational.

11.2.3 Rapid Inundation Zone

Failure of water management infrastructure such as a breach of the fluvial flood defences or overtopping of flood defences may result in areas that are at risk of rapid inundation. These areas, generally near to flood defences, may be impacted by high velocity floodwater with sudden onset and significant depth of flooding.

Developers will need to demonstrate that their sites are not affected by rapid inundation in the event of breach or other failure of flood defences.

12. Sequential Test and Site Allocations

12.1 Sequential Approach

This Section provides information on the Sequential Test in Local Development Plan-making and planning application processes and information on the approach taken by LCC to the Sequential Test and Site Allocation. Not all development will be required to undergo the Sequential Test, as described below, but may still be required to undertake a site-specific FRA, guidance about which is included in Section 14.

The sequential approach is a decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to sites at higher risk. This will help avoid the development of sites that are inappropriate on flood risk grounds. The sequential approach can be applied at all levels and scales of the planning process, both between different sources of flooding, within fluvial flood zones and within sites. All opportunities to locate new developments (except Water Compatible) in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

12.2 Applying Sequential Test – Plan-Making

As the LPA, LCC must demonstrate that throughout the site allocation process that a range of possible sites have been considered in conjunction with the flood risk information and that the Sequential Test has been applied. The Sequential Test requires an understanding of all sources of flooding within the District, including the fluvial flood zones in the study area and risk and potential sources of surface water flooding. Also the vulnerability classification of the proposed developments. Flood zone definitions are provided in Section 8.1 and mapped in Appendix A Figure 4 (and the Environment Agency's Flood Map for Planning (Rivers and Sea)) and Risk of Surface Water flooding is mapped in Appendix A Figure A.9. Flood risk vulnerability classifications, as defined in the PPG are presented in Table 12-1 and Table 12-2 sets out which development vulnerability classifications are considered appropriate within each flood zone. The NPPF acknowledges that some areas will be at risk of flooding from sources other than fluvial. All sources must be considered when planning for new development including; flooding from land or surface water runoff; groundwater; sewers; and artificial sources (see Section 9).

The flow diagram presented in Figure 12-1 illustrates how the Sequential Test process should be applied to identify the suitability of a site for allocation, in relation to the flood risk classification.

Table 12-1: Flood Risk Vulnerability Classification (PPG)

Vulnerability Classification	Development Uses
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as "essential infrastructure").
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Vulnerability Classification	Development Uses
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in "more vulnerable", and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water-Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 12-2: Flood Risk Vulnerability and Flood Zone 'Compatibility' (PPG[2], 2014)

Flood Risk Vulnerability Classification		Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone	1	✓	✓	✓	✓	✓
	2	✓	Exception Test Required	✓	✓	✓
	3a	Exception Test Required	×	Exception Test Required	✓	✓
	3b *[1]	Exception Test Required*	×	×	×	✓*

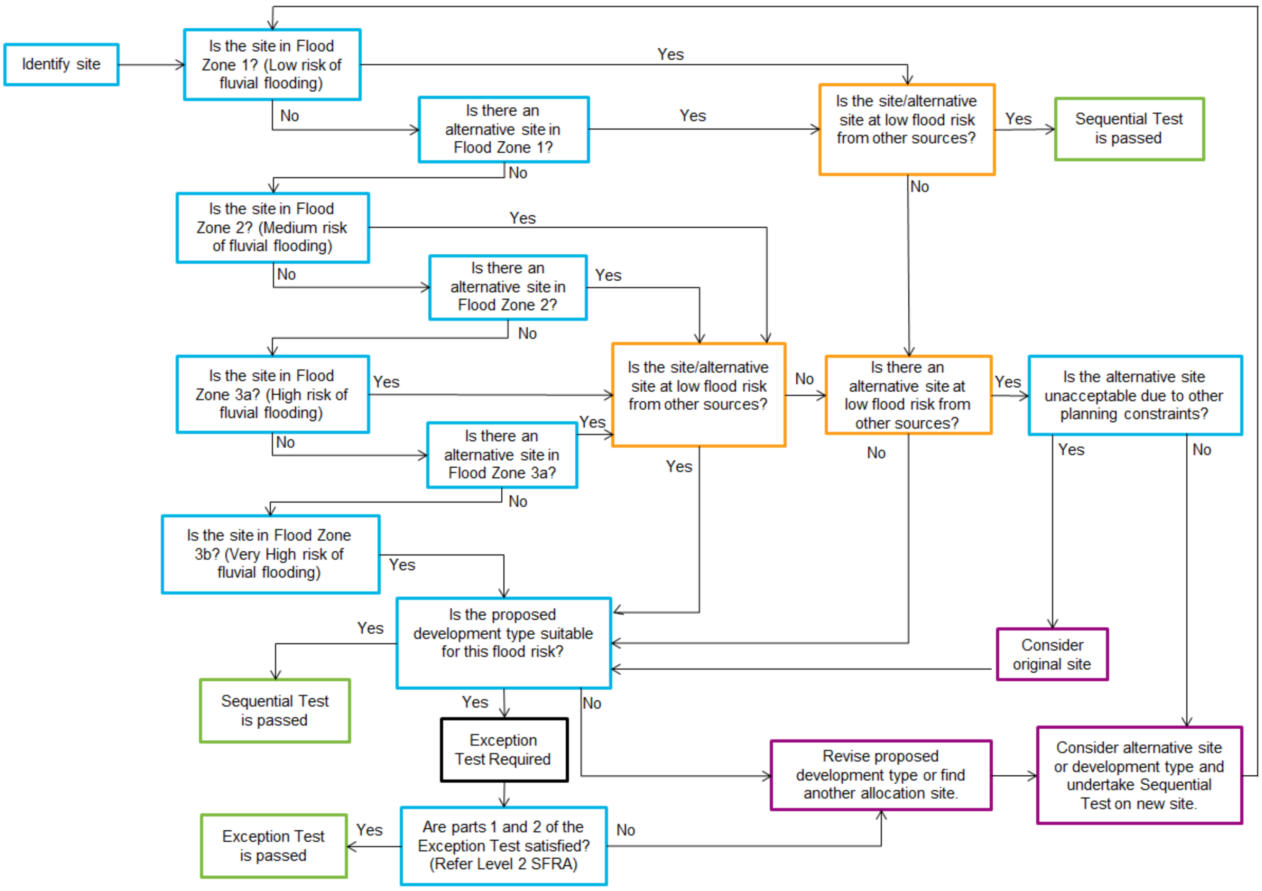
✓ - Development is appropriate × - Development should not be permitted

* In Flood Zone 3b (Functional Floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

[1]There are some areas within Flood Zone 3b that are already developed and are prevented from flooding by the presence of existing infrastructure or solid buildings. Whilst these areas will be subject to frequent flooding it may not be practical to refuse all future development.

Figure 12-1: Application of Sequential Test for Plan-Making



The recommended steps in undertaking the Sequential Test are detailed below. This is based on the Flood Zone and Flood Risk Vulnerability.

12.2.1 Recommended stages for LPA application of the Sequential Test in Plan-Making

LPAs take the following steps in the application of the Sequential Test:

1. Assign potential developments with a vulnerability classification (Table 12-1). Where development is mixed, the development should be assigned the highest vulnerability class of the developments proposed.
2. The location and identification of potential development should be recorded.
3. The flood zone classification of potential development sites should be determined based on a review of flood risk information contained within SFRA. Where these span more than one flood zone all zones should be noted, preferably using percentages. All sources of flooding need to be considered within the Sequential Test therefore the risk of flooding from all sources to sites needs to be identified.
4. The design life of the development should be considered with respect to climate change:
   - 100 years –for residential developments; and
   - 75 years – for commercial / industrial developments, or other time horizon specific to the non-residential use proposed.
5. Identify existing flood defences serving the potential development sites. If a site is defended in Flood Zone 3a it is sequentially preferable to a site that is undefended in Flood Zone 3a.
6. Highly Vulnerable developments to be accommodated within the LPA area should be located on those sites identified as being within Flood Zone 1 and low risk of flooding from other sources. If these cannot be located within this low risk area because the identified sites are unsuitable or there are insufficient sites in areas of low flood risk, sites in moderate risk of flooding (Flood Zone 2 and moderate risk of surface water) can then be considered. If sites in moderate flood risk areas are inadequate then additional sites in higher flood risk areas may need to be identified to accommodate development or opportunities sought to locate the development outside the LPA.

7. Once all Highly Vulnerable developments have been allocated to a development site, consideration can be given to those development types defined as More Vulnerable. In the first instance More Vulnerable development should be located on sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites remaining, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate More Vulnerable development, sites in Flood Zone 3a can be considered. More Vulnerable developments in Flood Zone 3a will require application of the Exception Test (see Section 12).
8. Once all More Vulnerable developments have been allocated to a development site, consideration can be given to those development types defined as Less Vulnerable. In the first instance Less Vulnerable development should be located on sites in Flood Zone 1, continuing sequentially with Flood Zone 2, then 3a. Only Essential Infrastructure and Water Compatible uses are appropriate in Flood Zone 3b Functional Floodplain.
9. Essential Infrastructure should be preferentially located in the lowest flood risk zones, however this type of development may be located in Flood Zones 3a and 3b, provided the Exception Test is satisfied.
10. Water Compatible development has the least constraints with respect to flood risk and it is considered appropriate to allocate these sites last. The sequential approach should still be followed in the selection of sites; however, it is appreciated that Water Compatible development by nature often relies on access and proximity to water bodies.
11. On completion of the Sequential Test, consideration may need to be given to the risks posed to a site within a flood zone in more detail. This more detailed study should consider the detailed nature of flood hazard to allow a sequential approach to site layout within a flood zone. Consideration of flood hazard within a flood zone would include:
    - flood risk management measures,
    - the rate of flooding,
    - flood water depth,
    - flood water velocity.

Where the development type is Highly Vulnerable, More Vulnerable, Less Vulnerable or Essential Infrastructure and a site is found to be impacted by a recurrent flood source (other than tidal or fluvial), the site and flood sources should be investigated further regardless of any requirement for the Exception Test.

12.2.2 Windfall Sites

Windfall Sites is a term to describe development on a site not specifically allocated for development in a development plan, but which unexpectedly becomes available for development during the lifetime of a plan. It is recommended that the acceptability of windfall applications in flood risk areas should be considered at the strategic level through a policy setting out broad locations of windfall development that would be acceptable or not in Sequential Test terms.

12.3 Applying Sequential Test – Planning Applications

It is necessary to undertake a Sequential Test for a planning application if both of the following apply:

- The proposed development is in Flood Zone 2 or 3.
- The Sequential Test hasn't already been applied for a development of the type intended for the proposed site by LCC while developing the Local Plan.

The Environment Agency publication 'Demonstrating the flood risk Sequential Test for Planning Applications[24]' sets out the procedure for applying the sequential test to individual applications as follows:

- Identify the geographical area of search over which the test is to be applied; this could be the LCC area, or a specific catchment if this is appropriate and justification is provided (e.g. school catchment area or the need for affordable housing within a specific area). For residential or mixed use development the Housing Market Characteristic Area should be used as defined in the Site Allocation Plan and Core Strategy.

[24] Environment Agency, April 2012, 'Demonstrating the flood risk Sequential Test for Planning Applications', Version 3.1 https://www.gov.uk/guidance/flood-risk-assessment-the-sequential-test-for-applicants

- Identify the source of 'reasonably available' alternative sites; usually drawn from the Site Allocation Plan, Aire Valley Leeds Area Action Plan, Natural Resources and Waste Local Plan, Employment Land Survey and other evidence base / background documents produced to inform the Local Plan.
- State the method used for comparing flood risk between sites; for example, the Environment Agency Flood Map for Planning, the SFRA mapping, site-specific FRAs if appropriate, other mapping of flood sources.
- Apply the Sequential Test; systematically consider each of the available sites, indicate whether the flood risk is higher or lower than the application site, state whether the alternative option being considered is allocated in the Local Plan, identify the capacity of each alternative site, and detail any constraints to the delivery of the alternative site(s).
- Conclude whether 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 proposed.
- The presence of defences may be considered sequentially by identifying existing flood defences serving the potential development sites. For example, a site in defended Flood Zone 3a is sequentially preferable to a site that is undefended in Flood Zone 3a.
- Where necessary, as indicated by Table 12-2, apply the Exception Test.
- Apply the Sequential approach to locating development within the site, as described in Section 12.2.

It should be noted that it is for LCC, taking advice from the Environment Agency as appropriate, to consider the extent to which Sequential Test considerations have been satisfied, taking into account the particular circumstances in any given case. The developer should justify with evidence what area of search has been used when making the application.

Ultimately, after applying the Sequential Test, LCC needs to be satisfied in all cases that the proposed development would be safe and not lead to increased flood risk elsewhere. This needs to be demonstrated within a FRA (see Section 14) and is necessary regardless of whether the Exception Test is required.

12.4 Sequential Test Exemptions

It should be noted that the Sequential Test does not need to be applied in the following circumstances:

- Individual developments proposed on sites which have been allocated in development plans through the Sequential Test.
- Minor development, which is defined in the NPPF as:
  - minor non-residential extensions: industrial / commercial / leisure etc. extensions with a footprint <250m^2.
  - alterations: development that does not increase the size of buildings e.g. alterations to external appearance.
  - householder development: for example, sheds, garages, games rooms etc. within the curtilage of the existing dwelling, in additional to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling resulting in a net addition e.g. subdivision of houses into flats.
- Change of Use applications, unless it is for a change of use of land to a caravan, camping or chalet site, or to a mobile home site or park home site.
- Development proposals in Flood Zone 1 (land with a low probability of flooding from rivers or the sea) unless the SFRA, or other more recent information, indicates there may be flooding issues now or in the future (for example, through the impact of climate change, see Section 10).
- Redevelopment of existing properties (e.g. replacement dwellings), provided they do not increase the number of dwellings in an area of flood risk (i.e. replacing a single dwelling within an apartment block).

12.5 LCC Site Allocations

The sequential test was completed for sites allocated in the Site Allocations Plan and the Aire Valley Leeds Area Action Plan and further details can be found in the separate background paper explaining the methodology used.

- Site Allocations Plan, Flood Risk Sequential and Exception Test, Background Paper, May 2017. https://www.leeds.gov.uk/SiteAllocationMaps/SAP_Submission_Documents_May%202017/CD1-30%20Flood%20Risk%20Sequential%20and%20Exception%20Test%20Background%20Paper,%20May%202017lr.pdf

13. Applying the Exception Test – Assessment of Site Allocations

The application of the Exception Test, where required, will ensure that new developments in flood risk areas will only occur where flood risk is clearly outweighed by other sustainability drivers. The purpose of the Exception Test is to ensure that, following the application of the Sequential Test, new development is only permitted in Flood Zone 2 and 3 where flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, considering climate change.

For the Exception Test to be passed:

- Part 1 - It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA and;
- Part 2 - A site-specific FRA must demonstrate that 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.

Both elements of the test will have to be passed for development to be allocated or permitted.

In order to determine Part 1) of the Exception Test, applicants should assess their scheme against the objectives within the LCC Sustainability Appraisal (SA) Framework. In order to demonstrate satisfaction of Part 2) of the Exception Test, the flood risk management measures outlined in Section 14 should be applied and demonstrated within a site-specific FRA.

13.1 Application of Exception Test for Allocated Sites

To support the identification of site allocations and development of the Leeds Local Plan, a Flood Risk Exception Test – Site Specific FRA study was undertaken in 2017 by LCC for particular parts of Leeds District including the Aire Valley. The study provided supporting information to the Local Plan development and sought to identify for each development site:

- Part A -Wider sustainability benefits to the community that outweigh flood risk;
- Part B - High level FRA demonstrated that the development will be safe for its lifetime, without increasing flood risk elsewhere, and, where possible, reduce flood risk overall.

This study identified which sites passed the Exception Test and gave an indication of the mitigation measures that would be needed requirements for the site to be developed. The information in Part B of the Exception Tests will need to be updated by the developer as sites come forward for development.

14. Guidance for Site Specific FRAs

14.1 Overview

The NPPF appreciates that it may not always be possible to avoid locating development in areas at risk of flooding. This Section provides guidance on the range of measures that could be considered in order to manage and mitigate flood risk. These measures should be considered when preparing a site-specific FRA; Table 14-1 sets out which of these measures would need to be considered as part of proposals for householder developments, extensions and new developments.

As noted in Section 2.2, it is essential that the development management process influencing the design of future development within the study area carefully mitigates the potential impact that climate change may have upon the risk of flooding. As a result, mitigation measures should be designed with an allowance for climate change over the lifetime of the proposed development as follows:

- 100 years for residential developments; and
- 75 years for commercial / industrial developments, or other time horizon specific to the non-residential use proposed.

14.2 Development Layout and Sequential Approach

A sequential approach to site planning should be applied within new development sites. Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. Most large development proposals include a variety of land uses of varying vulnerability to different sources of flooding. The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas (considering all sources of flooding) e.g. residential elements should be restricted to areas at lower probability of flooding whereas parking, open space or proposed landscaped areas can be placed on lower ground with a higher probability of flooding.

14.3 Finished Floor Levels

All More Vulnerable and Highly Vulnerable development within Flood Zones 2 and 3 should set Finished Floor Levels 300mm above the known or modelled 1 in 100 year annual probability (1% AEP) flood level including an allowance for climate change. Where developing in Flood Zone 2 and 3 is unavoidable, the recommended method of mitigating flood risk to people, particularly with More Vulnerable (residential) and Highly Vulnerable land uses, is to ensure internal floor levels are raised by an appropriate freeboard level above the design flood level to account for uncertainty in determining flood levels.

In certain situations (e.g. for proposed extensions to buildings with a lower floor level or conversion of existing historical structures with limited existing ceiling levels), it could prove impractical to raise the internal ground floor levels to sufficiently meet the general requirements. In these cases, the Environment Agency and/or LCC should be approached using their respective pre-application enquiry services to discuss options for a reduction in the minimum internal ground floor levels provided flood resistance measures are implemented up to an agreed level. There are also circumstances where flood resilience measures should be considered first. These are described further below. For both Less and More Vulnerable developments where internal access to higher floors is required, the associated plans showing the access routes and floor levels should be included within any site-specific FRA.

Table 14-1 provides an overview of the minimum requirements for finished floor levels for development in LCC area.

Table 14-1: Finished Floor Levels

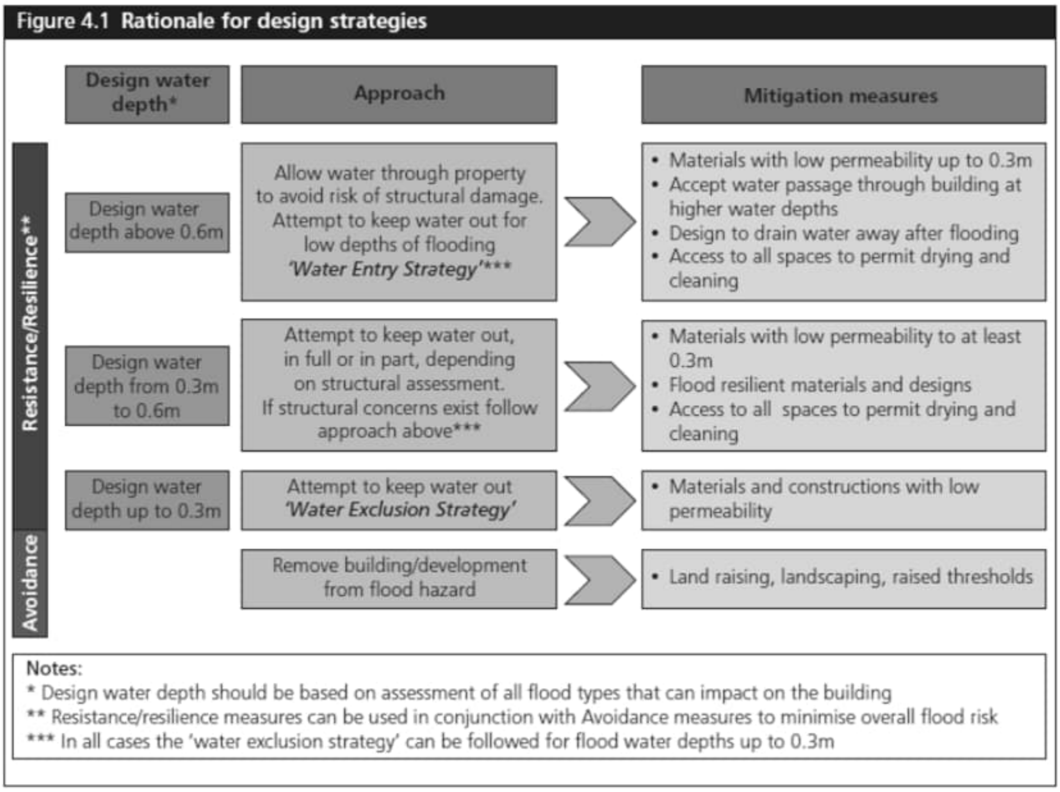
Development Type	Flood Zone 3	Flood Zone 2
Minor development (i.e. non-residential extensions with a floor space <250m^2 and minor householder developments undertaken within the curtilage of an existing property i.e. development directly linked to an existing residential building.)	Provide evidence to LCC that EITHER, Floor levels within the proposed development will be set no lower than existing levels AND, flood proofing of the proposed development has been incorporated up to 600mm above the level of the 1 in 100 annual probability flood event within an allowance for climate change where appropriate. Details of flood proofing / resilience and resistance techniques to be included in accordance with 'Improving the flood performance of new buildings' CLG (2007). OR, Floor levels within the extension will be set at a minimum of 300mm above the known or modelled 1 in 100 year (1% AEP) river flood event including climate change. Applicants should provide a plan showing floor levels relative to flood levels. All levels should be stated in relation to Ordnance Datum.	Provide evidence to LCC that, Floor levels within the proposed development will be set no lower than existing levels AND, flood proofing of the proposed development has been incorporated up to 600mm above the 1 in 100 annual probability flood event with an allowance for climate change where appropriate. Details of flood proofing / resilience and resistance techniques to be included in accordance with 'Improving the flood performance of new buildings' CLG (2007).
New residential development (More Vulnerable)	Where appropriate, subject to there being no other planning constraints (e.g. restrictions on building heights), finished floor levels should be set a minimum of 300mm above the 1 in 100 year (1% AEP) flood level including climate change. The design flood level should be derived for the immediate vicinity of the site (i.e. relative to the extent of a site along a watercourse as flood levels are likely to vary with increasing distance downstream) as part of a site-specific FRA. Sleeping accommodation should be restricted to the first floor or above to offer the required 'safe places'. Internal ground floors below this level could however be occupied by either Less Vulnerable commercial premises, garages or non-sleeping residential rooms (e.g. kitchen, study, lounge) (i.e. applying a sequential approach within a building).	
New non-residential development (e.g. Less Vulnerable)	Finished floor levels shall be set a minimum of 300mm above the flood level of the 1 in 100 year (1% AEP) flood event, with an allowance for climate change, for office developments and 300mm above the flood level of the 1 in 100 annual probability flood event, with an allowance for climate change, for all other less vulnerable developments in accordance with the Leeds CC Minimum Development Control Standards for Flood Risk. Where this is not possible then subject to agreement the developments can be designed to be floodable instead of raising floor levels and this may be beneficial to help minimise the impact of the development on the displacement of floodwater and the risk of flooding to the surrounding area. In addition, it is recommended that the design incorporates suitable flood resilience measures. However, it is strongly recommended that internal access is provided to upper floors (first floor or a mezzanine level) to provide safe refuge in a flood event. Such refuges will have to be permanent and accessible to all occupants and users of the site and a Flood Warning and Evacuation Plan (FWEP) should be prepared to document the actions to take in the event of a flood.	
Basements	Basements, basement extensions, conversions of basements to a higher vulnerability classification or self-contained units are not permitted in Flood Zone 3b. Self-contained residential basements and bedrooms at basement level are not permitted in Flood Zone 3a. Internal access to a higher floor situated 300mm above the 1 in 100 year (1% AEP) flood level including climate change must be provided for all other basements, basement extensions and conversions.	All basements, basement extensions and conversions must have internal access to a higher floor situated 300mm above the 1 in 100 year (1% AEP) flood level including climate change.

14.4 Flood Resistance 'Water Exclusion Strategy'

There is a range of flood resistance and resilience construction techniques that can be implemented in new developments to mitigate potential flood damage. The Department for Communities and Local Government (CLG) have published a document *'Improving the Flood Performance of New Buildings, Flood Resilient Construction'*[25], the aim of which is to provide guidance to developers and designers on how to improve the resistance and resilience of new properties to flooding through the use of suitable materials and construction details. Figure 14-1 provides a summary of the Water Exclusion Strategy (flood resistance measures) and Water Entry Strategy (flood resilience measures) which can be adopted depending on the depth of floodwater that could be experienced.

[25] CLG (2007) *Improving the Flood Performance of New Buildings, Flood Resilient Construction*

Figure 14-1: Flood Resistant / Resilient Design Strategies, Improving Flood Performance, CLG 2007



Resistance measures are aimed at preventing water ingress into a building (Water Exclusion Strategy); they are designed to minimise the impact of floodwaters directly affecting buildings and to give occupants more time to relocate ground floor contents. These measures will probably only be effective for short duration, low depth flooding, i.e. less than 0.3m, although these measures should be adopted where depths are between 0.3m and 0.6m and there are no structural concerns.

In areas at risk of flooding of low depths (<0.3m), implement flood resistance measures such as:

- Using materials and construction with low permeability.
- Land raising (without leading to displacement).
- Landscaping e.g. creation of low earth bunds (subject to this not increasing flood risk to neighbouring properties).
- Raising thresholds and finished floor levels e.g. porches with higher thresholds than main entrance.
- Flood gates with waterproof seals.
- Sump and pump for floodwater to remove water faster than it enters.

There are a range of property flood protection devices available on the market which are designed specifically to resist the passage of floodwater (Figure 14-2 and Figure 14-3). These include removable flood barriers and gates designed to fit openings, vent covers, and stoppers designed to fit WCs. These measures can be appropriate for preventing water entry associated with fluvial flooding as well as surface water and sewer flooding. The efficacy of such devices relies on their being deployed before a flood event occurs. It should also be borne in mind that devises such as air vent covers, if left in place by occupants as a precautionary measure, may compromise safe ventilation of the building in accordance with Building Regulations.

Figure 14-2: Examples of flood barriers, air bricks with covers and non-return valves

Figure 14-3: Example of flood gates

14.5 Flood Resilience 'Water Entry Strategy'

For flood depths greater than 0.6m, it is likely that structural damage could occur in traditional masonry construction due to excessive water pressures. In these circumstances, the strategy should be to allow water into the building, but to implement careful design in order to minimise damage and allow rapid re-occupancy. This is referred to as the Water Entry Strategy. These measures are appropriate for uses where temporary disruption is acceptable and suitable flood warning is received.

Materials should be used which allow the passage of water whilst retaining their structural integrity and they should also have good drying and cleaning properties. Alternatively, sacrificial materials can be included for internal and external finishes; for example, the use of gypsum plasterboard which can be removed and replaced following a flood event. Flood resilient fittings should be used to at least 0.1m above the design flood level. Resilience measures are either an integral part of the building fabric or are features inside a building that will limit the damage caused by floodwaters.

In areas at risk of frequent or prolonged flooding, implement flood resilience measures such as:

- Use materials with either, good drying and cleaning properties, or, sacrificial materials that can easily be replaced post-flood.
- Design for water to drain away after flooding.
- Design access to all spaces to permit drying and cleaning.
- Raise the level of electrical wiring, appliances and utility meters.
- Coat walls with internal cement-based renders; apply tanking on the inside of all internal walls.
- Ground supported floors with concrete slabs coated with impermeable membrane.
- Tank basements, cellars or ground floors with water resistant membranes.
- Use plastic water resistant internal doors.

Further specific advice regarding suitable materials and construction techniques for floors, walls, doors and windows and fittings can be found in '*Improving the Flood Performance of New Buildings, Flood Resilient Construction*[26].

14.5.1 Structures

Structures such as bus shelters, bike shelters, park benches and refuse bins (and associated storage areas) located in areas with a high flood risk should be flood resilient and be firmly attached to the ground and designed in such a way as to prevent entrainment of debris which in turn could increase flood risk and/or breakaway posing a danger to life during high flows.

14.6 Safe Access and Egress

Safe access and egress is required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.

A safe access/egress route should allow occupants to safely enter and exit the buildings and be able to reach land outside the flooded area (e.g. within Flood Zone 1) using public rights of way or other suitable free access routes without the intervention of emergency services or others during design flood conditions, including climate change allowances. This is of particular importance when contemplating development on sites located on dry islands. A safe access route is an important part of emergency planning and should be included within an evacuation plan (see Section 14.10).

Guidance prepared by the Environment Agency[27] uses a calculation of flood hazard to determine safety in relation to flood risk. Flood hazard is a function of the flood depth and flow velocity at a particular point in the floodplain along with a suitable debris factor to account for the hazard posed by any material entrained by the floodwater. The derivation of flood hazard is based on the methodology in Flood Risks to People FD2320, the use of which for the purpose of planning and development management is clarified in the above-mentioned publication.

Table 14-2: Hazard to People Rating *(HR=d x (v +0.5) +DF)* (Table 8.2 FD2320/TR2)[28]

Flood Hazard (HR)	Description
Less than 0.75	**Very low hazard –** Caution
0.75 to 1.25	**Dangerous for some** – includes children, the elderly and the infirm
1.25 to 2.0	**Dangerous for most** – includes the general public
More than 2.0	**Dangerous for all** – includes the emergency services

[26] CLG, 2007, Improving the Flood Performance of New Buildings, Flood Resilient Construction. http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf?bcsi_scan_E956BCBE8ADBC89F=0&bcsi_scan_filename=flood_performance.pdf
[27] Environment Agency, HR Wallingford, May 2008, Supplementary note on Flood hazard ratings and thresholds for development planning and control purpose. Clarification of Table 13.1 FD2320/TR2 and Figure 3.2 FD2321/TR1. http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/FD2321_7400_PR_pdf.sflb.ashx
[28] DEFRA, Environment Agency, March 2006, Flood Risks to People Phase 2 FD2321/TR2 Guidance Document.

For developments located in areas at risk of fluvial flooding safe access / egress must be provided for new development as follows in order of preference:

- Safe dry route for people and vehicles.
- Safe dry route for people.
- If a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people.
- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles. However, the public should not drive vehicles in floodwater.

In all these cases, a 'dry' access/egress is a route located above the 1 in 100 year annual probability (1% AEP) flood level including an allowance for climate change.

ADEPT/EA have produced joint guidance on flood risk emergency plans for new development 'ADEPT/EA Flood Risk Emergency Plans for New Development' [29].

14.6.1 Safe Refuge

In exceptional circumstances, dry access above the 1 in 100 year annual probability (1% AEP) flood level including climate change may not be achievable. In these circumstances the Environment Agency and LCC Emergency Planning Officer should be consulted to ensure that the safety of the site occupants can be satisfactorily managed. This will be informed by the type of development, the number of occupants and their vulnerability and the flood hazard along the proposed egress route. For example, this may entail the designation of a safe place of refuge on an upper floor of a building, from which the occupants can be rescued by emergency services. It should be noted that sole reliance on a safe place of refuge is a last resort, and all other possible means to evacuate the site should be considered first. Provision of a safe place of refuge will not guarantee that an application will be granted.

14.7 Floodplain Compensation Storage

Floodplain compensatory storage should be a last resort. All new development within flood risk areas must not result in a net loss of flood storage capacity. Where possible, opportunities should be sought to achieve an increase in the provision of flood storage. Where proposed development results in a change in building footprint, the developer must ensure that it does not impact upon the ability of the floodplain to store water and should seek opportunities to provide betterment with respect to floodplain and surface water storage.

Floodplain compensation must be provided on a level for level, volume for volume basis on land which is within the site boundary. Where land is not within the site boundary, it needs to be in the immediate vicinity, in the applicant's ownership and linked to the site[30]. Floodplain compensation must be considered in the context of the relevant 1 in 100 year annual probability (1% AEP) flood level including an allowance for climate change. When designing a scheme flood water must be able to flow in and out and must not pond. An FRA must demonstrate that there is no loss of flood storage capacity and include details of an appropriate maintenance regime to ensure mitigation continues to function for the life of the development. Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C62431.

[29] ADEPT/EA Flood Risk Emergency Plans for New Development' https://adeptnet.org.uk/floodriskemergencyplan
[30] In hydrological connectivity.
[31] CIRIA January 2004, CIRIA Report 624: Development and Flood Risk - Guidance for the Construction Industry

14.7.1 Flood Voids

The use of under-floor voids are discouraged in Flood Zone 2 and 3. They are generally considered to provide indirect compensation or mitigation, but not true compensation for loss of floodplain storage. The use of under-floor voids will typically require a specific planning condition alongside the approved plans as well as a maintenance plan for them to remain open for the lifetime of the development to be enforced by the LPA. Sole reliance on the use of under-floor voids to address the loss of floodplain storage capacity is generally not acceptable on undeveloped sites or for individual properties.

14.8 Flood Routing

All new development in Flood Zones 2 and 3 should not adversely affect flood routing and thereby increase flood risk elsewhere.

Opportunities should be sought within the site design to make space for water, such as:

- Removing boundary walls or replacing with other boundary treatments such as hedges, fences (with gaps).
- Considering alternatives to solid wooden gates or ensuring that there is a gap beneath the gates to allow the passage of floodwater.
- On uneven or sloping sites, consider lowering ground levels to extend the floodplain without creating ponds. The area of lowered ground must remain connected to the floodplain to allow water to flow back to river when levels recede.

In order to demonstrate that 'flood risk is not increased elsewhere', development in the floodplain will need to prove that flood routing is not adversely affected by the development, for example by giving rise to backwater affects or diverting floodwaters onto other properties. Demonstrating no impact of floodplain conveyance may require specific post development modelling, the extent of which will need to be agreed with the Environment Agency in advance. Potential overland flow paths should be determined, and appropriate solutions proposed to minimise the impact of the development, for example by configuring road and building layouts to preserve existing flow paths and improve flood routing, whilst ensuring that flows are not diverted towards other properties elsewhere. Careful consideration should be given to the use of fences and landscaping walls so as to prevent causing obstruction to flow routes and increasing the risk of flooding to the site or neighbouring areas.

14.9 Riverside Development

The Environment Agency is likely to seek an 8-metre-wide undeveloped buffer strip alongside fluvial Main Rivers for maintenance purposes and would also ask developers to explore opportunities for riverside restoration as part of any development. LCC will also seek a 8-metre-wide undeveloped buffer strip to be retained alongside the top of the bank of Ordinary Watercourses although subject to site specific circumstances and adequate access for maintenance and repair, this distance may be able to be reduced.

Under Section 109 of the Water Resources Act 1991 and/or Environment Agency Byelaws, any works within 8 metres of any statutory Main River (both open channels and culverted sections), on or near a flood defence structure or in a floodplain requires an Environment Agency Flood Risk Activity Permit under the Environmental Permitting regulations. Whilst Flood Defence Consents are dealt with outside of the planning process, since the requirements of the consenting process in relation to flood risk, biodiversity and pollution may result in changes to development proposals or construction methods, the Environment Agency aims to advise on such issues as part of its statutory consultee role in the planning process. Should proposed works require planning permission, the LPA and the Environment Agency should be consulted regarding permission to do work on or near a river, flood or sea defence by contacting enquiries@environment-agency.gov.uk.

As of 6 April 2012, responsibility for the consenting of works by third parties on Ordinary Watercourses under Section 23 of the Land Drainage Act 1991 (as amended by the Flood and Water Management Act 2010) has transferred from the Environment Agency to the LLFA, LCC. LCC is now responsible for the consenting of works to Ordinary Watercourses and has powers to enforce un-consented and non-compliant works. This includes any works (including temporary) within 8 metres that affect flow within the channel (such as in channel structures or diversion of watercourses). Enquiries and applications for Ordinary Watercourse consent can be found on the LCC website[32]

[32] https://www.leeds.gov.uk/emergencies/flooding-advice/getting-watercourse-consent

14.10 Flood Warning and Evacuation Plans

Evacuation is where flood alerts and warnings provided by the Environment Agency enable timely actions by residents or occupants to allow evacuation to take place unaided, i.e. without the deployment of trained personnel to help people from their homes, businesses and other premises. Rescue by the emergency services is likely to be required where flooding has occurred, and prior evacuation has not been possible.

For all developments (excluding minor developments and change of use) proposed in Flood Zone 2 or 3, a Flood Warning and Evacuation Plan (FWEP) should be prepared to demonstrate what actions site users will take before, during and after a flood event to ensure their safety, and to demonstrate their development will not impact on the ability of the local authority and the emergency services to safeguard the current population.

For sites in Flood Zone 1 that are located on 'dry islands,' it may also be necessary to prepare a FWEP to determine potential egress routes away from the site through areas that may be at risk of flooding during the 1 in 100 year (1% AEP) flood event including an allowance for climate change.

The Environment Agency has a tool on their website to create a Personal Flood Plan[33]. The Plan comprises a checklist of things to do before, during and after a flood and a place to record important contact details. Where proposed development comprises non-residential extension <250m^2 and householder development (minor development), it is recommended that the use of this tool to create a Personal Flood Plan will be appropriate.

FWEPs should include:

How flood warning is to be provided, such as:

- availability of existing flood warning systems (refer to Table 14-3 for existing flood warning areas);
- where available, rate of onset of flooding and available flood warning time; and
- how flood warning is given.

What will be done to protect the development and contents, such as:

- How easily damaged items (including parked cars) or valuable items (important documents) will be relocated;
- How services can be switched off (gas, electricity, water supplies);
- The use of flood protection products (e.g. flood boards, airbrick covers);
- The availability of staff/occupants/users to respond to a flood warning, including preparing for evacuation, deploying flood barriers across doors etc.; and
- The time taken to respond to a flood warning.

Ensuring safe occupancy and access to and from the development, such as:

- Occupant awareness of the likely frequency and duration of flood events, and the potential need to evacuate;
- Safe access route to and from the development;
- If necessary, the ability to maintain key services during an event;
- Vulnerability of occupants, and whether rescue by emergency services will be necessary and feasible; and
- Expected time taken to re-establish normal use following a flood event (clean-up times, time to re-establish services etc.)

Details of what could be included in a Personal Flood Plan are provided by the Environment Agency using their tool https://www.gov.uk/government/publications/personal-flood-plan.

There is no statutory requirement for the Local Planning Authority, the Environment Agency, Emergency Planning Officers or the emergency services to approve FWEPs as they are only required to be consulted on their adequacy. LCC will assess the suitability of the plan during the application and this should be done in consultation with the LPA.

[33] Environment Agency Tool 'Make a Flood Plan'. https://www.gov.uk/government/publications/personal-flood-plan

It will very rarely be appropriate to use a planning condition to defer the provision of an FWEP to a later date, because it may show that the development cannot be made safe and therefore call into question whether the development is acceptable in principle and therefore the production of a FWEP should be included within any FRA.

An informative drawing within the plan should be attached to any forthcoming decision notice. The responsibility to maintain the FWEP and enact the plan in the event of a flood incident lies with the building owner or any tenants or leaseholders.

14.11 Flood Warning Areas

There are 52 flood warning areas within the LCC District, as shown in Appendix A Figure A.15 and Table 14-3. The Environment Agency issues flood warnings to residents and businesses that have registered for the service in these specific areas when flooding is expected.

Table 14-3: Environment Agency Flood Warning Areas (refer to Appendix A - Figure A.15)

Watercourse	Environment Agency Flood Warning Area (Name)
Fir Green Beck, Bramham Beck	Bramham Beck at Bramham
Gledhow Beck	Gledhow Beck at Harehills
Meanwood Beck	Meanwood Beck at Headingley and Weetwood
	Meanwood Beck at Buslingthorpe, Mabgate and Quarry Hill
	Meanwood Beck at Buslingthorpe and Sheepscar
Oulton Beck	Oulton Beck at Oulton
River Aire	River Aire north bank from City Gate to Leeds City Station
	River Aire at Savins Mill Way
	River Aire at Woodlesford
	River Aire at Newton and Fairburn
	River Aire at Allerton Ings, Barnsdale Road and Properties
	River Aire at Kirkstall Road
	River Aire at Central Leeds including Sovereign Street and Asda House
	River Aire at Methley Junction
	River Aire at Burley, Kirkstall Works and Wellington Road Industrial Estate
	River Aire at Knowsthorpe, Thwaite Gate and Stourton
	River Aire at St Anns Mill and the Goits
	River Aire at Redcote Lane
	River Aire at Canal Wharfe between Bridge End and Crown Point Bridge
	River Aire at Castleford Lock Lane
	River Aire at Newlay
	River Aire at Kirkstall Forge
	River Aire at Cardigan Fields Leisure Park and Kirkstall Works
	River Aire at Cardigan Trading Estate
	River Aire at Neptune Street - Canal and River Trust car park
	River Aire at Esholt and Apperley Bridge
	River Aire at Sovereign Street, The Calls and Clarence Dock
	River Aire at Mickletown - Mill Lane, Nelson Court and Lower Mickletown
	River Aire at Neptune Street
	River Aire at Allerton Bywater
	River Aire at Mickletown
River Calder	River Calder at Methley and Mickletown

Watercourse	Environment Agency Flood Warning Area (Name)
River Wharfe	River Wharfe at Pool in Wharfedale
	River Wharfe at Burley in Wharfedale
	River Wharfe at Boston Spa
	River Wharfe at Billams Hill and riverside properties between Otley and Pool
	River Wharfe at The Avenue Collingham and Linton Ings
	River Wharfe at Harewood Bridge
	River Wharfe at Wetherby
	River Wharfe at Otley
River Wharfe, Collingham Beck	Collingham Beck at Collingham
Tyersal and Pudsey Beck	Tyersal and Pudsey Beck at Pudsey
Wortley Beck	Wortley Beck from Pudsey Road to Butt Lane
	Wortley Beck from Far Royd to City West One office park
	Wortley Beck from Stone Bridge Mill to Whitehall Roundabout
Wyke Beck	Wyke Beck at Foundry Mill
	Wyke Beck at Neville Road
	Wyke Back at Valley Road
	Wyke Beck at Fearnville
	Wyke Beck at Wykebeck Valley Road, Gipton
	Wyke Beck at Dunhills, Halton

15. Sustainable Drainage Developer Guidance

15.1 Surface Water Management

All major[34] developments and other development must not result in an increase in surface water runoff and, where possible, should demonstrate betterment in terms of rate and volumes of surface water runoff.

Unless demonstrated to be inappropriate, Sustainable Drainage Systems (SuDS) must be used to reduce and manage surface water run-off to and from proposed developments as near to source as possible in accordance with the requirements of the Technical Standards and supporting guidance published by Ministry of Housing, Communities and Local Government (MHCLG) and Department for the Environment, Food and Rural Affairs (DEFRA)[35]. In line with the Leeds Core Strategy, SuDS must be considered for all sites.

SuDS are typically softer engineering solutions inspired by natural drainage processes such as ponds and swales which manage water and seek to replicate the pre-development drainage system as close to its source as possible. A SuDS technique should seek to contribute to each of the four goals identified below:

1. Reduce flood risk (to the site and neighbouring areas) – Water Quantity,
2. Reduce pollution – Water Quality,
3. Create and sustain better places for people - Amenity, and
4. Create and sustain better places for nature – Biodiversity.

The requirement must be to discharge surface water run-off as high up the following hierarchy of drainage options as reasonably practicable:

a) into the ground (infiltration)

b) To a surface water body

c) To a surface water sewer, highway drain, or another drainage system

d) To a combined sewer

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc.). The SuDS Manual[36] identified several processes that can be used to manage and control runoff from developed areas. Each option can provide opportunities for storm water control, flood risk management, water conservation and groundwater recharge.

- **Infiltration**: the soaking of water into the ground. This is the most desirable solution as it mimics the natural hydrological process. The rate of infiltration will vary with soil type and condition, the antecedent conditions and with time. The process can be used to recharge groundwater sources and feed base flows of local watercourses, but where groundwater sources are vulnerable or there is risk of contamination, infiltration techniques are not suitable.
- **Detention/Attenuation**: the slowing down of surface flows before their transfer downstream, usually achieved by creating a storage volume and a constrained outlet. In general, though the storage will enable a reduction in the peak rate of runoff, the total volume will remain the same, just occurring over a longer duration.
- **Conveyance:** the transfer of surface runoff from one place to another, e.g. through open channels, pipes and trenches.
- **Water Harvesting:** the direct capture and use of runoff on site, e.g. for domestic use (flushing toilets) or irrigation of urban landscapes. The ability of these systems to perform a flood risk management function will be dependent on their scale, and whether there will be a suitable amount of storage always available in the event of a flood.

[34] Major development – 10 or more dwellings and 1000 sqm floor space
[35] Sustainable drainage systems: non-statutory technical standards - https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards; PPG Flood Risk and Coastal Change - http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/reducing-the-causes-and-impacts-of-flooding/why-are-sustainable-drainage-systems-important/
[36] CIRIA C753 SuDS Manual. https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

As part of any SuDS scheme, consideration must be given to the long-term maintenance of the SuDS to ensure that it remains functional for the lifetime of the development. Table 15-1 has been reproduced from the SuDS Manual, CIRIA C753 and outlines typical SuDS techniques.

The application of SuDS is not limited to a single technique per site. Often a successful SuDS solution will utilise a combination of techniques, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS. It should be noted, each development site must offset its own increase in runoff and attenuation cannot be “traded” between developments.

Table 15-1: Typical SuDS Components (Y; primary process. * some opportunities, subject to design)

Technique	Description	Conveyance	Detention	Infiltration	Harvesting
Pervious Surfaces	Pervious surfaces allow rainwater to infiltrate through the surface into an underlying storage layer, where water is stored before infiltration to the ground, reuse, or release to surface water.		Y	Y	*
Filter Drains	Linear drains/trenches filled with a permeable material, often with perforated pipe in the base of the trench. Surface water from the edge of paved areas flows into the trenches, is filtered and conveyed to other parts of the site.	Y	Y		
Filter Strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and particulates.	*	*	*	
Swales	Shallow vegetated channels that conduct and/or retain water and can permit infiltration when unlined.	Y	Y	*	
Ponds	Depressions used for storing and treating water.		Y	*	Y
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds. Based on geology these measures can also incorporate some degree of infiltration.	*	Y	*	Y
Detention Basin	Dry depressions designed to store water for a specified retention time.		Y		
Soakaways	Sub-surface structures that store and dispose of water via infiltration.			Y	
Infiltration Trenches	As filter drains but allowing infiltration through trench base and sides.	*	Y	Y	
Infiltration Basins	Depressions that store and dispose of water via infiltration.		Y	Y	
Green Roofs	Green roofs are systems which cover a building’s roof with vegetation. They are laid over a drainage layer, with other layers providing protection, waterproofing and insulation. It is noted that the use of brown/green roofs should be for betterment purposes and not to be counted towards the provision of on-site storage for surface water. This is because the hydraulic performance during extreme events is similar to a standard roof (CIRIA C697).		Y		
Rainwater Harvesting	Storage and use of rainwater for non-potable uses within a building, e.g. toilet flushing. It is noted that storage in these types of systems is not usually considered to count towards the provision of on-site storage for surface water balancing because, given the sporadic nature of the use of harvested water, it cannot be guaranteed that the tanks are available to provide sufficient attenuation for the storm event.	*	*	*	Y

The use of infiltration techniques is highly dependent on the underlying ground conditions. As part of this SFRA, an indication of the suitability of using infiltration SuDS techniques across the LCC District has been undertaken using the detailed BGS Infiltration SuDS Map (Appendix A Figures A.16, A.17, A.18). Detail about this dataset is provided in Section 7.

In broad terms, areas along the Main River valleys and the northern parts of LCC area have the greater constraints on the use of SuDS, for example there are particular areas where the depth to the water table is less than 3m below the ground surface.

The areas with most potential for widespread use of infiltration SuDS are those in the north-east of the District which are underlain by limestone and where the depth to the water table is greater than 5m below the ground surface. However, the opportunity for infiltration SuDS is variable across the study area and will need intrusive ground investigation to confirm the suitability on larger development sites. Note that detention measures are not constrained by geology, though in areas of permeable geology there will also be a degree of infiltration of runoff taking place.

15.2 Technical Standards and supporting guidance

A set of non-statutory Technical Standards have been published, to be used in conjunction with supporting guidance in the PPG[2], which set the requirements for the design, construction, maintenance and operation of sustainable drainage systems (SuDS).

Technical Standards that are of chief concern in relation to the consideration of flood risk to and from development relating to peak flow control and volume control have been adapted to be consistent with LCC requirements and are presented below:

Peak flow control

S2 For **greenfield developments**, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year (1% AEP) rainfall event should never exceed the peak greenfield runoff rate for the same event.

S3 For **developments which were previously developed**, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year (1% AEP) rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event.

Volume control

S4 Where reasonably practicable, for **greenfield development**, the runoff volume from the development to any drain, sewer or surface water body in the 1 in 100 year (1% AEP), 6-hour rainfall event should never exceed the greenfield runoff volume for the same event.

S5 Where reasonably practicable, for **developments which have been previously developed**, the runoff volume from the development to any drain, sewer or surface water body in the 1 in 100 year (1% AEP), 6- hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event but should never exceed the runoff volume from the development site prior to redevelopment for that event.

S6 Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S4 or S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk.

Flood risk within the development

S7 The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30 year (3.33% AEP) plus an allowance for climate change rainfall event.

S8 The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100 year (1% AEP) plus an allowance for climate change rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.

S9 The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year (1% AEP) plus an allowance for climate change rainfall event are managed in exceedance routes that minimise the risks to people and property.

All major development[37] must include provision for SuDS unless demonstrated to be inappropriate. The LLFA is a statutory consultee for these schemes and a Surface Water Drainage Statement will need to be completed and signed by a competent drainage engineer to accompany any planning application[38]. This must be cross-referenced within an FRA where appropriate.

Guidance on the evidence required to comply with the technical standards of SuDS in developments is available within the Leeds CC Minimum Development Control Standards for Flood Risk,. Applicants are strongly encouraged to discuss their proposals with LCC at the pre-application stage. The LCC have partnered with neighbouring LLFA within WYCA to produce detailed guidance for integrating SuDS into developments[39]. For schemes (including minor development) located within Flood Zones 2 and 3, SuDS will need to be addressed as part of an FRA and will be assessed by LCC as LLFA.

[37] Major development as defined in the Town and County Planning (Development Management Procedure) (England) Order 2010

[38] SuDS Planning Advice - https://www.leeds.gov.uk/docs/Minimum%20development%20control%20standards%20for%20flood%20risk.pdf

[39] Leeds City Region Sustainable Drainage Systems Guidance, February 2020, https://www.westyorks-ca.gov.uk/media/5397/lcr-suds-guidance-final-february-2020-1.pdf

Appendix A SFRA Supporting Maps

A.1 Map Topography

A.2 Map Leeds Watercourses

A.3 Map Geology

A.4 Map EA Flood zones

A.5 Map Flood Modelling Outlines (undefended)

A.6 Map Flood Modelling Outlines (defended)

A.7 Map Flood Modelling Outlines (undefended climate change)

A.8 Map Flood Modelling Outlines (defended climate change)

A.9 Map Surface Water Flooding, Map9A Flooding Heat Map

A.10 Map Susceptibility to Groundwater Flooding

A.11 Map Approximate reach location of Completed/Future FAS

A.12 Map Sewer Flooding

A.13 Map Reservoir Flooding

A.14 Map Historic Flooding

A.15 Map Flood Warning and Alert Areas

A.16 Map SuDS Constraints – Superficial Permeability

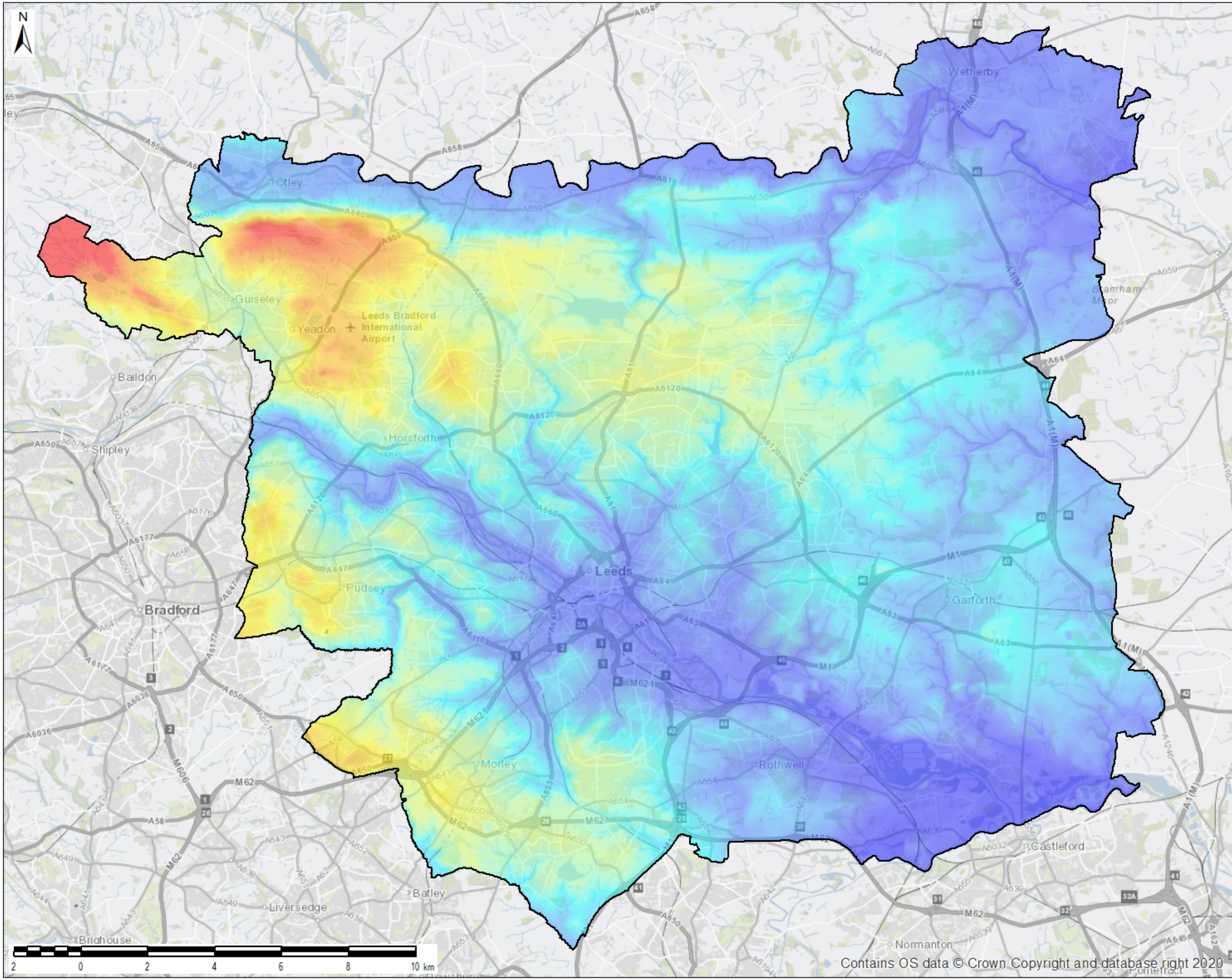
A.17 Map SuDS Constraints – Bedrock Permeability

A.18 Map SuDS Constraints – Infiltration Suitability

A.19 Map Opportunity Mapping - Working with Natural Processes

A.20 Map Functional Floodplain (Climate Change)

A.21 Map Developed and Undeveloped Functional Floodplain



LEGEND

Leeds City Boundary

Topography (mAOD)

High : 345

Low : 5

Copyright

Client

LEEDS CITY COUNCIL

Project Title

LEEDS CITY COUNCIL STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 1
TOPOGRAPHY

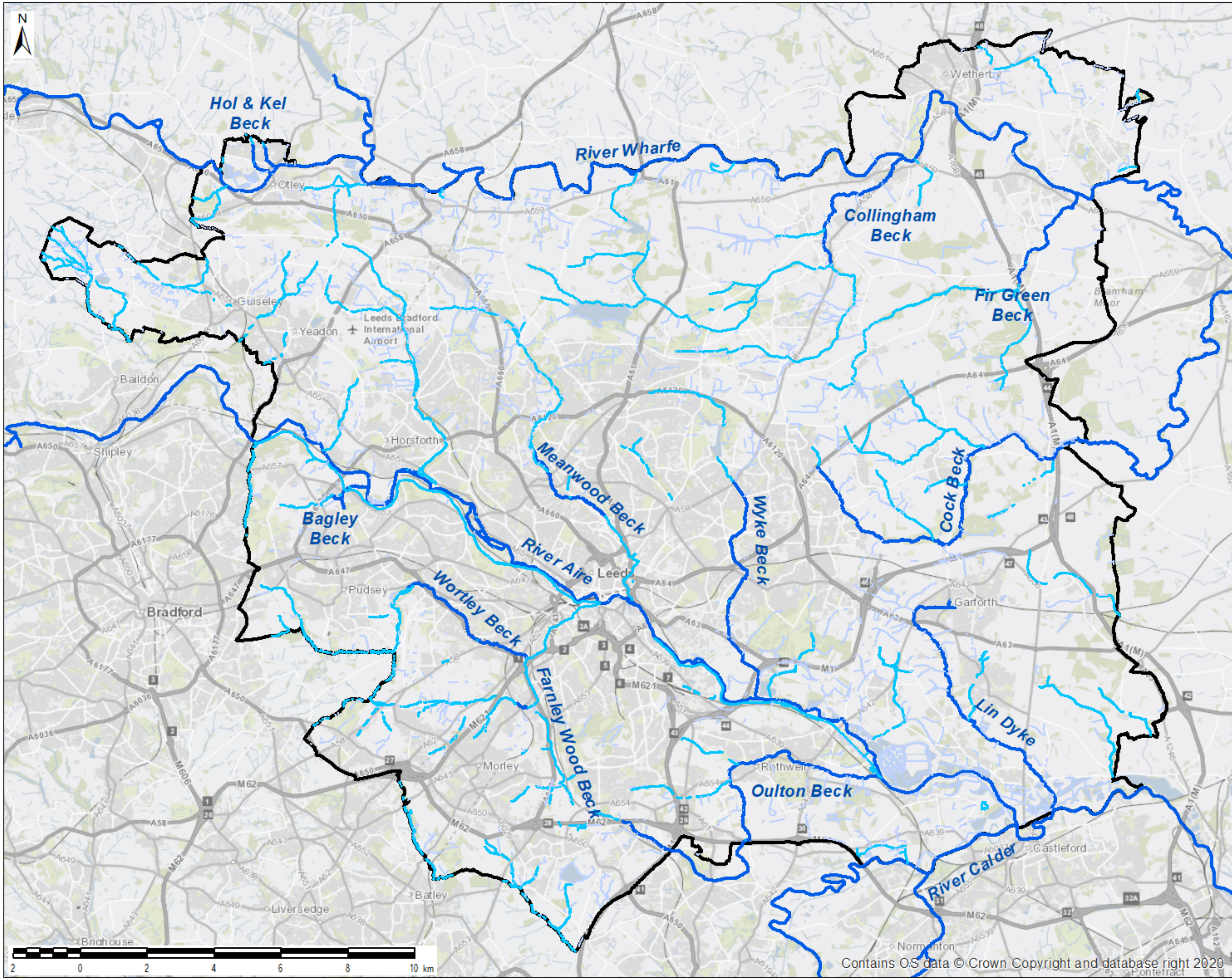
Drawn	Checked	Approved	Date
SW	CS	CS	15/09/2022

AECOM Internal Project No.	Scale @A4
60659301	1:146,656

AECOM
2 City Walk
Leeds LS11 9AR
Telephone (0113) 3916800
www.aecom.com

AECOM

Drawing Number	Rev
MAP 1	4



LEGEND

- Other Ditches and Streams
- Named Ordinary Watercourses
- Main Rivers
- Leeds City Boundary

Client

LEEDS CITY COUNCIL

Project Title

LEEDS CITY COUNCIL STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 2
LEEDS WATERCOURSES

Drawn	Checked	Approved	Date
SW	CS	CS	15/09/2022

AECOM Internal Project No.	Scale @A4
60659301	1:146,761

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2 City Walk
Leeds LS11 9AR
Telephone (0113) 3916800
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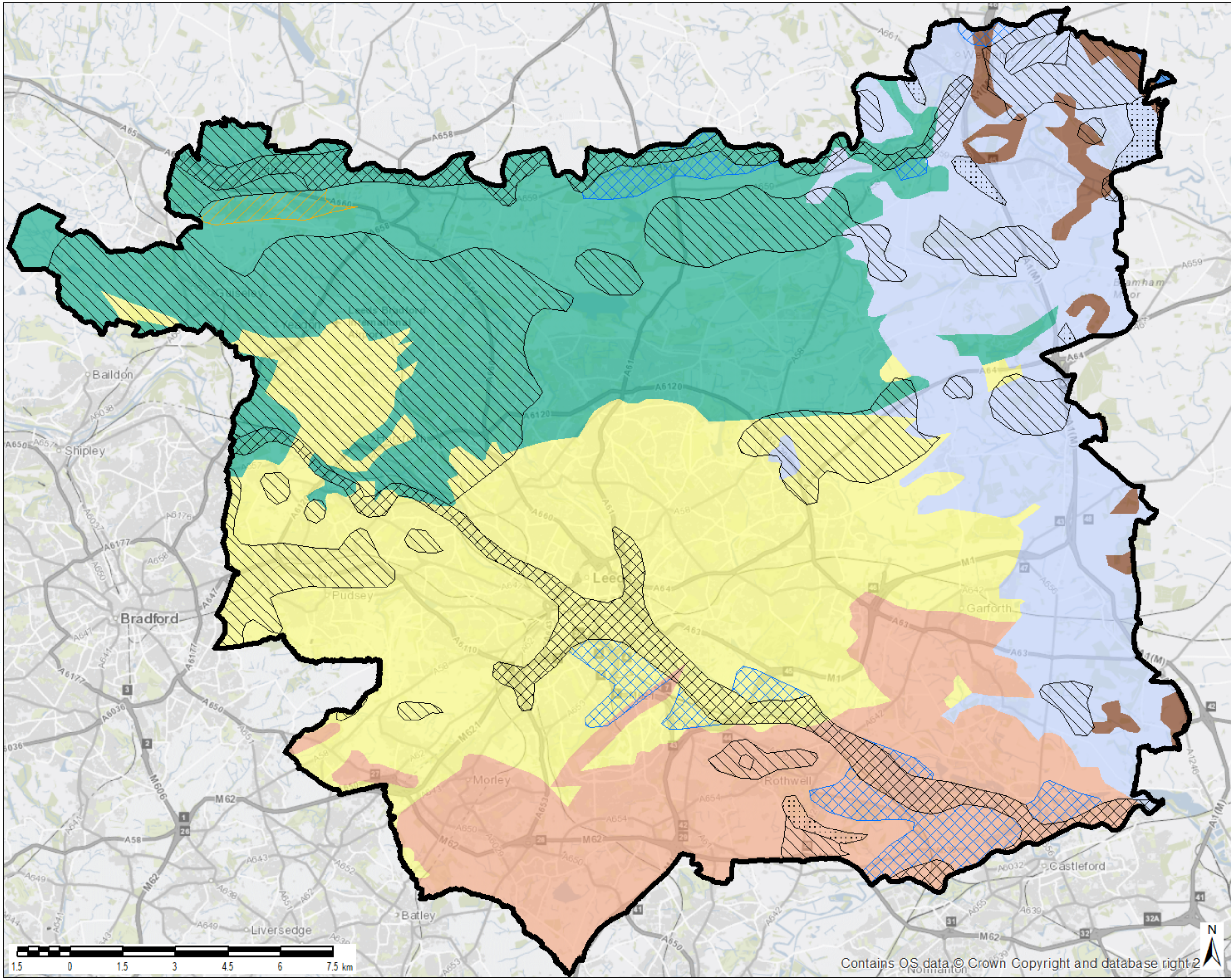
Drawing Number	Rev
MAP 2	2



THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT

LEGEND

Leeds City Boundary

Superficial Geology

- Alluvium
- Glacial Sand and Gravel
- Lacustrine Deposits
- Landslip
- River Terrace Deposits
- Till

Bedrock Geology

- Millstone Grit
- Pennine & South Wales Lower Coal
- Pennine & South Wales Middle Coal
- Permian Rocks (Undifferentiated)
- Triassic Rocks (Undifferentiated)
- Zechstein Group

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STRATEGIC FLOOD RISK ASSESSMENT

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MAP 3
BEDROCK AND SUPERFICIAL GEOLOGY

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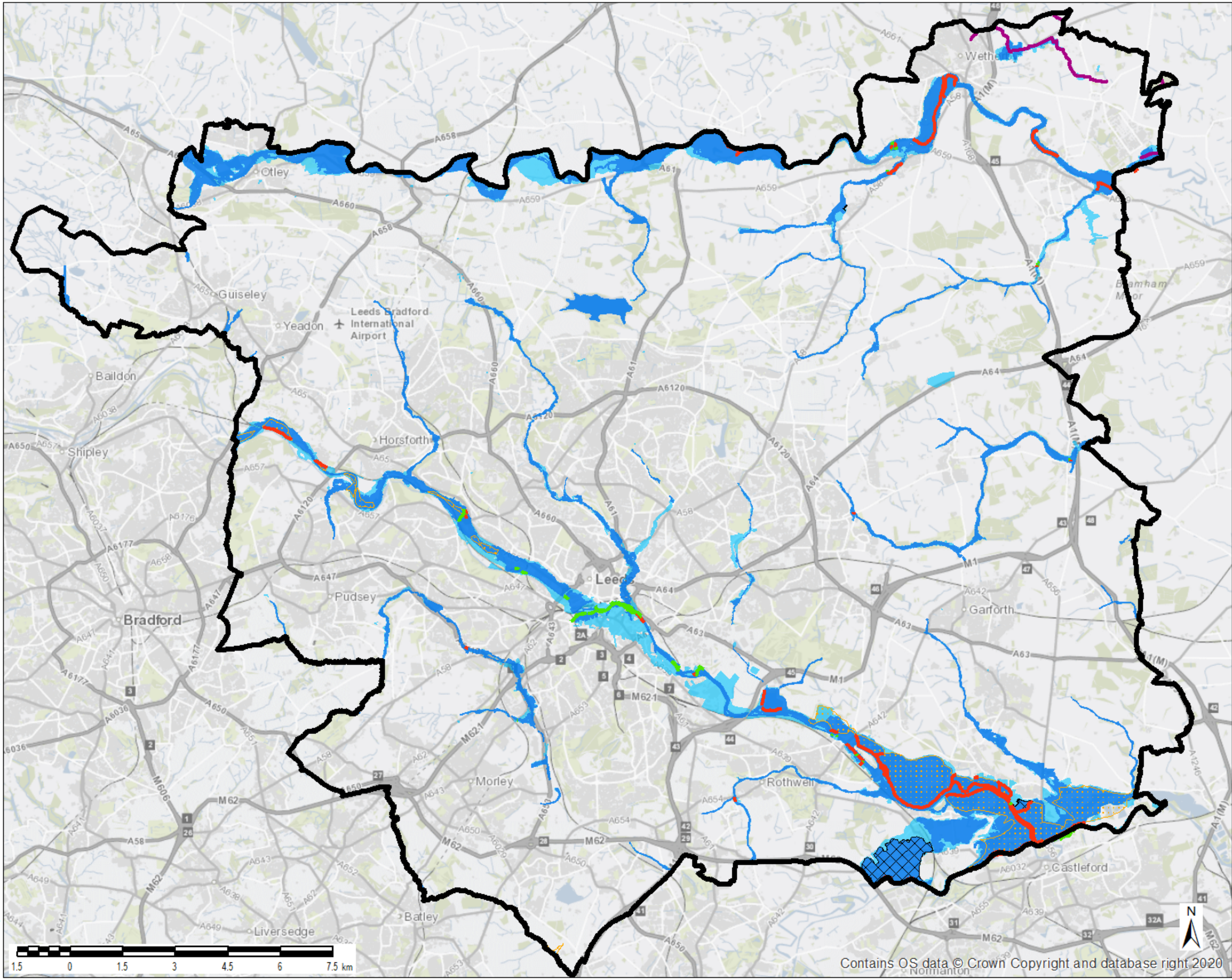
MAP 3	3



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LEGEND

- Leeds City Boundary
- IDB Channels
- Flood Zone 2
- Flood Zone 3

Leeds Flood Defences

- Embankments
- Walls
- Flood Storage Areas
- Defended Areas

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 4
ENVIRONMENT AGENCY FLOOD ZONES AND FLOOD DEFENCES

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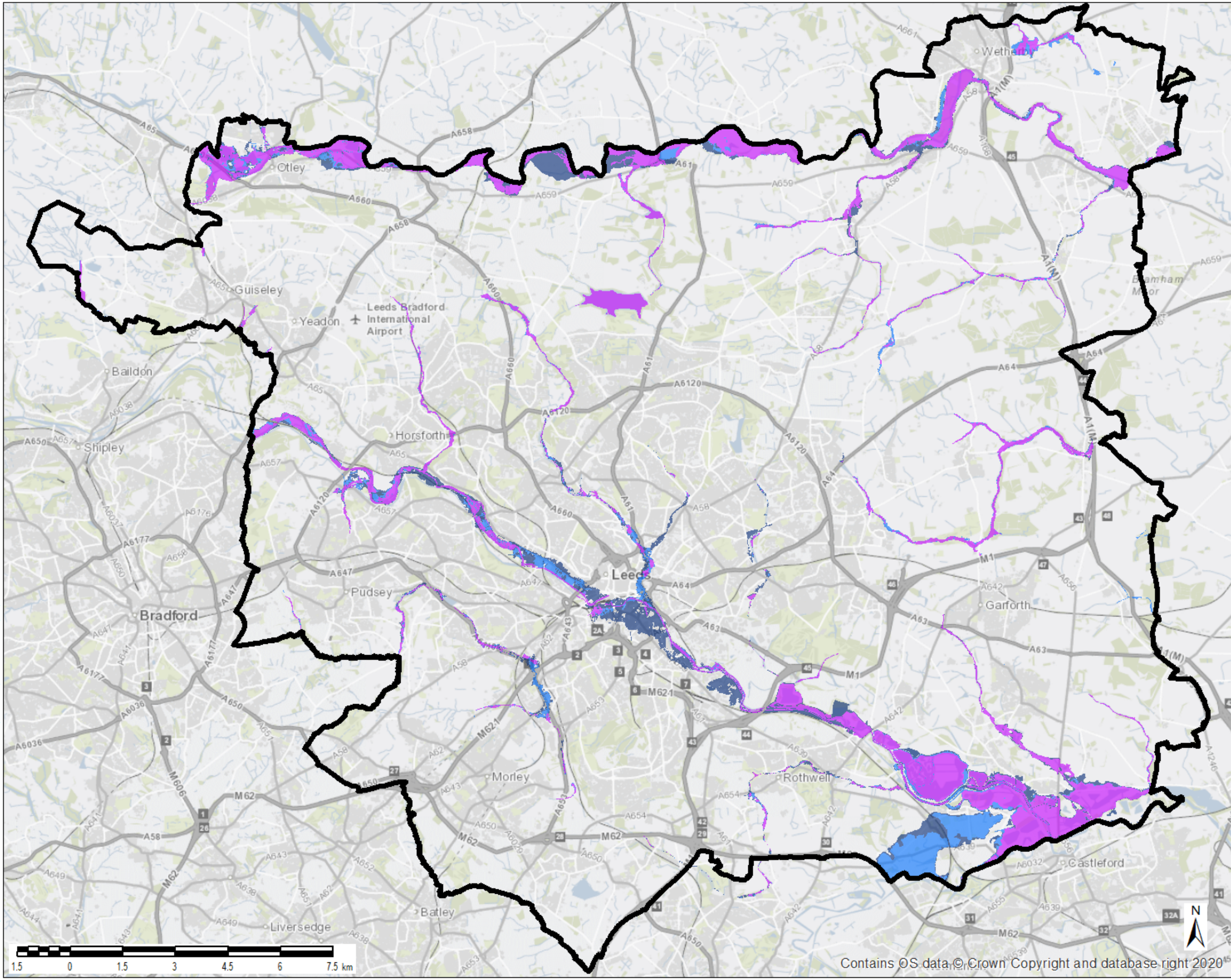
MAP 4	4



LEGEND

- Leeds City Boundary
- 20yrs Event
- 100yrs Event
- 1000yrs Event

Use of Modelled Flood Outlines

Numerous modelling studies have been carried out across the Leeds District. A review of the geographic extent and scenarios was undertaken as part of the SFRA and the most appropriate model output was chosen to represent flood outlines for key flood events under NPPF. Exact model outputs for each key event are not available for all areas and a suitable proxy has been identified where there are gaps in the data. The defended modelled flood outlines include Flood Alleviation Schemes that have been completed prior to the completion of the SFRA. Further Flood Alleviation Schemes are proposed and once these schemes are completed the on-line SFRA mapping will be updated to reflect the defended scenario.

Further details of the complex flood modelling within Leeds District is set out in a separate document. Modelled flood outlines and data should be requested from the Environment Agency for site specific flood risk assessments to ensure the most up to date and relevant modelling studies are used.

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 5
UNDEFENDED FLOOD OUTLINES FROM DETAILED MODELLING

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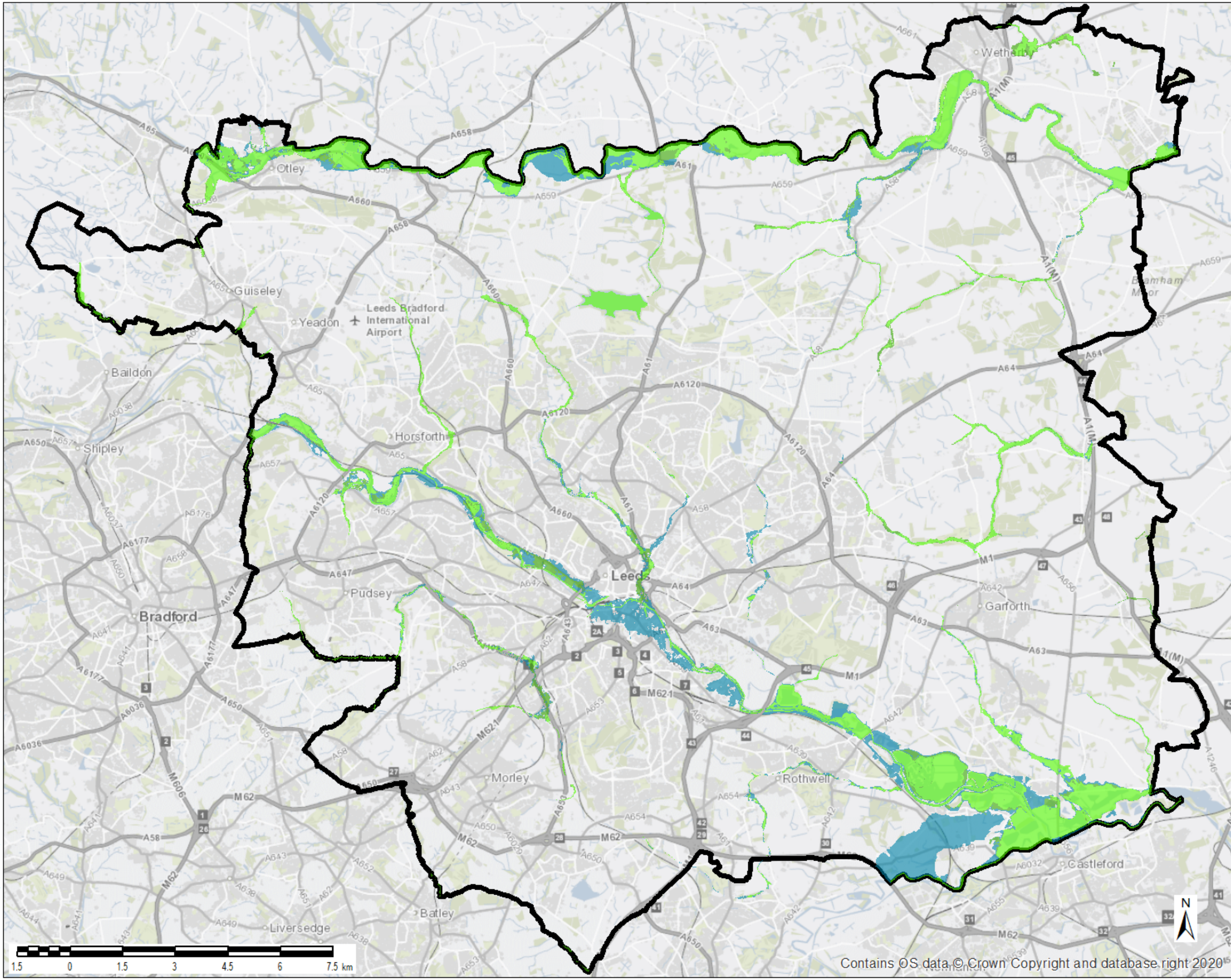
Drawing Number	Rev
MAP 5	5



LEGEND

Leeds City Boundary

Detailed Modelled Flood Outlines

- 20yrs Event
- 100yrs Event
- 1000yrs Event

Use of Modelled Flood Outlines

Numerous modelling studies have been carried out across the Leeds District. A review of the geographic extent and scenarios was undertaken as part of the SFRA and the most appropriate model output was chosen to represent flood outlines for key flood events under NPPF. Exact model outputs for each key event are not available for all areas and a suitable proxy has been identified where there are gaps in the data. The defended modelled flood outlines include Flood Alleviation Schemes that have been completed prior to the completion of the SFRA. Further Flood Alleviation Schemes are proposed and once these schemes are completed the on-line SFRA mapping will be updated to reflect the defended scenario.

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STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 6A
DETAILED MODELLED
FLOOD OUTLINES (DEFENDED)
PRESENT DAY SCENARIO
COMPLETED SCHEMES ONLY

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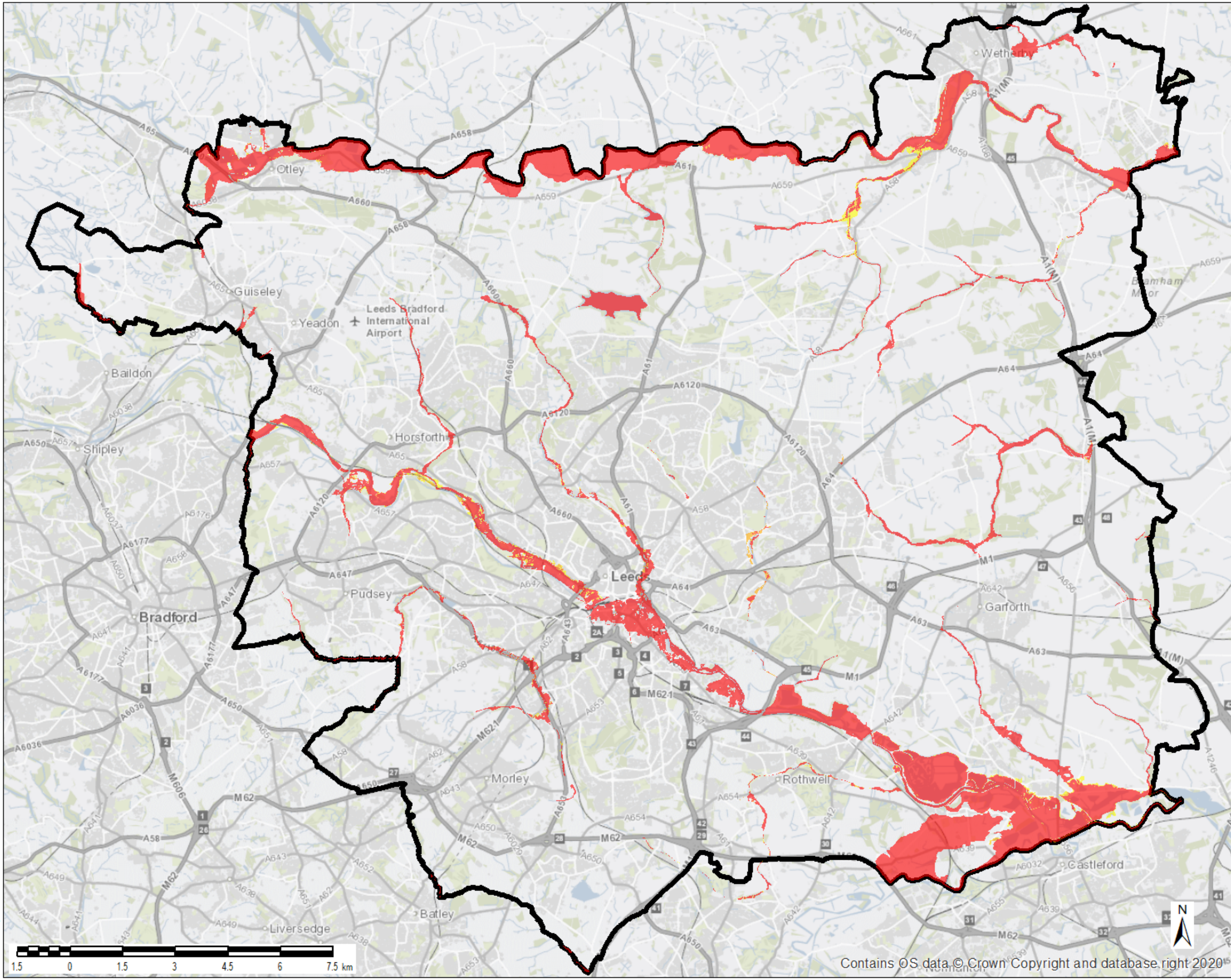
Drawing Number	Rev
MAP 6A	5



LEGEND

Leeds City Boundary

Detailed Modelled Flood Outlines Including Climate Change Allowances

100 years event +23%

100 years event +31%

100 years event +48/51%

Use of Modelled Flood Outlines

Numerous modelling studies have been carried out across the Leeds District. A review of the geographic extent and scenarios was undertaken as part of the SFRA and the most appropriate model output was chosen to represent flood outlines for key flood events under NPPF. Exact model outputs for each key event are not available for all areas and a suitable proxy has been identified where there are gaps in the data. The defended modelled flood outlines include Flood Alleviation Schemes that have been completed prior to the completion of the SFRA. Further Flood Alleviation Schemes are proposed and once these schemes are completed the on-line SFRA mapping will be updated to reflect the defended scenario.

Further details of the complex flood modelling within Leeds District is set out in a separate document. Modelled flood outlines and data should be requested from the Environment Agency for site specific flood risk assessments to ensure the most up to date and relevant modelling studies are used.

Client

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 7
DETAILED UNDEFENDED MODELLED FLOOD OUTLINES: 100 YEAR EVENT PLUS CLIMATE CHANGE

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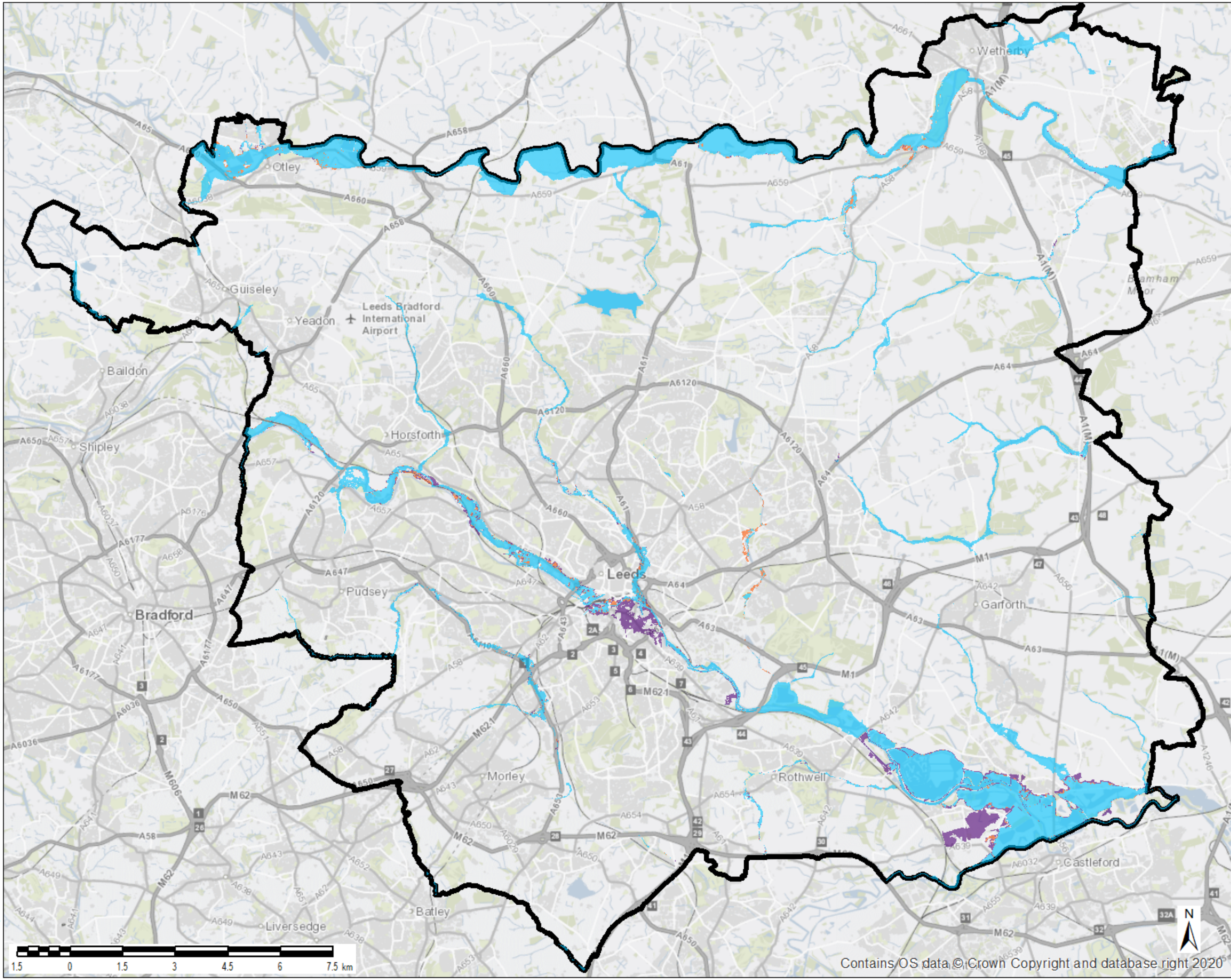
Drawing Number	Rev
MAP 7	6



LEGEND

Leeds City Boundary

Detailed Modelled Flood Outlines Including Climate Change Allowances

- 100 years event +23%
- 100 years event +31%
- 100 years event +51%

Use of Modelled Flood Outlines

Numerous modelling studies have been carried out across the Leeds District. A review of the geographic extent and scenarios was undertaken as part of the SFRA and the most appropriate model output was chosen to represent flood outlines for key flood events under NPPF. Exact model outputs for each key event are not available for all areas and a suitable proxy has been identified where there are gaps in the data. The defended modelled flood outlines include Flood Alleviation Schemes that have been completed prior to the completion of the SFRA. Further Flood Alleviation Schemes are proposed and once these schemes are completed the on-line SFRA mapping will be updated to reflect the defended scenario.

Further details of the complex flood modelling within Leeds District is set out in a separate document. Modelled flood outlines and data should be requested from the Environment Agency for site specific flood risk assessments to ensure the most up to date and relevant modelling studies are used.

Client
LEEDS CITY COUNCIL

Project Title
STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title
MAP 8A
DETAILED DEFENDED MODELLED FLOOD OUTLINES: 100 YEAR EVENT PLUS CLIMATE CHANGE COMPLETED SCHEMES ONLY

Drawn	Checked	Approved	Date
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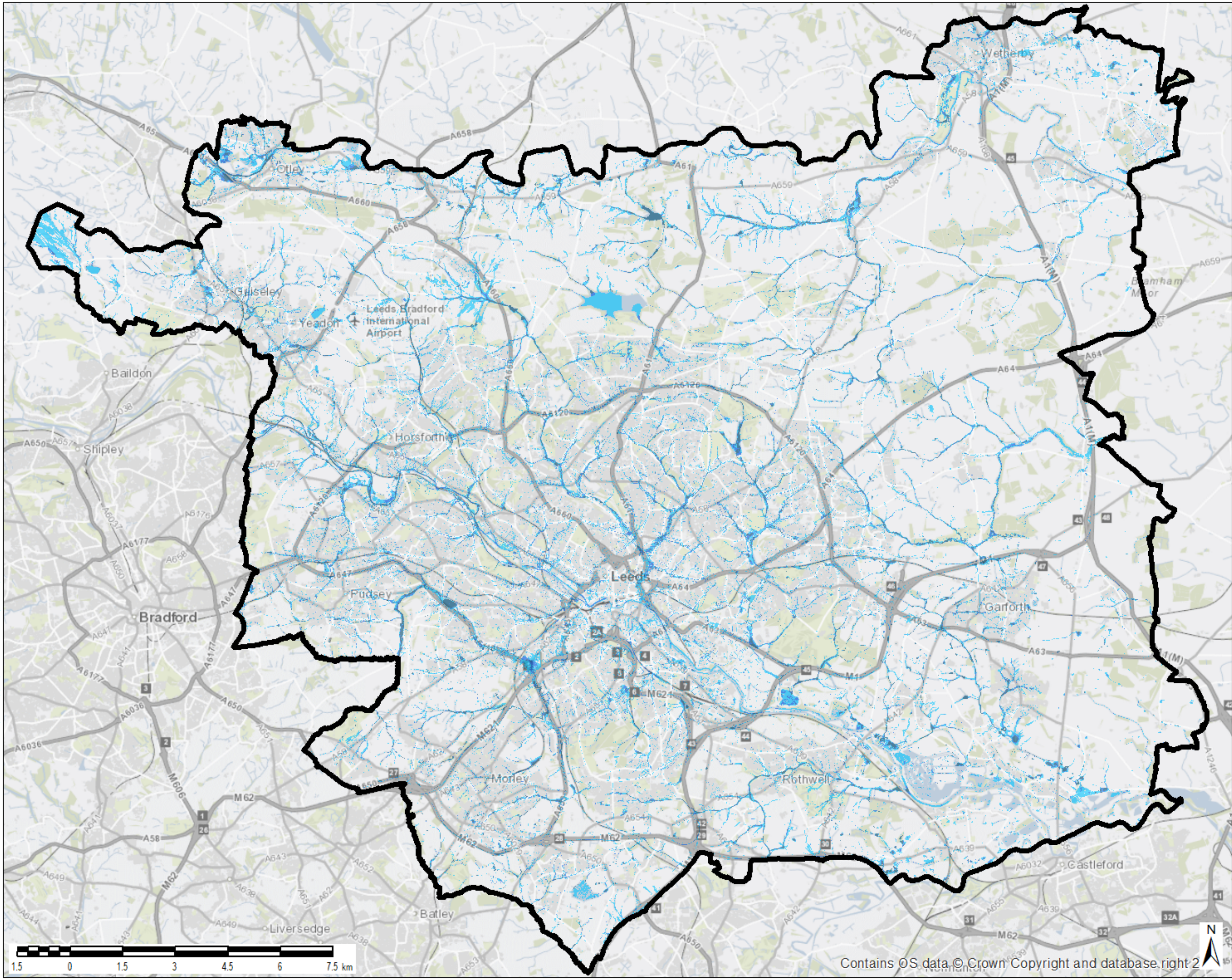
Drawing Number: MAP 8A
Rev: 6



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LEGEND

Leeds City Boundary

Surface Water Flooding

- 1 in 30 year event
- 1 in 100 year event
- 1 in 1000 year event

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 9
SURFACE WATER FLOODING

Drawn	Checked	Approved	Date
SW	CS	CS	15/09/2022

AECOM Internal Project No.	Scale @ A4
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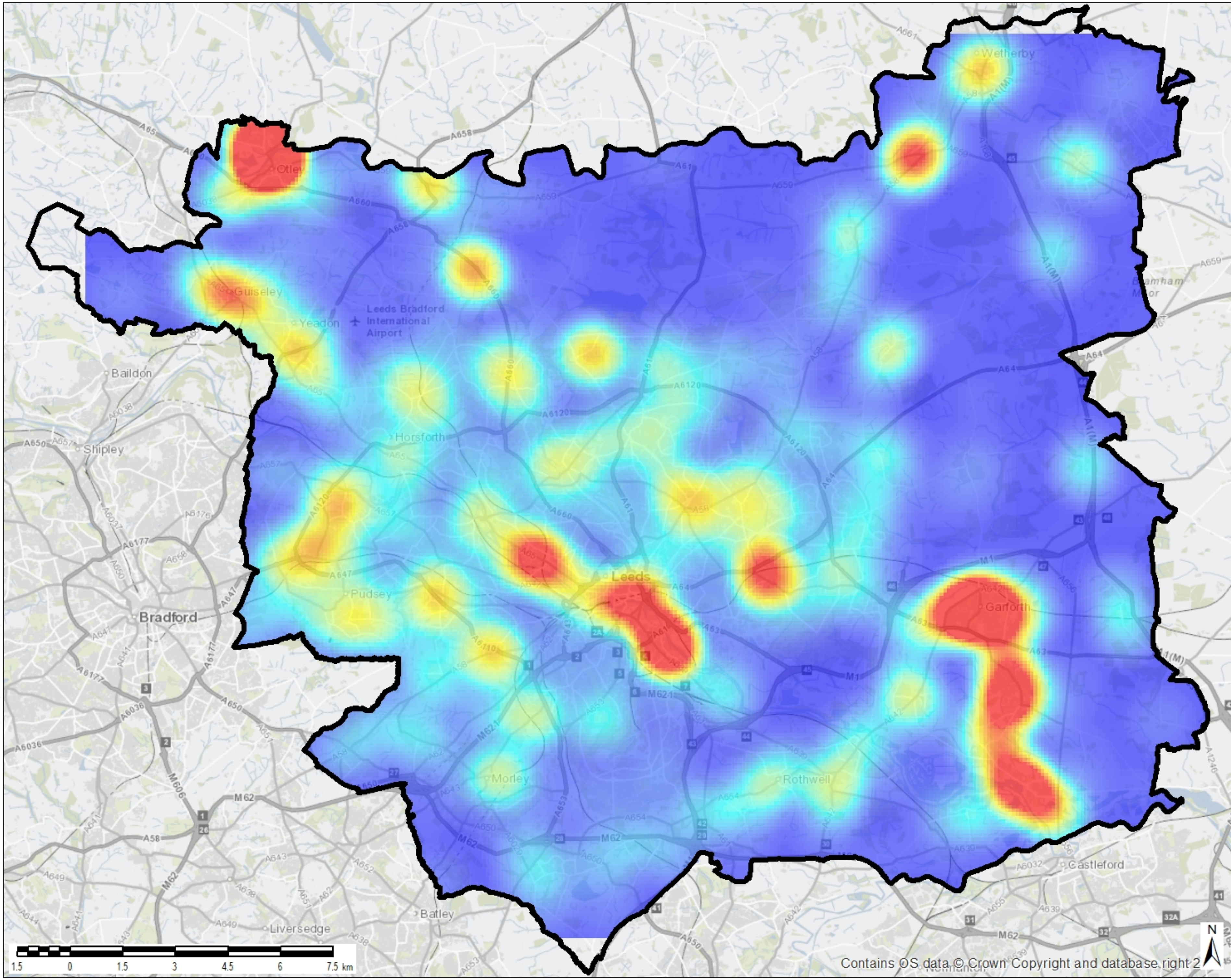
MAP 9	3



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LEGEND

Leeds City Boundary

Surface Water Flood Event Heat Map

More Frequent Flooding

Less Frequent Flooding

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STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 9A
FLOODING HEAT MAP
(MULTIPLE SOURCES INCLUDING SURFACE WATER)

Drawn	Checked	Approved	Date
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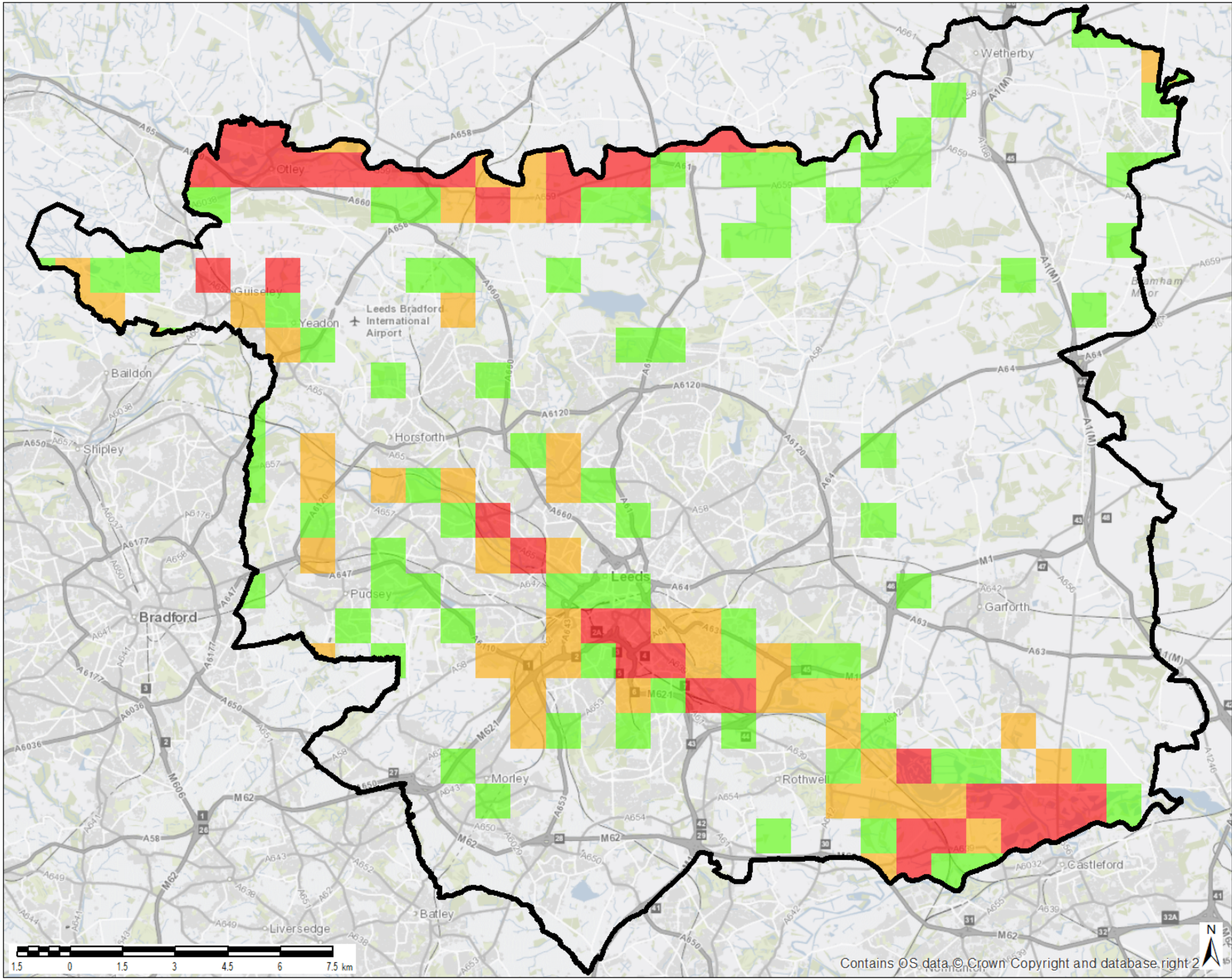
Drawing Number	Rev
MAP 9A	1



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LEGEND

- Leeds City Boundary
- Low Risk
- Moderate Risk
- High Risk

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Drawing Title

MAP 10
SUSCEPTIBILITY TO GROUNDWATER FLOODING

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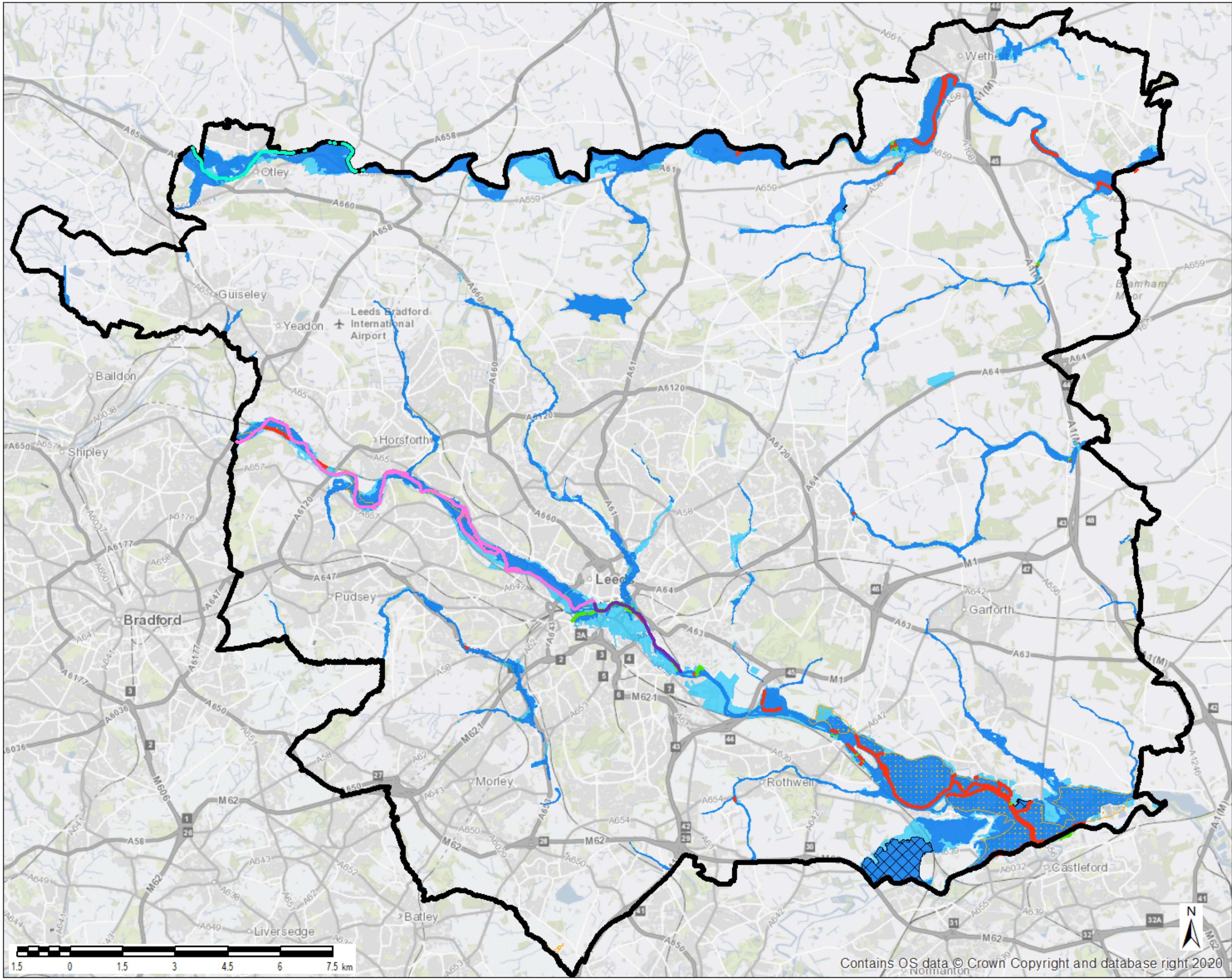
Drawing Number	Rev
MAP 10	3



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LEGEND

- LFAS1 (Complete)
- LFAS2 (Future Scheme)
- Otley FAS (Future Scheme)
- Leeds City Boundary
- Flood Zone 2
- Flood Zone 3

Leeds Flood Defences

- Embankments
- Walls
- Flood Storage Areas
- Defended Areas

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STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 11
APPROX REACH LOCATION OF COMPLETED/FUTURE FLOOD ALLEVIATION SCHEMES

Drawn	Checked	Approved	Date
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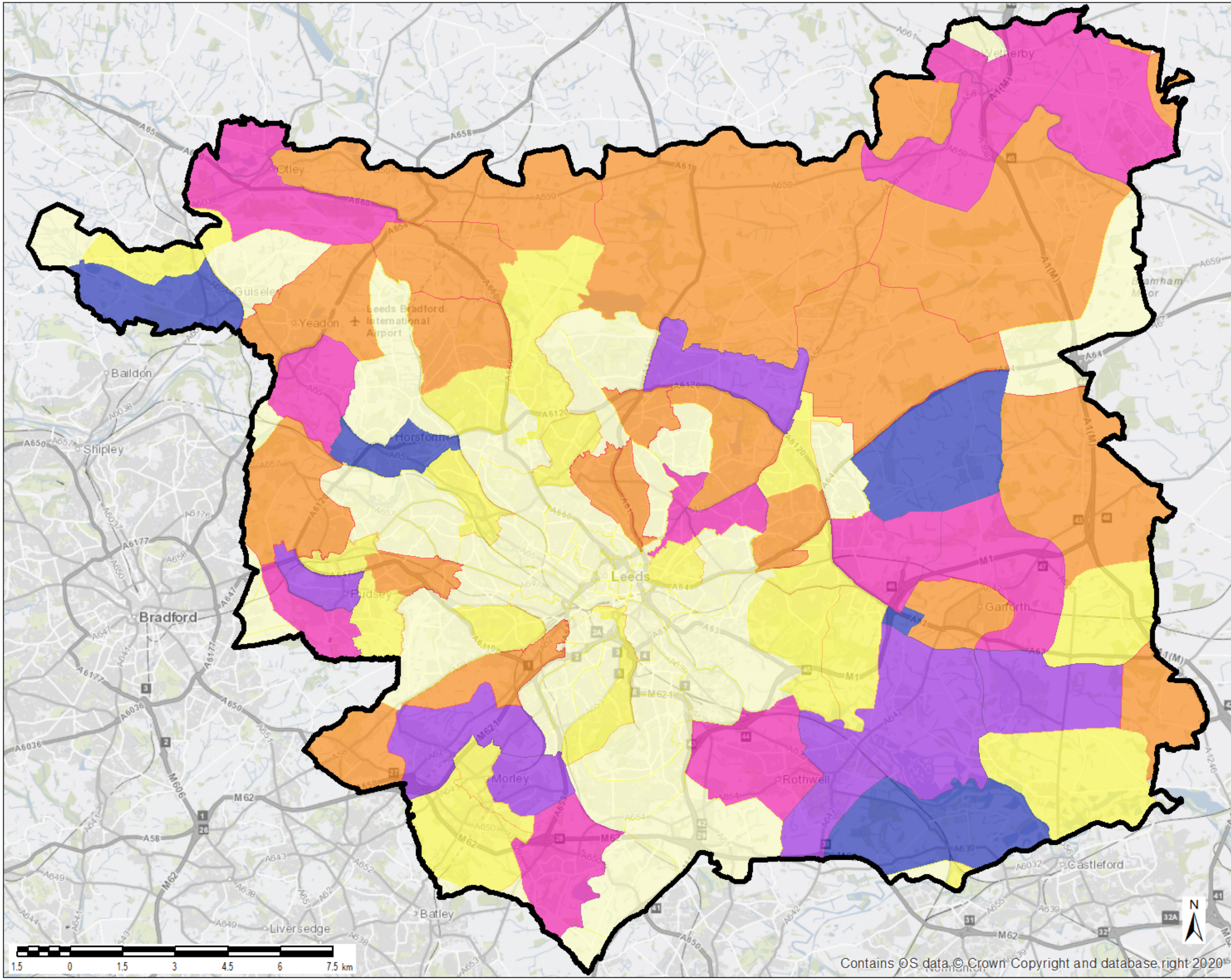
Drawing Number: MAP 11

Rev: 2



LEGEND

Leeds City Boundary

Sewer Flooding Count

- 0 - 5
- 6 - 10
- 11 - 20
- 21 - 30
- 31 - 50
- >50

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MAP 12
DG5 SEWER FLOODING RECORDS (INTERNAL AND EXTERNAL) 2011-2020

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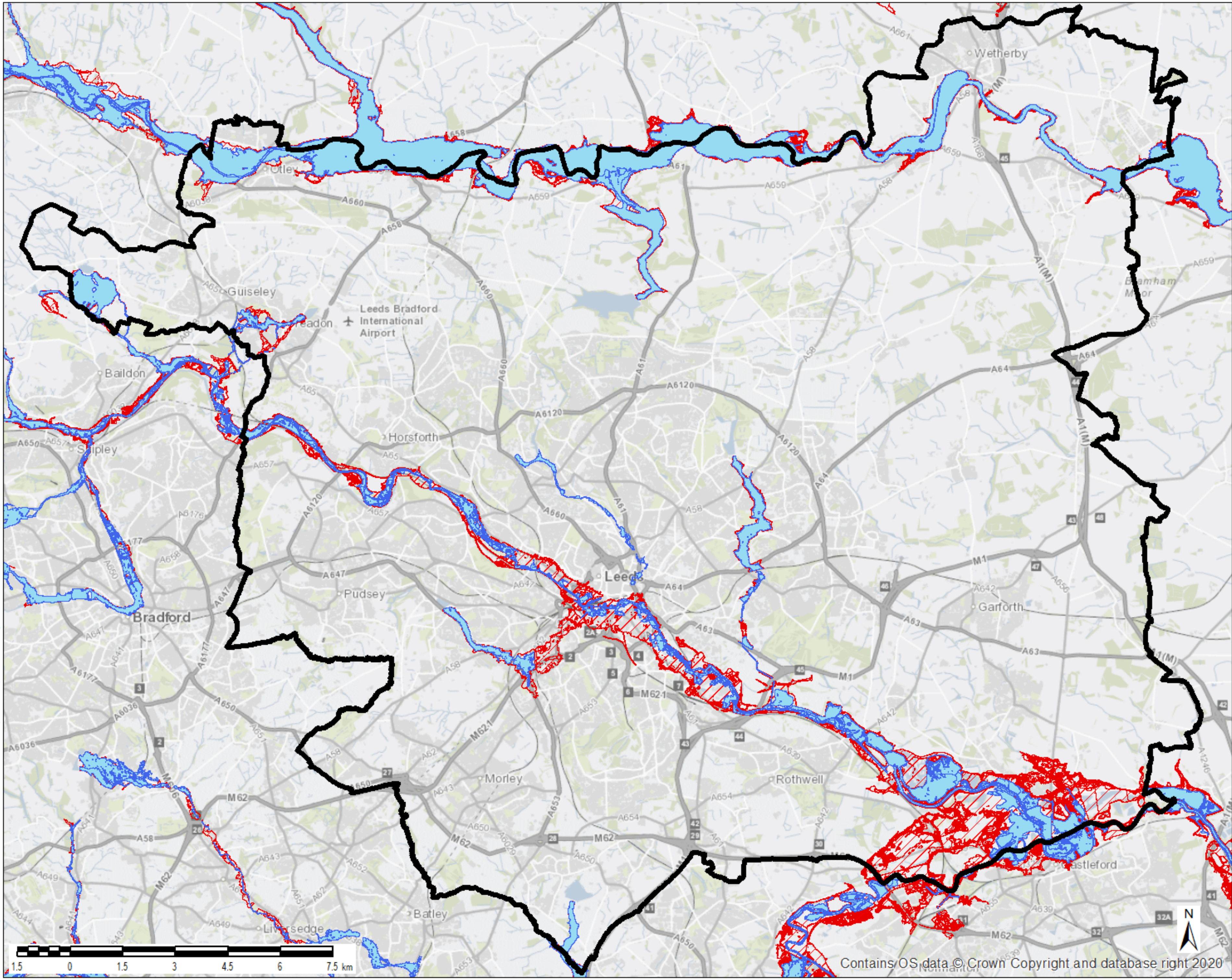
MAP 12	2



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LEGEND

- Leeds City Boundary
- 'Dry day' extent
- 'Wet day' extent

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MAP 13
RESERVOIR FLOODING

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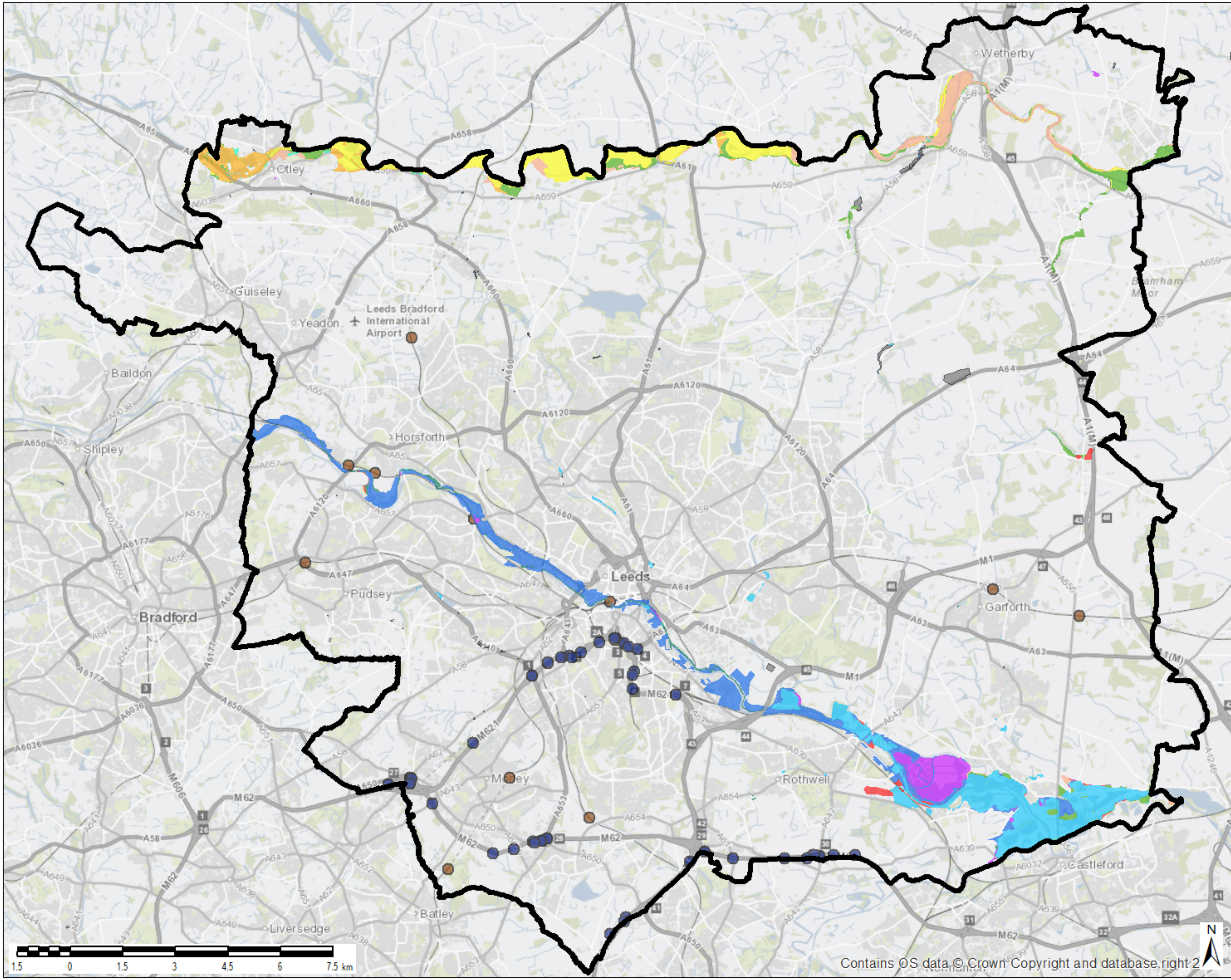
MAP 13	2



LEGEND

- Leeds City Boundary
- Ordinary Watercourse Flooding
- Groundwater Flooding
- Historic Network Rail Flooding
- Historic Highways Flooding

Main River Flooding

- December 1978
- January 1982
- February 1991
- January 1995
- February 1995
- October 2000
- December 2000
- February 2002
- June 2007
- December 2015
- March 2019
- February 2020
- November 2020
- Janaury 2021

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MAP 14
HISTORIC FLOODING
FROMALL SOURCES

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MAP 14	3

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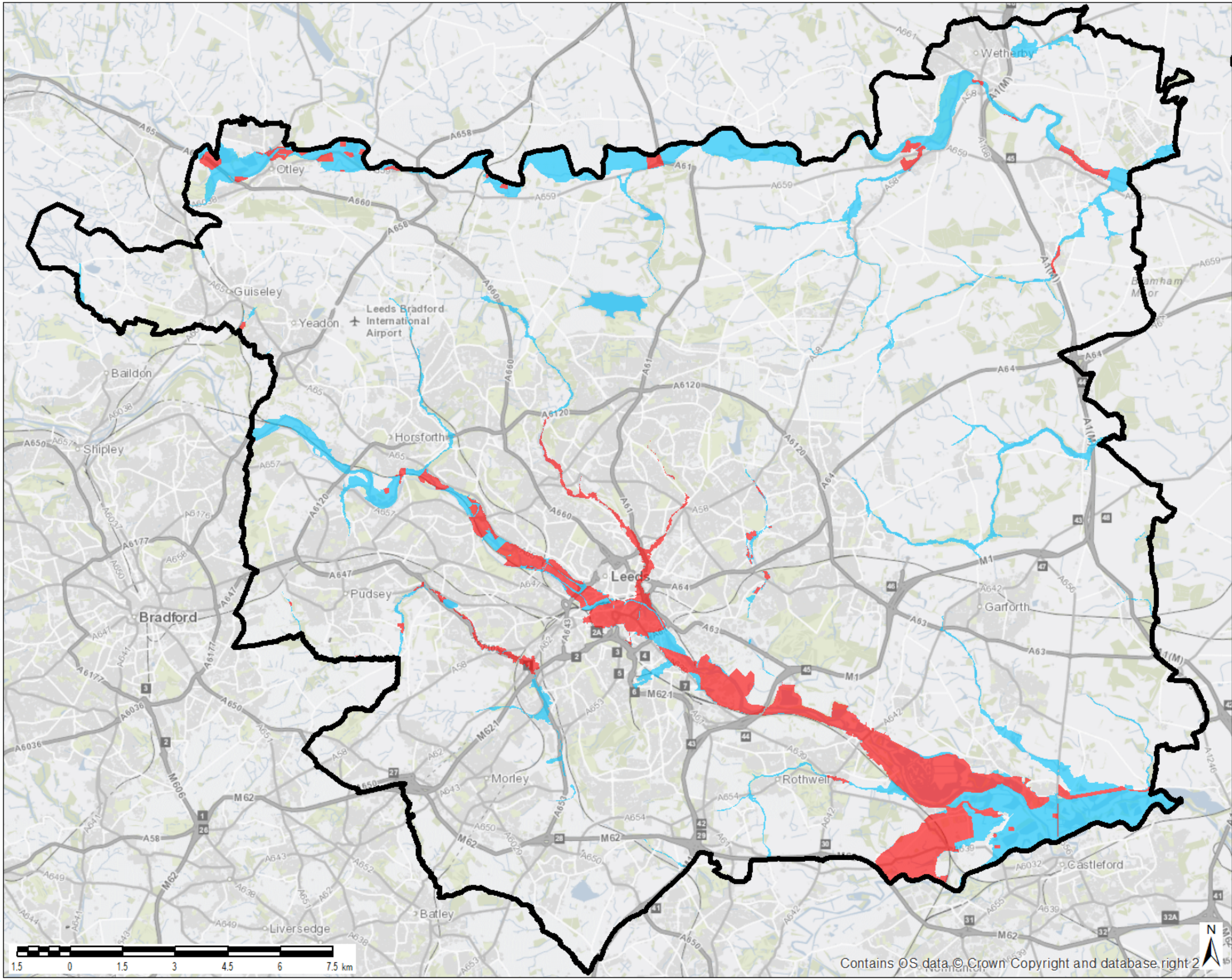
LEGEND

- Leeds City Boundary
- Flood Warning Areas
- Flood Alert Areas



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MAP 15
FLOOD WARNING AND ALERT AREAS

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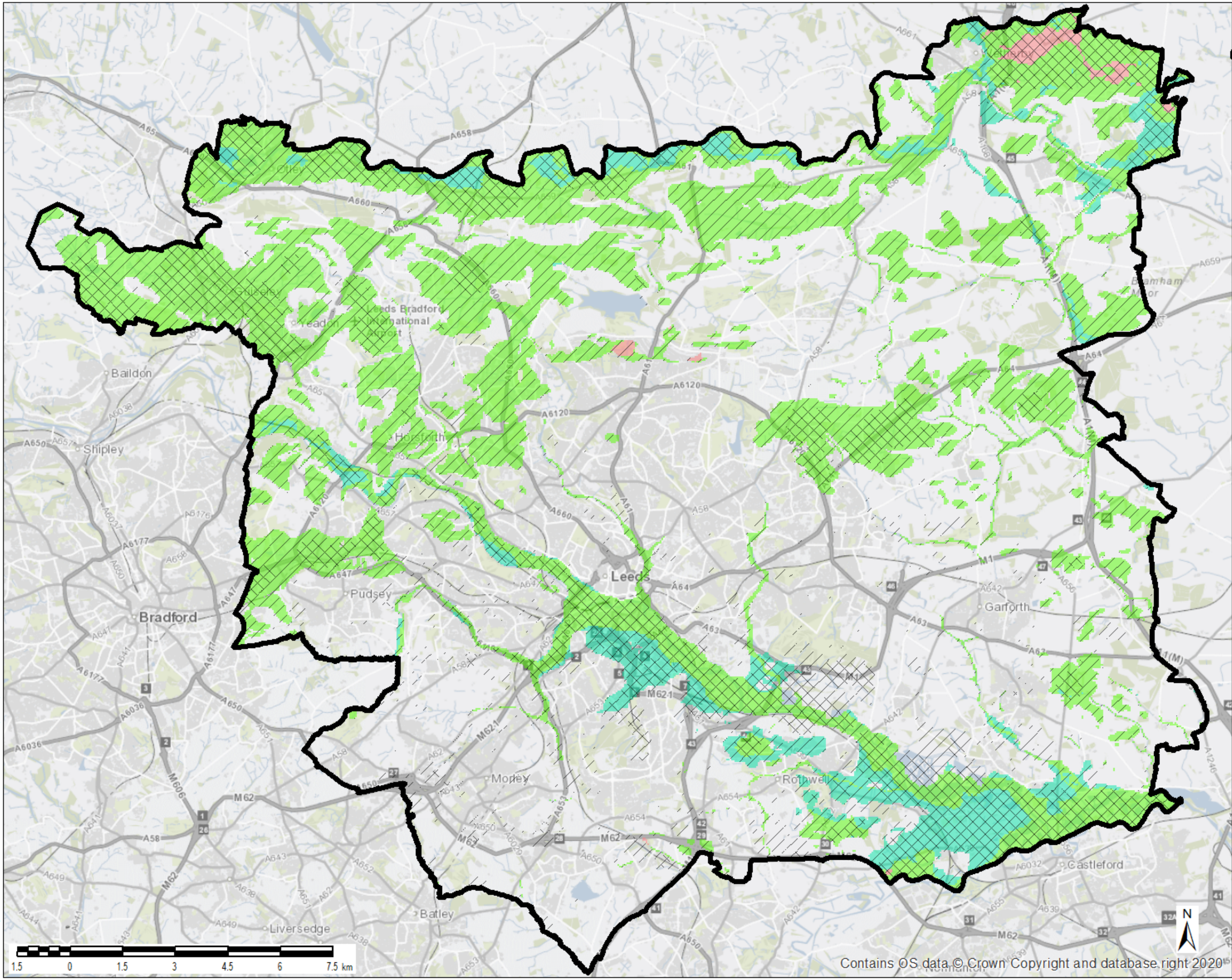
MAP 15	44



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LEGEND

Leeds City Boundary

Superficial Thickness

< 3 m thick

> 3 m thick

Superficial Permeability

Free draining

Highly variable permeability

Poorly draining

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STRATEGIC FLOOD RISK ASSESSMENT

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MAP 16
INFILTRATION SUITABILITY: SUPERFICIAL GEOLOGY THICKNESS AND PERMEABILITY

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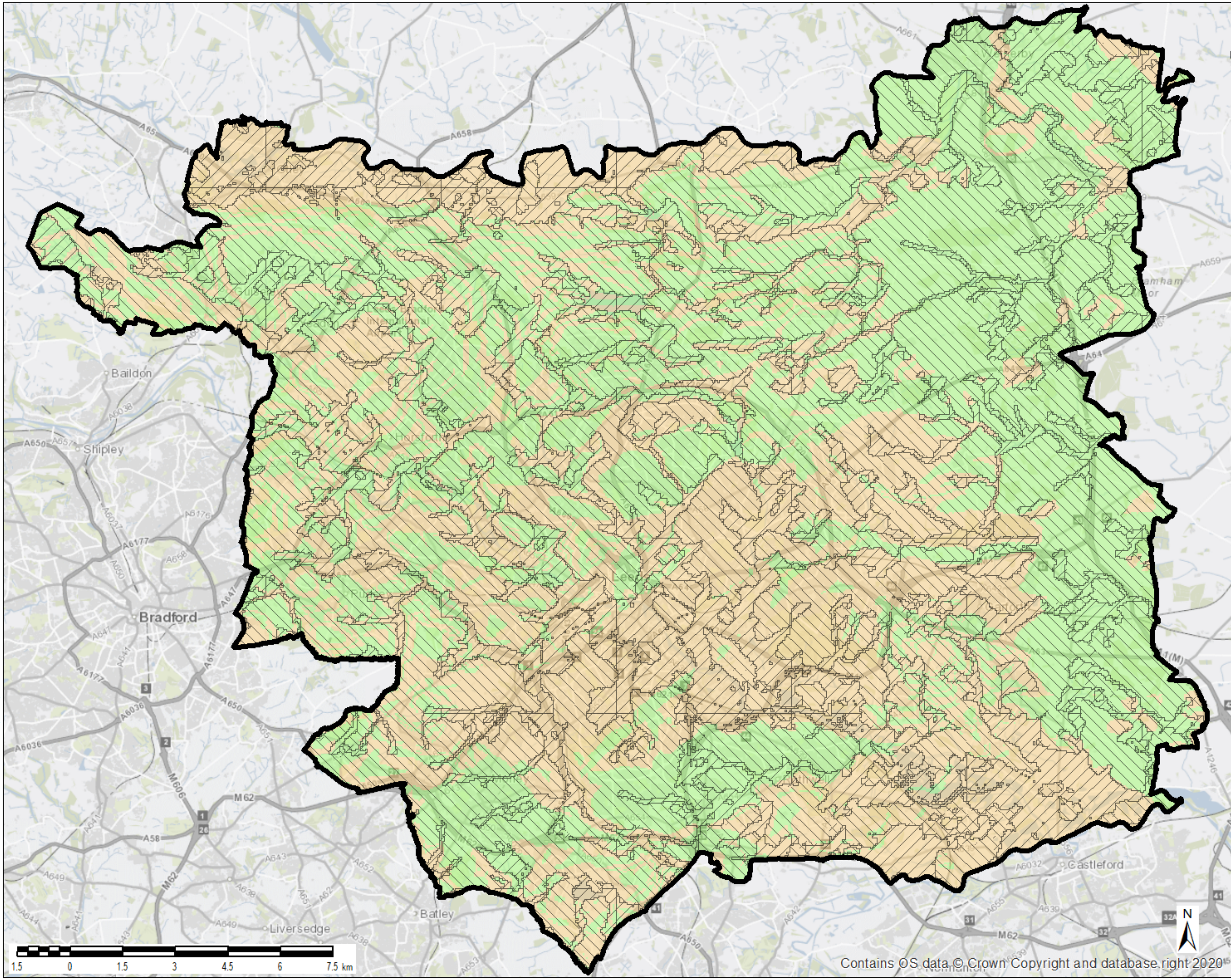
Drawing Number	Rev
MAP 16	3



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LEGEND

Leeds City Boundary

Depth to Water Table

3-5 m below ground surface

< 3 m below ground surface

> 5 m below ground surface

Bedrock Permeability

Free draining

Highly variable permeability

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 17
INFILTRATION SUITABILITY:
BEDROCK GEOLOGY
AND DEPTH TO WATER

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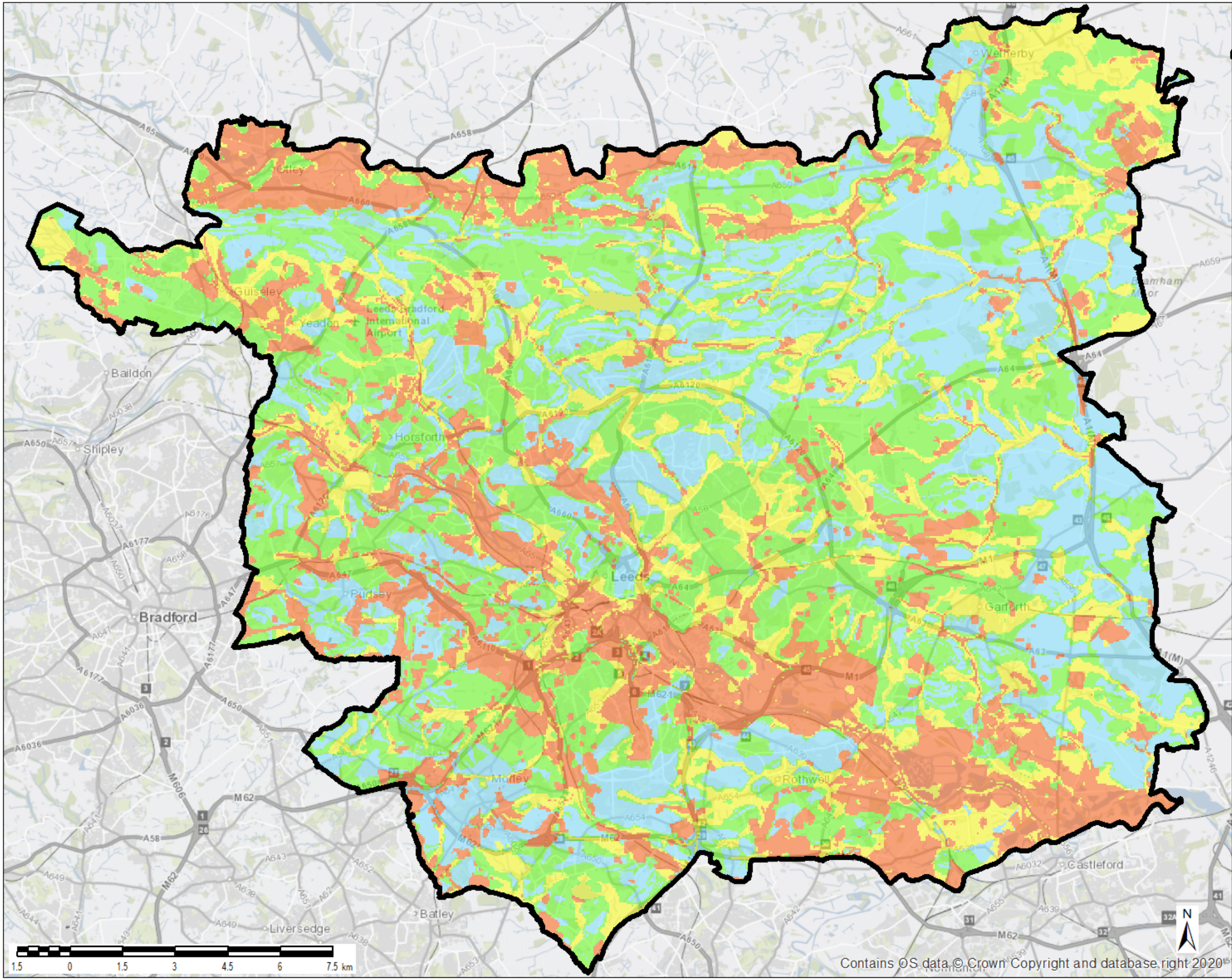
MAP 17	3



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LEGEND

- Leeds City Boundary
- Infiltration highly suitable
- Infiltration probably suitable
- Infiltration potentially suitable
- Significant contrains on infiltration

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MAP 18
INFILTRATION SUITABILITY: SUMMARY

Drawn	Checked	Approved	Date
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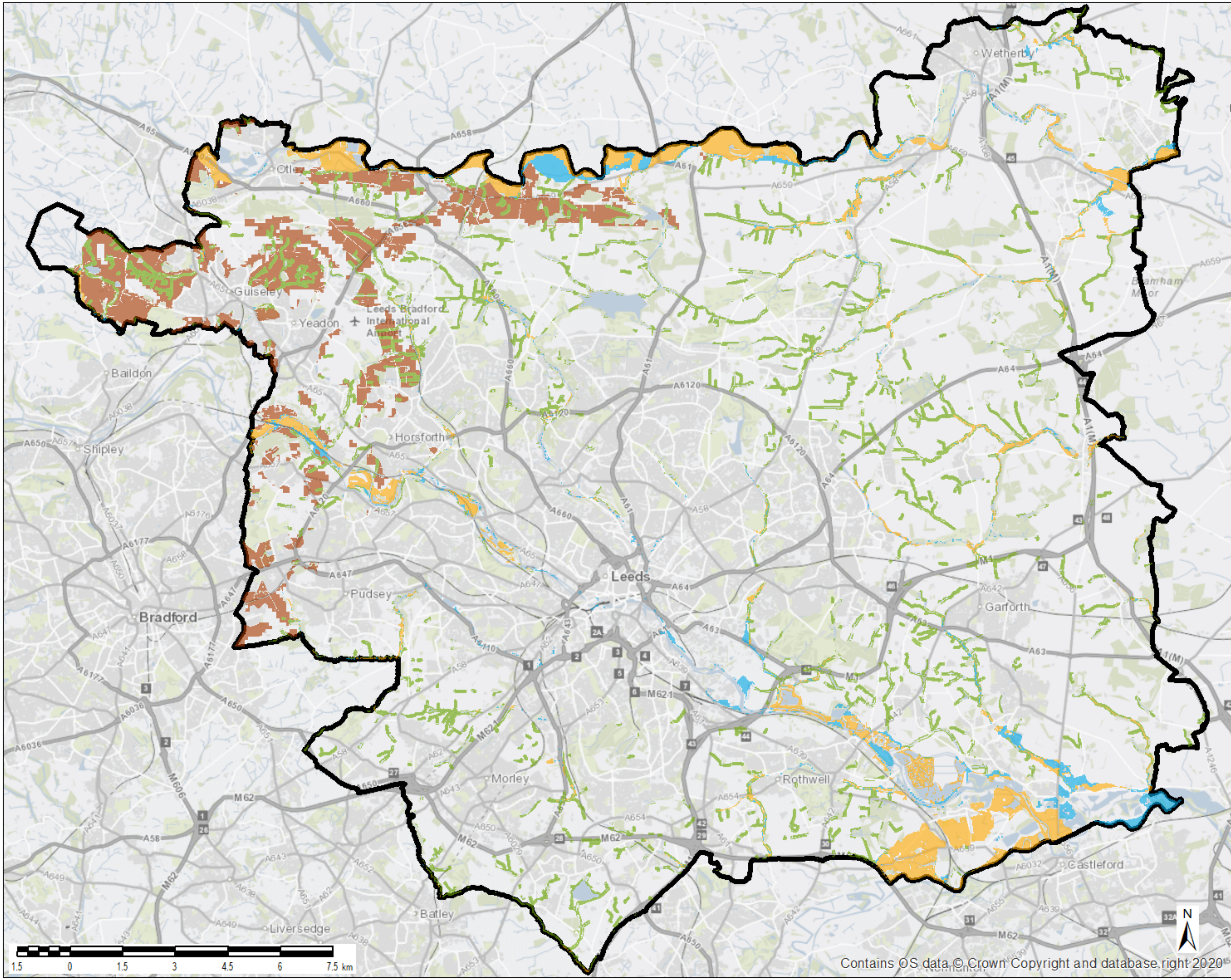
Drawing Number	Rev
MAP 18	3



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LEGEND

- Floodplain Reconnection Potential
- Floodplain Woodland Potential
- Riparian Woodland Potential
- Wider Catchment Woodland Potential
- Leeds City Boundary

Mapping outputs from the Environment Agency led research project 'Working with Natural Processes' (WWNP). Further information on the Working with Natural Processes project, including a mapping user guide, can be found in the project website published on GOV.UK.

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MAP 19
OPPORTUNITY MAPPING
WORKING WITH
NATURAL PROCESSES

Drawn	Checked	Approved	Date
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Drawing Number	Rev
MAP 19	5

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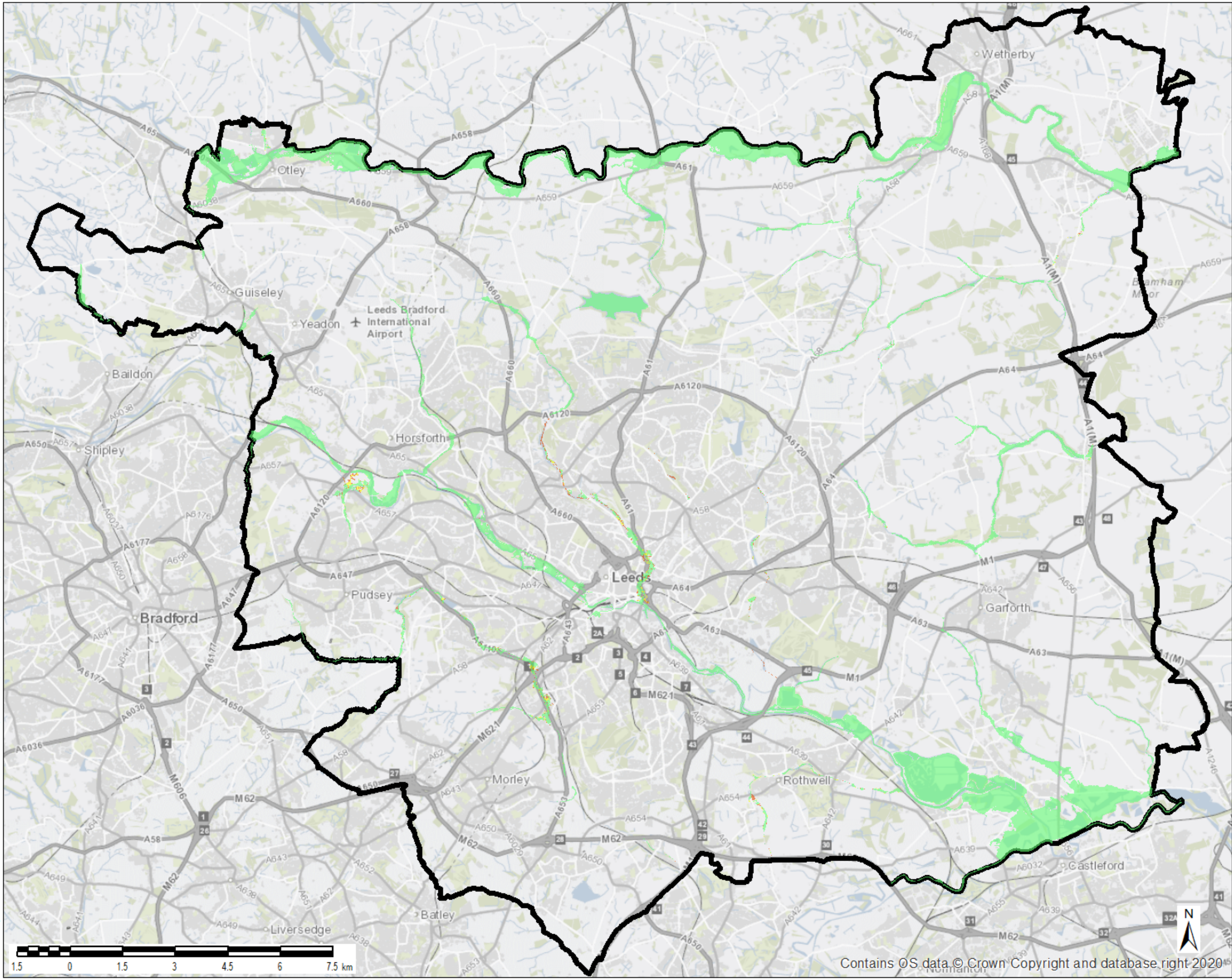
LEGEND

Leeds City Boundary

Detailed Modelled Flood Outlines Including Climate Change Allowances

- 20 years Event +23%
- 20 years Event +31%
- 20 years Event +48%



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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 20A
DETAILED DEFENDED MODELLED FLOOD OUTLINES: 20 YEAR EVENT PLUS CLIMATE CHANGE COMPLETED SCHEMES ONLY

Drawn	Checked	Approved	Date
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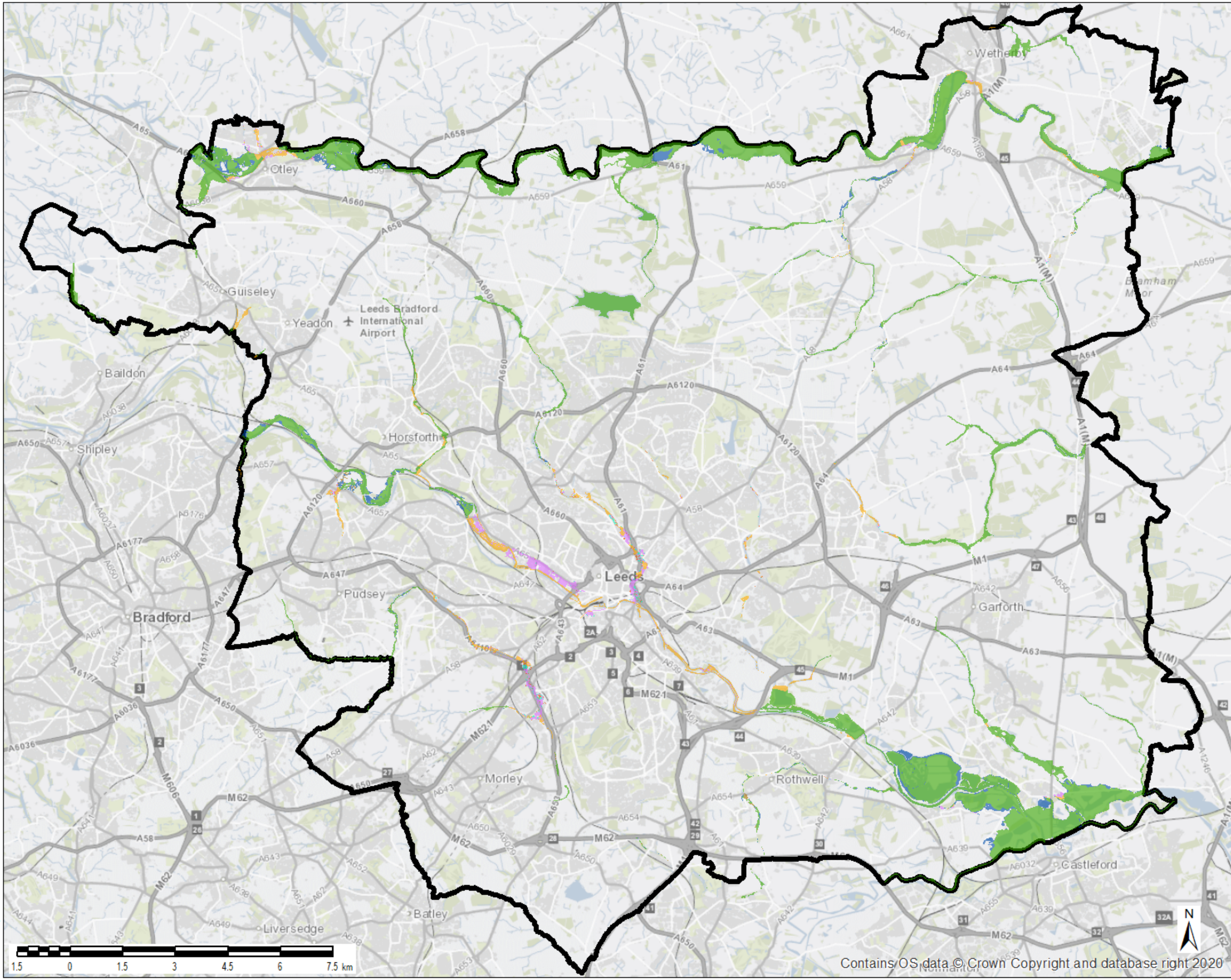
Drawing Number	Rev
MAP 20A	4

File Name: L:\DCS\Projects\...\Map_Functional_Floodplain(Climate_Change).mxd



LEGEND

Leeds City Boundary

Functional Floodplain (Existing Development)

- Present Day
- 23% Climate Change
- 31% Climate Change
- 48% Climate Change

Functional Floodplain (Undeveloped)

- Present Day
- 23% Climate Change
- 31% Climate Change
- 48% Climate Change

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Project Title

STRATEGIC FLOOD RISK ASSESSMENT

Drawing Title

MAP 21A
DEVELOPED AND UNDEVELOPED FUNCTIONAL FLOODPLAIN (PRESENT) DAY AND WITH CLIMATE CHANGE ALLOWANCES): COMPLETED SCHEMES ONLY

Drawn	Checked	Approved	Date
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Drawing Number	Rev
MAP 21A	2

Appendix B List of modelled flood outlines (use of proxies)

B.1 River Calder List of Modelling data (including proxies)

Reach/Watercourse	Target Return period	Proxy	Study/model	Comments
Aire - Lower Aire (including confluence of Calder)	Defended 1 in 20 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended 1 in 100 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended 1 in 1000 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 20 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 100 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 1000 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year +51%	Defended Climate Change 1 in 100 year +50%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year +51%	Undefended Climate Change 1 in 100 year +50%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Climate Change 1 in 20 year + 23%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Climate Change 1 in 20 year + 31%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Climate Change 1 in 20 year +51%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
Calder M62 to railway culverts	Defended 1 in 20 year	Defended 1 in 25 year	2015 Calder and Canals Model	
	Defended 1 in 100 year	No Proxy Required	2015 Calder and Canals Model	
	Defended 1 in 1000 year	No Proxy Required	2015 Calder and Canals Model	
	Undefended 1 in 20 year	Defended 1 in 25 year	2015 Calder and Canals Model	
	Undefended 1 in 100 year	No Proxy Required	2015 Calder and Canals Model	
	Undefended 1 in 1000 year	No Proxy Required	2015 Calder and Canals Model	
	Defended Climate Change 1 in 100 year + 23%	Defended 1 in 200 year	2015 Calder and Canals Model	
	Defended Climate Change 1 in 100 year + 31%	Defended 1 in 200 year	2015 Calder and Canals Model	
	Defended Climate Change 1 in 100 year +51%	Defended 1 in 200 year	2015 Calder and Canals Model	
	Undefended Climate Change 1 in 100 year + 23%	Undefended 1000 year	2015 Calder and Canals Model	

	Undefended Climate Change 1 in 100 year + 31%	Undefended 1000 year	2015 Calder and Canals Model	
	Undefended Climate Change 1 in 100 year +51%	Undefended 1000 year	2015 Calder and Canals Model	
	Climate Change 1 in 20 year + 23%	Defended 1 in 25 year	2015 Calder and Canals Model	< 100 year runs have the same extents
	Climate Change 1 in 20 year + 31%	Defended 1 in 25 year	2015 Calder and Canals Model	< 100 year runs have the same extents
	Climate Change 1 in 20 year +51%	Defended 1 in 25 year	2015 Calder and Canals Model	< 100 year runs have the same extents

B.2 Aire catchment List of Modelling data (including proxies)

Reach/Watercourse	Target Return period	Proxy	Study/model	Comments
Aire - Bradford border to Leeds City Centre (LFAS2)	Defended 1 in 20 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Defended 1 in 100 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Defended 1 in 1000 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Undefended 1 in 20 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Undefended 1 in 100 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Undefended 1 in 1000 year	No Proxy Required	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Defended Climate Change 1 in 100 year +51%	Defended Climate Change 1 in 100 year +50%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Undefended Climate Change 1 in 100 year +51%	Undefended Climate Change 1 in 100 year +50%	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
	Climate Change 1 in 20 year +51%	Defended 1 in 100 year	Leeds Flood Alleviation Scheme Phase 2, Step 2 Fluvial Hydraulic Modelling Report EUCR2, Mott MacDonald for Leeds City Council, February 2021	With LFAS Phase 2 Step 1 and Step 2 in place
Aire - LFAS1	Defended 1 in 20 year	No Proxy Required	FAS 1 Modelled Outlines EA 2021	
	Defended 1 in 100 year	No Proxy Required	FAS 1 Modelled Outlines EA 2021	
	Defended 1 in 1000 year	Undefended 1 in 1000 year	FAS 1 Modelled Outlines EA 2021	
	Undefended 1 in 20 year	No Proxy Required	FAS 1 Modelled Outlines EA 2021	
	Undefended 1 in 100 year	No Proxy Required	FAS 1 Modelled Outlines EA 2021	
	Undefended 1 in 1000 year	No Proxy Required	FAS 1 Modelled Outlines EA 2021	
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	FAS 1 Modelled Outlines EA 2021	
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	FAS 1 Modelled Outlines EA 2021	
	Defended Climate Change 1 in 100 year +51%	Defended Climate Change 1 in 100 year +50%	FAS 1 Modelled Outlines EA 2021	
	Undefended Climate Change 1 in 100 year + 23%	Undefended 1 in 1000 year	FAS 1 Modelled Outlines EA 2021	
	Undefended Climate Change 1 in 100 year + 31%	Undefended 1 in 1000 year	FAS 1 Modelled Outlines EA 2021	
	Undefended Climate Change 1 in 100 year +51%	Undefended 1 in 1000 year	FAS 1 Modelled Outlines EA 2021	

	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	FAS 1 Modelled Outlines EA 2021	FAS SoP includes climate change allowances, 20 year is defended.
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	FAS 1 Modelled Outlines EA 2021	FAS SoP includes climate change allowances, 20 year is defended.
	Climate Change 1 in 20 year +51%	Defended 1 in 100 year	FAS 1 Modelled Outlines EA 2021	FAS SoP includes climate change allowances, 20 year is defended.
Aire - A642 to M1	Defended 1 in 20 year	Flood Zone 3		area with little/no development, nature reserves and lakes
	Defended 1 in 100 year	Flood Zone 3		area with little/no development, nature reserves and lakes
	Defended 1 in 1000 year	Flood Zone 2		area with little/no development, nature reserves and lakes
	Undefended 1 in 20 year	Flood Zone 3		area with little/no development, nature reserves and lakes
	Undefended 1 in 100 year	Flood Zone 3		area with little/no development, nature reserves and lakes
	Undefended 1 in 1000 year	Flood Zone 2		area with little/no development, nature reserves and lakes
	Climate Change 1 in 100 year + 23%	Flood Zone 2		area with little/no development, nature reserves and lakes
	Climate Change 1 in 100 year + 31%	Flood Zone 2		area with little/no development, nature reserves and lakes
	Climate Change 1 in 100 year +51%	Flood Zone 2		area with little/no development, nature reserves and lakes
	Climate Change 1 in 20 year + 23%	Flood Zone 3		area with little/no development, nature reserves and lakes
	Climate Change 1 in 20 year + 31%	Flood Zone 3		area with little/no development, nature reserves and lakes
	Climate Change 1 in 20 year +51%	Flood Zone 3		area with little/no development, nature reserves and lakes
Aire - Lower Aire (including confluence of Calder)	Defended 1 in 20 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended 1 in 100 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended 1 in 1000 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 20 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 100 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended 1 in 1000 year	No Proxy Required	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Defended Climate Change 1 in 100 year +51%	Defended Climate Change 1 in 100 year +50%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Undefended Climate Change 1 in 100 year +51%	Undefended Climate Change 1 in 100 year +50%	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Climate Change 1 in 20 year + 23%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
	Climate Change 1 in 20 year + 31%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	

	Climate Change 1 in 20 year +51%	Defended 1in 100 year	Northern Forecasting Package: Lower Aire Model, Final Report v1.0, JBA for Environment Agency, July 2017	
Bagley Beck	Defended/Undefended 1 in 20 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Defended/Undefended 1 in 100 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Defended/Undefended 1 in 1000 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year +51%	Climate Change 1 in 100 year +50%	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year + 23%	Defended/Undefended 1 in 50 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year + 31%	Defended/Undefended 1 in 75 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year +51%	Defended/Undefended 1 in 100 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
Wortley Beck	Defended/Undefended 1 in 20 year	No Proxy Required	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Defended/Undefended 1 in 100 year	No Proxy Required	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Defended/Undefended 1 in 1000 year	No Proxy Required	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 100 year +51%	Climate Change 1 in 100 year +50%	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 20 year + 23%	Defended/Undefended 1 in 50 year	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 20 year + 31%	Defended/Undefended 1 in 75 year	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
	Climate Change 1 in 20 year +51%	Defended/Undefended 1 in 100 year	Wortley Beck Flood Modelling Study, Environment Agency, February 2017	
Meanwood Beck	Defended/Undefended 1 in 20 year	No Proxy Required	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Defended/Undefended 1 in 100 year	No Proxy Required	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Defended/Undefended 1 in 1000 year	No Proxy Required	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 100 year +51%	Climate Change 1 in 100 year +50%	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 20 year + 23%	Defended/Undefended 1 in 50 year	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 20 year + 31%	Defended/Undefended 1 in 75 year	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
	Climate Change 1 in 20 year +51%	Defended/Undefended 1 in 100 year	Northern Forecasting Package, Meanwood Beck Model Update, Final Report, JBA for Environment Agency, April 2017	
Wyke Beck	Undefended 1 in 20 year	No Proxy Required	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Undefended 1 in 100 year	No Proxy Required	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Undefended 1 in 1000 year	No Proxy Required	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	"As built" includes new survey - no defences
	Climate Change 1 in 100 year + 31%	Defended 1000 year	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	

	Climate Change 1 in 100 year +51%	Defended 1000 year	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Climate Change 1 in 20 year + 23%	Undefended 1 in 40 year	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Climate Change 1 in 20 year + 31%	Undefended 1 in 50 year	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
	Climate Change 1 in 20 year +51%	Undefended 1 in 75 year	Model Guide for Wyke Beck ISIS TUFLOW Model, JBA for Environment Agency, December 2015	
Oulton Beck	Defended 1 in 20 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Defended 1 in 100 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Defended 1 in 1000 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Undefended 1 in 20 year	Undefended 1 in 30 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	No difference 30 year defended/undefended. 20 year defended and undefended assumed no difference.
	Undefended 1 in 100 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Undefended 1 in 1000 year	No Proxy Required	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30% (defended)	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 100 year +51%	Climate Change 1 in 100 year +50% (defended)	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year + 23%	Defended 1 in 50 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year + 31%	Defended 1 in 75 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
	Climate Change 1 in 20 year +51%	Defended 1 in 100 year	Upper Aire Tributaries Flood Mapping, Final Report, JBA for Environment Agency, October 2020	
Lin Beck/Dyke	Defended/Undefended 1 in 20 year	Flood Zone 3		
	Defended/Undefended 1 in 100 year	Flood Zone 3		
	Defended/Undefended 1 in 1000 year	Flood Zone 2		
	Climate Change 1 in 100 year + 23%	Flood Zone 2		
	Climate Change 1 in 100 year + 31%	Flood Zone 2		
	Climate Change 1 in 100 year +51%	Flood Zone 2		
	Climate Change 1 in 20 year + 23%	Flood Zone 3		
	Climate Change 1 in 20 year + 31%	Flood Zone 3		
	Climate Change 1 in 20 year +51%	Flood Zone 3		
Oil Mill Beck	Defended/Undefended 1 in 20 year	Flood Zone 3		
	Defended/Undefended 1 in 100 year	Flood Zone 3		
	Defended/Undefended 1 in 1000 year	Flood Zone 2		
	Climate Change 1 in 100 year + 23%	Flood Zone 2		
	Climate Change 1 in 100 year + 31%	Flood Zone 2		
	Climate Change 1 in 100 year +51%	Flood Zone 2		
	Climate Change 1 in 20 year + 23%	Flood Zone 3		
	Climate Change 1 in 20 year + 31%	Flood Zone 3		
	Climate Change 1 in 20 year +51%	Flood Zone 3		
Ledsham Beck	Defended/Undefended 1 in 20 year	Flood Zone 3		
	Defended/Undefended 1 in 100 year	Flood Zone 3		
	Defended/Undefended 1 in 1000 year	Flood Zone 2		
	Climate Change 1 in 100 year + 23%	Flood Zone 2		

	Climate Change 1 in 100 year + 31%	Flood Zone 2
	Climate Change 1 in 100 year +51%	Flood Zone 2
	Climate Change 1 in 20 year + 23%	Flood Zone 3
	Climate Change 1 in 20 year + 31%	Flood Zone 3
	Climate Change 1 in 20 year +51%	Flood Zone 3
Guiseley Beck/Tran Mire Beck/ Nun Royd Beck/Shaw Beck/Calfhole Beck	Defended/Undefended 1 in 20 year	Flood Zone 3
	Defended/Undefended 1 in 100 year	Flood Zone 3
	Defended/Undefended 1 in 1000 year	Flood Zone 2
	Climate Change 1 in 100 year + 23%	Flood Zone 2
	Climate Change 1 in 100 year + 31%	Flood Zone 2
	Climate Change 1 in 100 year +51%	Flood Zone 2
	Climate Change 1 in 20 year + 23%	Flood Zone 3
	Climate Change 1 in 20 year + 31%	Flood Zone 3
	Climate Change 1 in 20 year +51%	Flood Zone 3

B.3 Wharfe catchment List of Modelling data (including proxies)

Reach/Watercourse	Target Return period	Proxy	Study/model	Comments
Wharfe - Otley (to Knotford) - including Kel Beck	Defended 1 in 20 year	Defended 1 in 25 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Includes Otley FAS scheme
	Defended 1 in 100 year	Defended 1 in 100 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Includes Otley FAS scheme
	Defended 1 in 1000 year	Baseline 1 in 1000 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Undefended 1 in 20 year	Baseline 1 in 25 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Undefended 1 in 100 year	Baseline 1 in 100 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Undefended 1 in 1000 year	Baseline 1 in 1000 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year +30%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Includes Otley FAS scheme
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year +30%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Includes Otley FAS scheme
	Defended Climate Change 1 in 100 year +48%	Defended Climate Change 1 in 100 year +50%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Includes Otley FAS scheme
	Undefended Climate Change 1 in 100 year + 23%	Baseline Climate Change 1 in 100 year + 20%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Undefended Climate Change 1 in 100 year + 31%	Baseline Climate Change 1 in 100 year + 30%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Undefended Climate Change 1 in 100 year +48%	Baseline Climate Change 1 in 100 year +50%	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	Does not include Otley FAS scheme
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	Otley Flood Alleviation Scheme Flood Risk Assessment, WSP for Leeds City Council, March 2020	
Wharfe - Knotford to Castley (railway culvert)	Defended 1 in 20 year	Defended in 1 in 25 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	Defences at Castley Lane (d/s A658) and Collingham
	Defended 1 in 100 year	No proxy required	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	Defences at Castley Lane (d/s A658) and Collingham
	Defended 1 in 1000 year	Flood Zone 2	Not included in current modelling	
	Undefended 1 in 20 year	Defended in 1 in 25 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	No defences in Leeds area in this section
	Undefended 1 in 100 year	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	No defences in Leeds area in this section
	Undefended 1 in 1000 year	Flood Zone 2	Not included in current modelling	
	Climate Change 1 in 100 year + 23% (undefended)	Defended Climate Change 1 in 100 year + 20%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
	Climate Change 1 in 100 year + 31% (undefended)	Defended Climate Change 1 in 100 year + 30%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
	Climate Change 1 in 100 year +48% (undefended)	Defended Climate Change 1 in 100 year + 50%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
	Climate Change 1 in 100 year + 23% (defended)	Defended Climate Change 1 in 100 year + 20%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	Defences at Castley Lane (d/s A658) and Collingham
	Climate Change 1 in 100 year + 31% (defended)	Defended Climate Change 1 in 100 year + 30%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	Defences at Castley Lane (d/s A658) and Collingham
	Climate Change 1 in 100 year +48% (defended)	Defended Climate Change 1 in 100 year + 50%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	Defences at Castley Lane (d/s A658) and Collingham
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020	
Wharfe - Castley (railway culvert) to A61	Defended 1 in 20 year	Flood Zone 3	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020 - Not in 2D Domain	
	Defended 1 in 100 year	Flood Zone 3	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020 - Not in 2D Domain	
	Defended 1 in 1000 year	Flood Zone 2	Not included in current modelling	
	Undefended 1 in 20 year	Flood Zone 3	Not included in current modelling	

	Undefended 1 in 100 year	Flood Zone 3	Not included in current modelling
	Undefended 1 in 1000 year	Flood Zone 2	Not included in current modelling
	Defended Climate Change 1 in 100 year + 23%	Flood Zone 2	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020 - Not in 2D Domain
	Defended Climate Change 1 in 100 year + 31%	Flood Zone 2	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020 - Not in 2D Domain
	Defended Climate Change 1 in 100 year +48%	Flood Zone 2	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020 - Not in 2D Domain
	Undefended Climate Change 1 in 100 year + 23%	Flood Zone 2	Not included in current modelling
	Undefended Climate Change 1 in 100 year + 31%	Flood Zone 2	Not included in current modelling
	Undefended Climate Change 1 in 100 year +48%	Flood Zone 2	Not included in current modelling
	Climate Change 1 in 20 year + 23%	Flood Zone 3	Not included in current modelling
	Climate Change 1 in 20 year + 31%	Flood Zone 3	Not included in current modelling
	Climate Change 1 in 20 year +48%	Flood Zone 3	Not included in current modelling
Wharfe - A61 to Collingham	Defended 1 in 20 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended 1 in 100 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 20 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 100 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year +48%	Defended Climate Change 1 in 100 year + 50%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year +48%	Undefended Climate Change 1 in 100 year + 50%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
Wharfe - Collingham to ds A1(M)	Defended 1 in 20 year	Defended in 1 in 25 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended 1 in 100 year	No proxy required	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020

	Defended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 20 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 100 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended Climate Change 1 in 100 year +48%	Defended Climate Change 1 in 100 year + 50%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year +48%	Undefended Climate Change 1 in 100 year + 50%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
Wharfe - A1(M) to LCC boundary	Defended 1 in 20 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended 1 in 100 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 20 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 100 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended 1 in 1000 year	No proxy required	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Defended Climate Change 1 in 100 year +48%	Defended Climate Change 1 in 100 year + 50%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year + 23%	Undefended Climate Change 1 in 100 year + 20%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year + 31%	Undefended Climate Change 1 in 100 year + 30%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Undefended Climate Change 1 in 100 year +48%	Undefended Climate Change 1 in 100 year + 50%	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.

	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	2018 Ouse and Wharfe Washlands Optimisation Study - Defended and Undefended Flood Modelling for Flood Map Creation, Environment Agency, Mott MacDonald, July 2018.
Hol Beck	Defended/Undefended 1 in 20 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended/Undefended 1 in 100 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended/Undefended 1 in 1000 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year +48%	Climate Change 1 in 100 year +50%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 23%	Baseline 1 in 50 year Event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 31%	Baseline 1in 75 year event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year +48%	Baseline 1 in 100 year event	River Wharf tributaries, Environment Agency, JBA 2021
Fir Green Beck	Defended 1 in 20 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended 1 in 100 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended 1 in 1000 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 20 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 100 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 1000 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 100 year +48%	Climate Change 1 in 100 year +50%	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 23%	Baseline 1 in 50 year Event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 31%	Baseline 1in 75 year event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year +48%	Baseline 1 in 100 year event	River Wharf tributaries, Environment Agency, JBA 2021
Collingham Beck	Defended 1 in 20 year	Defended in 1 in 25 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended 1 in 100 year	No proxy required	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended 1 in 1000 year	Flood Zone 2	Not included in current modelling
	Undefended 1 in 20 year	Flood Zone 3	Not included in current modelling
	Undefended 1 in 100 year	Flood Zone 3	Not included in current modelling
	Undefended 1 in 1000 year	Flood Zone 2	Not included in current modelling
	Defended Climate Change 1 in 100 year + 23%	Defended Climate Change 1 in 100 year + 20%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended Climate Change 1 in 100 year + 31%	Defended Climate Change 1 in 100 year + 30%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Defended Climate Change 1 in 100 year +48%	Defended Climate Change 1 in 100 year + 50%	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Undefended Climate Change 1 in 100 year + 23%	Flood Zone 2	Not included in current modelling
	Undefended Climate Change 1 in 100 year + 31%	Flood Zone 2	Not included in current modelling
	Undefended Climate Change 1 in 100 year +48%	Flood Zone 2	Not included in current modelling
	Climate Change 1 in 20 year + 23%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Climate Change 1 in 20 year + 31%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020
	Climate Change 1 in 20 year +48%	Defended 1 in 100 year	River Wharfe Catchment Study, Hydraulic Modelling Report, WSP for Leeds City Council, October 2020

Cock Beck	Defended 1 in 20 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended 1 in 100 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended 1 in 1000 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 20 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 100 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended 1 in 1000 year	No proxy required	River Wharf tributaries, Environment Agency, JBA 2021
	Defended Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	River Wharf tributaries, Environment Agency, JBA 2021
	Defended Climate Change 1 in 100 year + 31%	Climate Change 1 in 100 year + 30%	River Wharf tributaries, Environment Agency, JBA 2021
	Defended Climate Change 1 in 100 year +48%	Climate Change 1 in 100 year +50%	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended Climate Change 1 in 100 year + 23%	Climate Change 1 in 100 year + 20%	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended Climate Change 1 in 100 year + 31%	Undefended 1 in 1000 year	River Wharf tributaries, Environment Agency, JBA 2021
	Undefended Climate Change 1 in 100 year +48%	Undefended 1 in 1000 year	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 23%	Baseline 1 in 50 year Event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year + 31%	Baseline 1 in 75 year event	River Wharf tributaries, Environment Agency, JBA 2021
	Climate Change 1 in 20 year +48%	Baseline 1 in 100 year event	River Wharf tributaries, Environment Agency, JBA 2021
Eller Beck	Defended/Undefended 1 in 20 year	Flood Zone 3	
	Defended/Undefended 1 in 100 year	Flood Zone 3	
	Defended/Undefended 1 in 1000 year	Flood Zone 2	
	Climate Change 1 in 100 year + 23%	Flood Zone 2	
	Climate Change 1 in 100 year + 31%	Flood Zone 2	
	Climate Change 1 in 100 year +51%	Flood Zone 2	
	Climate Change 1 in 20 year + 23%	Flood Zone 3	
	Climate Change 1 in 20 year + 31%	Flood Zone 3	
	Climate Change 1 in 20 year +51%	Flood Zone 3	

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