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River Crane Catchment – Flood Risk Study

Prepared for The Crane Valley Partnership

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Executive Summary

The purpose of this flood risk study is to help provide the Crane Valley Partnership (CVP) with a complete picture of the current flood risk across the River Crane catchment and the catchment incorporating the Longford River and Portlane Brook. The study aims to address all sources of flooding within the catchment, including fluvial, surface water, groundwater, sewer and artificial.

The River Crane catchment encompasses several London Boroughs, namely Ealing, Harrow, Hillingdon, Hounslow, and Richmond upon Thames. The River Crane is an urban river and one of the main tributaries of the River Thames in Greater London. The River Crane catchment network includes the Yeading Brook, the River Roxbourne, Duke of Northumberland's River, Frog's Ditch and Whitton Brook.

The Crane catchment is subject to fluvial flooding from the River Crane and associated tributaries. In areas where large extents of flooding were predicted, risk to properties was predominantly mitigated due to the presence of adequate floodplains and green corridors along the Yeading Brook and River Crane. Three fluvial flooding hotspots to properties were identified across the catchment, situated at The Greenway in Ickenham, Langley Crescent and Cranes Water in Hayes, and Fulwell Park Avenue in Twickenham.

The catchment is bordered by a section of the River Thames that is subjected to tidal influence. The River Crane outfalls into the tidal River Thames near Isleworth Ait and is characterised as intertidal for 870 m upstream of the outfall.

Properties at risk of flooding from surface water are dispersed throughout the catchment. In the northern half of the Crane catchment (approximately the area to the north of Heathrow), surface water follows distinct flow paths due to the hilly nature of the catchments. Surface water flood risk is concentrated close to these flow paths before they enter local watercourses. In the southern half of the catchment, surface water flood risk is less defined. There are smaller flow paths but also pockets of flooding predicted, due to the flat environment in those areas. 45 surface water hotspots were identified, and they were based on surface water flood risk, historic flood reports, and Critical Drainage Areas. The impact of climate change on surface water flooding was approximated using the Flood Estimation Handbook with catchment-specific level descriptors and rainfall depth-duration-frequency estimates. These estimates indicate that climate change will likely increase the extents of surface water flooding in lower (more frequent) return period events.

The catchment is also at risk of flooding from other sources such as groundwater, sewers, and reservoirs. The southern section of the catchment is susceptible to groundwater flooding. This is mainly due to superficial deposit flooding and the level of susceptibility varies throughout the catchment. Overall, the sewer network is predicted to be highly vulnerable to sewer surcharge, with most of the catchment identified in the Thames Water Utilities Limited Capacity Assessment Framework as at risk since 2020. There are also a number of reservoirs within and just outside the catchment which may present a risk to the infrastructure and properties within the catchment. This risk is concentrated in areas around the southern boundary of the catchment in Richmond.

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Figures and Tables

Acronyms and Abbreviations

Abbreviation	Definition
AEP	Annual Exceedance Probability
CAF	Capacity Assessment Framework
CDA	Critical Drainage Area
CVP	Crane Valley Partnership
DNR	Duke of Northumberland's River
DRN	Detailed River Network
DWMP	Drainage and Wastewater Management Plan
EA	Environment Agency
Ealing	London Borough of Ealing
Harrow	London Borough of Harrow
Hillingdon	London Borough of Hillingdon
Hounslow	London Borough of Hounslow
IUD	Integrated Urban Drainage
LLFA	Lead Local Flood Authority
mAOD	metres Above Ordnance Datum
MCM	Multi-Coloured Manual
NPPF	National Planning Policy Framework
NRD	National Receptor Dataset
OSMM	Ordinance Survey Master Map

Abbreviation	Definition
PPG	Planning Practice Guidance
Richmond	London Borough of Richmond upon Thames
RoFSW	Risk of Flooding from Surface Water
Surrey	Surrey County Council
SWC	Smarter Water Catchment
SWMP	Surface Water Management Plan
TOID	Topographical Identifier
TWUL	Thames Water Utilities Limited
uFMfSW	Updated Flood Map for Surface Water

GLOSSARY

Term	Definition
Catchment	An area which drains to a specific watercourse, or a given point on a watercourse, waterbody, or other body of water.
Critical Drainage Area	Specific geographic areas (usually catchment areas) that have typically been identified as having multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) during heavy weather periods, leaving people, property, and local infrastructure at risk. These areas are defined by a borough's Surface Water Management Plan (SWMP) and does not include areas with critical drainage problems as designated by the EA.
Flood Risk	A combination of the probability and the potential consequences of flooding from all sources. This includes flood risk from rivers and the sea, directly from rainfall on the ground surface (surface water runoff), rising groundwater, overwhelmed sewers and drainage systems, the overtopping of reservoirs, canals and lakes, and other artificial sources.
Floodplain	An area of land which experiences flooding when flood management infrastructure exceeds capacity. In these times, water either flows over this area of land or is stored on them.
Local Lead Flood Authority	As defined in the Flood and Water Management Act (2010) as the unitary authority (or county council if there is no unitary authority) that leads in managing local flood risks.
Main River	A statutory type of watercourse designated as such by the Environment Agency. These watercourses tend to be larger rivers and streams but are not exclusively so. The Environment Agency has powers to carry out maintenance and operational works on these watercourses, including flood defence works.
Ordinary Watercourses	A watercourse that is not designated as a main river. It includes rivers, streams, land and roadside ditches, drains, cuts, culverts, dikes, sluices, some sewers (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows.
Return Period	Often referred to as recurrence intervals, or annual average exceedance probabilities, these convey information about the likelihood (or probability) of events, such as a rainfall or flood event, from happening. For example, a 100-year storm event is an event that has a 1 in 100 (1:100) chance (1% probability) of occurring in any given year.

1 INTRODUCTION

1.1 Project Background

The Crane Valley Partnership (CVP) have commissioned Metis Consultants (Metis) to provide a flood risk study for the River Crane Catchment and the catchment incorporating the Longford River and Portlane Brook. The study aims to address all sources of flooding within the catchment, including fluvial, surface water, groundwater, sewer and artificial.

1.2 Project Objectives

The project objectives for the flood risk study are the following:

- Have a complete picture of the current flood risk across the catchment as a whole, taking into consideration fluvial, tidal, surface water, groundwater, and sewer network flooding.
- Collect historic flood reports, Critical Drainage Areas (CDAs), Integrated Urban Drainage (IUD) models, and proposed works within the catchment boundary.
- Provide property counts for all properties, residential and non-residential, that are at risk of flooding for each associated flood type.
- Identify and report potential flooding hotspots across the catchment.

1.3 Site Description

1.3.1 Location

The River Crane catchment, defined and sourced from the EA, encompasses several London Boroughs, namely Ealing, Harrow, Hillingdon, Hounslow, and Richmond upon Thames (Richmond), shown in *Figure 1-1*. Also covered in this flood risk study is the catchment incorporating the Portlane Brook and Longford River, which are primarily located within Surrey County Council (Surrey) and the London Borough of Richmond, respectively. The Longford River is an artificial waterway, a distributary designed to embellish a park, that diverts water 19 km from the River Colne at Longford near Colnbrook in England, to Bush Park and Hampton Court Palace. The Portlane Brook is located in Surrey and borders the Kempton Park Racecourse before connecting to the River Thames at Lower Hampton Road. Although these rivers do not connect to the River Crane, their catchments will be assessed for different sources of flood risk and hereinafter is included in the term 'Crane catchment'.

1.3.2 Existing land use

The Crane catchment is an urban lowland river catchment and covers an area of approximately 125 km^2. This area extends across five west London boroughs and is home to over 650,000 people. Several major highways (including the M4, M40 and A30) cross the catchment and much of Heathrow, the UK's busiest passenger airport, lies within the catchment. The catchment is largely covered by residential and commercial development, but within this are semi-natural green corridors of around 60 km in length, running along the River Crane, Yeading Brook and other associated watercourses. While the catchment is heavily urbanised, many of the Hayes to Whitton flood-meadows have been conserved, forming a narrow, green vale, opening out to what remains of Hounslow Heath in the centre, creating a near-continuous belt of semi-natural habitat.

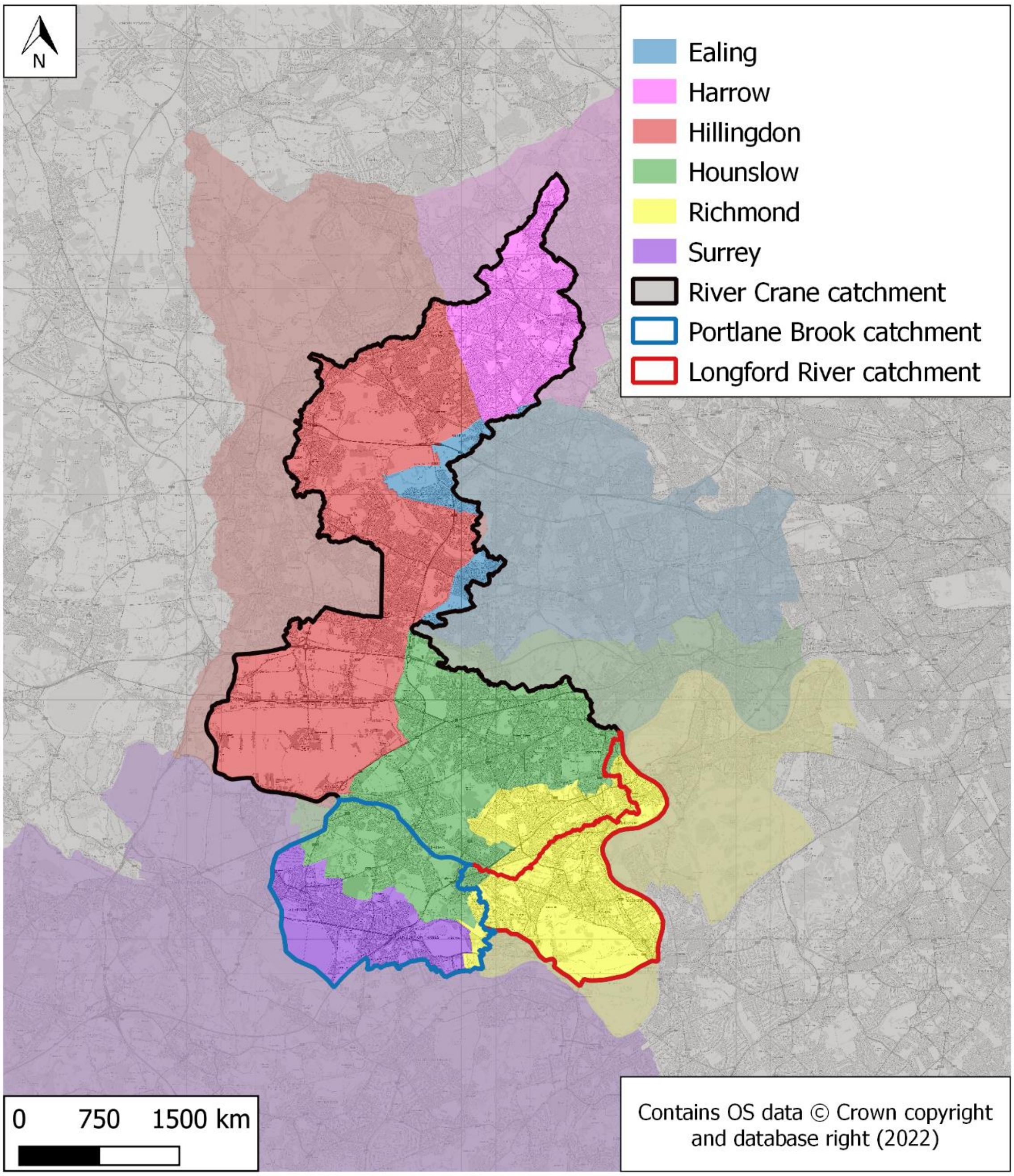

Figure 1-1. Site Location

1.3.3 Topography

The topography of the River Crane catchment generally slopes in a southern direction towards the River Thames. The highest parts are in the northern section of the catchment in Harrow. Notable high points are at Harrow Weald, which is at approximately 125 metres Above Ordnance Datum (mAOD) and Harrow on the Hill around Grove Wood, at 120 mAOD. The lowest part of the catchment is along the River Thames at the south-eastern boundary in Richmond. The ground level where the River Crane discharges into the River Thames is approximately 3 mAOD. The river channels of the Yeading Brook and River Crane form natural low points through the middle of the catchment flowing from north to south-east. There are also a number of railway embankments throughout the catchment which alter the natural topography. For example, the Chiltern Main Line and Great Western Main Line form local high points which may alter surface water flow paths. The general topography of the catchment is shown in *Figure 1* in *Appendix A* – Flood Risk Maps

1.3.4 Hydrology

The River Crane is an urban river and one of the main tributaries of the River Thames in Greater London. The River Crane catchment network includes the Yeading Brook, Duke of Northumberland's River, Frog's Ditch and Whitton Brook. The River Crane's main river network is shown in *Figure 1-2*. The Detailed River Network (DRN) for the entire catchment is shown in *Figure 2* in *Appendix A*.

The River Crane begins near the intersection of the Great Western railway line and the Yeading Brook, Hillingdon, when the Yeading Brook becomes the River Crane. The river runs 14 km through three north-west and west London boroughs, namely Hillingdon, Hounslow, and Richmond upon Thames, and joins the Thames at Isleworth. The Crane's form has been greatly altered by river engineering works; over centuries the watercourse has been subject to widening, narrowing, straightening, dredging and bank reinforcement. Currently, the tributaries to the River Crane are as follows:

- Duke of Northumberland's River (DNR): this man-made river has two distinct sections, constructed at different times. The Upper DNR is purely a tributary of the Crane and a distributary of the River Colne. It connects from the Colne at Longford and joins the Crane at the far west of Hounslow. The Lower DNR is a distributary of the Crane which flows to its confluence with the River Thames in Isleworth, within the borough of Hounslow
- The Yeading Brook is the Crane system's upper reach and is 25.6 km long. The Yeading Brook flows through Harrow from the east through two principal branches, the East and West. The Yeading Brook East, that begins as the River Roxbourne, enters Harrow at Newton Park East and flows in a south-westerly direction through South Ruislip and then west along the southern boundary of Northolt Aerodrome before its confluence with the Yeading Brook West. The Yeading Brook West enters North Harrow near Melbourne Avenue and flows in parallel with the Yeading Brook East in a south-westerly direction, until its confluence with the Ickenham Stream to the south. The Yeading Brook West then flows through rural land before its confluence with the Yeading Brook East just south of the A40 in Hillingdon. The Yeading Brook main branch continues to flow south passing through green open space to the southeast of Yeading and the easterly edge of Hayes. The Yeading Brook travels in parallel with the Grand Union Canal before crossing the Great Western Railway and becoming the River Crane.
- Frog's Ditch flows from south-west Hayes, crossing under the M4 motorway before flowing along the western and southern boundaries of Cranford Country Park. It joins the Crane immediately upstream of the Cranford Lane Road bridge at the southern end of the park.
- The Whitton Brook flows into the River Crane at the Cole Park Allotments site.

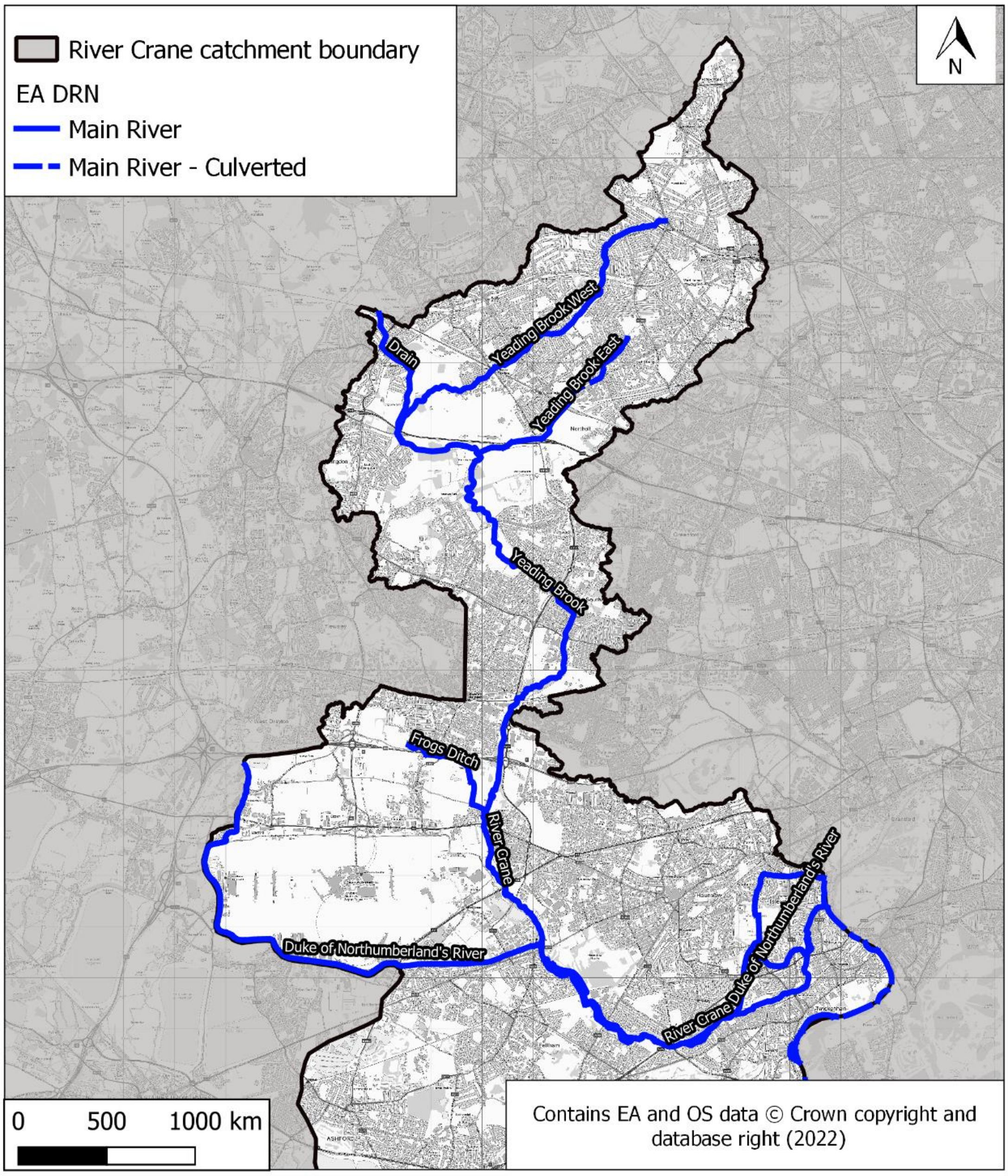

Figure 1-2. River Crane and associated watercourses

1.3.5 Geology

Located within the London Basin, the River Crane catchment is extensively underlain by Thames Group bedrock geology. According to the BGS Geology of Britain dataset, this group consists of clay, silt and sand and is dominated by the London Clay Formation. The London Clay Formation is the most prolific bedrock within the River Crane catchment, extending throughout all boroughs. It is associated with low infiltration rates due to its very low hydraulic conductivity. A small region in the north of the catchment, including parts of Hillingdon and Harrow is underlain by the Lambeth Group, which has a similar lithology as the London Clay. A very small region in the south-eastern corner of Harrow, around St. Dominic’s Sixth Form College, has Claygate Member and Bagshot Formation bedrock geology. These areas are likely to be more permeable and are associated with higher rates of infiltration than the London Clay. The bedrock geology of the River Crane catchment is shown in *Figure 3* in *Appendix A* – Flood Risk Maps

The north of the catchment has little to no superficial deposits. The south of the catchment (south of Southall, Ealing) has a mixture of River Terrace Deposits, which predominantly consists of sand and gravel with local accumulations of silt, clay, or peat. The southern border is made up of Kempton Park Gravel Member and Taplow Gravel Member with small deposits of Langley Silt Member in the south-eastern corner. There are Alluvium deposits along the flow path of the River Crane and the River Thames. Langley Silt is the predominant superficial deposit found in the middle section of the catchment, extending from Hounslow West in the south as far as Yeading to the north. There is also significant deposit of Lynch Hill Gravel Member (sand and gravel) within this section, particularly around Hayes and Harlington railway station. There are small deposits of Boyn Hill Gravel (Sand and Gravel) and Black Park Gravel (Sand and Gravel) in a north-east section of the catchment around Hayes End and Hillington town centre. The Kempton Park Gravel Member and the Taplow Gravel Member are designated Principal Aquifers. The Boyn Hill Gravel and Black Park Gravel are designated as Secondary A Aquifers. The superficial geology of the River Crane catchment is shown in *Figure 4* in *Appendix A* – Flood Risk Maps

1.3.6 Local Drainage Network

The entire sewer network within the River Crane catchment is owned and operated by Thames Water Utilities Limited (TWUL). The vast majority of sewers are separated, meaning that the surface water and foul water are conveyed in separate systems. Exceptions to this are small areas of Hounslow West and Whitton where the sewer systems remain combined, and foul and surface water are collected and conveyed into one system. The surface water sewers in the northern corner of the catchment flow into drains which combine at Headstone Manor Recreation Ground near the source of the Yeading Brook West. The surface water sewers in Harrow and Hillingdon all discharge into the Yeading Brook up until Cranbrook Park where it becomes the River Crane. Some outfall points into the Yeading Brook are located at Cannon Lane (Harrow), Whitby Road (Hillingdon), Uxbridge Road (Hillingdon) and around Staines Road Bus Station (Hounslow).

Most of the lower section of the catchment drains into Frog's Ditch or the River Crane, with outfalls located at Cranford Parkway Interchange, Hobbledown Heath, Crane Park and Kneller Gardens. The surface water sewers in Feltham, Hounslow flow into the Felthamhill Brook and those in north-west Hounslow generally flow into the River Crane. However, the surface water sewers in the Hounslow town centre catchment and around Isleworth generally flow into larger foul water sewers, thus do not drain into the River Crane or its tributaries. All the foul water sewers in the catchment area flow towards the Mogden Sewage Works in Hounslow, where the wastewater is treated and discharged into the River Thames at Isleworth Ait.

Although most of the catchment is served by separated sewer systems, there are conditions where the foul and surface sewers interact and exchange water between each other. This is due the presence of 'dual manholes', whose links were originally sealed but have been eroded over time or been removed to prevent flooding. Foul and surface water mixing leads to higher risk of foul flooding, increases the amount of surface water flowing into the Mogden sewage treatment works, and negatively impacts the quality of the surface water flowing into the rivers. According to the Harrow SWMP, dual manholes are found in several locations within Harrow. There is no available information on dual manholes within the other boroughs of the catchment.

2 EA Sources of Flood Risk

The Planning Practice Guidance (PPG) defines 'flood risk' as the combination of the probability and potential consequences of flooding from all sources, including:

- Rivers and the sea (Fluvial and Tidal);
- Directly from rainfall on the ground surface (Surface Water and Ordinary Watercourses);
- Rising groundwater (Groundwater);
- Overwhelmed sewers and drainage systems (Sewer); and
- Reservoirs, canals, lakes, and other artificial sources (Artificial).

Each of these sources of flood risk within the River Crane catchment is discussed in the following sections. Flood risk was identified in the catchment by overlaying flood risk data with the Ordnance Survey Master Map (OSMM) data and the national receptor database (NRD). Building data was extracted from the OSMM dataset which was then joined with the NRD dataset to identify if the building was residential or non-residential. Properties with a Multi-Coloured Manual (MCM) code of '1' were considered residential and all other MCM codes were considered non-residential. Properties with no MCM codes were considered to have unclassified land uses and for the sake of this assessment were classified as non-residential. Further detail into the flood risk data that was used is presented in the sections below. Note that all flood risk data sources used for the assessment of the River Crane catchment can be found in *Appendix B.*

Flood risk from the fluvial and surface water hydraulic modelling was assessed per 'return period' or 'storm event'. These events are calculated based on their probability of occurrence in any given year or their likely 'recurrence interval'. They can be described using their return period, such as the 1 in 100-year event (1:100) or 1 in 5-year event (1:5), or their annual average exceedance (AEP) probability of 1% AEP and 20% AEP, respectively. For example, a storm event with a return period of 1:100 (1% AEP) is less likely to occur in any given year and thus a much more severe storm than a 1:5 (20% AEP) event. The fluvial and surface water analysis uses the method of return periods to describe the probability of a storm event occurring and as a description of storm severity.

2.1 Fluvial Flooding

2.1.1 Definition

A fluvial, or main river, flood occurs when the water level in a river, lake or stream rises and overflows onto the surrounding banks, shores, and neighbouring land. The water level rise could be due to excessive rain or snowmelt. The damage from a river flood can be widespread as the overflow affects rivers downstream, which can cause dams and dikes to break and swamp nearby areas.

To determine the probability of river flooding, surface water models are validated against available flood records. Floodplains and adjacent open spaces in the natural environment help manage and convey fluvial flooding, mitigating the potential widespread impact. The impact of fluvial flooding on urban environments can be severe, causing significant social, economic, and environmental impacts.

2.1.2 Background Data

The Environment Agency (EA) completed a hydraulic model of the River Crane in 2008 (additional information on the River Crane model can be found in *Appendix C*). The EA is currently updating the River Crane hydraulic model and intends to publish it in June 2022. This updated model will supersede the information that has been provided in this report. The model incorporated the River Crane, the Yeading Brook, the Frog's Ditch, the Duke of Northumberland's River and Whitton Brook. The model did not contain the Portlane Brook and Longford River; therefore, these catchments were not assessed for their fluvial flood risk. The EA model of the River Crane was used to determine the catchment's vulnerability to fluvial flooding. The EA provided the River Crane model result outputs for various return periods, climate change and for both the defended and undefended scenarios. Undefended flood scenarios do not include the current flood defence assets in the model and often show a greater flood extent in locations that benefit from flood defence assets.

Table 2-1 presents all flood events that were available for this study and assessed for the fluvial flood risk on the River Crane.

Table 2-1. EA models for the River Crane

Scenario	Model	Return Period
Defended	Baseline	1:5, 1:10, 1:20, 1:50, 1:100, 1:1000
	Climate Change	1:100 CC (+20%)
Undefended	Baseline	1:100, 1:1000

To assess the fluvial flood defences within the River Crane catchment, the following datasets were analysed:

- **EA Flood Map for Planning (Rivers and Sea) – Spatial Flood Defences (without standardised attributes):** This dataset shows those defences constructed which have a standard of protection equal to or better than 1 in 100 (1%) for rivers and 1 in 200 (0.5%) from the sea.
- **AIMS Spatial Flood Defences (Incl. standardised attributes):** This dataset shows all the flood defences currently owned, managed or inspected by the EA. A defence is any asset that provides flood defence or coastal protection functions. Typically, these are earth banks, stone and concrete walls, or sheet-piling that is used to prevent or control the extent of flooding. This includes both man-made and natural defences.
- **EA Flood Map for Planning (Rivers and Sea) – Areas Benefiting from Defences:** This dataset shows those areas that benefit from the presence of defences in a 1 in 100 (1%) chance of flooding each year from rivers; or 1 in 200 (0.5 %) chance of flooding each year from the sea. If the defences were not there, these areas would flood in a 1 in 100 (1%)/ 1 in 200 (0.5 %) or larger flooding incident.

The flood defences within the River Crane catchment are shown in *Figure 11* of *Appendix A*. The 'Flood defences – without standard attributes' layer shows that there are a small number of fluvial flood defences which have a standard of protection equal to or better than 1 in 100 (1%) year flood event. For example, there are defences along Western Avenue in Hillingdon, providing flood protection to the A40 from flooding from the Yeading Brook. There are also fluvial flood defences that intersect the Yeading Brook at Ten Acre Wood, with a significant area downstream benefitting from these defences. There are also small stretches of flood defences along the River Crane at Berkeley Meadows and along the Duke of Northumberland's River at Staines Road in Hounslow.

There are other smaller flood defences which are designed to protect against small floods with a higher probability of occurring in any year. These flood defences include natural and man-made defences and are present for the majority of the Yeading Brook and River Crane channels. This type of flood defence is shown by the 'Flood defences – with standard attributes' layer. For example, there is a long flood defence channel fed from the Yeading Brook that stretches from the A312 around the Brookside area of Hayes to the southern end of Minet Country Park.

An overlap analysis of the OSMM building polygons and the available fluvial return period extents (listed in *Table 2-1*) was performed within the study catchment. The extent of flooding on each property was calculated as a percentage of the flood extent covering the property. All properties showing any sign of risk of flooding were extracted from the dataset, counted, categorized according to coverage extent (%) and analysed to identify potential hotspots throughout the catchment. Hotspots are used to establish areas of priority in terms of needed flood alleviation or mitigation efforts. Hotspots were identified based on locations that had multiple properties at risk and their flood extent coverages.

2.1.3 Assessment

Table 2-2 summarises the findings from the fluvial flood analysis on the River Crane with the associated mapping shown in *Figure 5*, *Appendix A.* Resulting property counts have been classified as either Residential or Non-Residential based on the NRD dataset.

Table 2-2. Property counts at risk of flooding

Return Period		Properties at Risk		
		Residential	Non-Residential	Total
Defended				
1:5	Ealing	0	0	0
	Harrow	1	0	1
	Hillingdon	8	3	11
	Hounslow	1	1	2
	Richmond	3	1	4
Totals		**13**	**5**	**18**
1:10	Ealing	0	0	0
	Harrow	1	0	1
	Hillingdon	10	3	13
	Hounslow	1	1	2
	Richmond	3	1	4
Totals		**15**	**5**	**20**
1:20	Ealing	0	0	0
	Harrow	1	0	1
	Hillingdon	15	4	19
	Hounslow	1	1	2
	Richmond	9	1	10
Totals		**26**	**6**	**32**
1:50	Ealing	0	0	0
	Harrow	1	0	1

Return Period		Properties at Risk		
		Residential	Non-Residential	Total
	Hillingdon	25	6	31
	Hounslow	1	2	3
	Richmond	16	1	17
Totals		**43**	**9**	**52**
1:100	Ealing	0	0	0
	Harrow	1	2	3
	Hillingdon	30	5	35
	Hounslow	2	3	5
	Richmond	17	1	18
Totals		**50**	**12**	**61**
1:100 (+20CC)	Ealing	0	0	0
	Harrow	2	2	4
	Hillingdon	77	8	85
	Hounslow	7	5	12
	Richmond	123	6	129
Totals		**209**	**21**	**230**
1:1000	Ealing	13	0	13
	Harrow	489	16	505
	Hillingdon	2,240	183	2,423
	Hounslow	272	46	318
	Richmond	1,169	47	1,216
Totals		**4,183**	**292**	**4,475**
Undefended				
1:100	Ealing	0	0	0
	Harrow	1	2	3
	Hillingdon	30	5	35
	Hounslow	2	3	5
	Richmond	17	1	18
Totals		**50**	**11**	**61**
1:1000	Ealing	14	0	14
	Harrow	454	15	469
	Hillingdon	2,303	204	2,507
	Hounslow	272	46	318
	Richmond	1,169	47	1,216
Totals		**4,212**	**312**	**4,524**

When evaluating the extent of flooding along the River Crane, there is a gradual growth in properties at risk alongside an increase in storm event severity. This is expected, as storm events that increase in severity result in more flooding to properties. In areas where large extents of flooding were predicted by the model, risk to properties was predominantly mitigated due to the presence of adequate floodplains and green corridors along Yeading Brook and River Crane. These areas include but are not limited to:

- Ruislip Gardens, Minet Country Park and Huckerby's Meadows in the borough of Hillingdon.
- Cranebank Nature Reserve, Donkey Wood, Brazil Mill Woods, Pevensey Road Nature Reserve and Little Park, and Crane Park in the borough of Hounslow.

An initial assessment of fluvial flood risk focused on identifying hotspots of property flooding in the catchment. The assessment first identified areas with properties at risk during more frequent return periods, including the 1:5 to 1:20, where properties are at the highest risk of flooding. Hotspots were subsequently confirmed if there was an increase in properties at risk with higher intensity return periods. Three hotspots were identified as being particularly at risk for fluvial flooding. They are described below and include:

- The Greenway in Ickenham, Hillingdon
- Langley Crescent and Craneswater in Hayes, Hillingdon
- Fulwell Park Avenue in Twickenham, Richmond upon Thames

Table 2-3 highlights properties at risk along The Greenway in Ickenham, Hillingdon for different return periods. They are further referenced in *Figure 2-1*.

Table 2-3. Property counts at the Greenway fluvial hotspot

Return Period	Properties at Risk		Return Period	Properties at Risk
1:5	10		1:10	12
1:20	16		1:50	24
1:100	29		1:100 CC (+20%)	34

All properties defined within the Greenway fluvial hotspot are classified as residential properties. They have been further categorized according to their estimated extent of flooding for the most severe return period, the 1:100-year return period (*Figure 2-1*).

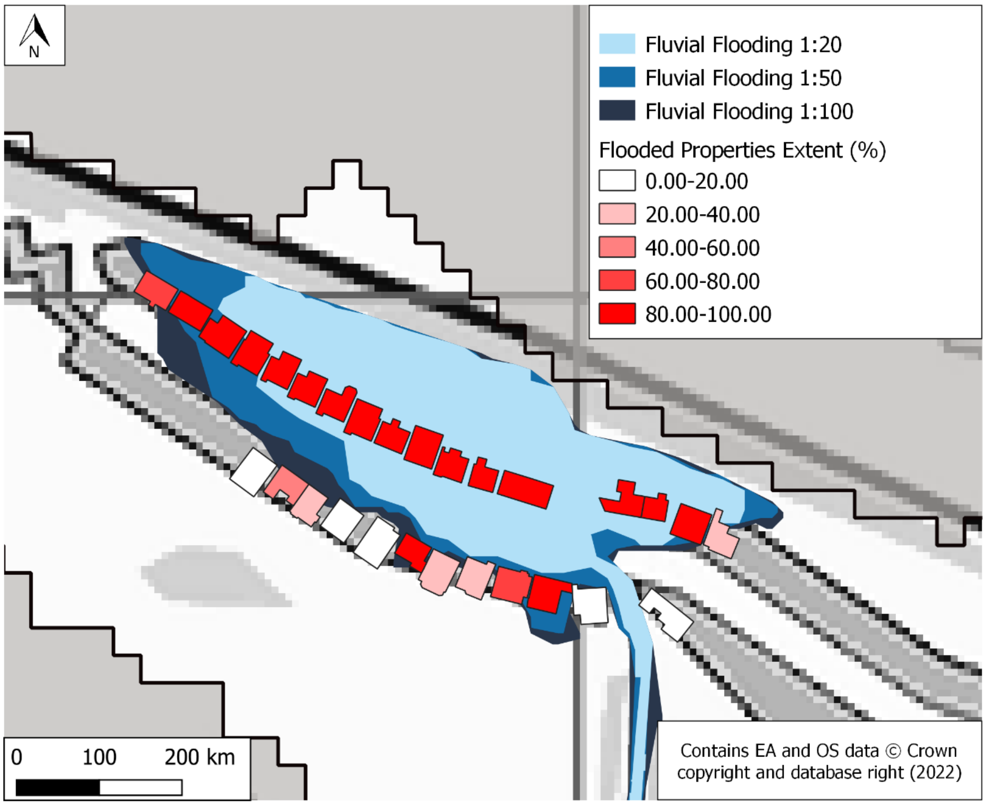

Figure 2-1. The Greenway fluvial hotspot

The second hotspot is situated adjacent to Langley Crescent and Craneswater, filtering into Park Lane, Hayes. This was chosen as a hotspot due to the significant increase in risk from climate change (CC), as shown in *Figure 2-2*.

Table 2-4: Property count at Langley Crescent and Craneswater hotspot

Return Period	Properties at Risk
1:100	4
1:100CC (+20%)	46

This provides an indication of the impacts of climate change on the River Crane. The River Crane's model outputs with climate change allowance are limited to the climate change allowance of 20% at this location. Therefore, this may be an underestimation of the impact of climate change as the EA is currently updating their river models based on the recently revised climate change allowances, of between 17% and 54%. Allowances are included for three future timeframes, labelled 2020s, 2050s and 2080s. *Figure 2-2* highlights the extent of climate change on the River Crane at Langley Crescent and Craneswater.

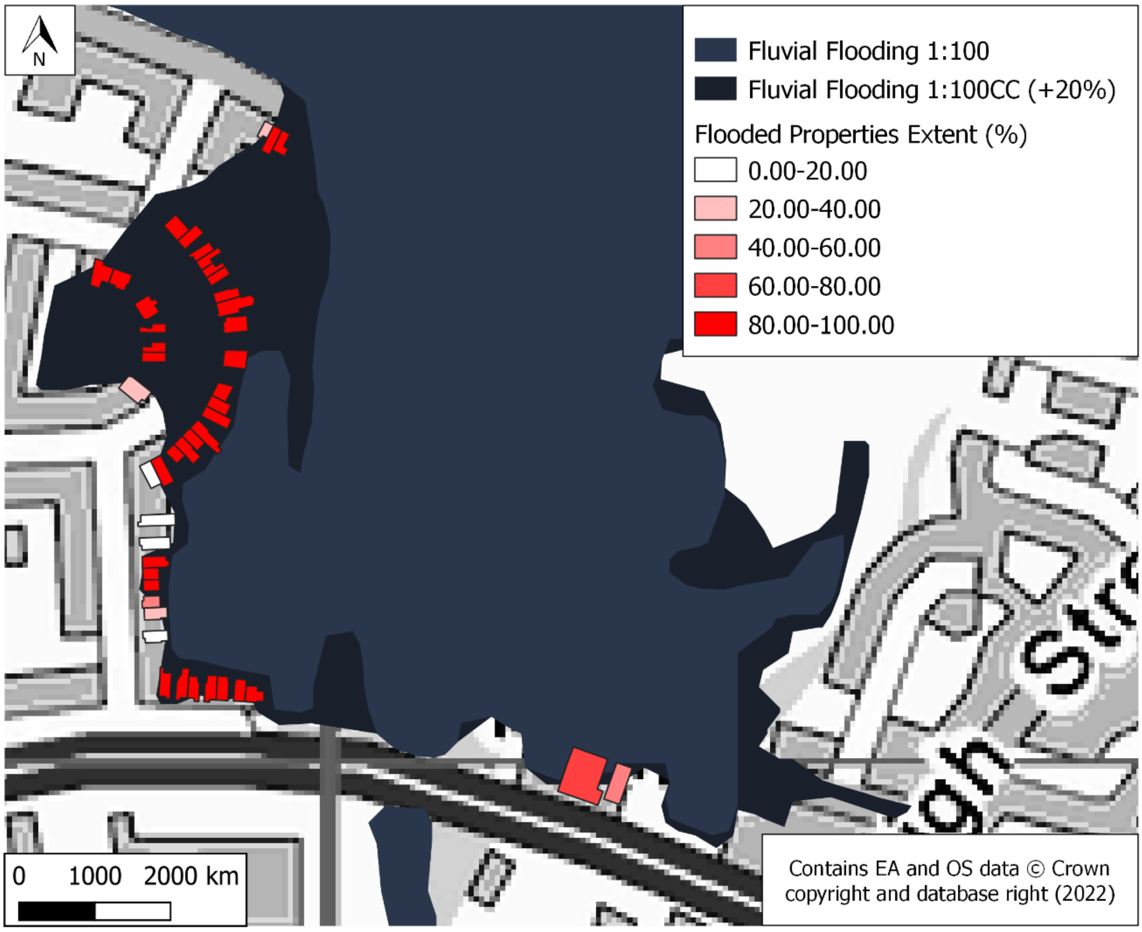

Figure 2-2. Langley Crescent and Craneswater fluvial hotspot

The final hotspot was identified along Fulwell Park Avenue in Twickenham, Richmond upon Thames. *Table 2-5* and *Figure 2-3* represent the property counts and the locations of the residential properties predicted to be impacted in the hotspot, respectively.

Table 2-5. Property count at the Fulwell Park Avenue fluvial hotspot

Return Period	Properties at Risk		Return Period	Properties at Risk
1:20	6		1:50	12
1:100	13			

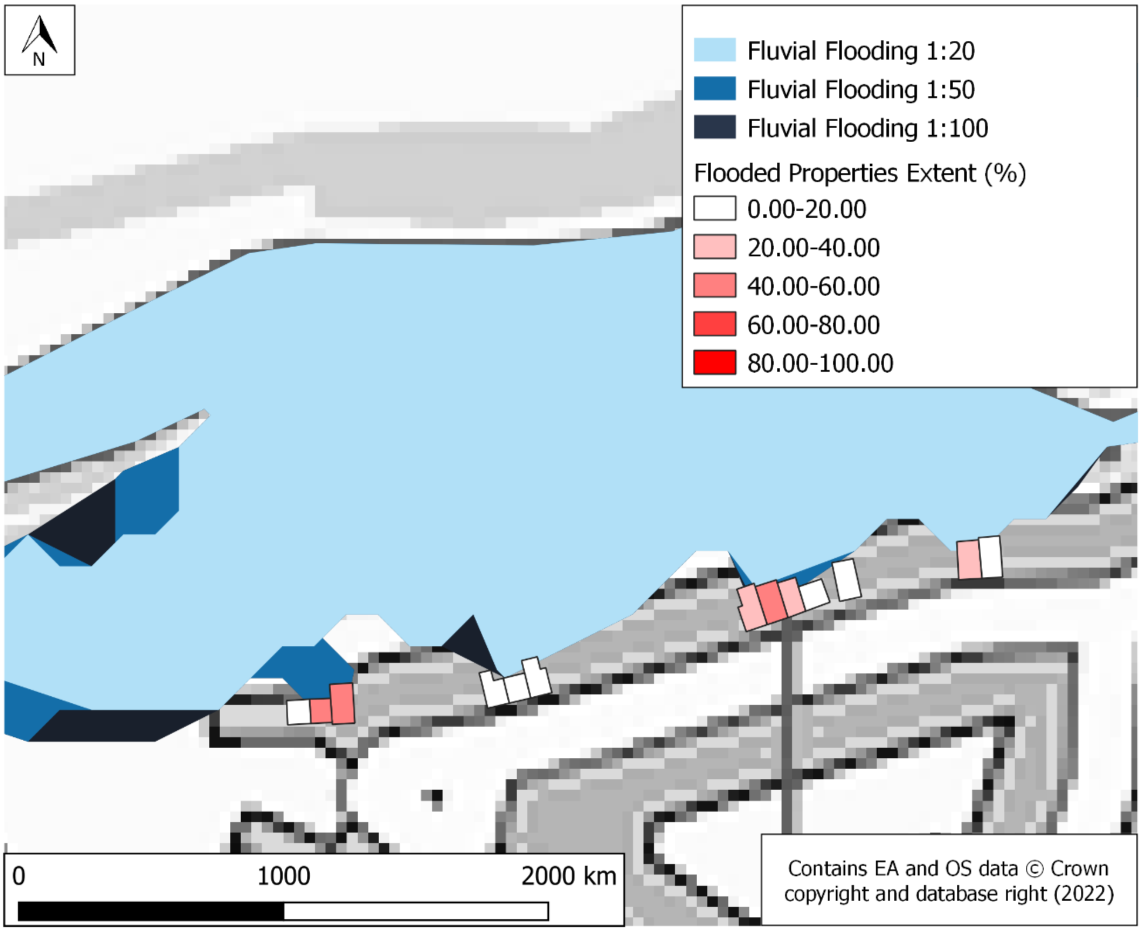

Figure 2-3. Fulwell Park Avenue fluvial hotspot

Fluvial flood extents across the Crane catchment are shown in *Figure 5* in *Appendix A*. *Figure 5* shows the 1:20, 1:50 and 1:100-year return period flood extents and the locations of identified potential hotspots.

Overall, the fluvial flood risk within the River Crane catchment is relatively low with the majority of properties protected by adequate green corridors, especially throughout Hillingdon and Hounslow. In accordance with *Table 2-2*, the highest property counts at risk of flooding occurred within the boroughs of Hillingdon and Richmond. Hillingdon incorporates the majority of the River Crane whereas the borough of Richmond has a limited presence of green corridors. Subsequently, all fluvial hotspots were located within these two boroughs.

2.1.4 Climate change

Based on the EA's UK climate change projections for peak river flow and peak rainfall intensity, it is expected that climate change will place a greater number of people, properties, and infrastructure at risk of fluvial flooding. The frequency and severity of fluvial flooding would increase, increasing the need for flood defence and mitigation measures.

The EA is currently updating their river models based on the recently revised climate change allowances. The outputs from the River Crane model updates will be available in June 2022. The peak river flow climate change allowances show the anticipated increases of peak flow that may occur in a catchment. The allowances are unique per management catchment. Management catchments are sub-catchments of river basin districts. The River Crane falls within the London Management catchment with the following peak flow climate change allowances shown in *Table 2-6*.

Table 2-6. London management catchment peak river flow allowances

	Central	Higher	Upper
2020s	10%	14%	26%
2050s	7%	14%	30%
2080s	17%	27%	54%

The River Crane model outputs include the 1:100 plus 20% CC allowance, based on a 1981 – 2000 baseline. This output covers the entirety of the River Crane network. There is a small section of the catchment, within Richmond upon Thames and Hounslow, which contain model results for 25%, 35% and 70% climate change allowances. Within Richmond, the additional climate change allowances (35% and 70%) indicate that the area around Twickenham stadium, including Chertsey Road and Whitton Road, may become at risk of fluvial flooding in the future. Therefore, the lack of additional climate change allowances for the entire catchment inhibits our ability to fully understand the impact of climate change on the whole catchment. The impacts on climate change should be assessed further when additional model outputs are available for the entire catchment.

2.2 Tidal Flooding

2.2.1 Definition

Tidal flooding occurs during extreme high tide and/or storm surge events. Water flows from the sea towards land, leading to the inundation of low-lying areas. This includes tidal river flooding and rivers whose level and flow are influenced by tides. Tidal flooding is becoming more common in cities and other urbanised areas as sea level rise associated with climate change increase the vulnerability of their infrastructure. These types of floods tend not to be a high risk to property or human safety due to tidal defences and tidal warning lead times, but further stress coastal infrastructure in low lying areas.

2.2.2 Assessment

The River Crane outfalls into the tidally influenced River Thames. Thus, a small section of the River Crane is characterised as intertidal for approximately 870 m upstream of the River Thames. The River Thames has fluvial and tidal flood defences. These defences continue along the River Crane for the entirety of the intertidal section, alleviating some flood risk from the tidal Thames within the Crane catchment. *Figure 11* in *Appendix A* highlights the areas benefitting from flood defences along the River Thames that are within the Crane catchment.

2.3 Surface Water Flooding

2.3.1 Definition

Surface water flooding is the result of high intensity rainfall which causes water ponding or flowing over the ground surface before entering an underground drainage network or watercourse. Ordinary watercourse flooding occurs under similar circumstances but is associated with non-main river watercourses or ditches. Surface water flooding is often exacerbated by the intensity or duration of the rainfall event, leaving soil, drainage channels and other drainage systems incapable of draining water at a sufficient rate. Extreme weather conditions can also lead to ordinary watercourses exceeding their capacity, overwhelming systems, and causing water to flow onto land. Surface water flooding typically occurs for a similar timescale as the rainfall event that caused it, but ponding can persist in low-lying areas for longer. Due to its typically shorter duration, surface water tends to have less serious consequences compared to other forms of flooding but can still cause significant local damage and disruption in sudden, intense rainfall events.

2.3.2 Background Data

For the purposes of this flood study, the risk of flooding from ordinary watercourses is covered within the 'surface water' terminology. Ordinary watercourses are not explicitly included in the Risk of Flooding from Surface Water (RoFSW). Due to the modelling methodology, mappings recognize depressions in the ground surface and simulate flow along natural drainage channels. Although the mapping appears to show flooding from ordinary watercourses, the conveyance effect of ordinary watercourses or drainage channels, structures and flood defences are not explicitly modelled.

Flooding from surface water is typically dispersed and fragmented, as it follows local topography and not a defined river channel. Therefore, it is more challenging to produce accurate property counts that reflect the surface water flood risk within a catchment. There is a higher proportion of properties situated at the edge of an area at risk of flooding, which meant a judgement had to be made as to which properties should be counted.

The 'Flood defences Harrow' dataset was used to shows the location of flood defence along ordinary watercourses within Harrow and the River Crane catchment. These flood defences are owned by Harrow council as Lead Local Flood Authority (LLFA). These defences include trash screens, by-pass channels, penstocks and culverts. Trash screens are located at Alexandra Avenue, Brook Drive, Cambridge Road, Headstone Manor, Roxbourne Park and Newton Farm Ecology Park and Gypsey Alley. There are culverts at Brook Drive and Village Way allotment, bypass channels at Alexandra Avenue, Newton Farm Ecology Park and Gypsey Alley and a penstock at Headstone Manor. Flood defences along ordinary watercourse in Harrow are also marked in *Figure 11* in *Appendix A.* The location of ordinary watercourse flood defences within the other boroughs in the catchment have not been included, as the data was not available at the time of writing this report.

There were multiple datasets available within the catchment to analyse the risk of flooding from surface water, including the updated Flood Map for Surface Water (uFMfSW) property point data (2014), the EA's RoFSW dataset (2021) and locally produced integrated urban drainage (IUD) modelling. The uFMfSW property point dataset and the locally produced IUD model datasets were used to determine the risk to properties within the catchment. Additional information regarding the RoFSW and IUD models can be found in *Appendix C.*

The uFMfSW property point dataset was produced by the EA in 2014. It uses the EA's 2013 uFMfSW dataset (renamed to the RoFSW dataset in 2016), OSMM building data and NRD property point data to determine a properties likelihood of flooding. The property point data applied a 2 m buffer to each individual property within the catchment. This captures properties with flood risk surrounding the perimeter of the property but not within it, as it may also result in property flooding. To determine the individual property's risk and severity of flooding, the flood extent to the property's buffered perimeter (wetted perimeter) was measured as it was presumed to be a better indicator of whether a property would flood.

The uFMfSW property point dataset contains attributes that show the results of the property counting methodology for different probabilities at different depths of flooding. Each property point shows the proportion of the buffered perimeter where depth is greater than the specified value (for each probability and depth of flooding). It covers the entire catchment and is based on the 1:30, 1:100 and 1:1000-year return periods. However, it should be noted that the EA guidance states that the property point data is not suitable to identify flood risk at an individual property level but can be used as a resource for understanding floor risk in a particular location.

2.3.3 Assessment

Within the catchment, there are some locations that have had IUD models built in recent years. IUD models generally contain more detailed information about the catchment it represents than the uFMfSW or RoFSW, resulting in more confidence in the model output. The IUD models presented in *Table 2-7* were used for the assessment of surface water flooding, where possible. For the areas without models, the EA's uFMfSW property point dataset was used.

Table 2-7. IUD models

Project Area	Return Period Modelled Outputs
Feltham	1:5, 1:20, 1:30, 1:75, 1:100, 1:200, 1:1000
Headstone	1:5, 1:20, 1:30, 1:40, 1:1000
Hounslow Town Centre	1:5, 1:20, 1:30, 1:40, 1:50, 1:75, 1:100, 1:200, 1:1000 1:5CC, 1:20CC, 1:50CC, 1:75CC, 1:100CC, 1:200CC, 1:1000CC
North Harrow	1:5, 1:20, 1:30, 1:50, 1:100, 1:200, 1:1000 1:5CC, 1:20CC, 1:50CC, 1:100CC, 1:200CC, 1:1000CC
Northwest Hounslow	1:5, 1:20, 1:30, 1:75, 1:200, 1:1000
Southall	1:5, 1:20, 1:30, 1:75, 1:100, 1:200, 1:1000
Yeading	1:5, 1:20, 1:30, 1:75, 1:100, 1:200, 1:1000 1:5CC, 1:20CC, 1:100CC

For the uFMfSW property point data, properties that were flooded above the 150mm threshold depth were counted as flooded, as this was the most conservative threshold value. The properties were counted for the 1:30 and 1:100-year return periods. In areas that were covered by an IUD model, a statistical analysis was performed with the IUD model's max depth results in the 1:30 and 1:100-year return periods. In so doing, the average flood depth was approximated for each individual property floor area. Properties with a very low average flood depth were removed through the application of a flooding threshold. This reduced the noise within the data, omitting properties with an insignificant or unlikely risk of flooding. Different depth thresholds were selected in accordance with property levels within each IUD model boundary.

Table 2-8 highlights the resultant property counts following the assessment of surface water flooding for the River Crane catchment. As stated before, the property counts in areas where IUD models were available were carried out using the most recent model results rather than the uFMfSW property point data.

Table 2-8. Property counts on surface water flooding

Return Period		Properties at risk		
		Residential	Non-Residential	Total
1:30	Ealing	100	3	103
	Harrow	648	21	669
	Hillingdon	798	101	899
	Hounslow	723	103	826
	Richmond	384	107	491
	Spelthorne	135	20	155
Totals		**2,788**	**355**	**3,143**
1:100	Ealing	501	4	505
	Harrow	2,023	82	2,105
	Hillingdon	3,133	285	3,418
	Hounslow	2,442	206	2,648
	Richmond	1,497	285	1,782
	Spelthorne	626	44	668
Totals		**10,222**	**906**	**11,126**

After the properties at risk of flooding were assessed, surface water flooding property hotspots were identified using the RoFSW flood map, the uFMfSW property point data, and IUD modelling outputs. Hotspots were identified using the following considerations and datasets:

- Clusters of properties classified as at risk from surface water flooding in the uFMfSW property point data and IUD modelling data were identified. The property clusters were assessed using the 1:30 return period results as these are most at-risk and confirmed using the 1:100 return period results.
- CDAs sourced from the London Boroughs of Ealing, Harrow, Hillingdon, Hounslow, and Richmond upon Thames and compared to the clusters of at-risk properties.
- Historic flood records from the London Boroughs of Ealing, Harrow, Hillingdon, Hounslow, and Richmond upon Thames. Where possible, reported flood incidences were used to correlate surface water model results (both from the RoFSW and IUD models) and clusters of at-risk properties.

An assessment of the flooding from surface water across the Crane catchment, identified 45 potential hotspots with the 1:30 and 1:100-year return periods reporting 1,427 and 3,761 properties predicted to be at risk of flooding respectively. The areas which are susceptible to surface water flooding are shown in *Figure 6* in *Appendix A.* The flood extents in the maps include the results from the IUD models and the RoFSW dataset for the 1:30 and 1:100-year return period events, in conjunction with the defined surface water hotspots. The mapped modelling for the River Crane catchment is consistent with flood risks above 100 mm. In relation to the property counts, different thresholds were based on the method of modelling used and the topography of the area. This techniques plots 'flooded' properties against their associated flood depths – thresholds were selected at positions where each IUD graph began to level off and in so doing, removed properties that may have insignificant overlaps with flood depths and unlikely to flood in reality. Hence, IUD thresholds will differ with changing topographies. A map detailing the CDAs within the River Crane catchment is shown in *Figure 7* in *Appendix A*.

Overall, the River Crane catchment is subject to a dispersed distribution of surface water flooding where the majority of properties at risk of flooding falling within the boroughs of Harrow, Hillingdon, and Hounslow. Sited historical flood records, CDAs and hotspots suggests the northern part of the Crane catchment to be at a higher risk of flooding from surface water.

2.3.4 Climate Change

The EA's RoFSW mapping and uFMfSW property point data does not provide information on future scenarios, such as climate change. Therefore, the effect of climate change was assessed by calculating equivalent return periods. This method uses Flood Estimation Handbook (FEH) equations and catchment descriptors, including depth-duration-frequency (DDF) values of rainfall patterns specific to the Crane catchment. This technique provides an indication of the impacts of climate change on surface water flooding within the catchment.

Table 2-9 shows what a return period (or storm event) including climate change is equivalent to when compared to a return period without climate change. This provides an indication of the increase in flood extent or increase in recurrence level of a particular return period with climate change. The catchment was analysed against the 1:30 and 1:100-year return periods for varying climate change percentages. Equivalents are dependent on storm durations, thus values shown in the table are averages.

Table 2-9. FEH climate change

Return Period Equivalents		
1:15 (+20% CC)	1:30	The 1:15 (+ 20% CC) is approximately equivalent to the 1:30 without CC
1:10 (+40% CC)	1:30	The 1:10 (+ 40% CC) is approximately equivalent to the 1:30 without CC
1:50 (+20% CC)	1:100	The 1:50 (+ 20% CC) is approximately equivalent to the 1:100 without CC
1:30 (+40% CC)	1:100	The 1:30 (+ 40% CC) is approximately equivalent to the 1:100 without CC

Climate is expected to increase the extent and recurrence of severe storms. The table indicated that a 1:15 plus 20% CC return period event would be the equivalent of the current 1:30- year return period event. This implies that the predicted impact of climate change (+20%) will double the severity and recurrence of a 1:15-year return period event on the Crane catchment. Climate change is likely to increase the intensity and the frequency of floods within the River Crane catchment, with river basins and low-lying floodplains becoming more vulnerable to fluvial flooding. Due to the increase in extreme rainfall events, the impacts of climate change on floods can cause considerable economic losses and introduces uncertainties in relation to the quantity and quality of water. For sustainable development, a basin-scale assessment of impacts of climate change on flooding may become necessary.

2.4 Groundwater flood risk

2.4.1 Definition

Groundwater flooding occurs because of the underground water table rising, which can result in water emerging through the ground and causing flooding in extreme circumstances. Groundwater flooding often occurs after extensive periods of heavy rainfall, potentially occurring for weeks or months. During these periods, a greater volume of water infiltrates through the ground, causing an underlying aquifer to rise above its regular depth. Springs and low-lying areas, where the water table is likely to be closer to the surface, pose greater risk of groundwater flooding. Groundwater flooding can occur in areas where the underlying soil and bedrock are vulnerable to becoming saturated. Therefore, ground composition and aquifer vulnerability are significant influences on the potential rate of groundwater flooding.

2.4.2 Background Data

The British Geological Survey (BGS) Susceptibility to Groundwater Flooding dataset was used to assess the groundwater flood risk within the River Crane catchment. This dataset classifies the potential for groundwater flooding into three categories, as follows:

- A: Limited potential for groundwater flooding to occur
- B: Potential for groundwater flooding of property situated below ground
- C: Potential for groundwater flooding to occur at surface

To assess the predicted number of properties which may be susceptible to groundwater flooding, this groundwater dataset was used in combination with the NRD and OSMM datasets. Property data was overlaid with the groundwater flood risk data to approximate groundwater flood risk throughout the catchment. Properties were considered 'at risk' if they lay within the boundary of the susceptibility to groundwater flooding layer.

There is no record of historic groundwater flooding within this catchment. However, this may be because flood events have not been reported or that they have been misreported as flooding from other sources.

2.4.3 Assessment

The northern region of the River Crane catchment, comprising of the Harrow, Ealing and the north Hillingdon sections are not predicted to be susceptible to groundwater flooding. This is likely explained by the impermeable London Clay bedrock and absence of superficial deposits. An exception to this is the small area in the south-eastern corner of Harrow which is underlain by the Bagshot formation as it has a limited potential for groundwater flooding.

However, the southern section of the catchment is susceptible to groundwater flooding at a range of different potentials. The groundwater flooding susceptibility in this region is extensively caused by permeable superficial deposits flooding which are associated with shallow unconsolidated sedimentary aquifers with underlying non-aquifer bedrocks. The exception to this, is the south-west corner of the catchment at Queen Mary Reservoir where there is a limited potential for clearwater flooding. This type of flooding is caused by the water table in an unconfined aquifer rising above the land surface in response to extreme rainfall.

The entire section of Richmond located within the catchment is considered susceptible to groundwater flooding. This is the same for Hounslow except for Hounslow West and Heston where there are only small areas which are susceptible to groundwater flooding. The majority of the south catchment is defined as Class C, i.e., has a potential for groundwater flooding to occur at the surface. Large sections of Hounslow and Richmond have the potential of groundwater flooding of property situated below ground. The susceptibility of groundwater flooding is likely explained by the permeable gravel and sand superficial deposits (Kempton Park Gravel Member and Taplow Gravel Member) which underlain the region. These permeable deposits are hydraulically connected with adjacent river networks such as the River Thames and River Crane, which suggests that groundwater levels are often close to the ground surface and that intense rainfall can cause a rapid response in groundwater levels. The areas which are susceptible to groundwater flooding are shown in *Figure 8* in *Appendix A*. This shows the findings of the groundwater flood analysis on the River Crane catchments, identifying the number of properties which are located within the three categories of groundwater susceptibility. Overall, the catchment is at risk of groundwater flooding, but this mainly concentrated in the south section of the catchment.

Table 2-10 Groundwater flooding property count

Groundwater flooding susceptibility	Borough	Properties at risk of flooding		
		Residential	**Non-residential**	**Total**
A	Ealing	0	2	2
	Harrow	241	119	360
	Hillingdon	855	105	960
	Hounslow	15	12	27
	Richmond	227	66	293
	Surrey	0	1	1
	Total	**1,338**	**305**	**1,643**
B	Ealing	0	2	2
	Harrow	12	0	12
	Hillingdon	1,092	363	1,455
	Hounslow	16,689	2,884	19,573
	Richmond	17,015	2,984	19,999
	Surrey	861	151	1,012
	Total	**35,669**	**6,384**	**42,053**
C	Ealing	23	12	35
	Harrow	421	40	461
	Hillingdon	3,599	1,905	5,504
	Hounslow	17,785	3,333	21,118
	Richmond	12,621	2,496	15,117
	Surrey	8,380	1,583	9,963
	Total	**42,829**	**9,369**	**52,198**
Total at risk		**79,836**	**16,058**	**95,894**

2.5 Sewer flood risk

2.5.1 Definition

Sewer flooding occurs when the amount of rainfall entering the sewer network is too large to be contained. A lack of capacity in the sewer networks may be due to:

- An increase in flow (such as climate change impacts on rainfall and / or new developments).
- Having to sustain events larger than the system designed event.
- The failure of key infrastructure such as pumps or valves.
- A watercourse having been fully culverted or incorporated into the drainage network.
- A lack of maintenance which can sometimes lead to total blockage or collapse.
- Groundwater infiltration into pipe networks in poor condition.
- Limited outflow from the sewer network due to high water levels in receiving watercourses.

The impact of sewer flooding is usually restricted locally but can be rapid and unpredictable. Flood waters from foul or combined sewers contain sewage which can be harmful to health. This can also occur through misconnections and dual manholes in surface water sewers.

2.5.2 Background Data

The number of properties that have flooded as a result of hydraulic inadequacy of the TWUL sewer network is recorded on the TWUL DG5 register. This dataset provides an indication of the risk of sewer flooding across the catchment. However, this dataset was not provided in time for the issue of this report. This will be included in updated version of the report when the data becomes available.

2.5.3 Assessment

TWUL owns and operates the sewer system throughout the River Crane catchment. The catchment is mainly served by separated surface and foul water sewers, except for small areas in Hounslow West and Whitton in Richmond upon Thames which have combined sewer networks. Modern sewer systems are designed to be separate systems, typically accommodating up to 1 in 30-year return period in surface water sewers, however the catchment varies in capacity due to age. Older segments have a lower capacity and may not be designed to accommodate rainfall events as significant as 1 in 30-year return period.

TWUL have responsibilities for all 'public sewers' (the drainage network which serves more than one property, including associated manholes) under the Water Industry Act 1991. Typically gullies or drains and the interconnecting pipework which drain into sewers are the responsibility of the private landowner or, for those draining the highway, the Highways Authority. Due to the interconnection between these different assets, any associated flooding may be caused by a combination of factors, therefore all relevant parties should be involved in subsequent investigations and, where necessary, work to resolve the root cause.

Many areas within this catchment have been identify as currently at risk of sewer surcharge and further areas are predicted to be at risk in the future. The sewer system within the Harrow section of the catchment is likely to be highly vulnerable to sewer flooding as it is extensively at risk at sewer surcharge from 2020. Another hotspot for sewer surcharge is Hounslow, particularly near the eastern border of the catchment around Hounslow town centre and Hounslow West. Overall, the catchment is considered vulnerable to sewer surcharge, however, due to data limitations mentioned in *Section 2.5.2,* the predicted risk of sewer flooding across the catchment cannot be determined.

2.6 Artificial Flooding

2.6.1 Definition

Artificial flooding can occur because of infrastructure failure or human intervention. Sources of artificial flooding include reservoirs, canals, ponds, and other artificial structures. The probability of a structural breach is low; however, the potential extent of damage can be significant. Artificial source failure could leave many properties at risk of flooding.

2.6.2 Background Data

The EA's 'Reservoir Flood Extents – Wet Day' was used to assess the risk of flooding from reservoirs within the River Crane catchment. This data shows the individual flood extents for all large, raised reservoirs in the event that they were to fail and release the water held on a "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. The data gives no indication of likelihood or probability of reservoir flooding. Flood extents are not included for smaller reservoirs or for reservoirs commissioned after the reservoir modelling programme began in October 2016.

2.6.3 Assessment

Although there are very few reservoirs located within the River Crane catchment, there are number of large reservoirs which lie outside the southwestern boundary of the River Crane catchment that presents a risk to the catchment area. A list of reservoirs that may present a risk to the River Crane catchment are outlined in *Table 2-11.* There is one canal located within the catchment, the Grand Union Canal. This canal flows easterly through the catchment at Hayes and the Paddington Arm of the Grand Union Canal flows northerly along the boundary of Hillingdon and Ealing. This canal has an overfill to the Yeading Brook at Minet Country Park and also flows over the River Crane in an aqueduct at Hayes. There is no flood risk data available for canals, but they may be considered a lower risk since the level of water is controlled by the Canal and River Trust. However, there may be a potential risk of flooding in the event of failure of the canal structures.

Table 2-11. List of relevant reservoirs

Reservoir Name	Owner/Operator	Local Authority
Obelisk Pond	The Crown Estate	Surrey County Council
Queen Elizabeth II	TWUL	Surrey County Council
Queen Mother Reservoir	TWUL	Royal Borough of Windsor & Maidenhead
Ruislip Lido	Hillingdon Council	Hillingdon Council
Spout Lane Lagoon	Heathrow Airport Holdings Ltd	Hillingdon Council
Virginia Water	The Crown Estate	Surrey County Council
Walton - Bessborough	TWUL	Surrey County Council

Walton - Knight	TWUL	Surrey County Council
Wraysbury Reservoir	TWUL	Surrey County Council

The sudden failure of any of these reservoirs could potentially have catastrophic consequences for some parts of the catchment. Reservoir flooding can occur with little or no warning, making evacuation difficult to plan. Seeking refuge from floodwaters upstairs may not be possible as the buildings could be unsafe or unstable due to the force of water from the breach or failure. The maintenance and regular inspection of the reservoirs is the responsibility of the reservoir owners, and the enforcement of the Reservoir Act (1975) is the responsibility of the EA. Through enforcement of regular inspections and maintenance, the risk of flooding due to reservoir failure is considered low.

Figure 10 in *Appendix A* indicates the risk of flooding from reservoirs to the River Crane catchment. Based on this, only small areas within the River Crane catchment are predicted to be at risk of reservoir flooding. This is mainly concentrated in the southwest and southeast corners of the catchment in Richmond, Hounslow, and the small area of Surrey County Council. There is also small area along the western border of the catchment and along the River Crane channel which are at risk from the Spout Lane lagoon and Ruislip Lido, which are both in Hillingdon.

The number of properties within the River Crane catchment that may be at risk from 1 or more of these reservoirs is shown in *Table 2-12*. Overall, the catchment is at risk of flooding from reservoirs but this is concentrated in the southwest and southeast corners of the catchment.

Table 2-12. Number of properties at risk of reservoir flooding

	Number of properties at Risk		
	Residential	**Non-residential**	**Total**
Ealing	1	0	1
Harrow	0	0	0
Hillingdon	745	27	772
Hounslow	4,092	189	4,281
Richmond	11,227	1,575	12,802
Surrey	12,654	549	13,203
Total	**27,227**	**2,340**	**29,567**

2.7 Impacts of integrated flood risk

The current flood risk data within the catchment is limited, as the majority of flood data only covers one type of flood risk source. In reality, flood risk from different sources will interact and impact each other. For example, river levels (fluvial or tidal) can influence the capacity of the surface water sewers discharging to the river and could increase the risk of surface water flooding in areas that are of lower topography. Sewer flood risk can be exacerbated through missed connections of surface water gullies into foul sewers, increasing the risk of foul sewer flooding. Additionally, sewers (both foul and surface water) that are in a bad condition (contain cracks or have not been properly maintained) and that are in areas with high groundwater tables can lead to water ingress into the sewer system, further reducing capacity and increasing flood risk.

Without detailed, integrated modelling throughout the catchment, it is difficult to determine how different sources of flooding interact. In addition to this, it can be difficult to validate the source of flood risk within a catchment (the Crane included) as flood incidents are often reported by individuals and the origin of the flood risk may not be investigated. Major flood incidents can be investigated by Local Authorities through Section 19 Investigations (see section 2.8), which investigate the source of flood risk from a particular event. This can be used as a helpful tool to understand flood risk in a particular location, however, they often don't provide a broader picture of how different sources of flood risk are interacting at a catchment scale.

2.8 Section 19 Investigations

A Section 19 (S19) report provides a summary of the response from the flood risk management authorities before, during and following a major flood event, to assist with the identification of measures to mitigate future risk. S19 reports were sourced from London Boroughs of Harrow, Hillingdon and Hounslow with the following investigations reported within the catchment boundary.

Table 2-13. S19 Reports within the Crane catchment

Section 19 Reports
Area Affected: Ferndale Avenue, Hounslow West **Date**: 2013/2018/2019 **Source of flooding**: Surface Water **Cause/pathway**: Flooding at the site is exacerbated by other factors including limited surface water drainage and blockages in the foul and surface water systems.
Area Affected: Victoria Road, Commercial Premises and Ruislip Manor Station, Ruislip HA4 9A. **Date**: 1952/2009/2014/2015/2016 **Source of flooding**: Surface Water **Cause/pathway**: Heavy rainfall could not drain away quickly enough, causing water to pond under the bridge.
Area Affected: Regent Avenue, (Including Long Lane, Windsor Avenue) UB10 9A **Date**: 2013/2014/2015/2016 **Source of flooding**: Surface Water **Cause/pathway**: Water flowed down Victoria Avenue into Regent Avenue and couldn't drain away. Water built up in the park in Brighton Close to the rear of properties along Regent Avenue spreading out into gardens. Windsor Avenue also experienced water building up on the road.
Area Affected: Sutton Court Road, Uxbridge UB10 9H **Date**: 2014/2015/2016 **Source of flooding**: Surface Water **Cause/pathway**: Heavy rain not absorbed within the school playing fields flowed towards the low-lying green space and ponded there. This built up until it spilled across to the adjacent private road and spilled across into resident's rear gardens homes.
Area Affected: Field End Road Eastcote High Street, Hawthorne Avenue, Eastcote HA5 1R **Date**: 2015/2016 **Source of flooding**: Surface Water **Cause/pathway**: overwhelming of surface water sewer by heavy rain.
Area Affected: Pembroke Road, and Ruislip High Street Ruislip HA4 8N **Date**: 2014/2015/2016 **Source of flooding**: Surface Water **Cause/pathway**: The surface water sewer could not cope with the amount of rainfall that fell. The road and subsequently the properties became flooded, and a surface water manhole became dislodged.
Area Affected: Eastcote Road, Eastcote HA4 8D **Date**: 2016

Section 19 Reports
Source of flooding: Surface Water **Cause/pathway**: Surface water from the tennis courts flowed into the garden of one property. At another location surface water from the school playing field ran into the gardens of some properties.
Area Affected: North View, Eastcote, Hillingdon, HA5 1. **Date**: 2014/2015/2016 **Source of flooding**: Heavy rain overwhelming the drainage network, gullies, sewer, and ordinary Watercourse **Cause/pathway**: Water built up on the roads, spilling over to front gardens and garages
Area Affected: Glebe Avenue, Ickenham UB10 8P **Date**: 2014/2015/2016 **Source of flooding**: Surface water and Ickenham Stream **Cause/pathway**: Surface water sewer outfalls were drowned by high levels in the Ickenham Stream Main River
Area Affected: Southbourne Gardens Ruislip HA4 9T **Date**: 2016 **Source of flooding**: Surface Water **Cause/pathway**: A short intense period of rain caused the surface water sewers to become overwhelmed. Water came down the driveway towards the property. Water was coming up from underneath the floor
Area Affected: Lawn Close, Ruislip HA4 6E **Date**: 2016 **Source of flooding**: Ordinary watercourse **Cause/pathway**: Ordinary Watercourse overflowing on Network Rail land
Area Affected: Grosvenor Vale, Ruislip HA4 6J **Date**: 2016 **Source of flooding**: Surface Water. **Cause/pathway**: A large amount of rain fell in a short period of time
Area Affected: Westfield Way at junction Beechwood Avenue, Ruislip, Hillingdon HA4 6H **Date**: 2014/2016 **Source of flooding**: Surface Water **Cause/pathway**: Overwhelming of the surface water sewer
Area Affected: Metropolitan Line near Ruislip Station, Ruislip HA4 **Date**: 2014/2016 **Source of flooding**: Surface Water **Cause/pathway**: Overwhelming of surface water sewer by very heavy rain
Area Affected: A40 Northolt, Ruislip HA4 **Date**: 2014/2016 **Source of flooding**: Surface Water **Cause/pathway**: To be investigated further, initial findings appear that the gullies and then surface water sewer were overwhelmed by very heavy rain and not able to freely discharge as the Yeading Brook was at a high level
Area Affected: Breakspear Road South, Ickenham UB10 8H **Date**: 2012/2013/2014/2015/2016 **Source of flooding**: Ordinary watercourses **Cause/pathway**: Overwhelming of ordinary watercourse and culverts under the road by extreme amount of heavy rain which flow into the River Pinn.
Area Affected: Harrow View HA1 4S

Section 19 Reports
Date: 2013/2013 **Source of flooding**: Surface Water **Cause/pathway**: Reported flooding in rear gardens and constant water running on the pavement of Walton Drive.
Area Affected: Spout Lane north, Heathrow TW19 6BW **Date**: 2013/2014 **Source of flooding**: Ordinary Watercourse **Cause/pathway**: Ordinary watercourses flowed on to Highway
Area Affected: Charville Lane, Ullswater Close, Kendall Close and Langdale Drive **Date**: 2013/2014 **Source of flooding**: Multiple - Main River - Yeading Brook, Ordinary Watercourse and surface water sewer **Cause/pathway**: River levels rising coming into back garden and Highway.

3 Summary and Recommendations

A flood risk study was performed on the River Crane catchment and the catchment incorporating the Longford River. The catchment is mostly urban and consists of large tributaries including the Yeading Brook and the Duke of Northumberland's River. Flood risk was assessed from all sources within the catchment, including fluvial, surface water, groundwater, sewer, and artificial flood risks.

The catchment is subject to fluvial flooding from the River Crane and associated tributaries. The EA's River Crane hydraulic model was used to assess fluvial flood risk in the catchment. In areas where large extents of flooding were predicted, there was little to no property risk due to the presence of adequate floodplains and green corridors. Property counts at risk of flooding depicted a slow but gradual growth across the catchment with the 1:5 and 1:100-year return periods reporting 18 and 61 properties respectively. Three potential hotspots were established at The Greenway in Ickenham, Langley Crescent and Craneswater in Hayes and Fulwell Park Avenue in Twickenham with a combined total of 46 residential properties predicted to be at risk in the 1:100-year return period.

Overall, the fluvial flood risk within the River Crane catchment is relatively low with the majority of properties protected by adequate green corridors, especially throughout Hillingdon and Hounslow. In accordance with *Table 2-2*, the highest property counts at risk of flooding occurred within the boroughs of Hillingdon and Richmond. Hillingdon incorporates the majority of the River Crane whereas the borough of Richmond has a limited presence of green corridors. Subsequently, all fluvial hotspots were located within these two boroughs.

Surface water flood risk is dependent on local topography. In the northern half of the Crane catchment (roughly north of Heathrow), surface water follows distinct flow paths due to the hilly nature of the catchments. Surface water flood risk is concentrated close to these flow paths before they enter local watercourses. In the southern half of the catchment, surface water flood risk is less defined. There are smaller flow paths but also pockets of flooding predicted, due to the flat environment in those areas.

Multiple datasets within the catchment were used to analyse the risk of flooding from surface water. The IUD models of Feltham, Headstone, Hounslow Town Centre, North Harrow, North-West Hounslow, Southall, and Yeading fell within the catchment boundary and, because their outputs are not currently incorporated within the EA's RoFSW map, were subsequently analysed. The EA's RoFSW covers the entire catchment and was used for areas without models. Properties estimated to be at risk of flooding were dispersed throughout the catchment, with the 1:30 and 1:100-year return periods showing approximately 3,000 and 11,000 properties at risk, respectively. 45 potential surface water hotspots were identified in conjunction with CDAs, historic flood reports and S19 investigations. The 1:30 and 1:100-year return periods saw approximately 1,500 and 4,000 properties at risk of flooding within the hotspots, respectively. The impact of climate change was approximated using the FEH catchment-specific level descriptors and rainfall DDF estimates. Within the catchment, the 1:50 (+ 20% CC) return period event is approximately equivalent to the 1:100 return period event.

Overall, the River Crane catchment is subject to a dispersed distribution of surface water flooding where the majority of properties at risk of flooding falling within the boroughs of Harrow, Hillingdon, and Hounslow. Sited historical flood records, CDAs and hotspots suggests the northern part of the Crane catchment to be at a higher risk of flooding from surface water.

The southern section of the catchment is predicted to be susceptible to groundwater flooding. The majority of the area is defined as Class C, i.e. has a potential for groundwater flooding to occur at the surface. Large sections of Hounslow and Richmond upon Thames have the potential of groundwater flooding of property situated below ground. The susceptibility to groundwater flood may be explained by the permeable gravel and sand superficial deposits (Kempton Park Gravel Member and Taplow Gravel Member) which underlain the region. Over 95,000 properties in the catchment are susceptible of groundwater flooding at some capacity. The most vulnerable areas are those which are susceptible to groundwater flooding at the surface (Class C) which affects approximately 43,000 residential and 9,500 non-residential properties.

Although there is a lack of data to determine the overall risk of sewer flooding, the catchment is vulnerable to sewer surcharge. The majority of the catchment's sewer network is predicted to be at risk of sewer surcharge in a 1:2-year return period event from 2020. The risk of reservoir flooding is considered low, however, there are a number of reservoirs within and outside the catchment that may present a significant flood risk if their defences were to fail. There are 30,000 properties at risk of flooding from one or more reservoirs, but this assessment is based off worst-case scenario.

Due to the urban nature of the Crane catchment, the nature of flood risk within the catchment is complex. To establish a complete picture of flood risk within the Crane catchment, we make the following recommendations:

- Local Authorities and TWUL should implement robust flood incident reporting systems so that a more accurate picture of flood risk is captured, and surface water and fluvial hydraulic models can be validated. If robust systems exist, reporting systems could be improved through increased stakeholder engagement and public awareness campaigns.
- Additional IUD modelling should be completed by Local Authorities in locations with reported flood incidents, high-flood risk areas or hotspots. The type of IUD modelling for each area should be chosen in accordance with the Chartered Institution of Water and Environmental Management urban drainage group code of practice, to determine what method of modelling can best represent the area. Additionally, catchment specific climate change allowances could be introduced to further understand the impact of climate change on surface water and sewer flood risk.
- TWUL or local authorities should carry out additional surveys in areas of high surface water and sewer flood risk on both foul and surface water sewers to confirm the locations of dual manholes to determine the effects they have on flooding and water quality. The surveys could be brought forward in conjunction with additional surface water and foul hydraulic modelling.
- The EA's updated fluvial hydraulic model of the River Crane was not completed in time to be used in this study. When it is published in Spring 2022, it should be assessed to incorporate the most up to date data for fluvial flood risk and further assess the impacts of climate change on the entire catchment.
- Local Authority planning policies should be assessed to identify where boroughs have robust policies for green belt or similar land (or have gaps where these are needed) protection to mitigate the impact of future flood risks identified, particularly climate change implications.
- Local Authorities and TWUL should collect and investigate drainage asset condition data and routine maintenance programme frequencies to better understand whether some assets may be influencing the flood risk in the area. This may provide a more comprehensive understanding of

flood risk throughout the catchment and help validate (or invalidate) the current flood risk maps available in the catchment.

- There is limited data regarding the interaction of different sources of flooding within the catchment. Integrated hydraulic modelling which incorporates different flood risk sources could brought forward in the future to understand the combined impact of flood risk in the catchment.

APPENDIX A – FLOOD RISK MAPS

List of Figures in Appendix A:

APPENDIX B – FLOOD RISK DATA SOURCES

Please refer to Appendix B – Flood Risk Data Sources.

APPENDIX C – MODELLING GAP ANALYSIS MEMO

Please refer to Appendix C – Modelling Gap Analysis Memo.