Royal Borough of Kensington and Chelsea Section 19 Flood Investigation: 12 July 2021

Final Technical Report

June 2022

www.jbaconsulting.com

THE ROYAL BOROUGH OF
KENSINGTON
AND CHELSEA

THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA

JBA consulting

JBA Project Manager

Anna Beasley
Pipe House
Lupton Road
Wallingford
OX10 9BS

Revision History

Revision Ref/Date	Amendments	Issued to
S3-P01 05/04/2022	Draft Report	Preeti Gulati Tyagi James Latham
S4-P01 24/05/2022	Draft Report for stakeholders	Preeti Gulati Tyagi James Latham
A1-P01 22/06/2022	Final Report	Preeti Gulati Tyagi James Latham

Contract

This report describes work commissioned by Preeti Gulati Tyagi, on behalf of Royal Borough of Kensington and Chelsea, by a purchase order dated 1 November 2021. Royal Borough of Kensington and Chelsea's representatives for the contract were Patricia Cuervo, Preeti Gulati Tyagi and James Latham. Lucy Archer-Lock, Tinwai Cheung and Anna Beasley of JBA Consulting carried out this work.

Prepared by	Tinwai Cheung BSc MSc Assistant Analyst
.....	Lucy Archer-Lock BSc Analyst
Reviewed by	Anna Beasley BSc MSc CEnv MCIWEM C.WEM Technical Director
.....	Paul Eccleston BA CertWEM CEnv MCIWEM C.WEM Technical Director

Purpose

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

JBA Consulting has no liability regarding the use of this report except to Royal Borough of Kensington and Chelsea.

Acknowledgements

We would like to thank Royal Borough of Kensington and Chelsea, the Environment Agency, Thames Water, Transport for London, London Fire Brigade, London Borough of Hammersmith and Fulham, Westminster City Council, City of London, Camden Council, Islington Council, Brent Council, local residents and Felicity Buchan MP for their input and support.

Copyright

Carbon Footprint

A printed copy of the main text in this document will result in a carbon footprint of 445g if 100% post-consumer recycled paper is used and 567g if primary-source paper is used. These figures assume the report is printed in black and white on A4 paper and in duplex.

JBA is aiming to reduce its per capita carbon emissions.

Executive summary

Background

Following flooding in Kensington and Chelsea on 12 July 2021, Royal Borough of Kensington and Chelsea (RBKC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010. It is a statutory requirement for an LLFA to investigate flooding to the extent that it considers it necessary or appropriate.

The flooding that occurred in RBKC caused internal flooding to at least 340 properties. RBKC appointed JBA Consulting to undertake this investigation on its behalf.

For more information see Section 1.

Stakeholder engagement

As part of the Section 19 investigation, multiple local stakeholders in RBKC were contacted, including residents, Council Members, other Council departments, as well as Councils in neighbouring boroughs and Risk Management Authority partners across the city. Council officers undertook site visits to affected areas to speak with residents and gather further information. The objectives of engagement were to: gather facts, opinions, and data to aid the understanding of the investigation; and enable the involvement of the community in the investigation.

For more information see Section 2.

Drainage, flood risk, and flood history in Kensington and Chelsea

Section 3 describes the watercourses, urban drainage network and topography of RBKC; it also describes the different sources of flood risk in the borough.

Section 4 summarises the flood history of RBKC. Sewer flooding and surface water flooding has been a recurring issue in RBKC. Storm events in 2004 and 2005 caused flooding in over 100 and 200 properties respectively, while the July 2007 floods caused flooding in over 500 properties, particularly impacting on basement properties. In recent years, there have been smaller events, in 2016 and 2018, which resulted in fewer than 20 properties each being flooded.

Flood risk management

The roles and responsibilities of various organisations and Risk Management Authorities in flood risk management is described in Section 5, and (Section 6). Section 6 details the activities that are currently being undertaken to reduce flood risk, including summaries of recent flood risk studies and flooding alleviation schemes that have been proposed or implemented in the borough. Some of these solutions include measures to slow the flow of water, interventions in the sewer network to protect individual properties and the previously proposed Counters Creek storm relief sewer.

The 12 July 2021 event

Analysis of the rainfall and river levels recorded during the event (Section 7) indicated that the return period of the storm event varied significantly across RBKC depending on the location and the storm duration. In the south of the Borough, the return period of the storm based on the radar data was less than 1 in 2 years. The maximum return period of the storm event, based on the radar data in Notting Hill, indicates that the storm event was likely to be up to a 1 in 185-year event (rounded to the nearest 5 years) in the areas that experienced the heaviest rainfall. This is comparable with the estimates from the Met Office across London of return periods of up to 179 years for the amount of rain that fell in one hour. The Chelsea tide gauge located on the River Thames shows that high tide coincided with the heavy rainfall. It is likely that the observed flooding was caused by extreme rainfall falling

on a heavily urbanised catchment which was exacerbated by high tide levels in the River Thames impeding sewer overflows to the river.

Incident response

The first reports of flooding in the Borough came at around 15:00, with many properties reporting flooding by 17:00. The Council took several calls from flooded residents, dispatching Liaison Officers (LALOs) to report from on the ground, and establishing the Borough Emergency Control Centre to coordinate with on-site teams and agencies outside of the borough, such as the police and London Fire Brigade. The Council also opened the Curve and Henry Dickens Court Community Centre for flooded residents who were then offered temporary accommodation in hotels.

London Fire Brigade took over 1,000 calls during the event and Thames Water received over 4,000 calls over 12 to 13 July. London Fire Brigade declared a major incident at 19:15 and requested resources such as sandbags and water pumps from organisations and boroughs across London. At 20:30 a London Resilience Partnership teleconference was held, and at 22:30 a London Resilience Communication Group public communications call was held. London Fire Brigade then sent a stand down message for the major incident at 23:09, but continued to work throughout the night across London to remove floodwater in properties.

For more information see Section 8.

Source-pathway-receptor analysis

The main source of flooding was the intense rainfall during the event. This then flowed overland and drained into highways gullies and the combined sewer system. However, because of the high volume of intense rainfall, many sewers surcharged, with drains overflowing on the streets. This, combined with the continuing large amount of rainfall, created a large amount of overland flow which then collected in basement properties or at the ground floor level. The high flow volumes in the sewers also flooded properties internally by backing up through domestic wastewater pipes and coming up through toilets and shower drains, primarily if the property was at the basement level.

There were reports of flooding on 76 streets, where over 340 properties were flooded. Holland Park, Notting Hill Gate and Sloane Square stations were closed, and there was also flooding on the A4, A40, and A3220. The Council had flooding of its commercial and operational estate, North Kensington and Kensington Central libraries, St Marks Care Leavers Centre, The Learning Disability Community Team, and several properties that are part of Lancaster West Estate. Three schools were flooded: Colville Primary School, Thomas Jones Primary School and Avondale Park Primary School. The Muslim Cultural Heritage Centre in North Kensington was also affected.

The flood costed many residents hundreds of thousands of pounds in damages. Many residents are still in temporary accommodation as of May 2022 and have reported a lasting negative impact to their mental health. The flood also affected many businesses, particularly along Portobello Road.

For more information see Section 9.

Recommendations

Recommendations have been made to RMAs (Section 10) and the local community within the borough (Section 11). These are summarised below; Section 11 also includes a list of resources for residents (Sections 11.6.2 to 11.6.3).

Recommendation	Owner(s)
Carry out an independent review of sewer flooding and implement the recommendations	Thames Water (in progress)

Engage with and scrutinise the findings of the Thames Water independent review	RBKC (in progress)
Opportunities to retrofit SuDS should be prioritised wherever possible whether that be through specific schemes with Thames Water or government funding or through routine incorporation into urban regeneration and highways projects	RBKC, Thames Water
SuDS opportunity mapping	RBKC (in progress)
Joint campaign of community engagement and information to residents on how to prepare for a flood, who to contact during a flood, what to do after a flood. Repeat annually. Clear and consistent signposting on websites.	RBKC, Thames Water
Investigate the feasibility of a government funded PFR scheme in RBKC, or in partnership across a wider London area using the Environment Agency Flood Resilience Framework	RBKC (in progress)
Develop and implement an independent forecasting system for surface water flooding	RBKC (in progress)
Share sewer forecasts with other RMAs	Thames Water
Work together to streamline and triage the flood reporting process	RBKC, Thames Water and wider London Boroughs
Review and improve the accuracy of tipping bucket rain gauge at Holland Park or install high capacity rain gauge to more accurately record periods of intense rainfall	Environment Agency
Consider increasing frequency of highway gully cleaning in flooding hotspots	RBKC
Regular review of Critical Drainage Areas	RBKC
Review and update Multi-Agency Flood Plan and implement a process of review annually and after any flood event	RBKC (in progress)
Implement a training and exercising framework for the Multi-Agency Flood Plan	RBKC
Implement recommendations of the London Resilience Partnership Debrief and Surface Water Flooding Task and Finish Group	RBKC and wider London RMAs
Formation of community Flood Action Groups	Community
Production of community Flood Plans	Community
Report past sewer flooding to Thames Water	Individual property owners
Personal or building-level Flood Plans	Individual property owners/management committees
Use of Flood Re insurance scheme	Individual property owners
Disconnecting roof water drainage / property level SuDS	Individual property owners

THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA

JBA consulting

Contents

List of Figures

List of Tables

Abbreviations

BRF	Borough Resilience Forum
CCFAS	Counters Creek flood alleviation scheme
CSO	Combined sewer outfall
Defra	Department for Environment, Food and Rural Affairs
GDPR	General Data Protection Regulations
FAA	Flood alert area
FEH	Flood Estimation Handbook
FFL	Finished floor level
FLIP	Flooding Local Improvement Project
FRA	Flood Risk Assessment
FWA	Flood warning area
FWS	Flood warning system
GDPR	General Data Protection Regulations
JESIP	Joint Emergency Services Interoperability Principles
LALO	Local Authority Liaison Officer
LBHF	London Borough of Hammersmith and Fulham
LLAG	London Local Authority Gold
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
LFRMS	Local Flood Risk Management Strategy
LRF	Local Resilience Forum
NRV	Non-return valve
Ofwat	Water Services Regulation Authority
PFR	Property Flood Resilience
RBKC	Royal Borough of Kensington and Chelsea
RFCC	Regional Flood and Coastal Committee
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water
SFRA	Strategic Flood Risk Assessment
SPD	Supplementary Planning Document
SWMP	Surface Water Management Plan
SuDS	Sustainable Drainage Systems
TBR	Tipping bucket rain gauge
TTT	Thames Tideway Tunnel
TW	Thames Water

Definitions

Counters Creek catchment	A catchment is the area of land where water collects when it rains and drains to a body of water, and is often bounded by hills. Kensington and Chelsea is part of the Counters Creek catchment, which also includes parts of Hammersmith and Fulham.
Combined sewer	A sewer designed to convey foul sewage and surface water, for example, from connected highway gullies and property curtilages.
Culvert	Where a watercourse flows through a pipe, often underground.
Foul sewer	Sewer which carries wastewater (e.g. from toilets, sinks, showers and kitchen appliances) to a sewage works for treatment
Geocellular system	A modular system of usually plastic crates designed to store surface water below ground, either to attenuate flows before discharging to a sewer or watercourse or as part of a soakaway.
Gully	Drainage pit covered by an open metal grate, located at the edge of a road. Drains rainwater from the road into either the Thames Water surface water sewer or into nearby watercourses
HYRAD	UK Met Office real-time radar display system for weather.
Lead Local Flood Authority	County councils and unitary authorities which lead in managing local sources of flood risk (i.e. flooding from surface water, groundwater and ordinary watercourses).
London Local Authority Gold	A delegate from one of the boroughs in London who is given executive powers to act on behalf of all the other boroughs to deliver a coordinated emergency response and to avoid having to convene representatives from every borough.
Major incident	An event which has the potential for serious consequences and requires arrangements to be coordinated by multiple emergency responder agencies.
Main River	A river or stream designated on the Main River Map. The Environment Agency has permissive powers to maintain and carry out improvements on main rivers, to manage flood risk.
Ordinary watercourse	All rivers which are not designated as 'Main Rivers'. Lead local flood authorities have permissive powers to carry out flood risk management work on ordinary watercourses.
Sewer flooding	When sewage leaks out of the sewers through drains or manholes on the street, or through toilets, sinks and showers inside properties. The main causes of sewer failures are blockages, collapses, failures of equipment (especially pumping stations) and hydraulic overload (insufficient sewer capacity).
Tide-locking	When the tide is at the same level or higher than the outfall of a sewer, water from the sewer will not be able to discharge into the body of water and will instead back up through the sewer.

1 Introduction

1.1 Background to investigation

Following flooding in Kensington and Chelsea on 12 July 2021, Royal Borough of Kensington and Chelsea (RBKC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010[1].

It is a statutory requirement for an LLFA to investigate flooding to the extent that it considers it necessary or appropriate. RBKC has outlined its requirement to carry out flood investigations in its Local Flood Risk Management Strategy[2]. It has no specific criteria to instigate an investigation.

The flooding that occurred in RBKC caused internal flooding to at least 340 properties and has therefore been considered by the LLFA as of sufficient consequence to merit investigation. RBKC has appointed JBA Consulting to undertake this investigation on its behalf.

Areas of London also flooded on 25 July 2021. RBKC was not as badly impacted by this event, so it is not included as part of this investigation.

1.2 Thames Water Reviews

Thames Water conducted an internal review[3] into the July 2021 flooding, which was published in November 2021. It discussed the severity of the storm event while acknowledging failings in communicating with local authorities and its customer contact centre response (see Section 10.1).

The London Flood Review[4], an independent review commissioned by Thames Water, is in progress in parallel to the Section 19 investigation. In conducting the review, the independent expert group appointed by Thames Water has four core objectives[5]:

1 Research, understand and report on the 'what, when, why and how' of the two July storms

2 Examine the flooding mechanisms and to consider performance of drainage systems against design standards, with specific focus on Counters Creek and Maida Vale Flood Alleviation Schemes

3 Consider how changes to existing and planned drainage system works, operations and/or policies might have alleviated the flooding and make London more resilient to future storms

4 Be as evidence based as possible

A Stage 1 'data discovery' report was released in March 2022[6]. This detailed a comprehensive review of the quality of data collected by the Review including rainfall and tide levels during the event. However, it has identified data gaps in number of flooded properties Thames Water have in its records, and its depth monitor dataset (see Section

1 Flood and Water Management Act 2010 Section 19: https://www.legislation.gov.uk/ukpga/2010/29/section/19

2 RBKC Local Flood Risk Management Strategy (2015): Local Flood Risk Management Strategy | Royal Borough of Kensington and Chelsea (rbkc.gov.uk)

3 Internal review into the 12 and 25 July 2021 storms in London, Thames Water (November 2021): july-flooding-internal-review.pdf (thameswater.co.uk)

4 London Flood Review: https://londonfloodreview.co.uk/

5 London Flood Review Terms of Reference: https://londonfloodreview.co.uk/wp-content/uploads/2021/12/London-flooding-independent-review-terms-of-reference-FINAL_-16-Dec.pdf

6 London Flood review Stage 1 Report: Stage 1 Report – London Flooding (londonfloodreview.co.uk)

10.1). The final report is expected by summer 2022. Interim and final reports will be available on the website.

2 Stakeholder engagement

2.1 Data collection

A wide range of different information has been collected and assessed to inform the Section 19 investigation. This has been used to understand the causes and impacts of flooding in Kensington and Chelsea and to establish the context of the area. This includes the following:

- Open-source data from GOV.UK – for example the Risk of Flooding from Surface Water mapping (RoFSW), the Flood Map for Planning, ground elevation information such as LiDAR etc;
- Local geographical data e.g., sewer network data, highway asset data
- Historic flood records
- Rainfall data, e.g., radar data and gauge data
- Questionnaires
- Many residents sent photos of the event. These have been used to compile the source-pathway-receptor model of the event.
- Data from the event, such as photographs, observations/notes, newspaper articles, road closure announcements and flooded property information

2.2 Stakeholder engagement

We engaged with multiple local stakeholders in RBKC, including residents, other Council departments and RMA partners.

The objectives of the engagement were to:

- Gather facts, opinions and data to aid the understanding of the investigation
- Enable the involvement of the community in the investigation

A list of key stakeholders and how we engaged with them is given in Table 2-1. The engagement terminology is taken from Environment Agency's 'Working with Others' (2013) methodology:

- Inform – provide information
- Consult – receive, listen, understand and feedback
- Involve – decide together
- Collaborate – act together
- Empower – support independent action

Table 2-1: Key stakeholders

Role	Organisation	Location	How to engage	Type of engagement
Highways Authority	Royal Borough of Kensington and Chelsea	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Environment Agency	Environment Agency (Thames)	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Emergency Planning	Royal Borough of Kensington and Chelsea	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Sewerage Undertaker	Thames Water	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Network Rail	Network Rail	London	Involve	Invitation to contribute, correspondence, data provision
Transport for London	Transport for London	London	Involve	Invitation to contribute, correspondence, data provision
Fire Brigade	London Fire Brigade	London	Involve	Invitation to contribute, correspondence, data provision
Residents	-	Royal Borough of Kensington and Chelsea	Consult	Online questionnaire, correspondence, data provision
Neighbouring Authority	London Borough of Hammersmith and Fulham	Hammersmith and Fulham	Involve	Invitation to contribute, correspondence, data provision
Neighbouring Authority	Westminster City Council	Westminster	Involve	Invitation to contribute, correspondence, data provision
Neighbouring Authority	City of London	City of London	Involve	Invitation to contribute, correspondence, data provision

Role	Organisation	Location	How to engage	Type of engagement
Neighbouring Authority	Camden Council	Camden	Involve	Invitation to contribute, correspondence, data provision
Neighbouring Authority	Islington Council	Islington	Involve	Invitation to contribute, correspondence, data provision
Waste Management, Culture and Leisure	Royal Borough of Kensington and Chelsea	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Housing Management	Royal Borough of Kensington and Chelsea	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision
Member of Parliament	Parliament	Royal Borough of Kensington and Chelsea	Involve	Invitation to contribute, correspondence, data provision

2.3 Site visits

As part of the Flood Investigation process, Council officers undertook site visits to the worst affected areas. The Council is grateful to those residents who volunteered their time to take part in one of these site visits. The site visits were an opportunity to:

- Meet with residents affected by flooding
- Hear first-hand accounts of what happened on 12 July 2021
- See the continuing impact on individuals and the community because of the flooding
- Review the topography of the affected areas
- Identify any opportunities for future actions.

The site visits included the following areas:

- Holland Park and Norland – Holland Villas Road, Holland Park Gardens, Holland Park Avenue, Royal Crescent, St Ann's Road, St James's Road, Stoneleigh Place
- Notting Hill and Ladbroke – Clarendon Road, Elgin Crescent, Blenheim Crescent, Ladbroke Grove, Arundel Gardens, Kensington Park Road, Portobello Road, Colville Terrace.
- Kensington – Edwardes Square and Pembroke Square
- Lancaster West Estate – Barandon Walk, Testerton Walk, Lower Clarendon Walk, St Marks Close, Lancaster Road, Bomore Road, Verity Close.

3 Drainage and flood risk in Kensington and Chelsea

3.1 Drainage network

3.1.1 River network

The principal watercourse found in RBKC is the River Thames, which forms the southern boundary of the Borough.

'Lost rivers' were once tributaries of the River Thames before they were culverted and became part of the sewerage system during the 19th century. There are two lost rivers within RBKC: the Westbourne River and Counters Creek. The Westbourne River flows along the eastern boundary of RBKC from The Serpentine to The Thames. The Serpentine is a reservoir in Hyde Park that was formed in 1730 by damming the part of Westbourne River. Counters Creek runs approximately 350 m along the southwestern boundary from Chelsea Harbour into The Thames, while the culverted section of Counters Creek runs along the entire western boundary of RBKC (Figure 3-1). In addition, the Grand Union Canal flows through the north of RBKC through Kensal Town.

3.1.2 Urban drainage

The sewer network in RBKC is almost entirely made up of combined sewers. If a sewer is 'combined' it carries foul sewage and surface water, for example, from connected highway gullies and building curtilages.

The sewer system is made up of local sewers that take domestic foul and surface water from properties to the trunk sewers, which are much larger and cover longer distances. These convey sewage eastwards to Beckton sewage treatment works, located within the London Borough of Newham. In RBKC, there are many trunk sewers, but there are in particular three sewers that are of importance because they service the entirety of North London and are relatively large.

These sewers are: the Middle Level Sewer Number 1, which starts at Wormwood Scrubs and runs under Bayswater and Piccadilly; and the Low Level Sewers which start at Hammersmith, with Number 1 passing through Chelsea Embankment and Victoria, and Number 2 which passes through South Kensington and the Strand (Figure 3-1). These sewers run from west to east and converge, along with the High Level sewer, at different elevations at Abbey Mills Pumping Station. The various sewage inflows are pumped to the same level and flow in one pipe, the Northern Outfall Sewer, to Beckton sewage treatment works where it is treated before being discharged into the River Thames.

Interceptor sewers were also built, running north to south and draining to a pumping station or discharging to the river, as storm relief sewers. During high volume flow events, the Middle and Low Level Sewers will divert some of their flows into the storm relief sewers. In RBKC, these include: the North Kensington Storm Relief Sewer which starts at Bramley Road and runs southbound to Upper Addison Gardens, crossing into Hammersmith and Fulham, ending near Hammersmith Bridge; the North Western Storm Relief Sewer that takes flows from Camden and Brent, to then cutting across RBKC via Notting Hill and Upper Addison Gardens; and the Ranelagh Storm Relief sewer and Ranelagh combined sewer overflow (CSO) (Figure 3-1). These sewers include the culverted section of Westbourne River, running through Hyde Park and combine at the southern boundary of the park. They then run along the south-eastern boundary of RBKC through Sloane Square Station. These storm relief sewers are generally larger than the Middle and Low Level sewers, and were built later (1920s).

Furthermore, other nearby interceptor sewers include: the Walham Green Storm Relief Sewer, the Hammersmith Storm Relief Sewer (which splits into different branches, such as the Brook Green branch), and the North End Sewer. These service Hammersmith and Fulham, but have an impact on the sewers in RBKC.

The interceptor sewers drain to either Hammersmith Pumping Station or Lots Road Pumping Station, where their flows are either pumped into Low Level Sewer Number 1 or, during high volume flow events, they are pumped into the River Thames at a maximum rate of between 25 to 50m^3/s[7] [8]. However, during high volume flow events, the toxicity of the water is low as foul sewage only makes up around 0.1% of total flow in a high volume event[9]. Counters Creek and Walham Green sewers drain to Lots Road Pumping Station, while North Kensington, North Western and Hammersmith storm relief sewers drain to Hammersmith Pumping Station.

Recent sewer developments include the Thames Tideway Tunnel. This sewer is 25km long, and 7m wide, running from west to east, located by and following the path of the River Thames, ending at Beckton Sewage Treatment Works. Its purpose is to improve water quality of the river by collecting the majority of the sewage discharges from the interceptor sewers that would normally discharge into the river, and is not designed or intended to alleviate flood risk from sewers. The Thames Tideway Tunnel is still under construction, and is due to finish in 2025.

7 London Flooding Review Stage 2 Report
https://londonfloodreview.co.uk/stage-2-report/

8 Chartered Institution of Water and Environmental Management Urban Drainage Group Training Day 2
https://www.youtube.com/watch?v=ZVyiL6GJeSM&ab_channel=CIWEM

9 Thames Water Response to Scrutiny of Thames Water Proposal Change Appendix 2
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

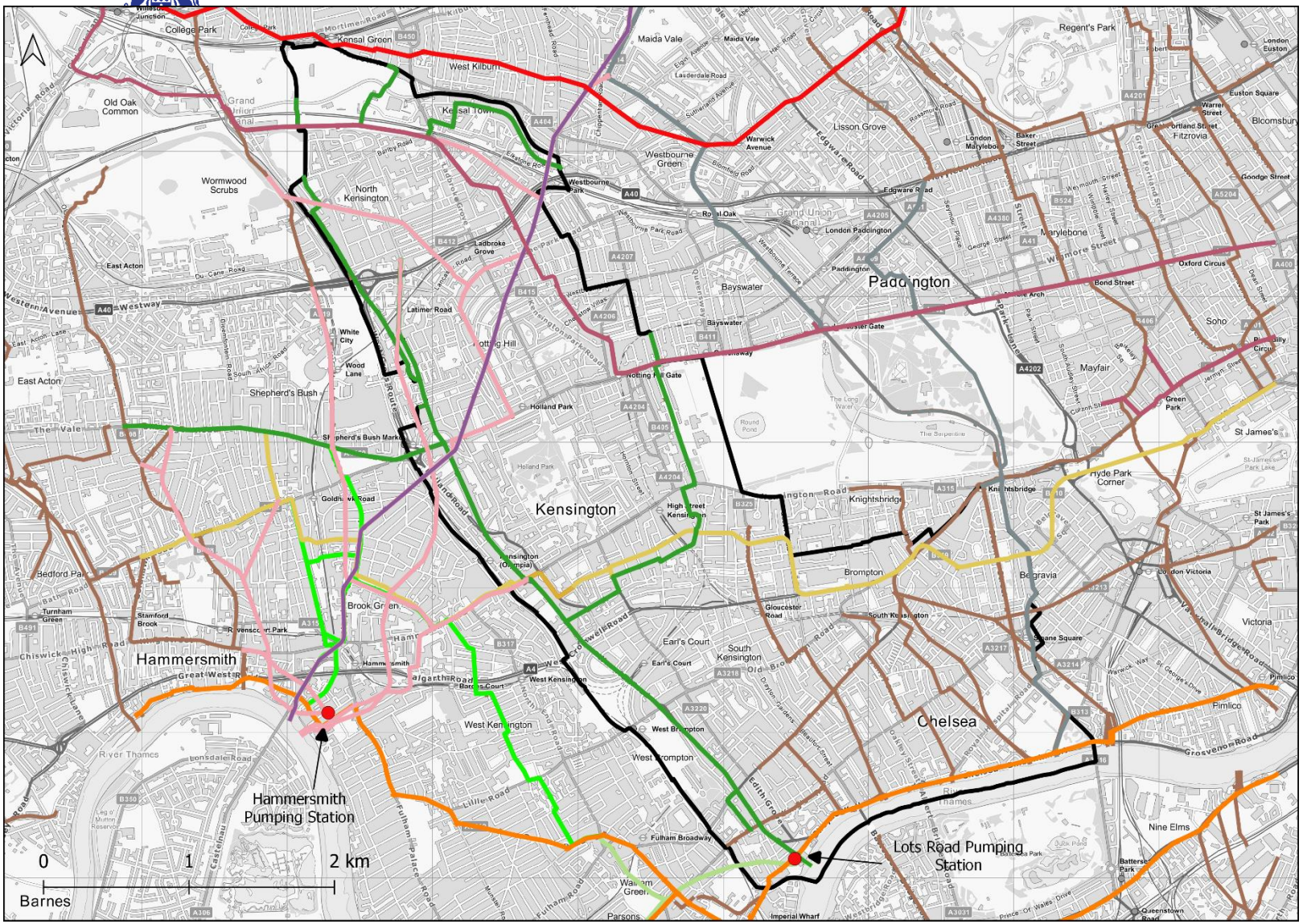


Figure 3-1: The trunk sewers in Kensington and Chelsea with the main sewers and interceptor sewers highlighted.

3.2 Flood risk

3.2.1 Surface water and sewer flood risk

RBKC has a history of sewer and surface water flooding following periods of heavy rainfall (see Section 4) and this was the main cause of flooding in the July 2021 event. As a highly urbanised central London borough with large areas of impermeable surfaces and little natural environment to provide floodwater storage, most of the stormwater will drain into the combined sewer system (see section 3.1.2). However, during periods of intense rainfall over a short duration, the sewers and drains can quickly reach maximum capacity, causing the sewers to surcharge and stormwater to overflow via manholes onto roads which act as a channel conveying water (Figure 3-2). The water drains according to the local topography: the highest local point is Notting Hill which slopes downwards southwards with the land flattening out from Holland Park to the River Thames.

The Environment Agency Risk of Flooding from Surface Water mapping (RoFSW) shows that the risk of surface water flooding is widespread across RBKC with a high number of isolated pooling points in low lying areas (Figure 3-4). There are flow paths along roads across RBKC. The west border of RBKC has a particularly large amount of pooling, especially in the north around the A40.

In addition to overland flow, floodwater can also come up directly into properties through toilets, sinks and shower drains (Figure 3-3). This occurs when they are at a similar elevation as the sewers, and also as water levels are pushed upwards as the sewer reaches capacity. In RBKC, this issue is prevalent in basement properties, which are at a similar level as the sewer.

Furthermore, while the interceptor sewers have their flows pumped to either Low Level Sewer Number 1 or into the River Thames, the other trunk sewers which drain southwards towards the river discharge under gravity. However, at high tide levels, the outfalls can become tide-locked, causing water to back up through the sewer system and affecting nearby local sewers. In addition, any operational issues with the pumping stations will also cause the sewers to back up.

As part of the 2014 Surface Water Management Plan (SWMP[10]), four Critical Drainage Areas (an area with critical drainage problems) were identified (Figure 3-5). These are located in Kensington, Holland Park, Sloane Square and North Kensington and show a complex interaction of surface and sewer water flooding.

Climate change is likely to increase the frequency and intensity of storm events. An indicator of the likely impact of climate change on surface water flooding is the difference between the 1% annual chance and 0.1% annual chance extents on the Environment Agency's Risk of Flooding from Surface Water mapping. Areas in RBKC most sensitive to changes between the 1% and 0.1% surface water extents are in the east of Kensington, east of Holland Road and the A3220. It is likely that the depth, extent, velocity and hazard posed by surface water flooding will increase with climate change.

10 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/surface-water-management-plan-swmp

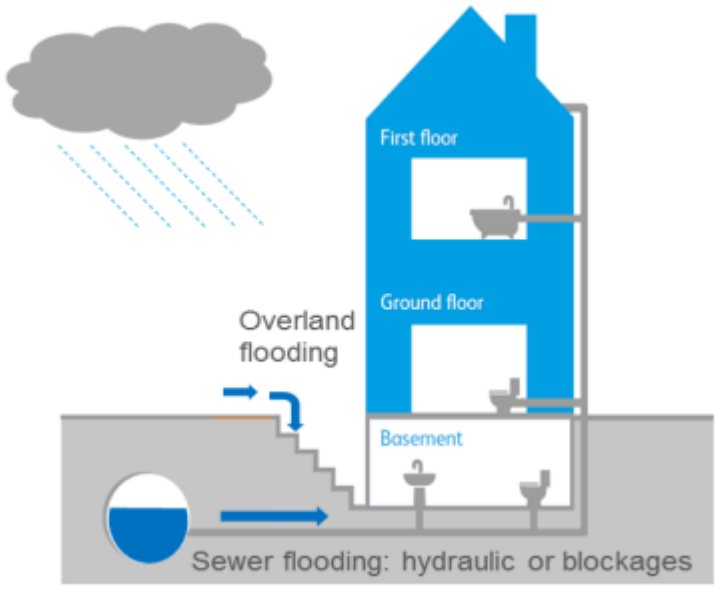


Figure 3-2: How sewer and overland flooding occurs (image reproduced from Thames Water[11]).

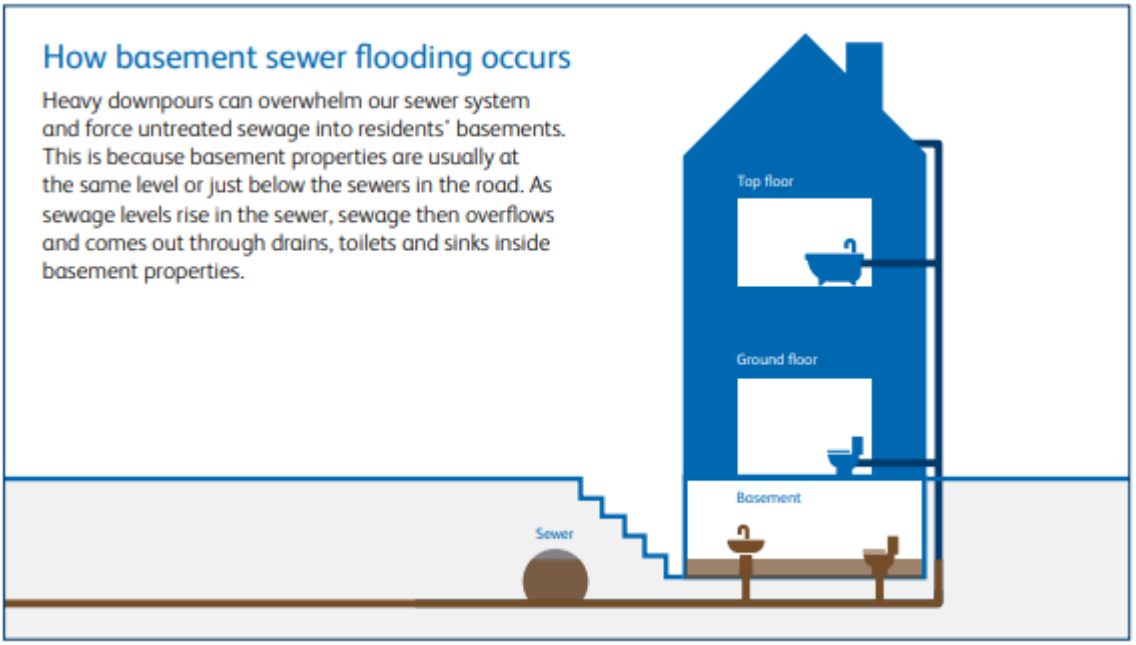


Figure 3-3: How sewer flooding occurs (image reproduced from Thames Water[12]).

11 The Counters Creek Flood Alleviation Scheme, Thames Water – A Summary
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project
12 Counters Creek Storm Relief Sewer Consultation – Phase 1, Thames Water

3.2.2 Fluvial and tidal flood risk

Fluvial and tidal flood risk in RBKC is along the River Thames, with modelling showing tidal is the dominant source of flooding. Fluvial and tidal flood risk is greatest in the south of the Borough in Chelsea, with this area located within the are likely to flood in a 1 in 100 annual chance event (known as Flood Zone 3). A small section along the western boundary of the Borough in South Kensington lies within the area likely to flood in a 1 in 1000 annual chance event (Flood Zone 2). In reality, the areas of the Borough within Flood Zones 2 and 3 are protected by flood defences with a 1 in 1000-year standard of protection by the Thames Barrier and extensive tidal defence river walls. The Environment Agency has not recorded any fluvial and/or tidal flood events within RBKC since the flood defences were built.

Climate change is predicted to result in higher sea levels caused by melting ice sheets and more extreme storm events which will create higher storm surges. Environment Agency modelling results (TE2100 Extreme Water Levels for the Tidal Thames) show that climate change will cause higher flood levels for a given probability of occurring on the tidal River Thames.

In addition, high river levels can cause 'tide-locking' of the storm sewer outflows, meaning water backs up at high tides, which can increase sewer flood risk.

3.2.3 Groundwater flood risk

Groundwater poses a flood risk in some areas of the borough to basement properties. The Borough has long had one of the highest densities of basement properties in the UK, and in recent years, there has been a trend to develop new and extended basements within properties, since it is difficult to develop laterally and upwards vertically, as there is little available space in the borough and many properties are listed buildings. Basement development can impede natural flows of groundwater, leading to higher levels in the vicinity of the 'upstream' side of basement structures[13].

3.2.4 Reservoir flood risk

There are no reservoirs located in RBKC. The Serpentine, which is located east of the Borough, poses a risk of flooding south of Knightsbridge down to Sloane Square. There is also a risk of flooding from the River Thames from reservoirs upstream in Spelthorne, Windsor and Maidenhead and Elmbridge.

13 Royal Borough of Kensington and Chelsea Residential Basement Study Report, Baxter
https://www.rbkc.gov.uk/wamdocs/baxters%20basement%20report%20final.pdf

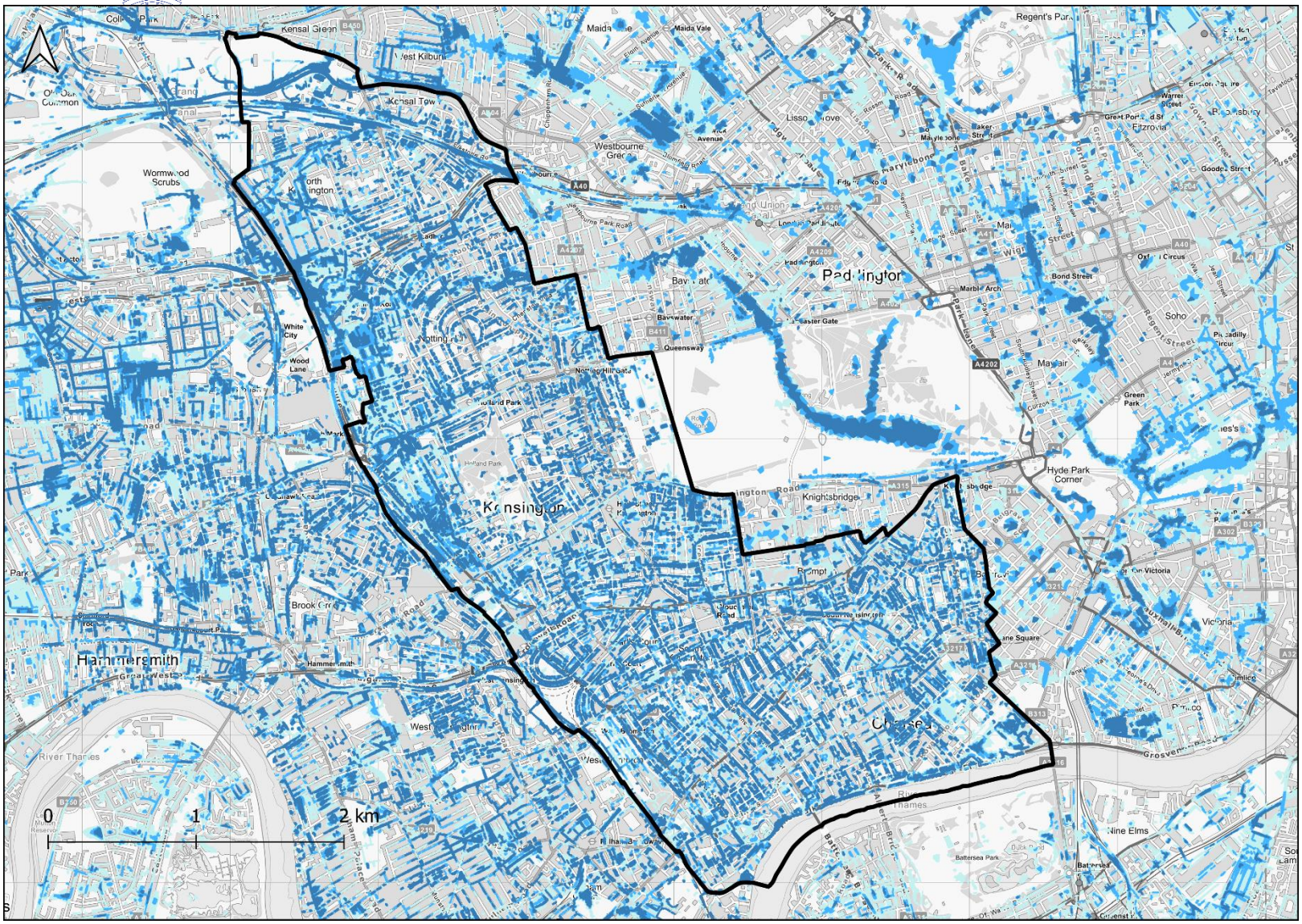


Figure 3-4: Risk of Flooding from Surface Water mapping

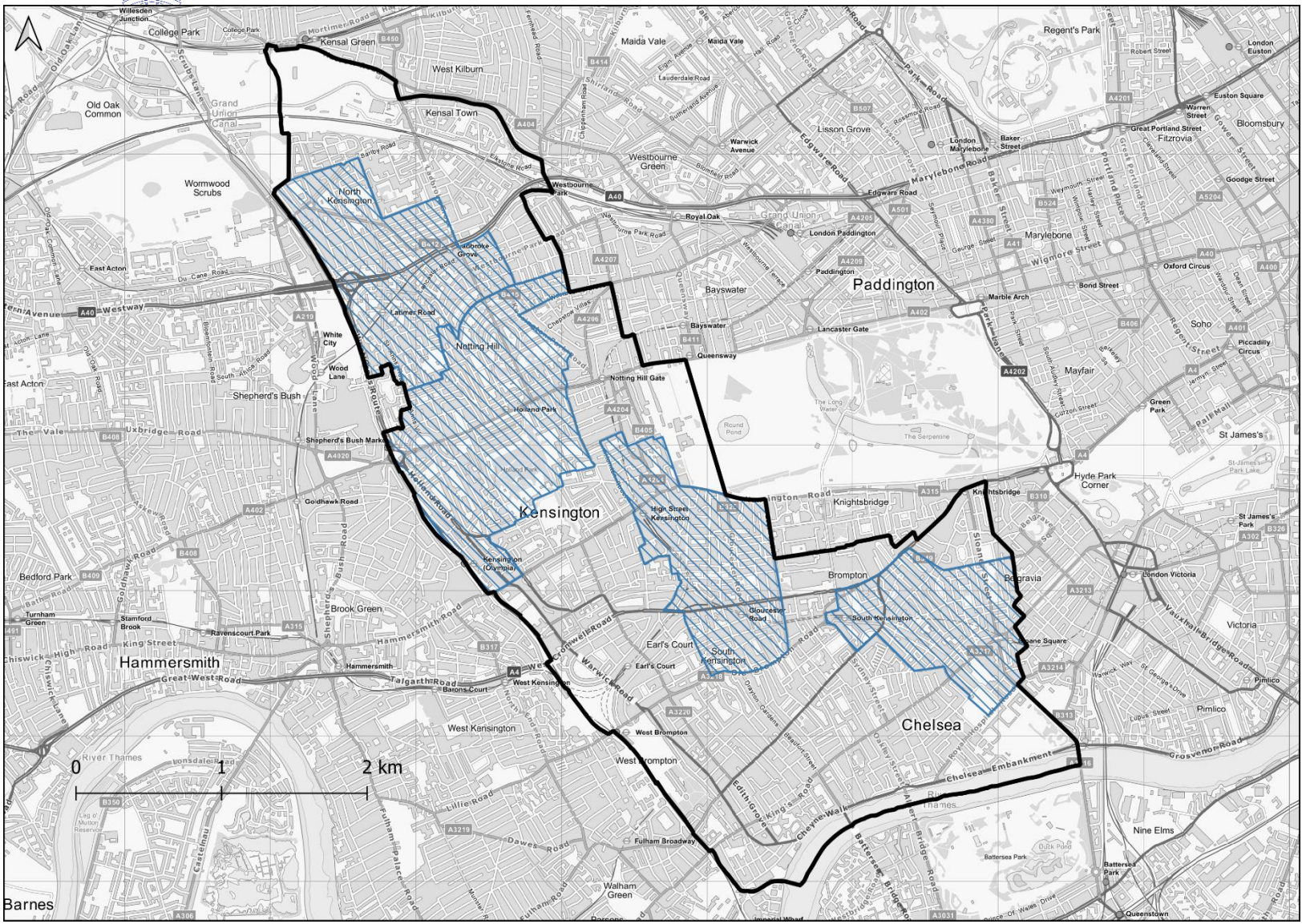


Figure 3-5: Critical Drainage Areas in Kensington and Chelsea

4 Flood history

There is a history of basement flooding, sewer flooding and surface water ponding in RBKC following periods of heavy rainfall. Local historical evidence[14] from Arundel Gardens suggests that there have been issues with surcharging sewers since 1888. These issues over time will have led to the construction of Storm Relief Sewers such as the North Kensington and North Western Storm Relief Sewers.

The flood records in Table 4-1 for the last 20 years are based on Thames Water's sewer flooding history database records. Reports of flooding before this are not as detailed[15].

The most severe event on record was on 20 July 2007. Thames Water recorded a total of 511 properties flooded as a result of surface water and sewer flooding following heavy rainfall, though this figure is likely to be underreported. The main flood mechanism was that the capacity of the drainage network was exceeded, causing flows to bypass gully inlets leading to ponding in low lying areas and surcharging of the sewer drainage network resulting in the flooding of basements which are directly connected to the combined sewer network.

Flooding was recorded across RBKC, with clusters of flooded properties in the central east of the RBKC, southeast of Shepherd's Bush Station. Some areas further south of this were also affected, including Kensington High Street, South Kensington, Sloane Square and Gloucester Road.

The Environment Agency has no recorded any fluvial and/or tidal flood events within RBKC since the 1930 Flood Act instigated the construction of the tidal flood defences. The 1953 flood came level with the Chelsea embankment.

Table 4-1: Flood history in Kensington and Chelsea

Date	Source of flooding	Description of impacts
29 July 1906	Intense rainfall/sewer	London flooded very badly. Most areas experienced a large degree of flooding, up to 5ft in some places. Lots of London places and basements flooded. Tube flooded – Richmond, Hammersmith and Waltham Green, West Kensington Station closed, and Metropolitan line between South Kensington and Mansion House closed.
5 September 1917	Intense rainfall/sewer	An overnight lightning storm was reported. Many city basements were flooded. Interview with meteorologist: "Rainfall was very heavy but unequally distributed – 1" rain locally to a ¼"; other places within a mile of the storm escaped scot-free. But that is characteristic of thunderstorm rain".
23 August 1921	Intense rainfall/sewer	In just over an hour, heavy rain fell flooding houses and railways. It was noted that there had been more rain recently than in the past four months combined.
11 July 1927	Intense rainfall/sewer	Within 45 minutes, 87 mm of rain was recorded to have fallen. The area surrounding Holland Park was flooded badly. Many buildings were also damaged by lightning.

14 Arundel Gardens, W11 (theundergroundmap.com)

15 British Chronology of Flash Floods, JBA Trust https://www.jbatrust.org/wp-content/uploads/2020/09/Thames.pdf

7 January 1928	Tidal	The river overtopped the banks after midnight and flooded streets, aggregating in basements. There was widespread flooding and damage as many were displaced from their homes and 14 people died in London.
12 July 1941	Intense rainfall/sewer	A severe thunderstorm caused basement flooding as the sewers exceeded its capacity.
31 January 1953	Tidal	Flooding due to tidal surges flooded Chelsea Embankment
3 August 2004	Intense rainfall/sewer	Significant basement flooding (approximately 100 reports of flooding). There was a large disruption to travel as Underground lines closed and traffic slowed. Several across London were also struck by lightning.
9 September 2005	Intense rainfall/sewer	Widespread basement flooding (approximately 200 reports of flooding). Transport was severely affected, with several train lines closed and the A4 being badly flooded.
11 October 2006	Intense rainfall/sewer	Flooding in Notting Hill Gate and Sloane Square stations.
20 July 2007	Intense rainfall/sewer	Devastating widespread flooding (over 500 reports of flooding) (see above)
23 June 2016	Intense rainfall/sewer	Basement flooding (less than 20 reports of flooding).
29 May 2018	Intense rainfall/sewer	Basement flooding (less than 10 reports of flooding).

5 Roles and responsibilities

Flood risk in England is managed by a range of different Risk Management Authorities (RMAs[16]). The Flood and Water Management Act places a duty on all flood risk management authorities to co-operate with each other. The act also provides Lead Local Flood Authorities and the Environment Agency with a power to request information required in connection with their flood risk management functions.

The following sections describe the roles of the various bodies involved in flood management, with roles and responsibilities for emergency response described in Section 5.2.

5.1 Organisations

5.1.1 Royal Borough of Kensington and Chelsea - Lead Local Flood Authority (LLFA)

Lead Local Flood Authorities (LLFAs) are responsible for coordinating the mitigation of risk of flooding from surface water, groundwater (water which is below the water table under the ground) and ordinary watercourses (non-main rivers). The LLFA is also responsible for developing, maintaining and applying a strategy for local flood risk management in their area and for maintaining a register of flood risk assets. LLFAs have a statutory duty to investigate significant flood events to the extent they consider necessary.

Royal Borough of Kensington and Chelsea is the LLFA for the whole of Kensington and Chelsea.

5.1.2 Environment Agency

The Environment Agency is sponsored by the Government's Department for Environment, Food & Rural Affairs (Defra), and is tasked with the protection and conservation of the water environment in England, the natural beauty of rivers and wetlands and the wildlife that lives there.

The Environment Agency's responsibilities include: water quality and resources; fisheries; conservation and ecology; and operational responsibility for managing the risk of flooding from main rivers (usually large streams and rivers), reservoirs, estuaries and the sea.

In RBKC, the Environment Agency is responsible for mitigation of risk of flooding from tidal sources, and maintaining tidal flood defences such as the Thames Barrier. It also issues flood warnings for tidal flooding from the River Thames.

5.1.3 Water and Sewerage Company

Thames Water is the water and sewerage company for RBKC.

Water and sewerage companies are responsible for the provision of wastewater collection and treatment systems, including for managing the risks of flooding from surface water and foul or combined public sewer systems providing drainage from buildings and yards. Because of the highly urbanised nature of RBKC, Thames Water is therefore responsible for the primary drainage pathways within the borough.

5.1.4 Highway Authority

Responsibility for managing flood risk on the road network is shared between Transport for London, who manage the 'red routes', and Royal Borough of Kensington and Chelsea Highway Authority which manages the remaining roads. Both are responsible for

16 https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities

maintaining the highway drainage system to an acceptable standard and ensuring that road projects do not increase flood risk.

5.1.5 Canal and River Trust

The Canal and River Trust is the charity entrusted with the care of manmade waterways in England and Wales, including the Grand Union Canal which flows through the north of RBKC through Kensal Town. The Trust is a navigation authority, and therefore has a statutory obligation to maintain navigation, through the inspection, maintenance and operation of water control structures within its ownership. The Trust does not have any specific statutory responsibilities in relation to flooding, but has responsibilities as an owner and operator of canals and other waterways. As a reservoir undertaker, the Canal and River Trust also has responsibility for the safety of the reservoirs under its control.

5.1.6 Residents and property owners

Property owners are responsible for the maintenance of any private drainage within their property.

Residents should find out about any flood risk in the area, sign up for the Environment Agency's free flood warnings[17] and make a written plan of how they will respond to a flood situation. Business owners should also make a flood plan for their business. There are measures that can be taken to reduce the amount of damage caused by flooding and properties at risk should be insured. Local residents can find out if their property is at risk, prepare for flooding, get help during a flood and get help after a flood.

5.2 Emergency roles and responsibilities

The emergency responsibilities of different organisations are outlined in Table 5-1.

Table 5-1: Roles and responsibilities in an emergency, during and after a flood event.

Local Authorities (Royal Borough of Kensington and Chelsea) – Category 1 responder
Will collaborate with a range of bodies which are not routinely involved in emergency response (e.g., building proprietors, land owners etc.)
Liaise with essential service providers
Coordinate emergency support within their own functions
Coordinate the activities of various voluntary sector agencies involved, and spontaneous volunteers
Liaise with central and regional government departments
Provide Investigation and Enforcement Officers under the provision of the Flood Environment Protection Act, 1985 as requested by Defra
Work in collaboration with Met Office to disseminate rain warnings for potential surface water flooding
Open rest centres for short term welfare needs
Provide medium to long-term welfare of survivors
May provide welfare facilities for use by agencies (circumstances and premise dependent)
Manage the local transport and traffic networks
Mobilise trained emergency social workers
Provide emergency shelter and welfare (not medical support)

17 https://check-for-flooding.service.gov.uk/

Local Authorities (Royal Borough of Kensington and Chelsea) – Category 1 responder
Deal with environmental health issues, such as contamination and pollution
Manage public health issues
Provide advice and management of public health
Clean up the pollution and facilitate the remediation and reoccupation of sites or areas affected by an emergency
Lead the recovery process
Manage public health issues
Provide advice and management of public health
Provide support and advice to individuals
Assist with business continuity

Police Force – Category 1 responder	Utility Providers – Category 2 responder
Save life	Work closely with emergency services and local authorities to deliver timely restoration of essential services to help minimise the wider impact on the community
Lead the joint emergency response (minor and localised flooding)	Alert emergency services to the risk of critical infrastructure being lost or challenged
Will establish and maintain cordons	Attend emergencies relating to their services causing risk to life and livelihoods
Process casualty information	Assess and manage risk of service failure
Responsible for identifying and arranging for the removal of fatalities	Deploy their own BC arrangements to protect critical infrastructure
Coordination and communication between emergency services and organisations providing support	Assist with recovery process
	Water utilities manage public health considerations

Fire and Rescue Service – Category 1 responder	Ambulance Service – Category 1 responder
Extinguish any fire	Ambulance Trust will endeavour to sustain life through effective prioritisation of emergency treatment at a scene
Rescue anyone trapped by fire, wreckage or debris	Ambulance Incident Commander has overall responsibility at the scene of an emergency
Deal with released chemicals or other contaminants in order to render the incident site safe	AIC will determine the priority of release of trapped, treatment and where necessary, decontamination of casualties
Will assist other agencies in removal of large quantities of flood water	Provide treatment, stabilisation and care at the scene
Will assist in the deployment of flood barriers, and other protective flood equipment	Seek spport and coordinate with British Red Cross and / or St John's Ambulance and other voluntary sector organisations in managing and transporting casualties
Carry out other specialist work, including flood rescue services	
Where appropriate, assist people where the use of fire service personnel and equipment is relevant	

Voluntary Services – Category 2 responder	Transport for London – Category 2 responder
Provide practical support: first aid, support emergency services operations, provide refreshments and emergency feedback arrangements Provide psycho-social support, equipment and information services as well as any disaster appeal funds or advice Support rest centres Support transport and communication Provide administration Provide telephone helpline support	Works with transport infrastructure owners and operators to facilitate contingency planning for natural hazards

Met Office – Category 2 responder	Military / MoD – Category 2 responder
Discuss predicted or ongoing severe weather events to help emergency responders assess the risk in their particular area and put preparations in place to mitigate the impacts Interpret meteorological information for responders where required Source other scientific advice available and act as a point of contact between the Met Office and responders If required, arrange for routine forecasts and other information to be supplied to aid the recovery process	Work closely with the Environment Agency, and will be deployed by National Government following request for mutual aid from the Environment Agency Support the deployment of flood defences Assisting population evacuation Tasking food and water distribution Support rest centres Provide provision of transport and/or drivers

Environment Agency – Category 1 responder
Leading public body for protecting and improving the environment in England Prevent or minimise the impact of an environmental incident Investigate the cause of an incident and consider enforcement actions Seek remediation, clean-up or restoration of the environment Issue Flood Warnings and ensure systems display current flooding information for potential fluvial, tidal or storm surge events (the Environment Agency do not have a responsibility to do warning and informing for surface water events) Provide information to the public on what they can do before, during and after a flood event Operate FloodLine and answer calls from the public Develop mapping and visuals on the likelihood and impact of flooding events (fluvial, tidal and storm surge) Monitor river levels and flows Work with professional partners and stakeholders and respond to requests for flooding information and updates Receive and record details of flooding and related information Operate water level control structures within its jurisdiction and in line with permissive powers Flood event data collection

Arrange and take part in flood event exercises
Respond to pollution incidents and advise on disposal
Assist with the recovery process, for example, by advising on the disposal of silt, attending flood surgeries

5.2.1 Local Resilience Forum (LRF)

Local Resilience Forums (LRFs) are a non-legal entity that is made up of Category 1 and 2 responders as defined in the Civil Contingencies Act, 2004. The purpose of the LRF is to ensure the effective delivery of those duties under the CCA, 2004 that need to be developed in a multi-agency environment. The establishment of this entity provide emergency responders to collectively plan and prepare for incidents and outline multi-agency arrangements to increase interoperability.

LRFs are typically developed based on police areas, and will aim to plan and prepare for localised incidents and catastrophic emergencies. A key output of the LRF is the establishment of a risk profile for the area covered by the LRF, which will outline the necessary arrangements required to prepare, respond to, and recover from these risks.

Under the Regulations, Category 1 responders much form a LRF as part of their obligation to cooperate with one another. Category 2 responders whose functions are exercisable within a local resilience area cooperate with other responders by attending meetings of the LRF or being represented at it. Category 2 responders are likely to be introduced to the LRF based on the risk profile of the area.

LRFs are organised as a collaborative mechanism aimed at achieving mutual aid arrangements and outcomes as agreed by partners. LRFs are able to monitor its own progress and strengths, and has an active role at identifying areas of improvements and putting in the necessary measures to increase interoperability between partner agencies.

However, the arrangements of LRFs are split differently in London. London has the same need as elsewhere for multi-agency cooperation at the local level. To achieve multi-agency cooperation at this level, the Regulations establish one pan-London LRF covering all of London, incorporating the Metropolitan Police and City of London Police Areas.

LRFs will operate in much the same way as LRFs elsewhere, however there are very distinct areas in London, each with specific emergency planning considerations which will require planning at a more localised level than that of pan-London.

For this reason, the revised Regulations specify that the London LRF must include in respect of each borough, a Borough Resilience Forum (BRF). The BRFs will primarily facilitate cooperation and information sharing at the operational level between local authorities and the emergency services and should not duplicate the work of the LRF.

Alongside pan-London LRF and BRFs, there are multi-borough sub-groups of the LRF which will support effective emergency planning by facilitating communication between member boroughs as well as communication between BRFs and pan-London LRF.

6 Current flood risk management activities

6.1 Flood risk studies and strategies

RBKC have produced a number of flood risk studies and strategies on which current flood risk management activities and emergency planning response in RBKC are based. These are summarised here and links to the documents given for further information.

6.1.1 Royal Borough of Kensington and Chelsea Surface Water Management Plan

The Royal Borough of Kensington and Chelsea Surface Water Management Plan (SWMP) was released in 2014[18]. A SWMP is a study to understand the flood risks that arise from local flooding, which is defined by the Flood and Water Management Act 2010 as flooding from risk from surface runoff, groundwater, and ordinary watercourses. The SWMP also looks at what options there may be to manage flood risk and who should take these options forward. SWMPs are led by a partnership of flood risk management authorities who have responsibilities for aspects of local flooding, including the LLFA, Local Authority, Sewerage Undertaker and other relevant authorities.

The dominant mechanisms for flooding in the area were identified as: topographical low lying areas particularly where obstructions impede flow; topographical low points (predominantly basement properties) which result in small, discrete areas of deep surface water ponding; sewer flood risk – areas where extensive and deep surface water flooding is likely to be the influence of sewer flooding mechanisms alongside pluvial and groundwater sources; and fluvial/tidal flood risk where extensive and deep surface water flooding is likely to be the influence of fluvial and tidal flooding mechanisms, alongside pluvial, groundwater and sewer flooding sources.

The SWMP identified opportunities to reduce the impact of surface water flooding across the catchment. This included generic measures such as swales, permeable paving, bioretention carpark pods and green roofs. More specific measures were also identified such as including pumping devices in basement properties to protect them from sewer flooding, communicating with residents to ensure they are aware of their personal responsibilities and how they can mitigate surface water flooding, promote use of SuDS features within council assets (roads, parks and footpaths) and private property (car parking areas, private parks etc.) and improve maintenance of areas identified to flood regularly or have blocked gullies.

As part of the SWMP, using the outputs of the surface water and local knowledge of the area, four Critical Drainage Areas were identified. These are located in Kensington, Holland Park, Sloane Square and North Kensington and show a complex interaction of surface and sewer water flooding.

6.1.2 Royal Borough of Kensington and Chelsea Local Flood Risk Management Strategy

The Royal Borough of Kensington and Chelsea Local Flood Risk Management Strategy[19] (LFRMS) was published in 2015 as part of the Council' s responsibilities under the Flood and Water Management Act 2010. The strategy sets out the roles and responsibilities of flood risk management partners along with the Council's responsibilities. The LFRMS encourages communities to have a greater say in local flood risk management decisions and is aimed at residents, businesses, other members of the public and flood risk management authorities.

The Strategy notes that it will help deliver Sustainable Drainage Systems (SuDS) as well as aiming to achieve sustainable development as defined by the National Planning Policy Framework and must take into consideration flood risk when development is proposed. The

18 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/surface-water-management-plan-swmp

19 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/local-flood-risk-management-strategy

Strategy should link with the Local and Neighbourhood Development Plans such as the Norland Neighbourhood Plan 2013-2028 which addresses flooding.

The Strategy is due to be revised later in 2022 and will take into account the recommendations of this Flood Investigation Report.

6.1.3 Royal Borough of Kensington and Chelsea Preliminary Flood Risk Assessment

The Preliminary Flood Risk Assessment for Kensington and Chelsea[20] was released in 2011 as part of the wider Drain London project which involved the delivery of high-level Surface Water Management Plans (SWMP). The PFRA has been undertaken to assist Royal Borough of Kensington and Chelsea to meet its duties as a Lead Local Flood Authority, with the delivery of the first stage of the Flood Risk Regulations (2009). This study has not identified any past floods that are considered to have had significant harmful consequences. This is based on the following local definition of harmful consequences: 'Memorable past floods or otherwise registered on a national scale (such as the July 2007 event) even if only occurring over a relatively small area.' Future flood risk from extreme events is estimated to be high in RBKC. Based on the Drain London surface modelling outputs, approximately 22,250 properties are estimated to be at risk from flooding during a rainfall event with a 1 in 200 annual chance of occurring.

6.1.4 Kensington and Chelsea Multi-Agency Flood Plan

Kensington and Chelsea published Multi-Agency Flood Plans[21] in 2013 for Surface Flooding and Thames Breach-Overtop Flooding.

The surface flooding plan covers the multi-agency response to a severe surface water flooding incident in RBKC, with the aim of mitigating the impact of such an incident occurring. It provides guidance on a multi-agency response to deliver the following objectives:

- To increase awareness and preparedness of communities at risk from surface water flooding through the provision of advice and information;
- Manage the wider impact of surface water flooding events in the borough to reduce disruption to the communities, utilities and environment;
- Manage precautionary actions to preserve life for the highest-impact surface water flood risks;
- To prioritise the identification of and required responses to protect the vulnerable within the community;
- Provide accurate and timely information to the public and local business on flood response;
- Lead recovery activity to support the recovery of communities and business; and
- Maintain critical services within each organisation as part of business continuity arrangements.

The Thames Breach plan covers the multi-agency response to a large scale Thames Breach/Overtopping flooding incident in RBKC, with the aims of mitigate the impact of such an incident occurring. It provides guidance on a multi-agency response to deliver the following objectives:

- To increase awareness and preparedness of communities at risk from flooding through the provision of advice and information;

20 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/flooding-planning-policies

21 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/flooding-planning-policies

- Manage the wider impact of flooding events in the borough to reduce disruption to the communities, utilities and environment;
- Manage precautionary actions to preserve life for the highest-impact flood risks;
- To prioritise the identification of and required responses to protect the vulnerable within the community;
- To support the Environment Agency in the provision of warnings to communities at flood risk;
- Provide accurate and timely information to the public and local business on flood response;
- Lead recovery activity to support the recovery of communities and business; and
- Maintain critical services within each organisation as part of business continuity arrangements.

6.2 Thames tidal defences

The Environment Agency are responsible for operating and maintaining tidal flood defences in RBKC. The Tidal Thames is defended to a 1 in 1000-year standard of protection, by a series of walls, embankments, flood gates and barriers, and the Thames Barrier. These defences were operating normally during the July 2021 event.

6.3 Gully cleaning programme

In RBKC, blockages and gully cleaning are managed by Waste Management, Culture and Leisure, who presently contract out the work to Suez Recycling and Recovery. If a gully needs replacing, then this is managed by Highways and Construction.

Gullies in RBKC are cleaned once or twice a year. Of the streets that were flooded during the event (see Section 9.3.1), their gully cleansing programme is listed below in Table 6-1.

Table 6-1: The gully cleaning programme in Kensington and Chelsea.

Once a year		Twice a year	
Alma Terrace, Allen Street	Addison Road	Kensington Park Road	Russell Gardens
Beckford Close	Ansleigh Place	Ladbroke Grove	Russell Road
Colville Square	Arundel Gardens	Lancaster Road	Sloane Square
Cope Place	Blenheim Crescent	Latimer Road	St Anns Road
Edwardes Square	Bramley Road	Ledbury Road	St Anns Villas
Holland Park Road	Brewster Gardens	Lonsdale Road	St James's Gardens
Kenway Road	Clarendon Road	Napier Place	Stanford Road
Melbury Road	Colville Road	Napier Road	Stoneleigh Place
Pembroke Gardens	Cornwall Crescent	Norland Road	Stoneleigh Street
Pembroke Road	Darnley Terrace	Norland Square	Upper Addison Gardens
Pembroke Square	Elgin Crescent	Notting Hill Gate	West Eaton Place
Radley Mews	Ellis Street	Pimlico Road	Westbourne Park Road
Rosmead Road	Elsham Road	Portobello Road*	Young Street
Scarsdale Villas	Holland Park Avenue	Princedale Road	
St Marks Road	Holland Park Gardens	Princes Place	

Stafford Terrace	Holland Road	Queensdale Road	
Warwick Road	Holland Villas Road	Royal Crescent	

*Other arrangements are in place for some sections of road that include market traders where the gully cleansing frequency is increased. From the junction to Chepstow Villas to the junction at Golborne Road, gullies on this section of Portobello Road are cleansed every six weeks, while the remaining parts, junctions from Chepstow Villas to Pembridge Road and Golborne Road to Swinbrook Road/Acklam Road, are cleansed twice per year.

6.4 Sustainable Drainage System (SuDS) schemes

SuDS aim to imitate natural hydrological and give benefits such as: reducing surface water flooding, improving water quality, and increasing biodiversity. SuDS achieve this by limiting the use of impermeable surfaces within developments to increase infiltration, infiltrating to the ground where possible and increasing water storage capacity in order to control peak runoff.

Several SuDS schemes have been implemented in RBKC. The Council has completed highways improvements works that incorporate rain gardens at the junction of Dalgarno Gardens and Barlby Road, as well as at Bevington Road Open Space. A SuDS project was also implemented by RBKC in 2019 at Holland Park[22]. It is integrated within the children's playground, allowing children to play in a woodland-themed environment, while slowing and storing water in the surrounding area through swales and attenuation ponds.

Thames Water carried out a SuDS scheme at Arundel Gardens in 2017 as part of the Counters Creek flood alleviation scheme (see section 6.5.3). Further SuDS schemes delivered as part of the Counters Creek project were delivered in the neighbouring London Borough of Hammersmith and Fulham.

The Council has secured funding from the Thames Regional Flood and Coastal Committee and the Thames Water Surface Water Management Programme fund for a SuDS project at Portobello Court on Lonsdale Road, and next to Portobello Road[23]. The project will take rainwater draining from roofs and the neighbouring Westbourne Grove through a series of raised planters, rain gardens, swales, detention basins and an attenuation storage system beneath the Multi Use Games Area. In doing so, the volume and speed of the rainwater entering the sewer will be reduced. It recently went through a round of public consultation between August 2021 to September 2021 and was voted to proceed by residents. The project is due for construction in the Autumn following a further round of design and engagement with residents.

New SuDS schemes are in various stages of design development within Council departments, including Housing, Highways and Parks.

As well as implementing schemes, the Council has strong planning policies requiring SuDS to be delivered through development[24] (see Section 6.7.2).

6.5 Counters Creek flood alleviation scheme

Following the 2007 summer floods, Thames Water increased their engagement in flood mitigation and launched the Counters Creek flood alleviation scheme[25] (CCFAS). The scheme originally comprised of four elements: a new storm relief sewer to increase sewer capacity, anti-flooding devices called FLIPs (flooding local improvement projects) to stop

22 https://www.rbkc.gov.uk/leisure-and-culture/parks/holland-park-adventure-playground

23 https://planningconsult.rbkc.gov.uk/PortobelloSuDS/consultationHome

24 Policy CE2 of Local Plan (2019)

25 The Counters Creek Flood Alleviation Scheme, Thames Water – A Summary
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

sewers surcharging into basements, sustainable drainage systems (SuDS), and local sewer upgrades. These are described in more detail in the following sections.

6.5.1 Storm relief sewer

The Counters Creek Flood Alleviation Scheme (CCFAS), as proposed, was a £250 to 300 million, 5km long, and 4m wide sewer that was initially planned to connect and discharge directly to the River Thames. This new sewer would connect with the existing main sewers (Section 3.1.2), providing greater sewer capacity during high volume flow events. A list of 200 potential sites for connecting the sewers together was developed, which was then narrowed down through various criteria[26]. These accounted for logistical requirements such as construction and temporary works accommodation, accessibility, while considering the impact to traffic and public transport, avoiding areas near schools, hospitals, heritage sites, and minimising noise.

Following the first round of public consultation on the CCFAS in 2014, which received opposition from residents and stakeholders who complained about the length of construction (two to four years), the obstructions and road closures, and the noise and air pollution, Thames Water narrowed down the 200 potential sites to 5 sites. Thames Water proposed to start from Kensington Olympia from where it would tunnel both north and south. To the north, the new storm relief sewer would connect with the Hammersmith Storm Relief Sewer (Brook Green branch) at Shepherds Bush, and the North Kensington Storm Relief Sewer, North Western Storm Relief Sewer, and the (old, culverted, lost river) Counters Creek sewer at Upper Addison Gardens. To the south, the proposed storm relief sewer would firstly intercept the North End Sewer at Mund Street (in Hammersmith and Fulham) and finally end at Cremorne Wharf on Lots Road, connecting both the Walham Green Storm Relief Sewer and the Middle Level Sewer Number 1 (Figure 6-1).

Cremorne Wharf would be the location of both the combined sewer outfall (CSO) and a pumping station. During high volume flow events, a pumping station would be required to pump sewage into the River Thames as a last resort solution. In addition to being adjacent to a pumping station already, the Lots Road Pumping Station, Cremorne Wharf was also a site where the Thames Tideway Tunnel would run underneath. As a result, Cremorne Wharf became a preferred site since sewage overflows from the new storm relief sewer could be diverted to the Thames Tideway Tunnel, instead of the river. However, further issues arose over this connection, since construction at Cremorne Wharf had been reserved for the Thames Tideway Tunnel from 2017 to 2024, which would have delayed the CCFAS storm relief sewer until after 2024. Furthermore, by connecting to the Thames Tideway Tunnel instead of the river, the CCFAS storm relief sewer would become dependent on the level of the Thames Tideway Tunnel, and could only discharge its flows into the Thames Tideway Tunnel once its levels were suitably low[27]. If an event occurred where the sewer levels in the Thames Tideway Tunnel were too high, then the new storm relief sewer would discharge into the river as a last resort, and was expected to at least once a year.

Overall, Thames Water stated that the principal issue with the new storm relief sewer was that it could only reduce the risk of sewer flooding from hydraulic overload if the other main sewers (such as the North Kensington Storm Relief sewer), which in turn were connected to local sewers, had connections to the CCFAS storm relief sewer[28]. Since there were only five locations which were suitable for a connection to be made, then there were only five areas which would have a local reduction in flood risk, with little reduction in flood risk elsewhere. Thames Water also felt that with their programme of FLIP installation in the past decade

26 Counters Creek Storm Relief Sewer Consultation – Phase 1, Thames Water

27 Thames Water Response Appendix 1

https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

28 Thames Water Response to Scrutiny of Thames Water Proposal Change

https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

and its performance in the 2016 floods, the FLIPs provided a level of protection similar to the proposed storm relief sewer.

As a result, plans for the storm relief sewer were dropped in January 2018 and the CCFAS focused on the remaining measures to reduce flood risk in the area[29] (FLIPs, SuDS and local sewer improvements). Under the original scheme, the CCFAS was to bring £14.2m of annualised benefit between 2015 to 2020; without the storm relief sewer, the remaining elements of the scheme brought in under £3m of annualised benefit in the year 2020[30]. The Water Services Regulation Authority (Ofwat) fined Thames Water £130m for dropping the plans for the storm relief sewer and failing to meet its performance commitment.

29 18-01-08 Thames Water letter to Councillors
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

30 Ofwat PR19 draft determinations – accounting for past delivery actions and interventions
https://www.ofwat.gov.uk/wp-content/uploads/2019/07/PR19-Draft-Determinations-Thames-Water-Accounting-for-past-delivery-actions-and-interventions.pdf

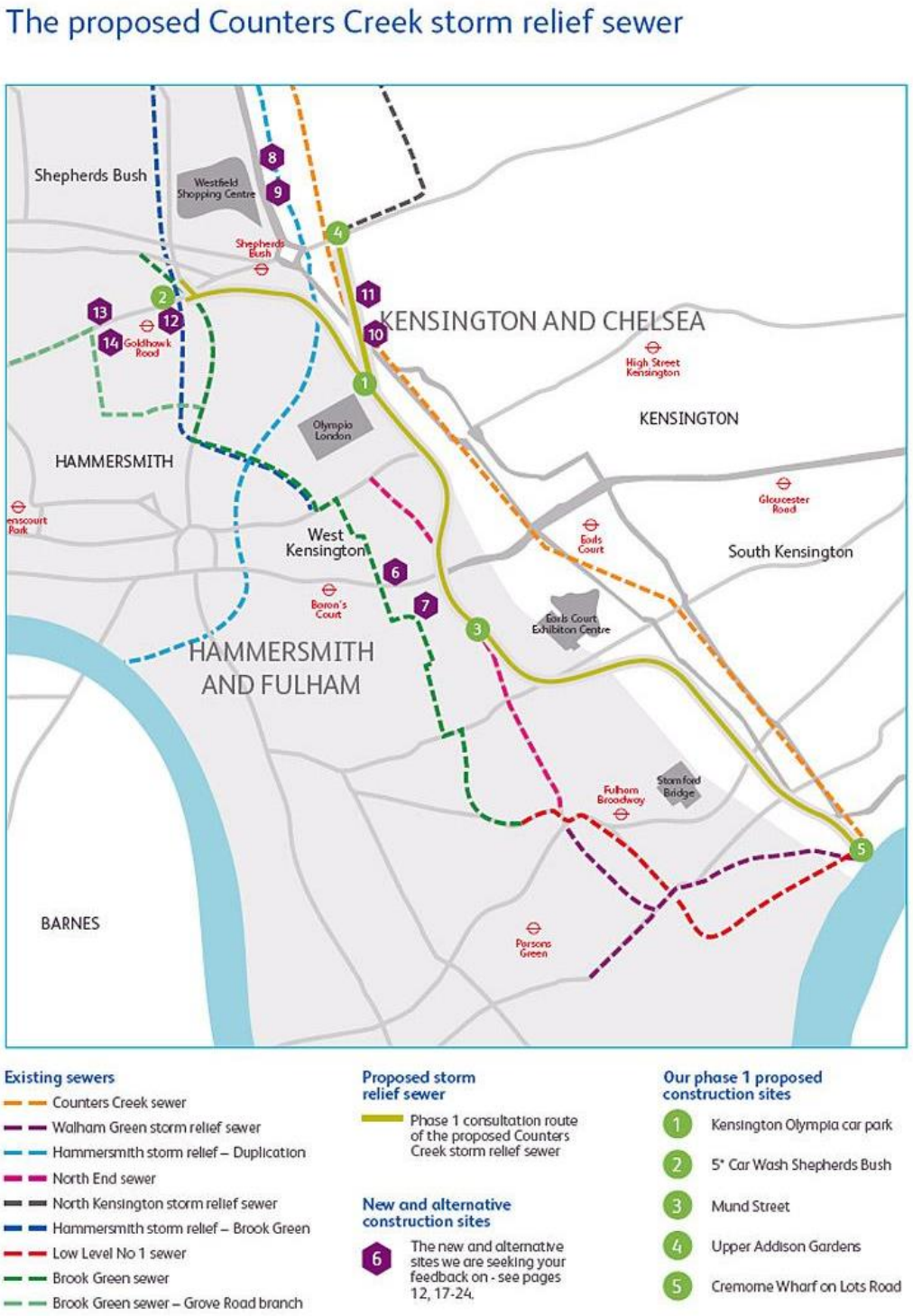


Figure 6-1: The proposed site locations for the proposed storm relief sewer (image reproduced from LBHF[31]).

31 https://www.lbhf.gov.uk/articles/news/2015/06/council-says-no-sewer-works-sites

6.5.2 FLIPs (Flooding Local Improvement Projects)

A FLIP is a water pump that takes domestic foul and rainwater away from a property, into the main sewer in the road, even when the sewer is full[32]. A non-return valve is installed to prevent backflow from the sewer when it is full, so that the FLIP can still take sewage into the sewer (Figure 6-2).

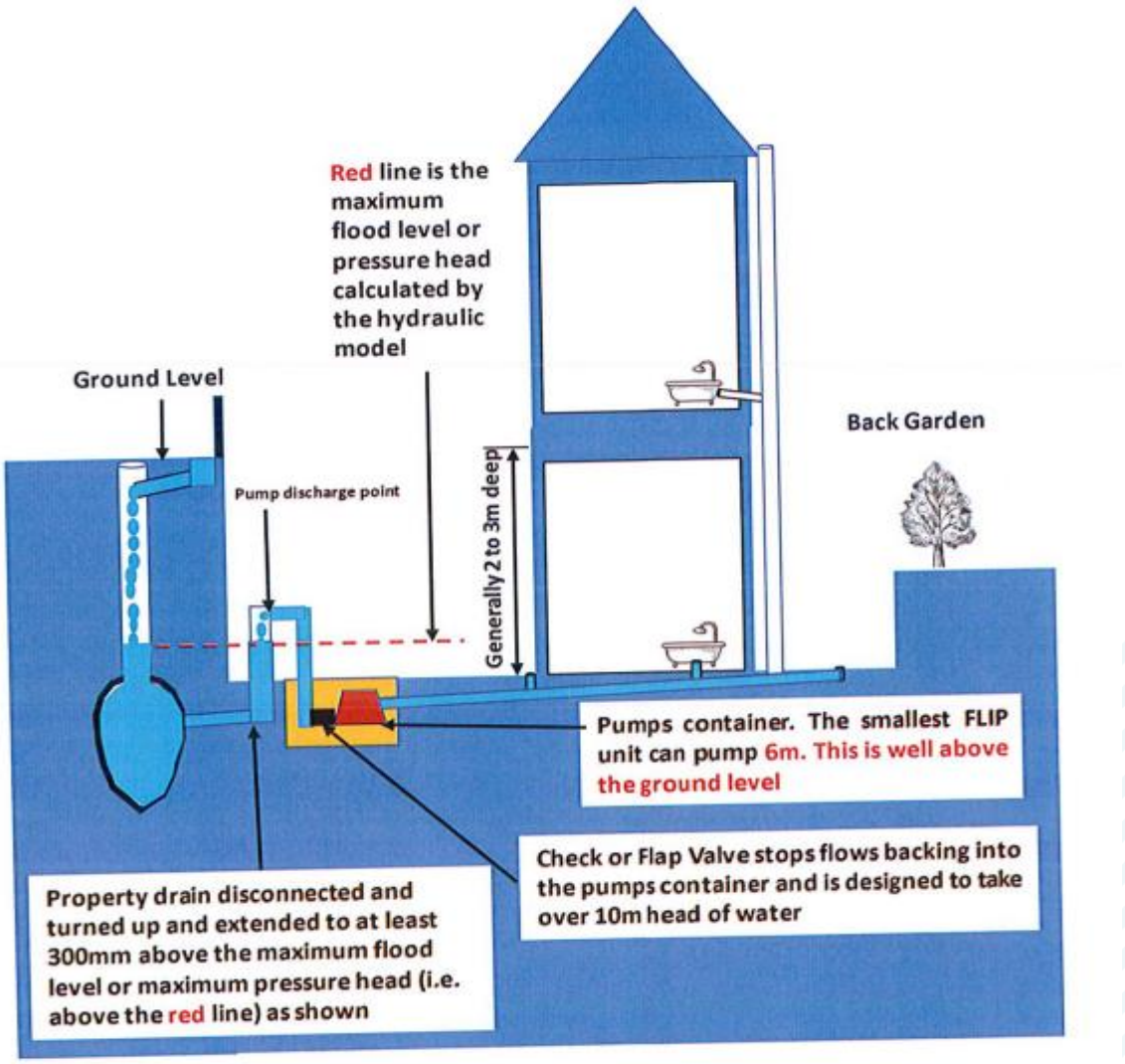


Figure 6-2: How a FLIP works (image reproduced from Thames Water[33]).

Thames Water undertook a programme of FLIP installations between 2010 to 2020. By 2018, when the plans for the storm relief sewer were dropped, 1,300 FLIPs had been

32 Counters Creek Strategic Sewer Flood Alleviation

33 Thames Water Response Letter to Scrutiny of Thames Water Proposal Change https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

installed in total in the Counters Creek catchment[34], with 343 being installed in RBKC[35]. As of January 2022, there are 475 FLIPs in RBKC.

Each FLIP costs approximately £130,000, with the main costs being associated with surveying and installation[36]. They are effective at protecting individual properties from flooding. However, where there are large numbers of them along a particular sewer, there is a risk that they may increase flood risk to nearby unprotected properties on the same sewer.

Residents were selected for a FLIP if they had experienced hydraulic sewer flooding in the past, in addition to if the associated event had a return period of less than or equal to ten years; alternatively, if the property was in a high flood risk area as predicted by the hydraulic model developed by Thames Water, then the property would also qualify for a FLIP.

FLIPs were initially proposed as a temporary measure that would complement the storm relief sewer. Since the withdrawal of the storm relief sewer, FLIPs are now a permanent measure in addressing flood risk[37]. Since 2020, having run out of funding for the CCFAS, Thames Water have not installed any more FLIPs. However, it has recently made £10 million available for FLIPs, across the whole of London[38]. Following the fine by Ofwat over missing their performance commitment, it has been given a new performance commitment until 2024 which only requires Thames Water to develop their hydraulic model of the area, and did not include any on-the-ground installations[39].

However, Stage 1 of the Thames Water Independent Review suggests that Thames Water will consider restarting a longer-term FLIP installation programme as one of its actions following the July 2021 floods[40].

6.5.3 Arundel Gardens SuDS scheme

In March 2017, Thames Water finished work to implement a SuDS scheme at Arundel Gardens. Work started November 2016 and cost £737,000[41]. The road was resurfaced with porous asphalt where rainwater would drain downwards into a geocellular system which collects the rainwater (Figure 6-3). By preventing surface water runoff from ponding on the street level, the SuDS decreases the peak volume of runoff and elongates the time of its entrance into the sewer system. It, along with two other SuDS projects in Hammersmith and Fulham (LBHF), was part of a pilot study to install drainage systems underneath residential roads in central London. The area installed with SuDS covers approximately 18% of Arundel Gardens and is designed to provide benefits for a much larger area.

34 18-01-08 Thames Water letter to Councillors
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

35 Thames Water response to Scrutiny of Thames Water Proposal Change Appendix 1 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

36 Counters Creek Strategic Sewer Flood Alleviation

37 Thames Water Response to Scrutiny of Thames Water Proposal Change Appendix 2
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

38 https://parliamentlive.tv/event/index/bc2c9d2b-4b2e-4d92-80d4-8dfe3da23f6f

39 Ofwat PR19 draft determinations – accounting for past delivery actions and interventions
https://www.ofwat.gov.uk/wp-content/uploads/2019/07/PR19-Draft-Determinations-Thames-Water-Accounting-for-past-delivery-actions-and-interventions.pdf

40 https://londonfloodreview.co.uk/stage-1-report/

41 Susdrain Counters Creek SuDS Retrofit Pilot Study, London
https://www.susdrain.org/case-studies/pdfs/005_18_03_28_susdrain_suds_awards_counters_creek_suds_retrofit_pilot_study_light.pdf

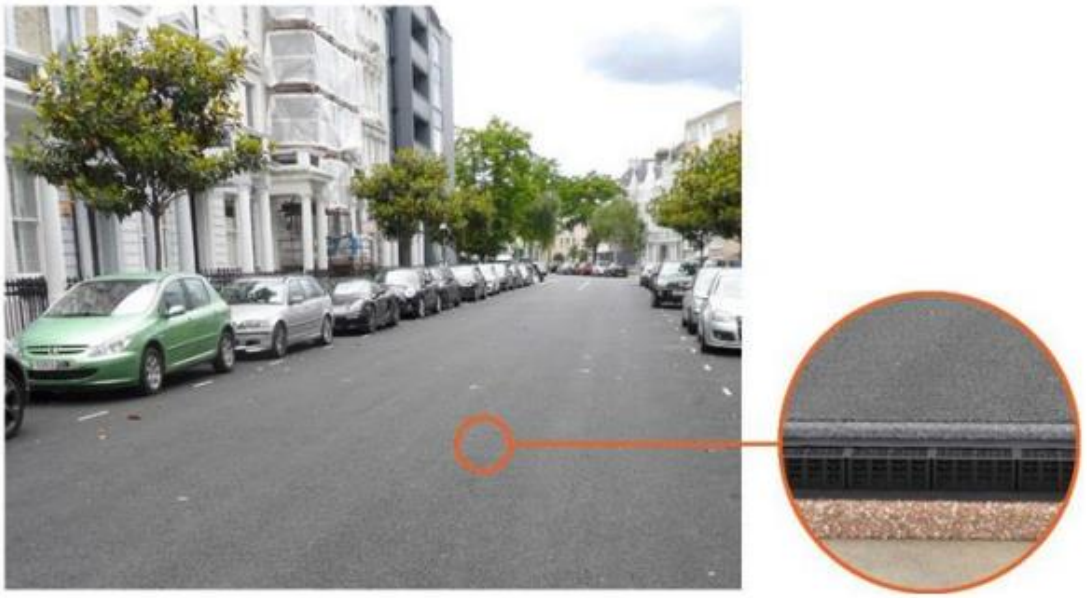


Figure 6-3: The SuDS scheme at Arundel Gardens showing the geocellular system underneath the road (image reproduced from Susdrain[42]).

6.5.4 Local sewer upgrades

The Counters Creek scheme also involved the construction of upgrades to local sewers[43]. The project started in February 2019 and was completed in June 2020, costing £8m. Of the eight upgraded streets within the Counters Creek catchment, one was in RBKC, at Queensdale Road, with the rest in LBHF. Its principal measure was a pumping well that was installed to draw water from the sewer upstream to lower the levels, such that the area's drainage is not impeded by high water levels in the trunk sewers. This type of scheme is sometimes referred to as cut-and-pump.

The sewers at Norland Square were also enlarged by Thames Water in 2004.

6.5.5 Pumping Stations

Lots Road Pumping Station is an old Victorian facility that became operational in 1904. It was designed to pump storm water into the Thames. It is made up of 5 diesel pumps and 3 electric, all of which are currently required to be operated manually.

Hammersmith Pumping Station is also an old Victorian facility. It is made up of nine pumps.

Thames Water also submitted a planning application to install a pumping station at Queensdale Road in June 2019.

6.6 Property flood resilience (PFR)

PFR involves installing flood resistance and resilience measures at individual properties to reduce the risk of damage and the time taken to recover after a flood event. Only a few residents in the borough, as reported in the online questionnaire, have any PFR at their property.

Of those who do have PFR resistant measures, some have flood barriers to limit the ingress of overland flow into their property, and some have non-return valves (NRVs). NRVs can

42 Counters Creek SuDS Retrofit Pilot Study, London

43 Barhale Counters Creek Flood Alleviation Scheme
https://waterprojectsonline.com/custom_case_study/counters-creek-fas-2020/

be fitted onto manhole chambers to prevent sewage flooding from coming up through toilets and sinks in properties. NRVs only allow one direction of flow, the flow of domestic wastewater out from properties to the sewer, acting like a FLIP without the pumping effect. Some residents also have a water pump to pump water out of their property to somewhere else. A few residents have also had PFR surveys carried out at their property privately.

6.7 Planning and development control

Local Planning Authorities (LPAs) must take the probability of flooding from all sources and the risks involved into account when determining planning applications. Flood risk is considered within the planning process in two main ways: using the planning system to avoid locating unnecessary new development in areas of high flood risk, and mitigating the flood risk and surface run-off impacts of new development on downstream areas through planning policies.

With regard to fluvial and tidal flood risk, the Environment Agency is a statutory planning consultee in relation to applications within Flood Zones 2 and 3 (other than where their Flood Risk Standing Advice is applied by the LPA). Since 2015, Lead Local Flood Authorities (LLFA), in this case the Royal Borough of Kensington and Chelsea, have assumed the statutory consultee role on surface water and groundwater. Thames Water is not a statutory consultee in the planning process, but developers are encouraged to go through a pre-planning enquiry process to check that there is sufficient capacity to connect new properties to the sewer network.

As part of the SWMP, using the outputs of the RoFSW (the local outputs given to the Environment Agency in 2014) and local knowledge of the area, four Critical Drainage Areas were identified. These are located in Kensington, Holland Park, Sloane Square and North Kensington and show a complex interaction of surface and sewer water flooding. If a planning application is being made in one of these areas, a flood risk assessment is needed to support it. More information can be found on the RBKC website[44].

RBKC has a number of planning policy documents and evidence base relating to flood risk, which are summarised below.

6.7.1 Royal Borough of Kensington and Chelsea Level 1 Strategic Flood Risk Assessment (2022)

The Strategic Flood Risk Assessment[45] (SFRA) provides a comprehensive and robust evidence base on flood risk issues to support the production of the Local Plan. It is used to inform decisions on the location of future development and the preparation of sustainable policies for the long-term management of flood risk. The SFRA was first published in 2009, and has been updated several times, most recently in 2022.

The SFRA provides a comprehensive set of maps presenting flood risk from all sources that can be used as evidence base for use in the emerging Local Plan and advice for applicants carrying out site-specific Flood Risk Assessments and outline specific measures or objectives that are required to manage flood risk.

The SFRA has recommendations focusing on:

- Reduction of flood risk through site allocations and appropriate design
- Promoting SuDS to mimic natural drainage routes and improve water quality
- Mitigation of risk, improved emergency planning and flood awareness

44 https://www.Royal Borough of Kensington and Chelsea.gov.uk/planning-and-building-control/planning-policy/critical-drainage-areas

45 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/strategic-flood-risk-assessment

6.7.2 Sustainable Drainage Systems Guidance

Royal Borough of Kensington and Chelsea have Sustainable Drainage Systems (SuDS) guidance[46] available for minor developments and major developments.

Major development (10 of more residential properties or large commercial developments) needs to reduce the rate of surface water runoff from the site to the equivalent of that of the site before any development occurred (known as greenfield rate). Minor development needs to reduce runoff rates from the site by 50% and include SuDS measures in the design of surface water drainage. Impermeable surfaces are resisted as part of planning applications, including in rear gardens. These policies are being reviewed and strengthened as part of the New Local Plan Review[47].

6.7.3 Basements Supplementary Planning Document (SPD)

The Royal Borough of Kensington and Chelsea have produced a Basements Supplementary Planning Document (SPD) which was adopted in April 2016. This provides more detailed guidance and advice on the adopted Local Plan Policy CL7: Basements. Habitable uses of basements within Flood Zone 3 should not be permitted for self-contained basement dwellings, whilst the exception test should be passed for other basement development in Flood Zone 3 and self-contained basement dwellings in Flood Zone 2. A flood risk assessment is required for surface water and sewer flooding if the basement property falls within a Critical Drainage Area.

6.7.4 Flood warnings

The Environment Agency is the lead organisation for providing warnings of tidal and river flooding. Flood Warnings are supplied via the Flood Warning System (FWS) service, to homes and business within Flood Zones 2 and 3.

There are currently three Flood Alert Areas (FAA) in the Borough covering risk from the River Thames:

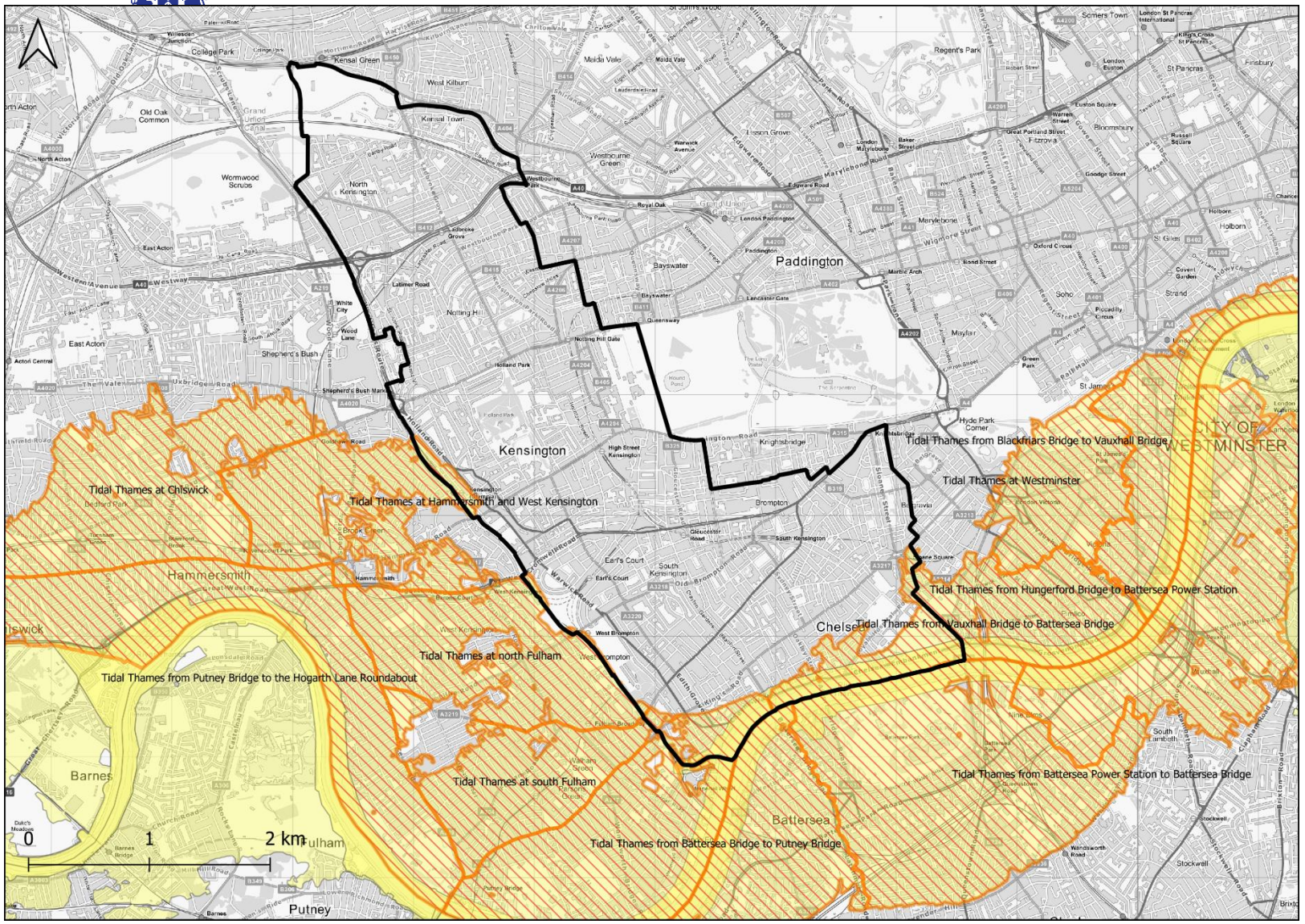
- Tidal Thames riverside from the Thames Barrier to Putney Bridge
- Tidal Thames in the boroughs of Tower Hamlets, City of London, City of Westminster and Kensington and Chelsea
- Tidal Thames in the boroughs of Kensington and Chelsea, Hammersmith and Fulham, Ealing and Hounslow
- There are currently five Flood Warning Areas (FWAs) in the Borough covering risk from the River Thames:
- Tidal Thames from Vauxhall Bridge to Battersea Bridge
- Tidal Thames from Battersea Bridge to Putney Bridge
- Tidal Thames at South Fulham (currently under review)
- Tidal Thames at North Fulham (currently under review)
- Tidal Thames at Hammersmith and West Kensington

Flood warning coverage is shown in Figure 6-4. Flood Alerts and Warnings are issued based on a combination of river levels at gauges and operational information from the Thames Barrier.

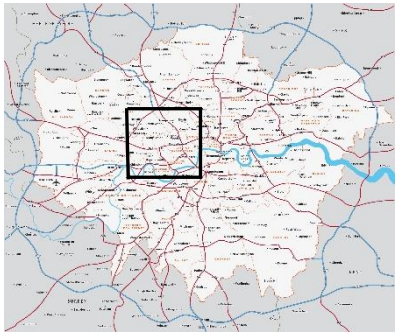
There is no flood warning service for flooding from surface water or groundwater.

46 https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/sustainable-drainage-systems

47 New Local Plan Review (NLPR) – Draft Policies Regulation 18 February 2022 – Royal Borough of Kensington and Chelsea – Planning Consultations (rbkc.gov.uk)



Flood Alert and Warning Areas



Legend

- Flood Warning Areas (labelled)
- Flood Alert Areas
- Royal Borough of Kensington and Chelsea

Royal Borough of Kensington and Chelsea Section 19 Flood Investigation

THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA

JBA consulting

Figure 6-4: Flood alert and warning areas in Kensington and Chelsea

7 Hydrological analysis of 12 July event

7.1 Rainfall event data

In order to undertake hydrological analysis of the 12 July event, nearby gauge data was requested from the Environment Agency. The Environment Agency have a tipping bucket rain gauge (TBR) at Holland Park. Gridded observed rainfall data based on radar from the Met Office was also obtained for comparison. Figure 7-1 shows the rainfall totals on 12 July for both the Holland Park gauge, and for the radar data in the corresponding 1km cell. Figure 7-2 shows the cumulative rainfall totals.

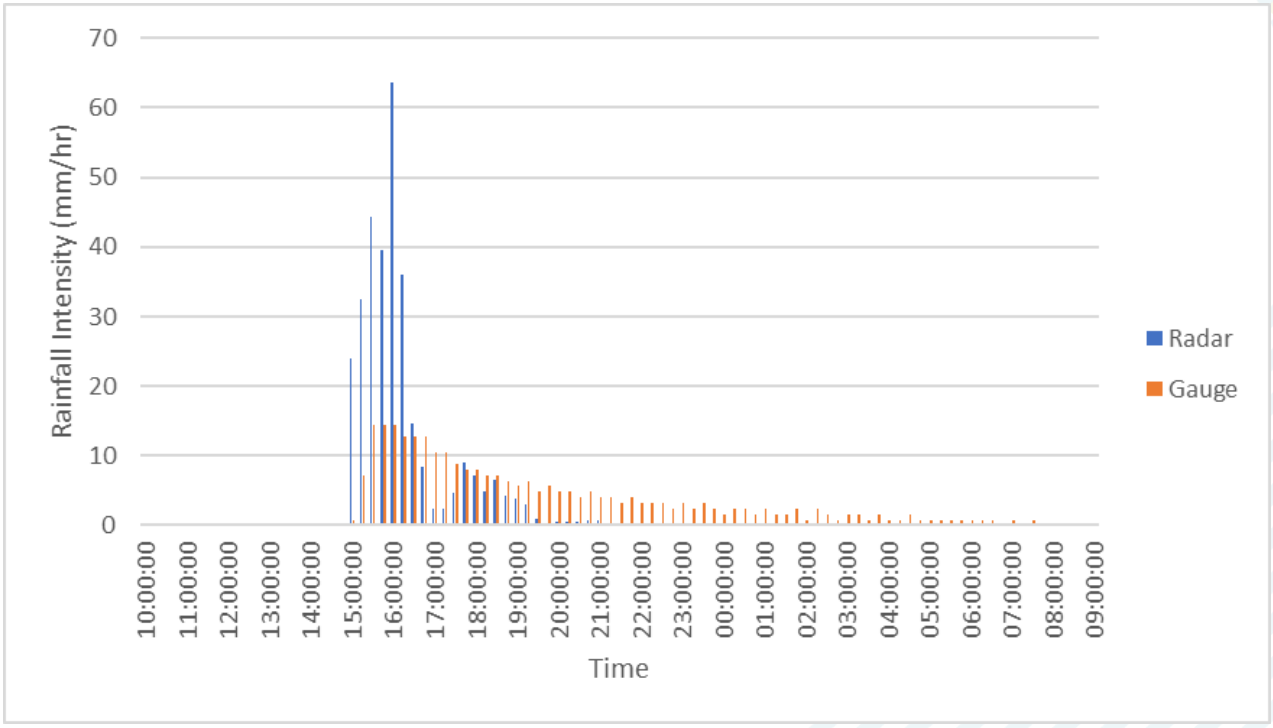


Figure 7-1: Rainfall totals from 10:00 12 July 2021 to 09:00 13 July 2021 from radar data for Holland Park (radar grid square 120) and from Holland Park gauge

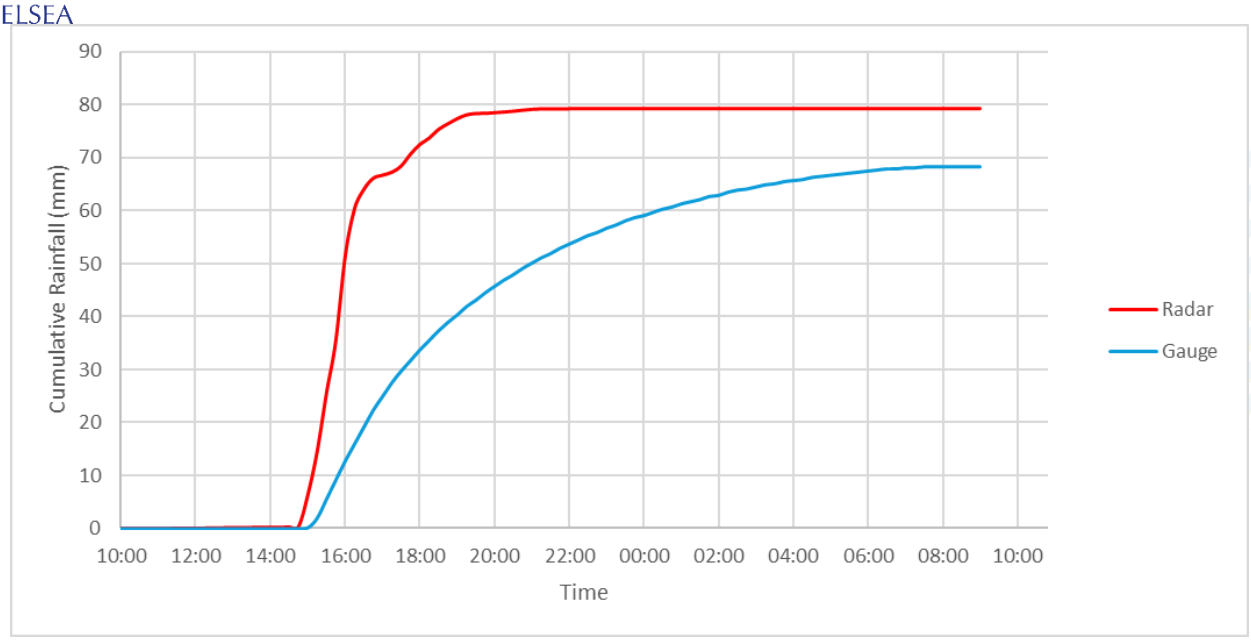


Figure 7-2: Cumulative rainfall from 10:00 12 July 2021 to 09:00 13 July 2021 from radar data for Holland Park (radar grid square 120) and from Holland Park gauge

The Environment Agency TBR at Holland Park shows that rainfall started at 15:00 on 12 July, with the maximum recording of 3.6mm (intensity of 14.4 mm/hr) occurring at 15:30, 15:45 and 16:00. The rainfall gradually became less intense after this, but continued until around 07:00 on the 13 July. A total of 68.0mm is recorded at Holland Park gauge over the preceding 16 hours. Between 15:00 and 18:00, 31.8mm was recorded, and between 15:00 and 07:00 68.0mm was recorded. However, the quality check of the data provided by the Environment Agency indicates that the TBR recording is 8% lower than the check gauge on 12 July.

The other closest rainfall gauges are Kew Gardens (period of record supplied 31/01/2009-31/12/2013) and St James Park (period of record supplied from 01/01/1961 to 31/08/2008), but these are no longer active.

The rain gauge at Putney Heath is south of RBKC, and approximately 6km from the Holland Park gauge. This gauge shows the rainfall event started at 15:00. As with the Holland Park rain gauge, the maximum recording of 16.0mm (intensity of 64 mm/hr) at Putney Heath occurred at 15:30 and gradually became less intense after this, stopping at 23:45. Between 15:00 and 18:00, 43.5mm was recorded (intensity of 14.5mm/hr), which is higher than at the Holland Park gauge (Table 7-1).

Table 7-1: Cumulative rainfall totals (mm) in Holland Park and Putney Heath on 12 July

	15:00-16:30 (1.5 hr)	15:00-18:00 (3hr)	15:00-21:30 (6.5hr)	15:00-23:30 (8.5hr)	14:30-07:00 (16.5hr)
Holland Park TBR	16.0	31.8	51.2	57.4	68.0
Holland Park radar	60.0	70.3	78.9	78.9	79.1
Ratio (radar:TBR)	3.75	2.21	1.54	1.37	1.16
Putney Heath TBR	37.4	42.8	46.5	46.6	46.6
Putney Heath radar	38.6	40.0	43.5	47.6	48.2
Ratio (radar:TBR)	1.03	0.93	0.93	1.02	1.03

Gridded observed rainfall data based on radar from the Met Office has been compared with the rain gauge data and used as a sensitivity check. The radar data at Holland Park, which has 100% coverage of radar data, indicates there was a small amount of rain from 14:30, with the rain increasing from 15:00. The radar data shows that the most intense rainfall in RBKC occurred at 16:00, with a maximum depth of 19.8mm (intensity of 79.2mm/hr) in Notting Hill. In the grid square containing Holland Park TBR, the radar rainfall at 16:00 was 15.9mm (intensity of 63.7mm/hr), which is significantly higher than the 3.6mm (intensity of 14.4 mm/hr) recorded at the TBR at this time. The radar data also shows that the intensity eased after this, with very little rainfall recorded after 21:30, and none after 23:30. Radar data indicates a total of 78.9mm was recorded between 15:00 and 21:30. This contradicts the Holland Park TBR, which shows a further 10.2mm of rain fell between 21:30 and 07:00.

Responses from residents indicate that the storm event occurred from approximately 15:00 – 18:00 on 12 July. This timing aligns well with the data recorded at both the Holland Park TBR and by radar.

As mentioned above, the radar data from the Holland Park TBR shows far higher rainfall than that recorded at the TBR. In contrast, the Putney Heath TBR data shows similar recordings compared to the radar data. Whilst looking at the gauges alone suggests that more rainfall was recorded at Putney Heath, the radar data shows there was significantly more rain recorded at Holland Park during 12 July event. This would confirm what the quality information reports about the Holland Park rain gauge underestimating the rainfall on 12 July. However, there is still a substantial difference between the radar rainfall and the TBR rainfall, even when accounting for an under-recording of 8% at the TBR identified by the Environment Agency's quality check of the gauge data.

Given the known under-recording at Holland Park TBR and reasonable comparison of radar and TBR data at Putney Heath, the Holland Park TBR has not been used further for rainfall return period analysis.

The radar data (Figure 7-3) shows the significant spatial variation in rainfall across RBKC. The highest rainfall occurred across the central part of Kensington, around Notting Hill and Holland Park, with much lower rainfall in the areas of Chelsea along the Thames. This indicates that the area experiencing high amounts of rainfall during the event was relatively localised. Across the wider area, the radar data shows that during the storm event an

intense band of rain formed rapidly over London, and travelled in a south-westerly direction.

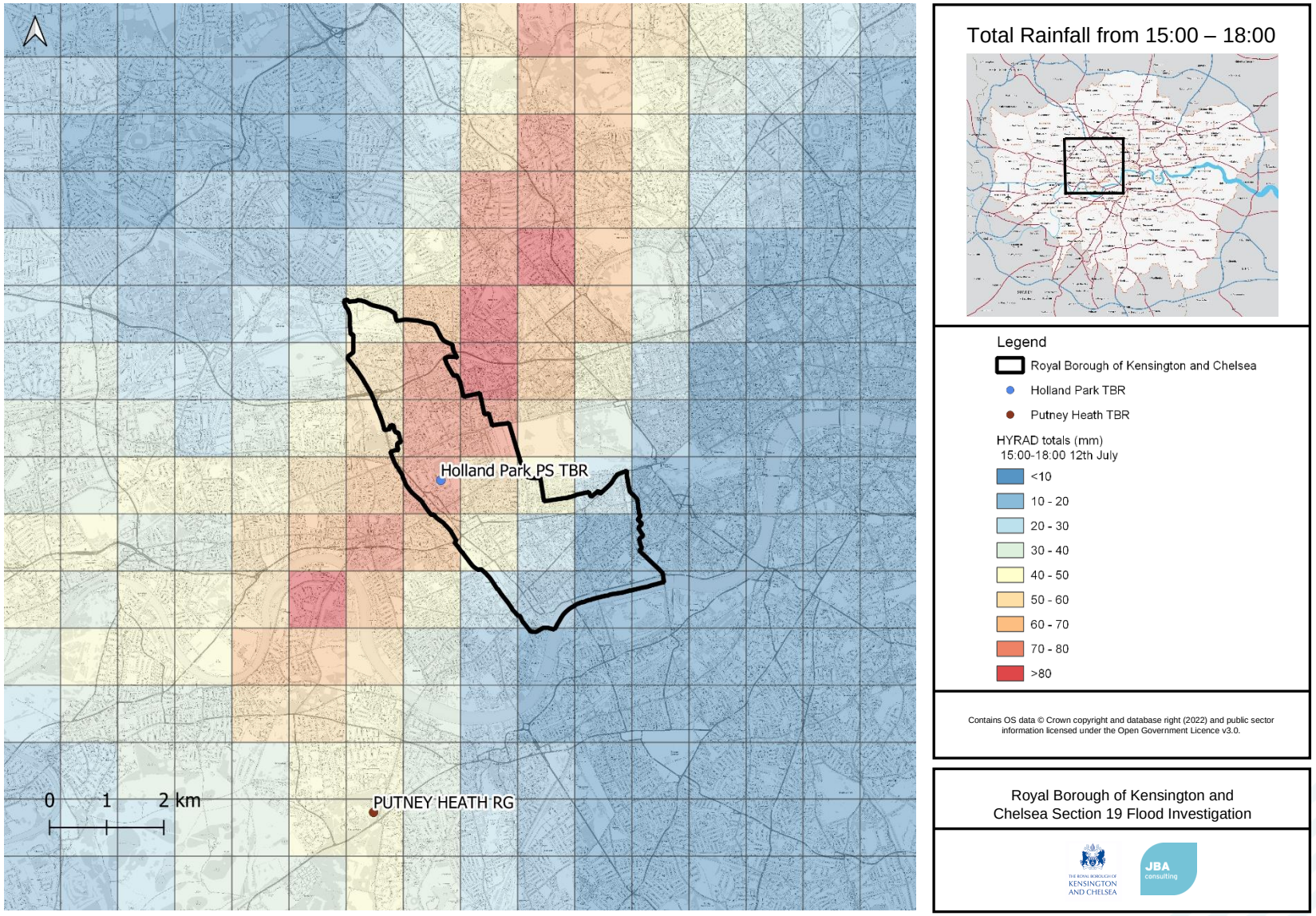


Figure 7-3: Radar rainfall totals for Kensington and Chelsea from 15:00 -18:00 on 12 July

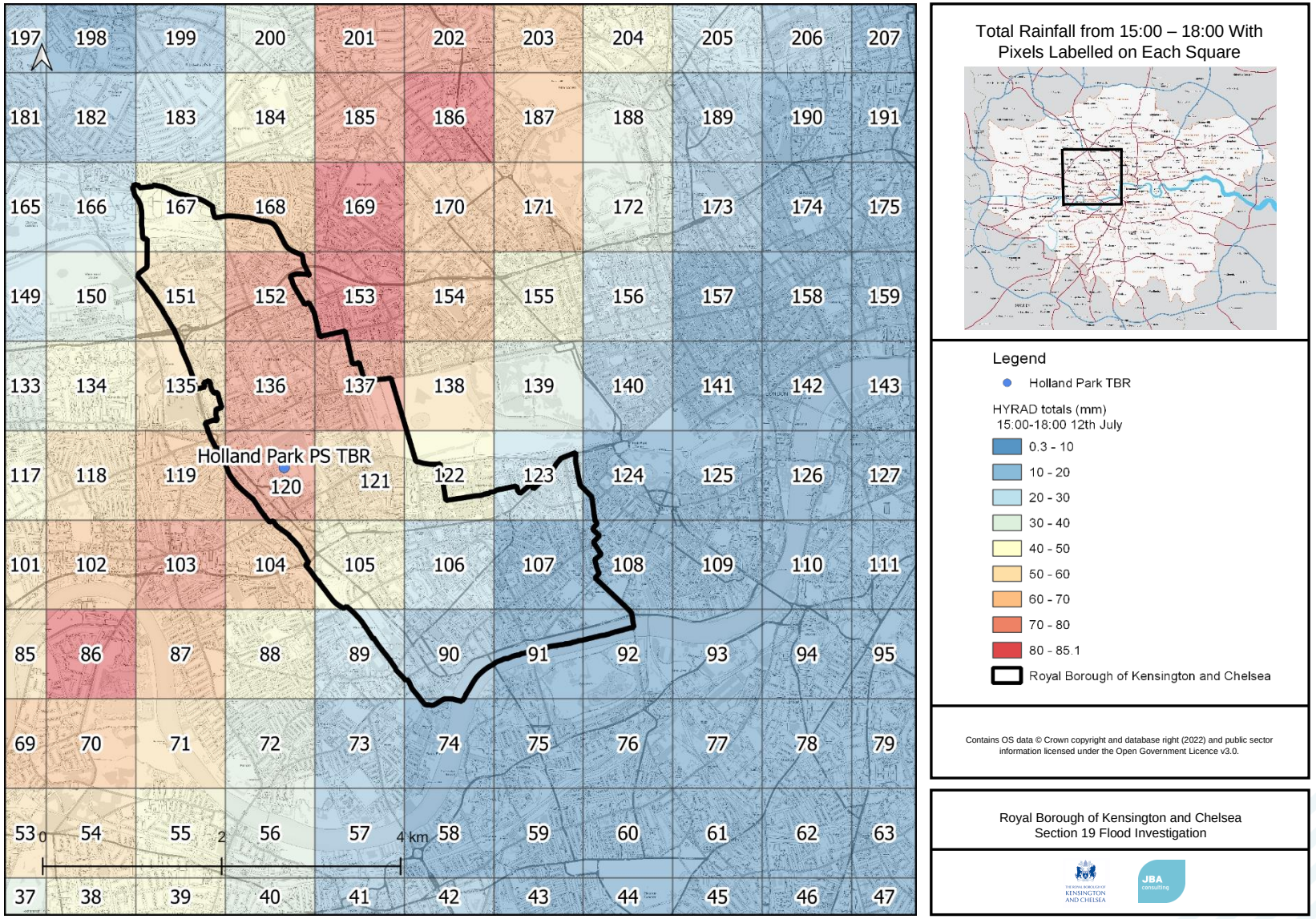


Figure 7-4: Radar pixels – rainfall totals for Kensington and Chelsea from 15:00-18:00 on 12 July

7.2 Storm event return period estimation

The Flood Estimation Handbook (FEH) web service[48] was used to determine the storm event rarity at the Holland TBR in RBKC, as well as the areas within the RBKC showing maximum and minimum recorded rainfall. The web service uses data from the FEH13 rainfall model to estimate the rarity of a storm event, depending on rainfall total and duration. Within a single storm, the return period of shorter, more intense bursts of rainfall can also be calculated to determine the critical period and return period. In this study, in addition to the return period of the total event (16.5 hours), the return period for the most intense rainfall experienced across the following shorter periods have been calculated: 1-hour, 1.5-hour, 2-hour, 3-hour and 6.5-hour and 8.5-hour. Table 7-2, Table 7-3 and Table 7-4 detail the calculated rainfall return periods based on grid squares 120, 152 and 107 respectively (Figure 7-4).

Table 7-2: Grid square 120 (location of Holland Park rain gauge)

Storm Duration (Hours)	Maximum rainfall total (mm)	Return Period (rounded to nearest five years)
1	45.9	75
1.5	60.0	125
2	65.8	115
3	70.3	90
6.5	78.9	70
8.5	79.1	60
16.5	79.1	40

Table 7-3: Grid square 152 (location of highest rainfall total in RBKC)

Storm Duration (Hours)	Maximum rainfall total (mm)	Return Period (rounded to nearest five years)
1	54.4	140
1.5	67.5	185
2	71.3	145
3	75.4	105
6.5	84.9	80
8.5	85.0	70
16.5	85.0	50

Table 7-4: Grid square 107 (location of lowest rainfall total in RBKC)

Storm Duration (Hours)	Maximum rainfall total (mm)	Return Period (rounded to nearest year)
1	5.0	<2
1.5	6.0	<2

48 https://fehweb.ceh.ac.uk/

Storm Duration (Hours)	Maximum rainfall total (mm)	Return Period (rounded to nearest year)
2	7.8	<2
3	10.3	<2
6.5	12.0	<2
8.5	12.4	<2
16.5	12.4	<2

The return period of the storm event varies significantly across RBKC depending on the location and the storm duration. In the south of the Borough, the return period of the storm based on the radar data grid square 107 was less than 1 in 2 years. The maximum return period of the storm event, based on the radar data in Notting Hill (grid square 152), indicates that the storm event was likely to be up to a 1 in 185-year event (rounded to the nearest 5 years) in the areas that experienced the heaviest rainfall in RBKC. This is comparable with the estimates from the Met Office of return periods of the storm across London of up to 179 years for the amount of rain that fell in one hour[49].

7.3 Tide level data

The Chelsea tide gauge located on the River Thames shows that high tide coincided with the heavy rainfall, occurring at 15:45 on 12 July, at a level of 3.80mAOD[50]. The low tide during that day had a level of -1.98mAOD.

7.4 Comparison with other flood events

Flooding also occurred in north-east London on 25 July 2021 following heavy rainfall. However, there are no known incidents of flooding in RBKC during this event. A total of 20.6mm was recorded over 7 hours at the Holland Park TBR, which is significantly lower than the rainfall on the 12 July 2021 event. The maximum 15-minute recorded rainfall was 3.4mm at 16:00. However, there is a data quality flag for the gauge data on the 25 July stating that a quality check is needed. The radar data for the grid square covering the Holland Park gauge recorded 19.7mm over 7 hours, which is significantly lower than the total rainfall recorded on 12 July 2021. The TBR and radar are more consistent on 25 July than they were on 12 July. A high tide of 4.09mAOD occurred on 25 July 2021 at 15:00, which coincides with the peak rainfall.

On the 20 July 2007, there was also widespread flooding across RBKC following heavy rainfall. 50.4 mm was recorded at the Holland Park TBR during this event over approximately 9 hours, of which 46mm was recorded over 2 hours, (radar data not available for this event), which is lower than on 12 July.

49 Thames Water (2021). Internal Review into 12 and 25 July 2021 storms in London: https://www.thameswater.co.uk/media-library/home/about-us/investing-in-our-region/flooding-review/july-flooding-internal-review.pdf

50 Environment Agency (2021) CHELSEA TL 15 MIN

8 Incident response

8.1 Prior to the event

On 11 July 2021, the Met Office issued a yellow weather warning of rain for the next day, July 12, midday to midnight. The Met Office forecasted 20 to 30mm of rain in an hour for the south-west, east and the south-east of England, where some areas would receive up to 60mm of rain in two or three hours. The area covered by the warning (updated at 08:54 on 12 July) extended from the Devon/Cornwall border to the Suffolk coastline. There was no further information to indicate that flooding was more likely in London than elsewhere in southern England. On 12 July, intense rainfall started at around 15:00.

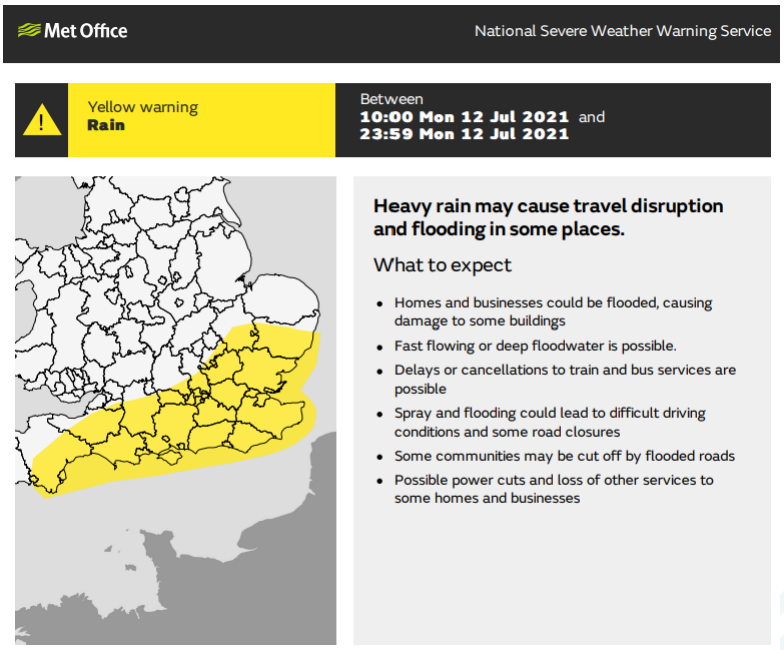


Figure 8-1: Yellow warning of rain for 12 July 2021 (image reproduced from Met office[51]).

8.2 During the event

The questionnaires collected as part of the Section 19 investigation suggest that the first flooding to properties was reported at around 15:00, with the majority of flooded properties reporting flooding at around 17:00. The first notification of flooding was alerted to the London Resilience Group Duty Manager at 17:30.

London Fire Brigade took more than 1,000 calls during the event. The London Resilience Partnership notes that the London Fire Brigade requested help with contacting local authorities to support with provision with sandbags at 17:45. London Local Authority Gold (LLAG) then sent a message to all London Local Authorities to help with sandbag provision at 18:41. This was then responded to at 19:51 when sandbags were shared with London Fire Brigade by Local Authorities.

Thames Water received nearly 4,000 calls over 12 to 13 July. However, since their lines were busy during the event, many tried to contact Thames Water online, with nearly 7,000 contacts to Thames Water being made over social media.

51 https://digital.nmla.metoffice.gov.uk/IO_162f4248-ee82-469f-91d2-30a056a41a69/

Thames Water and London Fire Brigade also sent their own teams to various areas across London, but with the number of events occurring across the city, their resources were stretched thinly.

In RBKC, the Council also took several calls from flooded residents. It dispatched Local Authority Liaison Officers (known as LALOs) to report from on the ground, while establishing the Borough Emergency Control Centre. The control centre took calls from residents while coordinating with the on-site teams, the police, London Fire Brigade, and was the contact point for other agencies outside of the borough.

At 16:45, Thames Water switched on three of its seven pumps at Lots Road, and switched on the remaining pumps by 17:00 (Table 8-1). The pumps were operational for between 2.5 and 7.25 hours. At Hammersmith Pumping Station, one of the pumps failed and was offline throughout the event, reducing the maximum capacity of the station by 3.2m³/s.

Table 8-1: Operation of Lots Road pumping station (table reproduced from Thames Water[52])

Location (select from List)	Time Pumping Started (mm:hh)	Time Pumping Ceased (mm:hh)	Total run hours (Hours and minutes)
Lots Road SPS Diesel	16:45	00:00	7H 15M
	16:45	22:30	5H 45M
	17:00	21:30	4H 30M
	17:00	19:30	2H 30M
Lots Road SPS Electric	16:45	20:30	3H 45M
	17:00	21:00	4H
	17:00	00:00	7H

Many residents have reported the sudden draining of flood water between 17:30 and 18:00. Photographs in Figure 8-2 taken 14 minutes apart show this occurring on Arundel Gardens, with similar accounts on Holland Park Gardens and elsewhere in the Borough.

52 Thames Water Response to RBKC Questions Appendix A
https://www.rbkc.gov.uk/committees/Meetings/tabid/73/ctl/ViewMeetingPublic/mid/669/Meeting/8610/Committee/1613/SelectedTab/Documents/Default.aspx

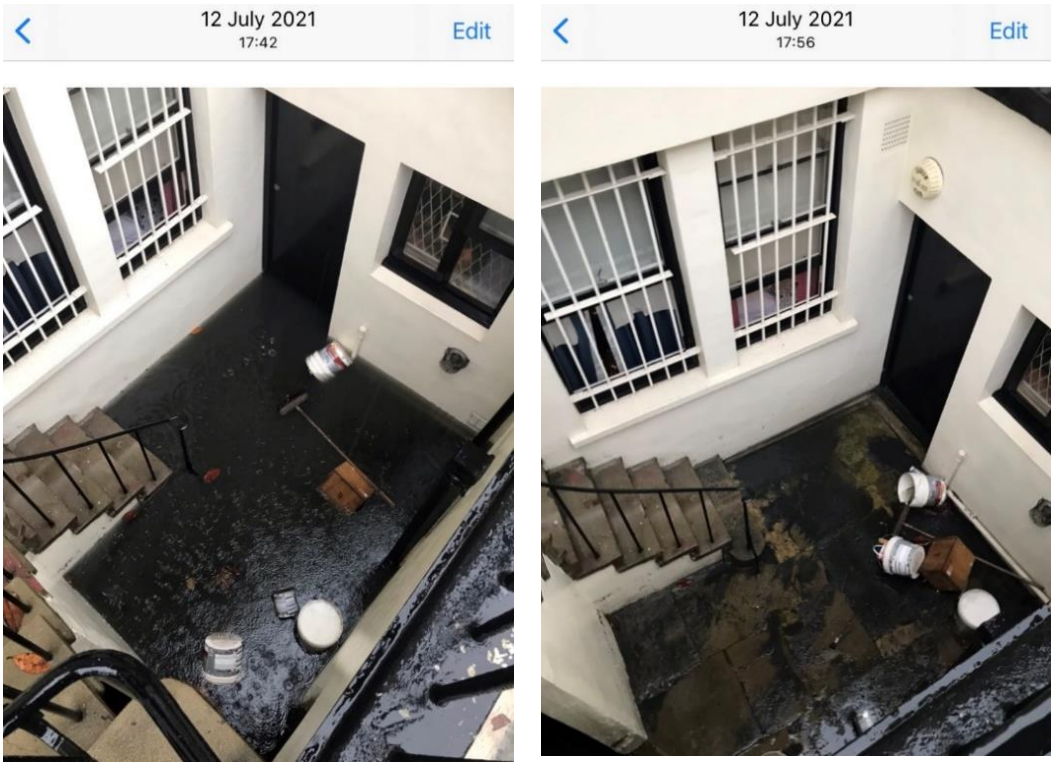


Figure 8-2: Photographs taken 14 minutes apart on Arundel Gardens at 17:42 and 17:56 (images provided by a resident).

The Council opened The Curve and Henry Dickens Court Community Centre for flooded residents who were then offered temporary accommodation in hotels.

While the rain stopped at around 18:00, many properties in RBKC still had floodwater which had to be removed. At 19:15, London Fire Brigade declared a major incident and requested resources such as sandbags and water pumps from organisations and boroughs across London, including the Environment Agency. At 19:43, a London Resilience Partnership conference was proposed, and from 20:30 to 21:50, the conference was held. At 22:30 a London Resilience Communication Group public communications call was held and an update was sent to Local Authorities at 22:53. London Fire Brigade then sent a stand down message for the major incident at 23:09, but continued to work throughout the night across London to remove the floodwater still in properties.

8.3 After the event

In RBKC, the Council and Thames Water were involved in cleaning properties and organising temporary accommodation. Thames Water had 26 cleaning jobs in RBKC, while the Council logged 99 cases of street cleaning issues and 61 cases of large item removals from properties. After one week, some flooded residents had returned home, while the majority remained in hotels. Those in privately rented accommodation had their landlords and insurance take up the cost of temporary accommodation.

9 Source-pathway-receptor analysis

A source-pathway-receptor analysis examines a flooding event by separating it into: its source, such as rainfall, snowmelt, overtopping of rivers; its pathway, which is how the runoff moves across the land, such as through a sewer network, from the ground as a result of groundwater flooding; and the receptors, which are the people and organisations affected by the flooding.

This section starts by giving a broad overview of the source, pathways, and receptors involved in the flooding event across RBKC (Sections 9.1-9.3), to then giving a more detailed source-pathway-receptor analysis each street that was flooded during the event (Section 9.4).

9.1 Source

The 12 July rainfall event had 68.0mm of rainfall recorded at the Environment Agency TBR at Holland Park which fell from 15:00 on 12 July to 07:00 13 July. The rainfall was most intense between 15:00 – 16:00 on 12 July.

The Chelsea tide gauge on the River Thames recorded a high tide at 15:45 on 12 July, at a level of 3.80mAOD. This was not a direct source of flooding but was a significant contributary factor, impeding flows from every gravity CSO discharging into the Thames.

During large rainfall events such as this one, the large amount of rainfall is usually the source of the sewer flooding, with only around 0.1% of the total flow in a sewer being foul[53].

9.2 Pathway

The sewers, roads and local drainage were pathways of the flood event that conveyed the stormwater.

9.2.1 Sewer network

The Middle Level Sewer Number 1 which runs from Wormwood Scrubs through Bayswater, and the Low Level Sewer Number 2 which runs from Hammersmith through South Kensington, were the main sewers in RBKC that were likely to first reach capacity given their small diameter of 1m (Section 3.1.2). It is difficult to know which sewers had their capacities exceeded and at which location without access to Thames Water's hydraulic model and in-sewer depth gauges.

Upon reaching capacity, the main sewers would overflow into the interceptor sewers, the North Kensington, North Western, Ranelagh Storm Relief sewers and the Ranelagh CSO. The interceptor sewers already have sewage flowing in them, since, for example, the North Kensington Storm Relief sewer starts on Bramley Road in RBKC, and the North Western Storm Relief sewer starts in two locations, one in Camden and one in Brent, meaning it has already accumulated flow by the time it reaches RBKC.

When both flows combine, the existing flow in the interceptor sewers and the overflows from the main sewers can cause the sewers to surcharge, causing flooding above ground on the streets they run under. Flows from the interceptor sewers can then also back up into local sewers which would normally flow into the interceptor sewer, causing sewer surcharging in these local sewers also. However, given the complexities of the system, it is difficult to locate where sewers would have surcharged without any model results or in-sewer depth monitoring data.

53 Thames Water Response to Scrutiny of Thames Water Proposal Change Appendix 2
https://www.rbkc.gov.uk/planning-and-building-control/planning-policy/counters-creek-project

Figure 9-1: Surface water flooding which can be made up of pluvial (rainfall) and sewer flooding from surcharged sewers (images reproduced from residents' response to the RBKC questionnaire). Left: Lower Clarendon Walk; Right: Holland Park Avenue.

Since the interceptor sewers are the largest sewers in the area (for example, the North Western Storm Relief sewer is 2.5m wide in diameter), where this sewer surcharges, it is possible that a larger amount of water will rise up to the street level than the amount of water that rises from a local sewer that has its flows backed up from the interceptor sewer, since the local sewer is smaller in diameter. This may explain the 'fountains' of stormwater that formed in some areas at manholes from surcharged sewers, some of which rising to over 1m (Figure 9-2). Manholes are the main pathway for water from the sewer to flow out onto the street.

Thames Water has modelled the effect of the tide on the sewer network in North London. The model results showed that the high tide impeded drainage from the sewer network in RBKC, along the North Western Storm Relief Sewer, from Maida Vale to Hammersmith, with the tidal level increasing depths in some manholes in RBKC by 0.5m.

Tide-locking and the operational issues experienced at both pumping stations, the delay in switching on the pumps at Lots Road Pumping Station and the failure of one of the pumps at Hammersmith Pumping Station, were significant contributing factors to flooding in the borough. With all the gravity outfalls tide-locked, the only route for water to discharge from the sewer system was through the pumping stations. However, there was also limited capacity upstream in the local sewers due to the extreme volume of rainfall, which prevented flows from reaching the pumping stations at all.

Figure 9-2: Fountains forming at manholes where the sewers are surcharged (images reproduced from a resident and *i* newspaper[54]). Left: junction to St Marks Road and Lancaster Road; Right: Cornwall Crescent.

9.2.2 Overland flow

The surcharging of sewers is one contributor to overland flow; the other being the intense rainfall directly onto the surface.

Once floodwater collects on the surface, the roads can then act as a channel to convey water since they are largely straight and have no major obstructions (Figure 9-3). Furthermore, the dense urban layout of cities increases hydrological connectivity as flows from neighbouring streets synchronise, increasing the resultant water level as the water drains into the next street. Areas of high urban and hydrological connectivity were:

- The Notting Hill area of Ladbroke Grove, Portobello Road, Arundel Gardens, Elgin Crescent, Blenheim Crescent, Lower Clarendon Walk, St Marks Road, Camelford Court, Clarendon Road.
- The surrounding area by Royal Crescent and Holland Villas Road, starting from Bramley Road, running south through St Anns Road, Stoneleigh Street to St Anns Villas, St James's Gardens, Norland Square, Queensdale Road, Princedale Road, Royal Crescent, Holland Park Avenue; then onto Holland Villas Road, Addison Road, Warwick Road, Napier Road, Edwardes Square, Cope place and Scarsdale Villas.

This list of streets is not exhaustive and a comprehensive list of flooded streets and the pathways that contributed to its flooding is shown below in Section 9.4.

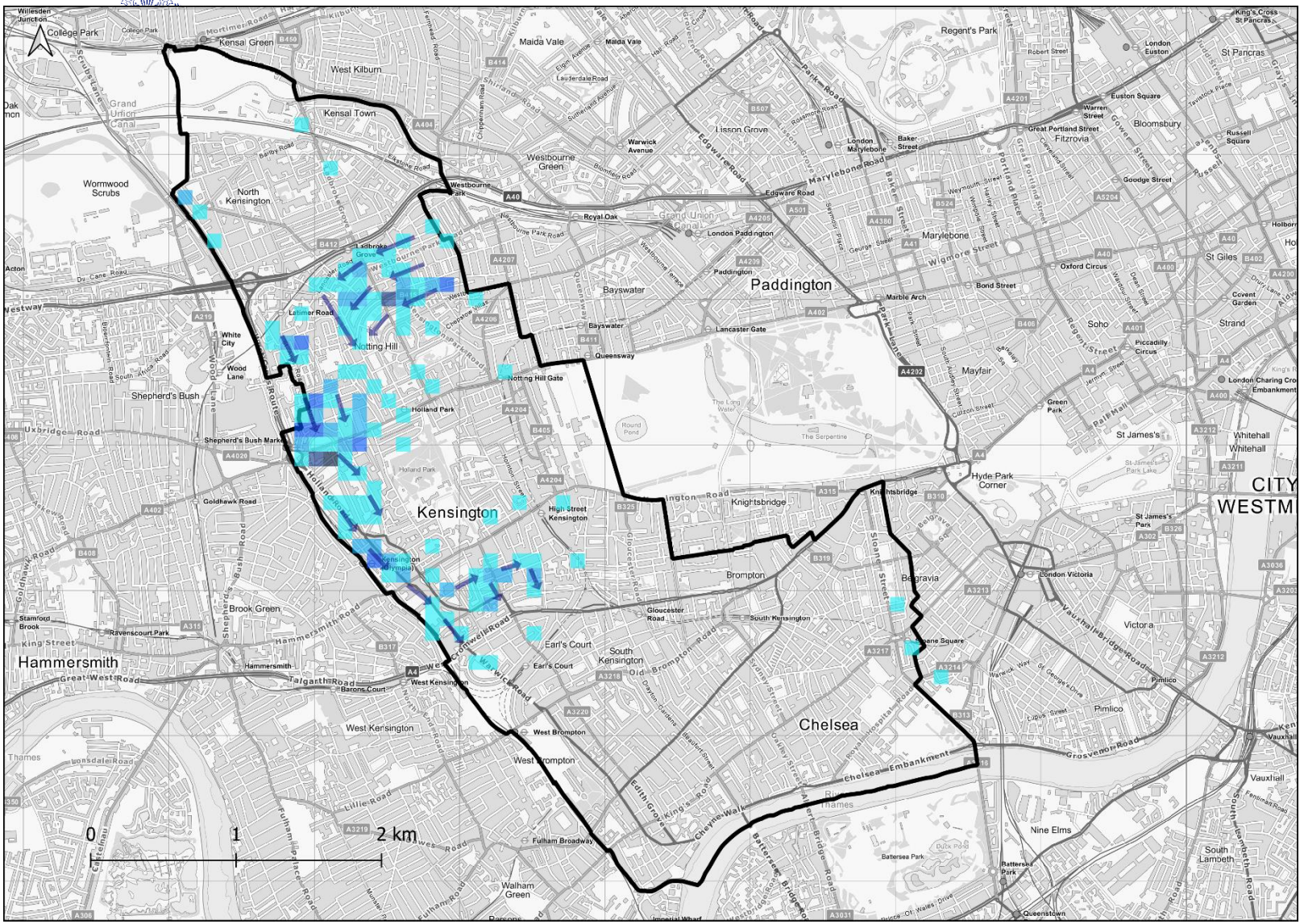
54 https://inews.co.uk/news/uk/london-flooding-brian-may-belongings-ruined-flash-floods-home-1101697

Figure 9-3: Roads acting as channels conveying floodwater. The images shown are the A3220, A40 and Portobello Road (images reproduced from the Standard[55] [56] and Daily Mail[57])

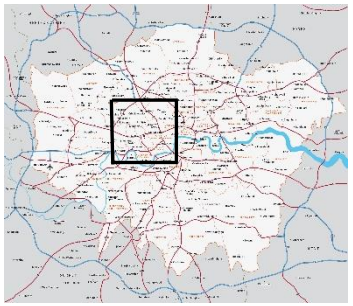
55 https://www.standard.co.uk/news/uk/london-flash-floods-chaos-train-lines-met-office-weather-forecast-b945347.html

56 https://www.standard.co.uk/news/uk/london-flash-floods-chaos-train-lines-met-office-weather-forecast-b945347.html

57 https://www.dailymail.co.uk/news/article-9779719/Flood-warnings-issued-Met-Office-TWO-INCHES-rain-set-hit-South.html



Reports of Flooding from Thames Water and RBKC Questionnaire



Legend

General flow direction

Flood incidents from Thames Water and RBKC questionnaire reports

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15

Royal Borough of Kensington and Chelsea

Royal Borough of Kensington and Chelsea Section 19 Flood Investigation

THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA

JBA consulting

Figure 9-4: Heatmap of the locations of flooded properties in a 100 m² area and the general direction of flow as recorded from Thames Water database and the RBKC questionnaire.

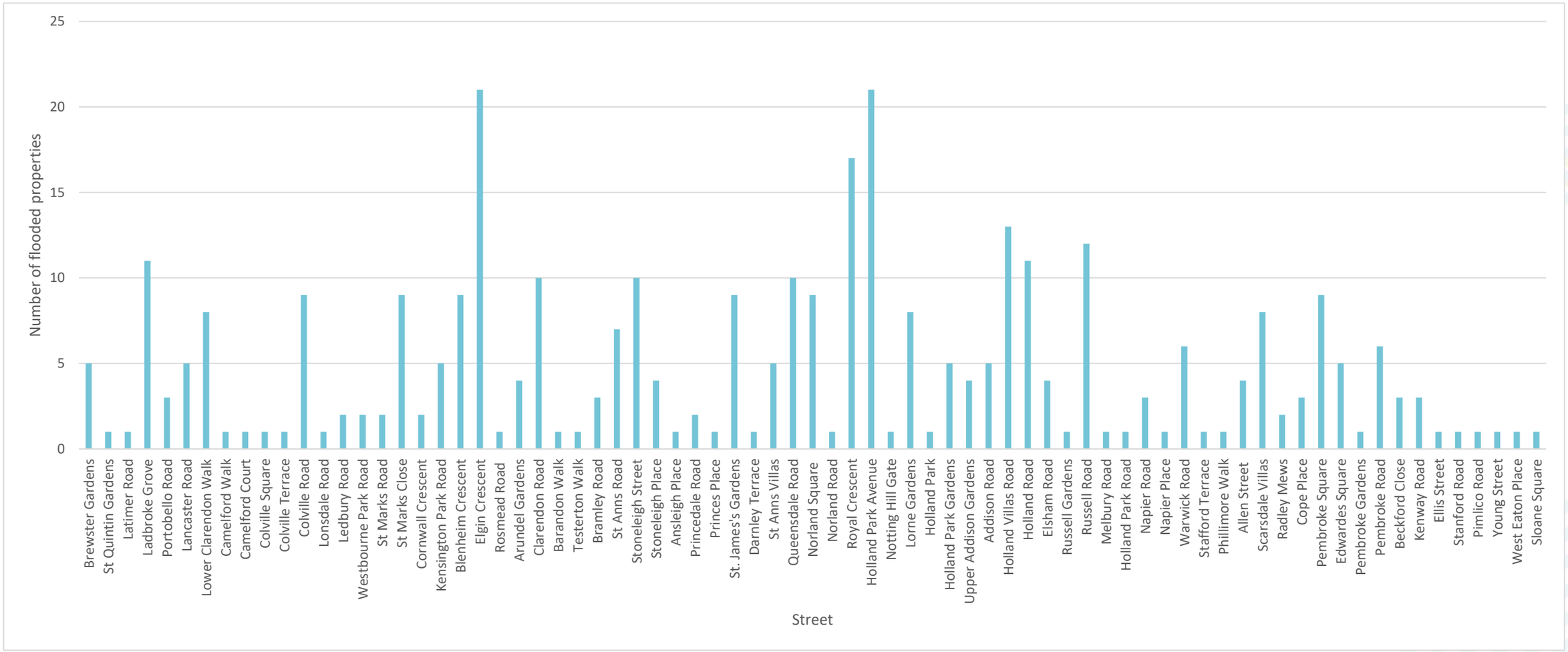


Figure 9-5: Number of flooded properties by street, listed by proximity, recorded in the Thames Water database and RBKC questionnaire.

9.2.3 Individual property drains

The final pathway this floodwater can take occurs through property drains into basement flats at the same level as the sewer, or when the sewers reaches capacity, causing the water to back up through the drains at each property. The floodwater then enters the property through toilets, sinks and drains.

9.3 Receptor

9.3.1 Streets

Data was collated from various sources, including Thames Water, the Council, media reports, and the online questionnaire that was sent out by the Council from the middle of January to the start of February. From these sources, flooding was reported on 76 streets (Table 9-1).

Table 9-1: Streets that had reports of flooding

Flooded streets		
Addison Road	Holland Road	Radley Mews
Allen Street	Holland Villas Road	Rosmead Road
Ansleigh Place	Kensington Park Road	Royal Crescent
Arundel Gardens	Kenway Road	Russell Gardens
Barandon Walk	Ladbroke Grove	Russell Road
Beckford Close	Lancaster Road	Scarsdale Villas
Blenheim Crescent	Latimer Road	Sloane Square
Bramley Road	Ledbury Road	St Anns Road
Brewster Gardens	Lonsdale Road	St Anns Villas
Camelford Court	Lorne Gardens	St James's Gardens
Camelford Walk	Lower Clarendon Walk	St Marks Close
Clarendon Road	Melbury Road	St Marks Road
Colville Road	Napier Place	St Quintin Gardens
Colville Square	Napier Road	Stafford Terrace
Colville Terrace	Norland Road	Stanford Road
Cope Place	Norland Square	Stoneleigh Place
Cornwall Crescent	Notting Hill Gate	Stoneleigh Street
Darnley Terrace	Pembroke Gardens	Testerton Walk
Edwardes Square	Pembroke Road	Upper Addison Gardens
Elgin Crescent	Pembroke Square	Warwick Gardens
Ellis Street	Phillimore Walk	Warwick Road
Elsham Road	Pimlico Road	West Eaton Place
Holland Park	Portobello Road	Westbourne Park Road
Holland Park Avenue	Princedale Road	Young Street
Holland Park Gardens	Princes Place	
Holland Park Road	Queensdale Road	

Several streets have a main or interceptor sewer running underneath them. Table 9-2 shows the streets that have these sewers running underneath them and which are connected to manholes and drains on the main road, increasing the likelihood that flooding would have been exacerbated by these sewers. The streets are listed in the direction that sewage would flow.

Table 9-2: Streets which have main or interceptor sewers running underneath them

	Streets				
Middle Level Sewer Number 1	**Low Level Sewer Number 2**	**North Kensington Storm Relief sewer**	**Ranelagh CSO/Ranelagh Storm Relief sewer**	**Counters Creek**	**North Western Storm Relief sewer**
Barlby Road	Russell Road	Bramley Road	Chesham Street	Brewster Gardens	Tavistock Road
Ladbroke Grove	Kensington High Street	Royal Crescent	West Eaton Place	Latimer Road	Portobello Road
Portobello Road	Warwick Gardens	Lorne Gardens	Sloane Terrace	Stable Way	Ladbroke Grove
Bevington Road	Pembroke Square	Holland Road	Sloane Square	Freston Road	Lansdowne Road
Basing Street	Earls Court Road	Bracewell Road	Holbein Place	St Anns Villas	Lansdowne Rise
Colville Houses	Scarsdale Place	St Quintin Avenue	Chelsea Bridge Road	Royal Crescent	Norland Square
Colville Square	St Albans Grove	St Marks Road		Upper Addison Gardens	Addison Avenue
Colville Road	Queen's Gate Terrace	Westbourne Park Road		Lower Addison Gardens	Holland Park Avenue
Chepstow Villas	Queen's Gate	Cornwall Crescent		Holland Villas Road	Holland Road
Pembridge Crescent	Thurloe Place	Clarendon Road		Holland Road	Elgin Crescent (crossing)
Pembridge Gardens	Brompton Road	Holland Park Avenue		Warwick Road	Arundel Gardens (crossing)
Notting Hill Gate	Beaucamp Place	Upper Addison Gardens		Finborough Road	
	Pont Street	Elsham Road		Gunter Grove	
				Ashburnham Road	

9.3.2 Property

Basement properties were flooded by both overland flows that collected at the basement level, and sewer flooding that came up from toilets and drains in basements which were at

a similar level to the local sewer. Sewage from toilets was particularly damaging to property since it would stain the walls and the flooring, leaving tracks and black marks, and would need to be replaced entirely. Depending on the damage, some residents reported from the Section 19 online questionnaire that it costed them hundreds of thousands of pounds and that their insurance premium then tripled. For example, Lancaster West Estate spent £200,000 on repairs to their properties and £100,000 on temporary accommodation for their tenants who were affected by the flood. Overall, the Council to date has spent close to £900,000 on all costs associated with the flooding of its properties.

Ground floor properties were flooded by overland flows coming from surcharged sewers and overflowing drains, in addition to the intense rainfall. However, in some cases, the flooding in basements was so great that it rose to the same level as the ground floor. Figure 9-6 to Figure 9-8 show examples of flooding in the neighbourhood.

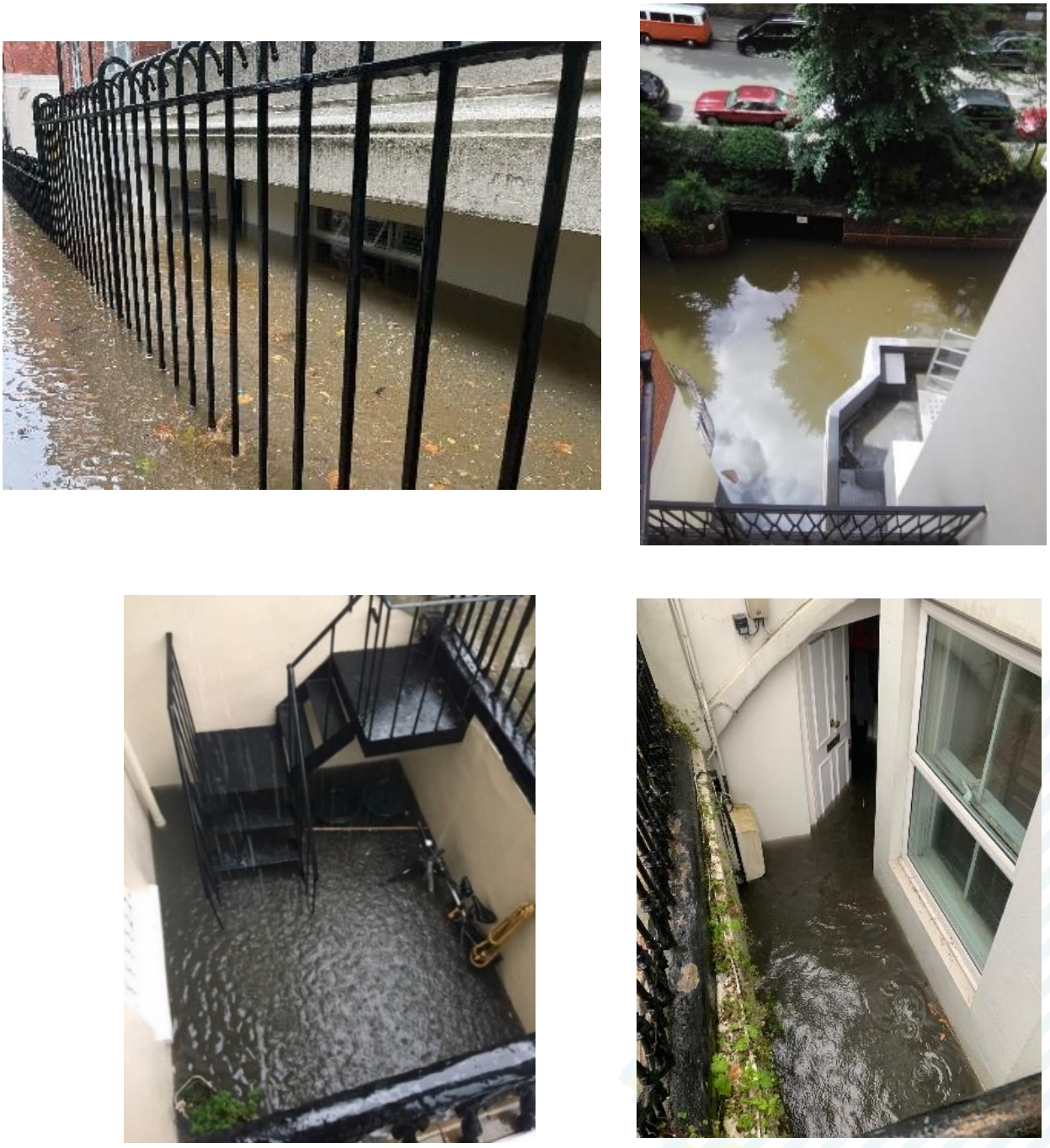


Figure 9-6: Floodwater collecting in basements (images reproduced from residents' responses to the RBKC questionnaire). Top left: Holland Villas Road; Top right: Holland Villas Road; Bottom left: Flooding at 4 Royal Crescent with the water black from sewage overflowing from the manholes on the road and from the toilets inside the property[58]; Bottom right: Cornwall Crescent.

58 Photo provided by Eleo Carson and Robert Orr-Ewing

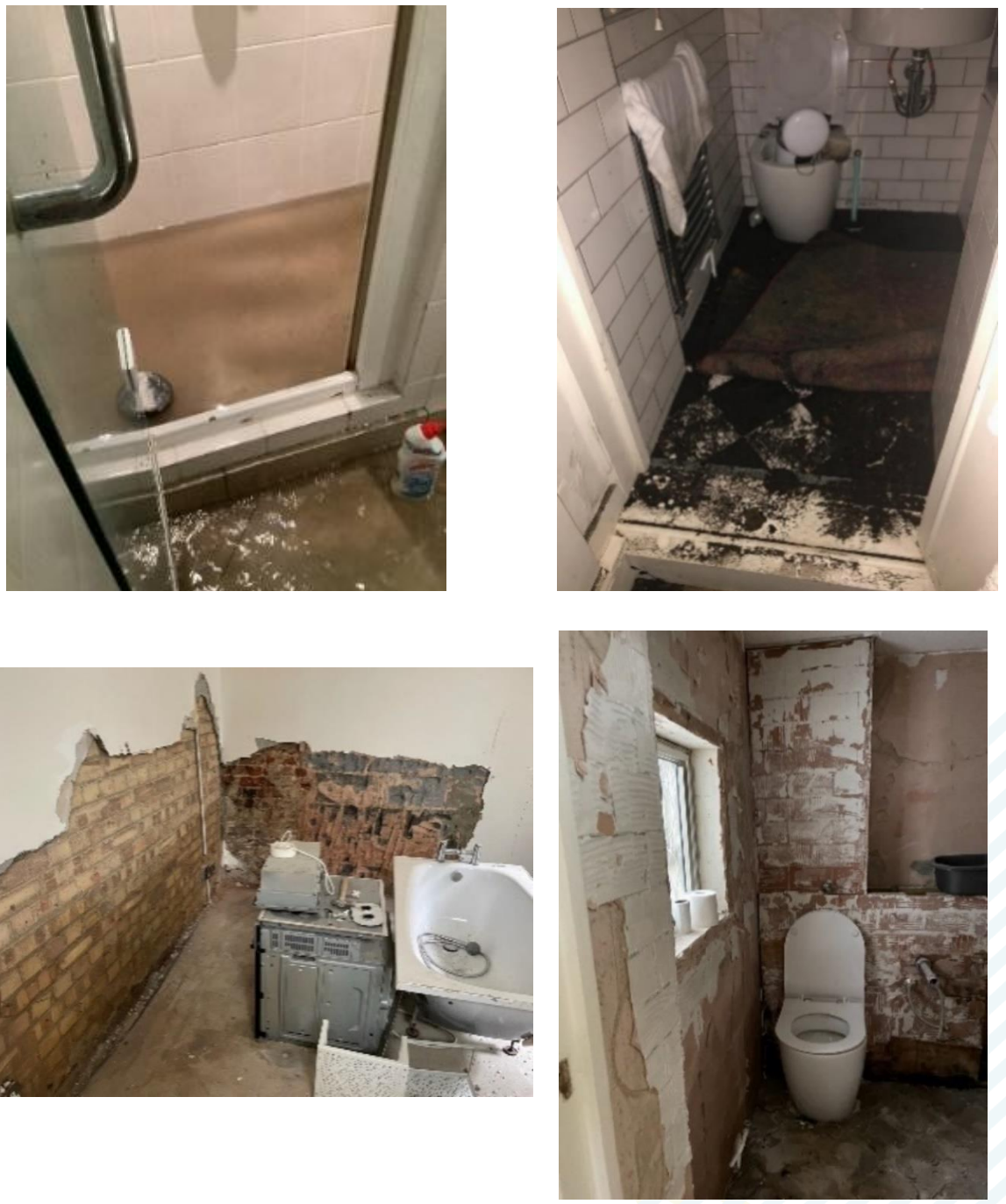


Figure 9-7: Sewer flooding coming up from shower drains and toilets, and its damages (images reproduced from residents' responses to the RBKC questionnaire). Top left: Holland Park Avenue; Top right, bottom left and bottom right: St James's Gardens.

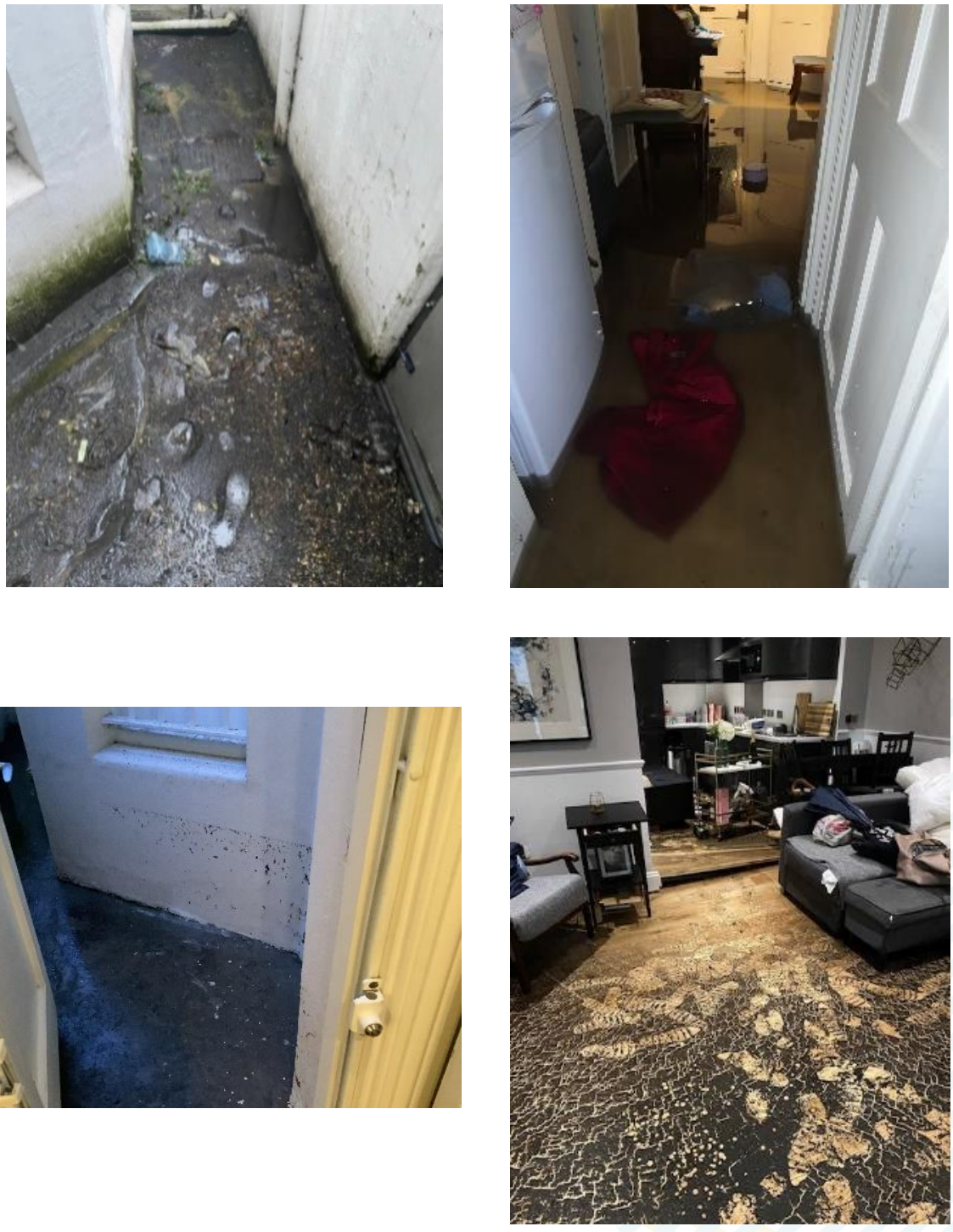


Figure 9-8: Damages to properties due to flooding (images reproduced from residents' responses to the RBKC questionnaire). Top left: Colville Road; Top right: Norland Square; Bottom left: Holland Park Avenue; Bottom right: Warwick Road.

9.3.3 People

The flood water posed a risk to the life: during the event, water inside properties rose quickly and to a large depth, particularly in basement properties; in addition, many properties were flooded with sewage posing a risk to health.

Many residents, particularly the vulnerable and elderly, struggled to leave their property safely, and in some cases neighbours had to help flooded residents out of their property.

Many residents also came back from work to find their property flooded. Many had to be housed in temporary accommodation and have found it very stressful travelling back and forth to their flooded property to arrange repairs, while still going to work and looking after their family. There are many residents who are still in temporary accommodation (as of March 2022) as repairs or even clearing out of the property have not been finished yet, particularly if they were in an area that was flooded badly. Some residents chose to stay in their properties in poor and unhealthy conditions rather than leave.

Residents have had to deal with the stress of their property being flooded as well as their possessions being ruined. Many residents have reported a negative and lasting impact on their mental health from the floods. Insurance premiums for many properties have also increased since the flood, increasing the financial strain that was already on residents due to the pandemic. Many felt they had little help from authorities following the flood.

Given the severity and speed of the incident, if a similar event were to occur at night, the casualties could be much higher. In particular, many residents may be asleep and unaware that their property is being flooded, and the overall response to the flood would be slower.

One elderly resident sadly passed away in September 2021 after suffering stress and trauma in the months following her property being badly flooded.

Below are some comments from residents that were received from the online questionnaire:

"I left the property on the day of the flood as it was totally uninhabitable and I did not know if it was even safe to be there. There was no assistance from any authority on what has happened or what to do next."

"I am very worried about future flooding, what caused it and what is being done? Do I need flood defences? What might they be?"

"The insurance is paying for the accommodation but the content was on me, so I had a significant financial impact including a monthly fee on the storage of the belongings I could save."

"The shop will need to close for 3 weeks which is very unfortunate and a big loss of business. Insurance will cover some of it but there is a lot of time and work involved; it's not only about the financial compensation; it's finding the right time to close a business in these uncertain times."

"I've been living in a hotel with my 12 year old son. I've gained a lot of weight because we don't have access to cooking facilities. Spent 5 months out of work because of the stress"

"It affected my mental health; could not connect with family in any meaningful way and despite the cramped conditions in remaining rooms, I did not want to leave home"

"The place stank for nearly 3 months. The floor of the basement is still badly marked and will have to be cleaned (c£2000)……The basic clean up cost me c£1000 in extra labour costs and the purchase of two dehumidifiers which have been on constantly since. I am purchasing and installing a flood door at the front of the basement (C£4000). I was fortunate that since my flooding was only rainwater, the sludge was minimal and carpets could be cleaned."

"Mentally, I have been totally traumatised, my cat and dog have had to be re homed, which broke my heart. Treasured photographs totally destroyed. Then living in a hotel out of a

suitcase. My work suffered and I kept bursting into tears at the drop of a hat. I felt as if my whole world had fallen apart."

"Our block of flats was declared uninhabitable, due to the loss of electricity and water. When those were restored (after three months!) we returned. However, the lifts were totally ruined, and therefore inoperable. My husband and I have to walk up five flights of stairs to reach our flat—difficult as we are both in our 70s. The lifts are still not working."

9.3.4 Infrastructure

During the event, there were road closures on the A4, A40, A3220 in RBKC. While no other formal road closures were made because of the speed of the event, many roads were significantly flooded; highway drains were overflowing, some manholes would have fountains of water spewing out in the middle of the road, preventing traffic from moving past, and the intense rainfall caused a large amount of runoff to collect and flow on the roads.

Three Underground stations in RBKC were closed during the event: Holland Park, Notting Hill Gate and Sloane Square. Transport for London estimated that, across the city, the flood resulted in a loss of close to £2 million due to fewer journeys being travelled per person, as well as the lost economic benefit they would have produced if they had travelled.

Figure 9-9: Flooding inside Sloane Square Station (image reproduced from Standard[59]).

9.3.5 Services

Several of the Council's properties were affected by the flood[60]:

- Eight residential properties on Lower Clarendon Walk,
- St Marks Care Leavers Centre, with seven care leavers being moved to temporary accommodation,
- The Learning Disability Community Team,
- North Kensington Library and Kensington Central Library were both closed for several days, with North Kensington Library being more badly flooded,
- And 33 various other commercial and operational properties owned by the Council, including those in the Baseline Studios on the Lancaster West Estate.

Three schools were also flooded: Colville Primary School, Thomas Jones Primary School and Avondale Park Primary School. Many businesses were affected by the flood, particularly those on Portobello Road, which had floodwater flowing all the way down the street.

59 https://www.standard.co.uk/news/uk/london-flash-floods-chaos-train-lines-met-office-weather-forecast-b945347.html

60 A5 Response to and Recovery From Floods on 12 July 2021
https://www.rbkc.gov.uk/committees/Meetings/tabid/73/ctl/ViewMeetingPublic/mid/669/Meeting/8579/Committee/1593/SelectedTab/Documents/Default.aspx

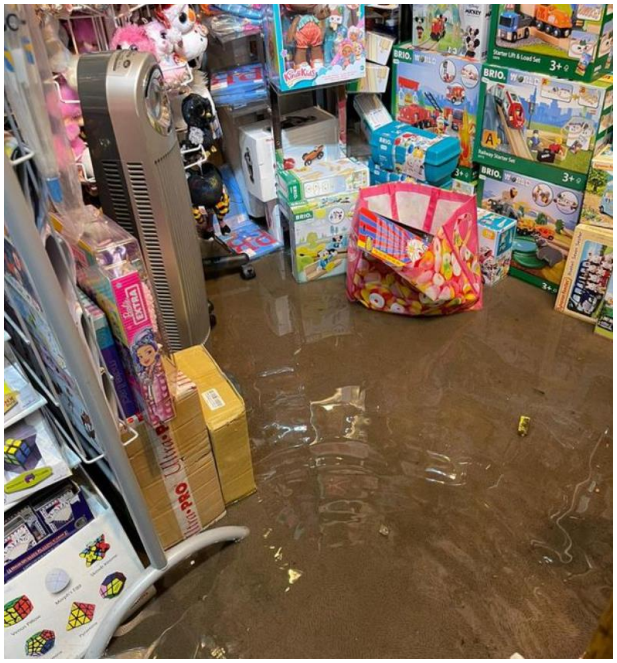


Figure 9-10: Internal flooding damaging the stock of businesses (image reproduced from My London, taken at Portobello Road[61]).

9.4 Source-pathway-receptor summary

Table 9-3 gives a detailed source-pathway-receptor analysis of the flooded streets in RBKC, including the flood depths various properties on the street were flooded by, the number of FLIPs on the street if any, and the flow direction of the local sewers on the street. Where the sewer flow direction is not included is because sewage does not flow in a single direction on that street and there are multiple complex flow directions. The table is informed by responses to the questionnaire, reports from the Council, and Thames Water's Sewer Flooding Historic Database entries for the event. Where there is no detailed data available for a flooded street, a flooding report was submitted for the street, but no further details were given.

For the 76 streets which were reported to have flooded, around 65% had at least one FLIP on their street, while 35% of flooded streets did not have any FLIPs on them (Figure 9-12). There are properties that the Council is aware of which have a FLIP installed but suffered from flooding in July 2021.

61 https://www.mylondon.news/news/west-london-news/i-waist-high-water-londoners-21041092

Table 9-3: Source-pathway-receptor analysis by street

*Number of properties flooded internally based on responses to the Section 19 questionnaire, reports from the Council, and Thames Water's Sewer Flooding Historic Database entries for the event. The actual number is likely to be higher.

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
Addison Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	5	25	50	Several properties experienced flooding from sewage surcharging from drains and manholes that flowed overland into properties, or sewage that came up from toilets in basement properties, or a combination of both. Several residents made insurance claims for hundreds of thousands of pounds as extensive repairs to basements and lifts were made. Flow in the sewers flows southward down this street. There are a number of FLIPs along the A3220 part of Addison Road.
Alma Terrace, Allen Street	Intense rainfall	Combined sewer capacity exceeded	4	10	15	Some properties were flooded by sewage coming up from toilets and shower drains. Sewage in the sewers flows southward down this street. There are no FLIPs on this street.
Ansleigh Place	Intense rainfall	N/A	≥1	N/A	N/A	There are no FLIPs on this street.
Arundel Gardens	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	4	25	30	The drains overflowed causing water to enter properties. The sewers also surcharged and floodwater came from back gardens into properties. Water disappeared suddenly in the space of less than 15 minutes (Figure 8-2). The sewers flow from west to east on this street. There are no FLIPs on this street.
Barandon Walk	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	N/A	30	N/A	The majority of basements on this street were flooded, which includes Council offices for the W11 Lancaster West team as well as commercial properties. A large local sewer that flows from east to west across the estate surcharged, causing floodwater to come up from a manhole and flood the basements. This sewer then drains into North Kensington Storm Relief sewer and Counters Creek sewer.

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
Beckford Close	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	3	90	90	The drains overflowed causing water to enter properties. The floodwater also caused irreparable damage to cars on the street. Some residents did not have access to clean water for five days. There are no FLIPs on this street.
Blenheim Crescent	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	9	25	45	The drains and sewers overflowed, causing floodwater to collect at both the basement and ground floor level. Every single property that was flooded had its basement flooded on this street. The sewers flow from east to west. There are several FLIPs at the end of this street by the Clarendon Road junction.
Bramley Road	Intense rainfall	Sewer capacity exceeded	3	135	135	There were reports of the back-up pumps for a block of flats failing to operate, causing much worse flooding and damages to property and possessions. The North Kensington Storm Relief sewer begins at the north end of this street, with sewage flowing southward. There are no FLIPs on this street.
Brewster Gardens	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	5	10	15	There was both overland flow as water flowed on the road from overflowing drains and sewer flooding in basements as the sewers surcharged. The sewers flow from north to south on this street. There are no FLIPs on this street.
Camelford Court	Intense rainfall	N/A	≥1	N/A	N/A	There are no FLIPs on this street. This street is in an area of high hydrological connectivity.
Camelford Walk	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	1	20	20	Surface water from overflowing drains flowed downhill from St Mark's Road, including a drain by Thomas Jones Primary School, collected at the bottom of the hill which is Camelford Walk. There are no FLIPs on this street. There are a limited number of highway gullies in the area, causing water to be routed as overland flow. Furthermore, where there are drains, if they overflow, a larger amount of water overflows onto the street since there is a reduced number

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
						of ways that water can leave the sewer. Located in an area of high hydrological connectivity, there are only highway drains on the main roads such as Lancaster Road, St Marks Road, Cornwall Crescent, with the exception of a few drains near Clarendon Walk, where a sewer flowing from Ladbroke Crescent flows through the middle of the area.
Clarendon Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	10	10	40	The drains overflowed mainly at the front of properties, causing water to flow into the properties. However, some also had flooding coming from the rear of their property, in addition to some experiencing flooding due to inadequate roof drainage. Part of the North Kensington Storm Relief sewer runs underneath this street. There are no FLIPs on this street.
Colville Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	9	50	120	Sewage overflowed from the drains and sewers which flowed downhill, collecting at the basement level. Since the drains were blocked and the sewers were surcharged, water was unable to drain away and entered the basement properties. The interior of several properties was severely damaged. The sewers flow from north to south on this street. There is one FLIP on this street by the junction to Lonsdale Road.
Colville Square	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	1	10	10	The sewer near the intersection of Colville Square and Colville Terrace was surcharged, causing a 1.2m high fountain. The floodwater then flowed into basement properties. The sewers flow from north to south on this street. There no FLIPs on this street.
Colville Terrace	Intense rainfall	N/A	≥1	N/A	N/A	This street is in an area of high hydraulic connectivity both north to south with Colville Square, Lonsdale Road and Colville Road, and east to west with Portobello Road and Elgin Crescent. The street was flooded and water flowed in the direction towards Portobello Road. There are a few FLIPs on this street.
Cope Place	Intense	Surface water	3	10	15	This street had issues with surface water drainage that failed to

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
	rainfall	drainage capacity exceeded				drain the floodwater away. The surface water then collected in basements. The local sewer flows from west to east. There is one FLIP at the junction of Cope Place and Abingdon Road.
Cornwall Crescent	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	2	30	30	The drains and sewers overflowed, causing floodwater to enter properties. A 0.5m high fountain formed on the main road where the sewer surcharged and flooded the road by up to 10cm. The sewer flows from east to west. There are no FLIPs on this street.
Darnley Terrace	Intense rainfall	N/A	≥1	N/A	N/A	The local sewer flows from east to west on this street. There are many FLIPs on this street.
Edwardes Square	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	5	10	30	Multiple ground floor properties were affected by floodwater overflowing from drains at the back and front of properties, entering the property, while multiple basement flats were affected by sewage coming up from toilets. Floodwater also came from back gardens. The basement flats were generally more badly affected than ground floor properties as they had both surface water flooding as overland flow and sewage coming up from toilets. There are many FLIPs on this street, installed following local flooding in 2016 to the northwest of Edwardes Square.
Elgin Crescent	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	21	25	90	In addition to the drains and sewers overflowing on the main road, most flooded properties had their gardens flooded first from the communal garden, which then flowed into their property. There were reports of waves flowing from Portobello Road, and there was significant ponding at the junction of Kensington Park Road and Elgin Crescent. Surface water flowed rapidly across roads which then also entered properties. Sewage also flowed up from toilets in basement flats. Many of the flooded properties had their basements flooded and extensive damage to their flooring and

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
						walls. During the event, some households in basement properties had to evacuate their children through the basement window. After a while, water levels suddenly lowered as the water drained back into the sewer. There are a limited number of FLIPs on this street.
Ellis Street	Intense rainfall	Combined sewer capacity exceeded	1	30	30	Sewage surcharged from the sewers and flowed into properties. The sewers flow from west to east on this street. There are no FLIPs on this street though there are some on Cadogan Gardens.
Elsham Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	4	N/A	N/A	Multiple properties were flooded on this street, particularly basement/lower ground floor flats. The local sewers flow from north to south on this street. There is one FLIP on this street.
Holland Park	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	1	N/A	N/A	The drains overflowed as the sewers surcharged causing floodwater to flow along the street and into properties. There are no FLIPs on this street.
Holland Park Avenue	Intense rainfall	Combined sewer capacity exceeded	21	25	40	Several residents experienced large amounts of sewer flooding coming up from the toilets in their basements. One resident had flooding coming from their roof and ceiling, likely due to inadequate roof drainage. In addition, Holland Park Station was flooded. The street is slightly downhill from neighbouring streets, causing water to collect along this street. There are a few FLIPs on this street.
Holland Park Gardens	Intense rainfall	Surface water drainage/combined sewer capacity	5	30	50	Water came up from overflowing drains and manholes, as well as through external drains in lightwells. The floodwater originated at the junction of Holland Park Gardens and Holland Park Avenue. Water flowed into properties, primarily basement

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		exceeded				properties. After a while, water suddenly drained away as a result of the water draining back into the sewers. There are a few FLIPs on this street.
Holland Park Road	Intense rainfall	N/A	1	N/A	N/A	On this street, Leighton House Museum was flooded due to the large amount of rainfall, flooding the electrical switch room. The local sewer flows from east to west on this street. There are no FLIPs on this street.
Holland Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	11	50	100	Multiple properties were flooded by either sewage coming up from toilets in their basements, or sewage surcharging from the sewers on the street and flowing into their properties. Sewage flows from north to south on this street. There are a large number of FLIPs on this street by Holland Gardens and Napier Place.
Holland Villas Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	13	105	300	This street was heavily flooded as the sewers surcharged and came up from the manholes, starting from the junction at Upper Addison Gardens and this street and continuing along the rest of this street. A large amount of water then collected in basements, with multiple properties being flooded by more than a metre. There are also two FLIPs on this street. Addisland Court was affected particularly badly, with flood depths reaching up to 3m and flooding basements entirely and even reaching the ground floor. The flood has made many flats uninhabitable and forced residents into temporary accommodation. The boiler and electric for the building are still undergoing repairs, so the building is being serviced by a temporary boiler and electricity. At Addisland Court, water entered the car park, which is at the basement level. The building has a few water pumps but which were old and were overwhelmed quickly during the event, causing the electricity in the building to short-circuit. With none of the water being pumped out, the water level quickly rose and

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
						to a very deep level. Holland Villas Road had the joint largest maximum internal flood depth alongside Royal Crescent.
Kensington Park Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	5	10	10	Flooding was caused by the drains and sewers being overloaded, as well as, in one particular case, inadequate roof drainage. There are no FLIPs on this street.
Kenway Road	Intense rainfall	Combined sewer capacity exceeded	3	20	30	Multiple basement properties were flooded by sewage coming up from their toilets. Sewage flows from north to south on this street. There are no FLIPs on this street.
Ladbroke Grove	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	10	20	30	Properties along this street were flooded by overflowing highway drains and surcharged sewers causing water to collect in gardens and then at the basement level, both inside and outside of the basement properties. Several residents had issues with their rooftop drainage and their guttering. Kensal House at the north end of the street was flooded as well as North Kensington Library. There are a few FLIPs on this street.
Lancaster Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	5	80	100	Surcharged drains and sewers caused flooding on this street and a 1m high fountain formed at the intersection of Lancaster Road and St Marks Road, preventing vehicles from passing. Floodwater from the streets and gardens then entered properties. Sewage flows from east to west on this street. There are a few FLIPs on this street.
Latimer Road	Intense rainfall	Combined sewer capacity exceeded	≥1	N/A	N/A	The local sewer flows from north to south. There are no FLIPs on this street.
Ledbury Road	Intense rainfall	Combined sewer capacity	2	15	15	The sewers surcharged causing sewage to flow on the streets and enter properties, flooding basements. The floodwater receded shortly after as the sewer levels lowered. Sewage flows

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		exceeded				from north to south on this street. There are no FLIPs on this street.
Lonsdale Road	Intense rainfall	N/A	1	N/A	N/A	Colville Primary School was flooded. Sewage flows from east to west on this street. There is one FLIP on this street at the junction of Colville Road.
Lorne Gardens	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	8	N/A	N/A	Sewage flows from east to west on this street and is taken to the sewers that run through Holland Park Avenue. There are no FLIPs on this street.
Lower Clarendon Walk	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	8	N/A	N/A	Ground floor and lower ground floor properties on this street were flooded by water flowing down the side-street. Water flowed quickly down the street, which acted as a channel, forcing the water in one direction, causing it to collect by and enter properties. This area has a high hydrological connectivity. The local sewer runs from Lancaster Road flowing southward through Lower Clarendon Walk and joins up with the local sewer at Clarendon Road. In addition, a large local sewer runs underneath this street also. Part of North Kensington Storm Relief sewer runs underneath St Marks Road and which carried a large amount of flow during the event which may have contributed to flooding along Lower Clarendon Walk. There are no FLIPs on this street.
Melbury Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	≥1	N/A	N/A	Properties had flooding in their basements where sewage backed up from the local sewers and came up into basements. There are no FLIPs on this street.
Napier Place	Intense rainfall	Surface water	1	N/A	N/A	Sewage flows from north to south, draining into the sewers on Holland Road. There are no FLIPs on this street.

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
Napier Road	Intense rainfall	Surface water drainage/combined sewer capacity	3	10	15	Multiple basement flats were flooded though it is difficult to determine the exact causes of flooding along this street. Sewage flows from east to west, draining into the sewers on Holland Road. There are a large number of FLIPs on this road from the junction to Napier Place to the Holland Road junction.
Norland Road	Intense rainfall	Surface water drainage/combined sewer capacity	1	50	50	Surcharged sewers caused sewage to flow on the road, with a 1m high fountain forming at the manhole and entering properties. There are no FLIPs on this street.
Norland Square	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	9	15	30	Multiple residents were badly affected by sewer flooding that came up through their toilets in their basements. Others also had floodwater enter their property via overland flow due to the drains and sewers overflowing. The sewers drain into the sewers on Queesndale Road. There are several FLIPs on this street.
Notting Hill Gate	Intense rainfall	N/A	1	N/A	N/A	Notting Hill Gate Station was flooded. The Middle Level Sewer Number 1 runs next to the station. There are no FLIPs on this street.
Pembroke Gardens	Intense rainfall	N/A	≥1	N/A	N/A	Sewage flows from north to south on this street. There are no FLIPs on this street.
Pembroke Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	6	5	10	Floodwater overflowed from drains on this street, entering properties from the front via overland flow. There are no FLIPs on this street.
Pembroke Square	Intense rainfall	Surface water drainage/combined sewer capacity	9	10	30	Several properties along this street were affected by both sewage overflowing in the street through manholes and also coming up from toilets in basements. There was a large variation in impact across the properties along the street, as some properties had multiple internal manholes inside their

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		exceeded				property which flooded, while other properties are raised from the ground and have steps leading up to the property, and were less badly affected. However, for many, insurance premiums increased substantially. Sewage flows from east to west on this street. There are no FLIPs on this street.
Phillimore Walk	Intense rainfall	N/A	1	N/A	N/A	Central Kensington Library was flooded and closed for several days. Sewage flows from east to west along this street. There are no FLIPs on this street.
Pimlico Road	Intense rainfall	N/A	≥1	N/A	N/A	Sewage flows from east to west on this street. There are no FLIPs on this street.
Portobello Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	3	140	150	The intense rainfall along with surcharged drains caused a large volume of water to flow freely down the road, flooding several businesses. Basements were worst affected due to sewer flooding coming up through toilets in the property. With the amount of water reported to have been flowing through the street, and which is captured on video on social media, it is likely that the number of properties flooded on this street is significantly underreported. Vehicles moving through the water created bow waves, which then inundated properties along the street. There were reports of water coming from east to west from Colville Terrace across Portobello Road and into Elgin Crescent. Many businesses on this junction to Colville Terrace and Elgin Crescent are reported to have been flooded according to residents' accounts. Many gullies along Portobello Street were blocked as the large amount of floodwater failed to drain away. However, after two hours, the water suddenly drained away as the sewer levels lowered. There are no FLIPs on this street.
Princedale Road	Intense rainfall	Combined sewer capacity	2	20	20	After two hours of flooding, the water receded suddenly. There are no FLIPs on this street.

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		exceeded				
Princes Place	Intense rainfall	N/A	≥1	N/A	N/A	Sewage flows from east to west and follows the remainder of the street southward, draining into the sewers on Queensdale Road. There are no FLIPs on this street.
Queensdale Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	10	30	100	There was a large amount of sewer flooding that came through shower drains and toilets in basement properties. In addition, some residents reported surface water flooding from the street and other residents' properties. Sewer flow is highly complex on this street, with multiple inflows from Princedale Road, Princes Place, Norland Road and Norland Square. There are a large number of FLIPs on this street.
Radley Mews	Intense rainfall	Surface water drainage	2	25	50	One resident had issues with their roof drainage. Sewage flows from south to north. There are no FLIPs on this street.
Rosmead Road	Intense rainfall	Combined sewer capacity exceeded	1			Sewage flows from east to west, flowing into the sewers under Elgin Crescent. There are no FLIPs on this street.
Royal Crescent	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	17	60	300	Some properties were flooded by sewage coming up through toilets in basements. However, the majority of flooded properties were flooded by overflowing drains and manholes, both in the front and back of properties, which then collected in basements. Large amounts of water entered the properties, with one resident pumping out 130m^3 and being flooded by up to 3m internally. For several residents, the flooding lasted for approximately two hours, until the water suddenly drained away. The sewers on either side of Royal Crescent meets underneath the junction of Royal Crescent and St Anns Villas where it then flows into a separate pipe that flows southward and passes Holland Park Avenue. This is the Counters Creek sewer. There are numerous FLIPs on this street. Royal Crescent had the joint

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
						largest maximum internal flood depth along with Holland Villas Road.
Russell Gardens	Intense rainfall	Combined sewer capacity exceeded	1	N/A	N/A	One property on this street experienced flooding from sewage coming up from toilets and shower drains in their basement. Sewage flows from east to west, starting from Holland Road, going through Russel Gardens, and flowing into Russell Road. There are no FLIPs on this street.
Russell Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	12	30	60	Several properties were flooded by sewage coming from toilets and shower drains in basements, or floodwater from overflowing drains and manholes that collected in basements, or a combination of both. There are several FLIPs on this street.
Scarsdale Villas	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	8	65	100	Properties were flooded by sewage coming up from the toilets in basements or floodwater from overflowing drains which flowed into properties. Sewage flows from east to west on this street. There are no FLIPs on this street.
Sloane Square	Intense rainfall	N/A	1	N/A	N/A	Sloane Square Underground Station was flooded internally due to the Ranelagh CSO which passes through it. Water made its way through the station cascading down the steps. There are no FLIPs on this street, though there are numerous FLIPs on Lower Sloane Street and a few on Sloane Gardens.
St Anns Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	7	60	100	There was a large amount of sewer flooding on this street that came up through the drains and manholes onto the street which then flowed into properties. Floodwater also flowed from the rear of properties. There were also reports of a burst pipe by Henry Dickens Community Centre, though Thames Water has said it has no record of this. Sewage flows from north to south. There are a few FLIPs on this street by the junction to Darnley Terrace.

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
St Anns Villas	Intense rainfall	Sewer capacity exceeded	5	50	70	Sewage flows from north to south on this street. The main line of the Counters Creek sewer runs underneath this street. One property was flooded due to floodwater entering through airbricks. There are a large number of FLIPs on this street.
St James's Gardens	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	9	90	150	In addition to overflowing drains and sewers, some properties had flooding due to sewage coming up from their toilets in their basements, and blockages in their roof drainage. Sewage flows from east to west on both sides of St James's Gardens. There are a numerous FLIPs on this street.
St Marks Close	Intense rainfall	N/A	9	N/A	N/A	On this street, St Marks Care Leavers Centre was flooded on the ground floor. Seven care leavers had to be moved to temporary accommodation. This area has a high hydrological connectivity as many of the side-streets are interlinked, allowing a fast flow of water. There are no FLIPs on this street.
St Marks Road	Intense rainfall	N/A	2	N/A	N/A	Water on this road drains southward as it flows down on an incline. Thomas Jones Primary School, and Kensington and Chelsea's Learning Disability Community Team were flooded near towards the end of the road. The sewers underneath this street also flow southward. The sewer that runs underneath this street is part of North Kensington Storm Relief sewer. There are no FLIPs on this street.
St Quintin Gardens	Intense rainfall	N/A	1	N/A	N/A	A main trunk sewer runs underneath nearby, and in addition, the main line of Counters Creek sewer starts nearby here. There are no FLIPs on this street.
Stafford Terrace	Intense rainfall	N/A	1	N/A	N/A	On this street, Linley Sambourne House experienced large amounts of flooding. Sewage flows from east to west on this street. There are no FLIPs on this street.
Stanford Road	Intense rainfall	Combined sewer capacity	1	25	45	One property on this street was flooded by sewage coming up from their toilet in the basement. There are no FLIPs on this

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		exceeded				street though there are several on Eldon Road nearby.
Stoneleigh Place	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	4	45	45	Multiple residents on this street experienced flooding that had various causes. For most, the overflowing drains on the street caused water to flow into properties. Many, too, had overland flow coming from their back gardens. Some residents had sewage coming out of their toilet and bath, while one resident had flooding come from the roof where their roof drainage was inadequate. There is one FLIP on this street.
Stoneleigh Street	Intense rainfall	Surface water drainage capacity exceeded	10	100	150	A large amount of water from drains overflowed into the street, in addition to the large amount of rainfall, causing ponding next to properties. The floodwater then flowed into properties at the basement level, which were also inundated by flooding coming from gardens. Some had sewer flooding that came up from their toilets in their basements. There is one FLIP on this street which acts as a communal FLIP. When the street was flooded, the electrics for the FLIP were affected. While elsewhere the floodwater began to recede after the rain stopped, London Fire Brigade were pumping out the water that remained on the street until the following morning, partly due to the FLIP which had failed to pump any water.
Testerton Walk	Intense rainfall	Surface water drainage capacity exceeded	N/A	N/A	N/A	A large local sewer that flows from east to west across the estate surcharged, causing floodwater to come up from a manhole and flood this street. This sewer then drains into North Kensington Storm Relief sewer and Counters Creek sewer. The basement area along this street was flooded as a result. Out of the Lancaster West Estate, the flood depth was to be larger than at Barandon Walk, but the impact was less since the basement area is mainly used for car parking.
Upper Addison Gardens	Intense rainfall	Surface water drainage	4	0	0	There was minimal flooding across this street as water came up from drains and manholes and the rainwater failed to drain

Street name	Source	Pathway	Receptor (properties flooded internally) *	Average internal depth (cm)	Maximum internal depth (cm)	Description
		capacity exceeded				away. The floodwater remained localised to the road and did not enter properties. Access to the road was the main issue at this street. This street was badly flooded in 2007 but was not as badly affected in the 12 July 2021 flood. There are a large number of FLIPs on this street.
Warwick Gardens	Intense rainfall	N/A	≥1	N/A	N/A	The Low Level Sewer Number 2 runs underneath this street and is likely to have surcharged and caused flooding to several (unreported) properties along this street. There are no FLIPs on this street, though there are many FLIPs nearby along Addison Road, Holland Road and Edwardes Square, which could have some influence over the local hydraulics in this area.
Warwick Road	Intense rainfall	Combined sewer capacity exceeded	6	75	100	The sewers surcharged causing water to flow onto the road and collect in basements. Sewage flows from north to south on this street. There are several FLIPs on this street by the junction to West Cromwell Road.
West Eaton Place	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	≥1	N/A	N/A	Floodwater came up through drains and manholes on this street. Ranelagh CSO is connected to two manholes on this street, which can increase the likelihood of sewer surcharging on this street during a flood event. There are no FLIPs on this street.
Westbourne Park Road	Intense rainfall	Surface water drainage/combined sewer capacity exceeded	2	0	0	The street was flooded by sewage coming up through drains and manholes but the floodwater remained localised to the road and did not enter properties. Sewage flows from east to west on this street. There are no FLIPs on this street.
Young Street	Intense rainfall	N/A	≥1	N/A	N/A	Sewage flows from north to south on this street. There are no FLIPs on this street though there are numerous in the area, in Kensington Square and Thackeray Street.

9.4.1 Estimated flood depths

This section presents some statistics on the flood depths for the affected streets based on estimates by residents taken from the online questionnaire (Figure 9-11). Where the flood depth is zero, there were no responses from any residents on that street who reported any observed flood depths. The flooded streets are listed by proximity so that streets that were in badly affected areas could be viewed in groups, while highlighting their hydrological connectivity. It also includes a heatmap of the number of FLIPs in a given area (Figure 9-12).

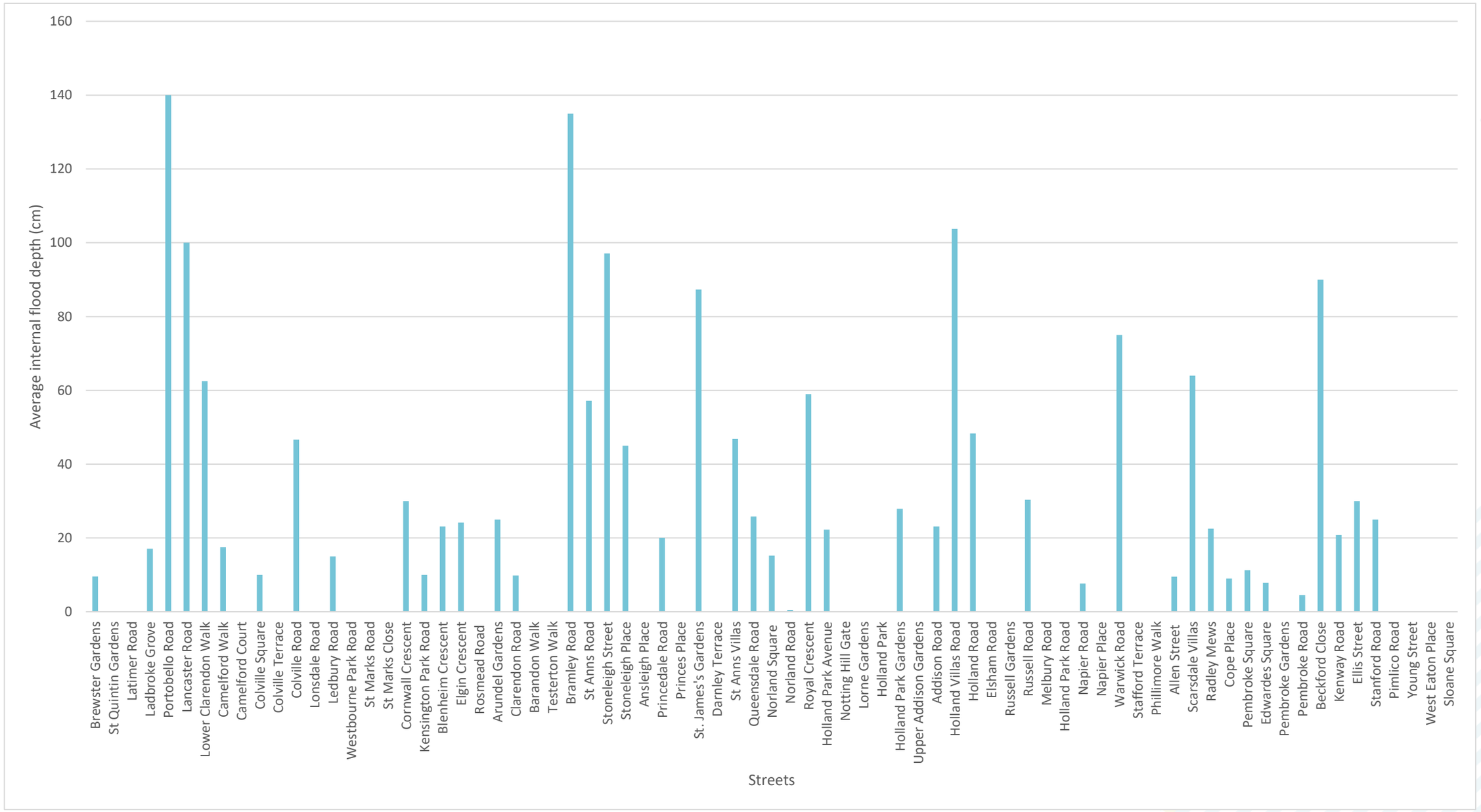


Figure 9-11: The average internal flood depth recorded by street, listed by proximity, as reported on the RBKC questionnaire. Where the flood depth is equal to zero no data was provided from the questionnaire.

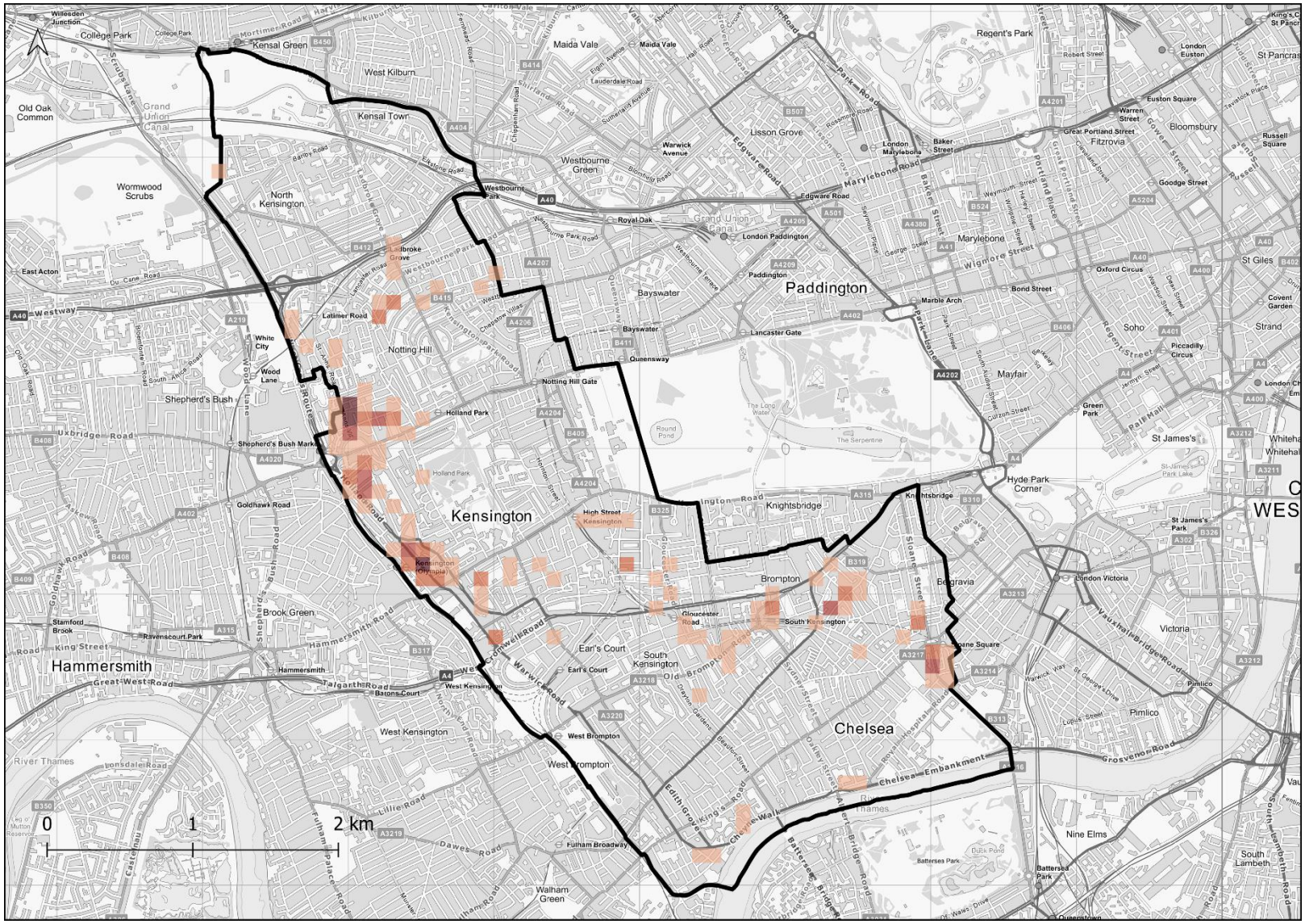


Figure 9-12: Heatmap of the number of FLIPs in a 100 m² area.

10 Discussion and recommendations for RMAs

10.1 Thames Water Independent Review

In November 2021, Thames Water carried out an internal review of its response during the event[62]. The report found that Thames Water would need to improve the availability of its contact centre during the event, its communications with Category 1 responders and providing greater assistance in their role as a Category 2 responder, and being able to respond to more calls for clean-ups after the event. Solutions such as greater communications with elected representatives and establishing a control centre in the flooded area as a point for residents to visit and clean-up teams to operate from were suggested.

Thames Water has also commissioned an independent review to understand how its assets performed during the event[63]. The first stage of the report was released in March 2022, concerning what data was collected and its quality, including rainfall, tidal and groundwater data. However, it has identified data gaps in number of flooded properties Thames Water have in its records, and its depth monitor dataset.

The independent review will next consider: the pathways and receptors of flooding; the performance of their assets, sewers and flood alleviation schemes; improvements to their systems such as local sewer upgrades and FLIPs; and potential future solutions such as SuDS and reconsidering old solutions, such as the proposed Counters Creek storm relief sewer. The review will use Thames Water's hydraulic models to look at the operation of the system. The solutions that Thames Water will implement in the future will also be dependent on their funding from Ofwat.

RBKC are in ongoing communication with Thames Water as part of the Independent Review, and were able to comment on its scope and terms of reference. The Section 19 investigation cannot pre-empt the findings of this review, but RBKC will continue to engage with the review as a key stakeholder and on behalf of residents, and will scrutinise the outputs and findings.

10.2 Hydrometric data improvements

The Environment Agency tipping bucket rain gauge located at Holland Park was shown to have under-recorded the amount of rainfall during the event. While it is already noted by the Environment Agency to be recording around 8% lower than the true value, measurements by rainfall radar show a difference much larger than 8%.

It is recommended that the Environment Agency undertake a review of the suitability of the equipment at Holland Park since it underreported the amount of rainfall during peak intensity, and consider replacing it. High capacity rain gauges are available that can more accurately record periods of intense rainfall.

10.3 Retrofitting Sustainable Drainage Systems (SuDS)

Retrofitting SuDS in urban areas is increasingly seen as a way of mitigating the impact of intense storms, particularly in smaller, more frequent events. Several SuDS projects have been implemented already in RBKC funded by Thames Water and through Thames Regional Flood and Coastal Committee at Arundel Gardens, Holland Park and Portobello Court (see Section 0 and 6.5.3). Proposals for SuDS at Allom & Barlow and Lancaster West estates as part of climate adaptation work are currently under consideration. It should be noted, however, that the rainfall return period in parts of the borough far exceeded the design

62 https://www.thameswater.co.uk/about-us/investing-in-our-region/london-flooding-response

63 https://londonfloodreview.co.uk/

standards applied to new and retro-fit SuDS systems, so they could have reduced but not prevented flooding in these areas.

Not only do SuDS reduce surface water runoff but they have many other benefits, improving water quality, biodiversity and tree cover, as well as having benefits to residents around air quality, heat reduction, health and well-being and place-making.

It is recommended that further opportunities to retrofit SuDS should be prioritised and supported by funding whether that be through specific schemes with Thames Water or Flood and Coastal Risk Management Grant in Aid funding or through their routine incorporation into urban regeneration and highways improvements projects. Whilst the construction of a number of small schemes in the Borough is welcomed and should reduce risk locally, the rate of implementation of SuDS is presently far too slow to make a significant impact on flood risk at the Borough scale, nor sufficient to mitigate the increased flood risk as a result of climate change.

Mapping the needs, opportunities and constraints for SuDS retrofit is a relatively low-cost exercise which could identify areas where SuDS are (a) possible and (b) would have a positive impact, which could provide a basis for opportunistic improvements.

10.4 Community engagement

Community engagement can be defined as the process communities and RMA partners undergo to work together in the building of resilience through collaborative action, shared capacity building and development of strong relationships build on mutual trust and respect.

Community engagement activities will increase with the establishment of Flood Action Groups in the area (section 0) as they will naturally help increase the risk awareness and knowledge of the community. RBKC can provide support through existing links with community groups such as the Kensington Society, individual Residents' Associations and the Residents Flooding Steering Group to help to enable community actions such as the formation of Flood Action Groups and flood warning schemes (see Section 0).

Some questionnaire responses indicated that residents felt there was a lack of help during the event (e.g. which organisation to call to get help). Many also did not know who to contact after the event to have contents removal, cleaning, temporary accommodation, surveying of damages and potential solutions. RBKC has a high proportion of rented properties, and some tenants felt let down by landlords after the event.

RBKC and Thames Water's websites already have some information on dealing with flooding and what to do after a flood (a list of resources can be found in Section 11.6.2 and 11.6.3). These pages should be regularly reviewed to ensure they are up to date in terms of clearly signposting who to contact and report flooding to, and include links to support services which will help homeowners and businesses understand their flood risk, and sources that will help them prepare for a flooding event and deal with the aftermath.

Most importantly the Council and Thames Water should engage with residents and community groups to ensure that they know about these resources – working together to coordinate a joint campaign with consistent messaging, and repeating this campaign annually would be extremely beneficial. Resources should be advertised in a number of ways, through leaflets posted through homeowners doors, to Flood Action Groups who will signpost in their emergency planning and communications, on the RMA websites, and through face-to-face engagement activities.

It is recommended that any campaign should have particular focus on:

- Residents of basement flats, who are at particularly high risk to life
- Landlords are made aware of the risk to their properties and encouraged to inform and advise their tenants, and help them to recover

- Vulnerable residents, and those for whom English is a second language
- Those without access to the internet and social media

30 days 30 ways September campaign was referred to in the London Resilience Partnership Debrief Report. Recommendation 24 outlined this campaign should be used to promote community and personal resilience. Using this campaign to advertise different resources can help flood action groups gain wider insight into the different actions organisations are doing to help increase resilience.

10.5 Property Flood Resilience

Property Flood Resilience (PFR) can provide effective products and measures, at an individual property level to reduce the impact of future floods, by either aiming to limit water entry in the first place (resistance) or by adapting the internal fabric of the property to limit damage and recovery time (resilience) if flooding does occur. Resistance measures can be passive (being deployed automatically), such as flood doors, sump pumps, automatic airbricks and non-return valves, or require manual installation, such as flood barriers, portable pumps and puddle pumps. Given the primary flood risk in the Borough is from intense rainfall events for which there is currently no warning system available to the public, passive measures should be preferred as these do not require fitting ahead of a flood event. Resilience measures include raising electrics, using porous plaster, and fitting solid floors or tiled floor coverings instead of carpets.

RBKC contains a large number of flats and apartments where a communal approach to measures such as sump pumps, flood walls, etc may be required by management companies.

Although resistance measures are not able to entirely prevent flood water ingress, they aim to limit damage and ensure properties are adapted to cope with the impacts of floods and recover quickly from these disruptive events. They are generally significantly lower in cost than resilient adaptation works to the property fabric itself, whereby flood water entering a property would lead to minor or no damage. Installation of Kitemarked products is generally recommended, as they have been tested in flood conditions to British Standards.

There are three main ways of funding PFR, as explained below.

- Funding by property owner (see Section 11.4)
- Central Government and Local Levy funded schemes
- Flood Recovery Grants

10.5.1 Central Government and Local Levy funded schemes

Risk Management Authorities can apply to the Environment Agency to request central government funding for a scheme. Alternatively, local levy funding raised from local authorities may be available through an application to the relevant Regional Flood and Coastal Committees (RFCC).

If funding is approved, Risk Management Authorities in England can access the Environment Agency Flood Resilience Framework to procure the survey, supply, and installation of PFR measures to domestic properties. The framework is designed to allow a more streamlined procurement process, and to deliver PFR schemes which apply best

practice in survey and installation, as outlined in the CIRIA Code of Practice for PFR (C790)[64].

The framework requires the survey of ingress routes at a property, and the sale and installation of PFR products to be undertaken by different suppliers, to ensure independence. The use of Kitemarked products is also recommended within the framework, to improve the consistency and effectiveness of installed products. Following installation, an audit is carried out by an independent surveyor to make sure that measures have been installed correctly and the resident understands how to deploy and maintain the equipment.

A funded scheme, managed by a Risk Management Authority, provides a more consistent approach to increasing the resilience of a community through installation of PFR. Schemes often include a large number of properties, and therefore it can take significantly longer for a property to receive PFR measures than if a resident were to fund the properties individually. As in the case of any PFR delivery route, it also remains the decision of an individual resident whether they wish to have PFR measures installed at their property as part of the scheme.

RBKC should investigate the feasibility of getting funding for PFR through this route, and potentially could partner with other London Boroughs affected to administer a wider scheme.

10.5.2 Flood Recovery

The final approach is through Flood Recovery Grants (previously termed as Repair and Renew Grants).

Following flood events in the past which have affected a large number of properties, the UK Government has issued Flood Recovery Grants to improve the resistance and resilience of properties affected by flooding, beyond repairs which would be covered by insurance. These grants cover fluvial, coastal, surface water and groundwater flooding.

The grant schemes are generally administered by Local Authorities. However, eligible residents are responsible for arranging and paying for the property survey and installation of PFR measures upfront, which is then claimed back from the Local Authority once installation is complete and signed off.

Flood Recovery Grants have not been offered by central government in this case.

10.6 Surface water flood warning

There is currently no national flood warning service for surface water flooding, and emergency plans are based on severe weather warnings which are high level and cover large areas. Although lead times are always likely to be short for events similar to July 2021, more detailed forecast information would allow the decision-making process around emergency planning to be better informed, enable emergency responders to provide a more rapid response to surface water flooding, installation of PFR measures by residents, and for asset managers to undertake pre-emptive maintenance works.

Thames Water does internally forecast high flows within the sewer network using a real-time modelling system originally developed for the 2012 Olympics, but do not share the information externally. It is recommended that Thames Water share its forecasts with RBKC and other RMAs/Category 1 responders so that they are better equipped to respond to an event.

---

[64] CIRIA (2021) Code of practice for property flood resilience (C790). Available at: https://www.ciria.org/Resources/Free_publications/CoP_for_PFR_resource.aspx

It is also recommended that RBKC develops its own independent forecasting system for surface water flooding. Relatively quick to implement would be a system based on live rainfall radar data for the area. This would allow triggers to be set on the basis of predicted rainfall for implementation of emergency plans, including informing Flood Action Groups/Flood Wardens to implement actions. Assumptions would need to be made on how likely surface water flooding would be as a result of the predicted rainfall, and care would need to be taken over the dissemination of warnings, to ensure that there were not too many 'false alarms', meaning people would be less likely to act.

A number of other Local Authorities around the UK are also developing more sophisticated surface water flood forecasting systems as part of Defra funded Flood and Coastal Resilience Innovation Projects[65]. It is anticipated that commercial systems could be available within 1-2 years.

A national surface water flood forecasting system, which might for example send push notifications to areas at risk, is a long-term goal which has been discussed with Defra and which RBKC would support.

10.7 Flood reporting

There is no single location or point of contact for residents to report incidents of flooding to their property, either locally or nationally. This means that no organisation has the full picture of the scale of the event while it is happening, and that afterwards, there is no single repository of data on which properties flooded. This is particularly problematic for surface water and sewer flooding (as opposed to river flooding for instance) due to a lack of clarity over which organisation is the lead RMA.

During the event itself, the majority of residents rang the Fire Brigade and Thames Water for help, along with fewer calling the RBKC contact centre. Initial reports of flooding within RBKC came to Housing Management rather than the Resilience team.

After the event, online surveys have been collected by Thames Water, RBKC (for the purposes of this investigation), and Felicity Buchan MP. Over 100 reports were received by Thames Water, and over 300 responses were submitted to the online questionnaire by Kensington and Chelsea, yet only around 30 properties submitted reports to both organisations. Meanwhile, the survey carried out by Felicity Buchan MP had over 700 responses. Detailed data sharing between organisations is limited by the General Data Protection Regulations (GDPR). It is also expected that large numbers of properties did not report flooding at all. This may be for a number of reasons, including worries about insurance and saleability of property.

At a street level, for one of the worst-affected streets in terms of the number of affected properties, Elgin Crescent, out of the 21 different properties that reported flooding, 19 reported to at least Thames Water, their neighbourhood flood group, or the questionnaire conducted by this Section 19 Investigation (Figure 10-1). However, only three reported to Thames Water, the organisation that is most able to act upon the information. Furthermore, out of those three reports, only one reported to both Thames Water and filled out the RBKC Section 19 Investigation online questionnaire, and no households reported to all three of the organisations.

In the short term within RBKC and other boroughs affected in July 2021, it is very important that as many residents as possible report to Thames Water via its online form if their property was affected internally. This information will inform the Thames Water independent review and provide the evidence for any business case for additional funding

65 https://www.gov.uk/guidance/flood-and-coastal-resilience-innovation-programme

for mitigation of sewer flooding. All residents who have not yet reported directly to Thames Water[66] should do so as soon as possible via this link:

Thames Water Flooding questionnaire

In the longer term, it is recommended that RMAs work together to streamline and triage the flood reporting process. RBKC is a member of a pan-London working group which has been set up since July 2021 to look at the options for taking this forward in London. There are a number of initiatives already in existence in the UK which try to tackle this problem (e.g. FORT[67]), and the use of the existing Environment Agency Floodline service is also being considered.

RBKC are in progress of setting up a live form on their website to submit all future flooding reports. It will be stated explicitly that data from the form will be shared with Thames Water so that it will avoid GDPR limitations and the report is on their database so that Thames Water can appropriately implement solutions in the area. Personal details will not be shared but data such as the location of flooding will be shared. The form will be accessible on the Council website.

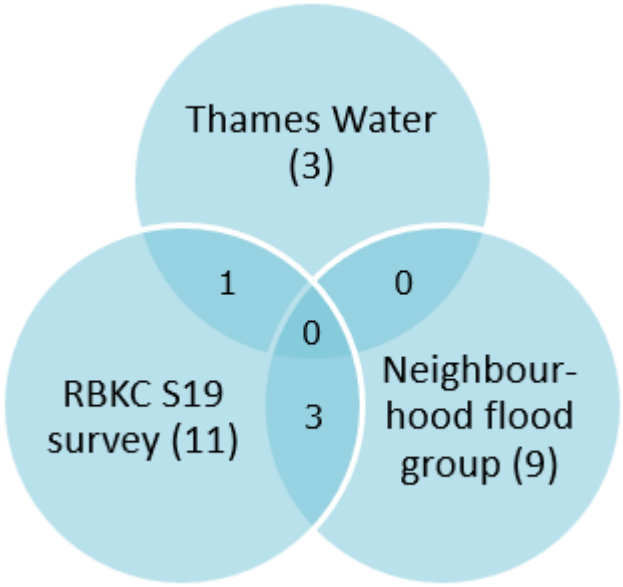


Figure 10-1: Number of flood reports on Elgin Crescent to each organisation

10.8 Highway gully cleaning

Blocked highway gullies can exacerbate surface water flooding, although it should be noted that in a large event this has a minor impact. This is because they drain into the combined sewer, so once the sewers are surcharged the sewer becomes the main control on flooding. However, RBKC should consider increasing the frequency of gully cleaning in flooding hotspots (currently annually or biannually). Some residents also commented that they would like to be informed as to the gully cleaning schedule for their area.

10.9 Review of Critical Drainage Areas (CDAs)

Critical Drainage Areas (CDAs) are used by the Local Planning Authority to decide when smaller new developments require a Flood Risk Assessment. These should be reviewed regularly and after each flood event to ensure that they are fit for purpose.

66 Flooding questionnaire (Page 1 of 11) (office.com)

67 https://swim.geowessex.com/glos/Report/Splash

10.10 London Councils' pan-London response to the July 2021 floods

Following the events in July 2021, the London Resilience Partnership developed a debrief that included 30 recommendations, which the partnership is now in the process of implementing. Some of these recommendations posted in the debrief report are discussed in more detail in the following sections. In addition, the Mayor of London convened a roundtable of the relevant organisations, which continues to meet. Boroughs, together with the Environment Agency and other relevant partners established a Task and Finish Group to explore the issue of long-term surface water flood risk management. The Task and Finish Group remit covers governance, funding, communications, long term strategy and evidence[68].

The following sections explore in more detail some of the recommendations emerging from the debrief and Task and Finish Group work.

10.10.1 Increasing interoperability

Interoperability is an important factor to the successful response to any incident. The Joint Emergency Services Interoperability Principles, also termed JESIP, was created to increase the collaboration between the blue-lights services. JESIP principles have since formed best practice in various emergency management arrangements.

References to JESIP in the Multi-Agency Flood Plan can assist in increasing interoperability between responders to flooding events. Resources such as the Joint-Decision Making Model and METHANE reports, although standard best practice and potentially already outlined in agency specific plans, can assist the Multi-Agency Flood Plans response priorities.

Reference to JESIP within the plan will also be a positive factor in any post incident inquiry and meets note 47 in Annex B of the London Resilience Partnership Debrief Report.

10.10.2 Resilience Direct

Resilience Direct is another tool that can help increase interoperability. Resilience Direct is an online private 'network' which enables civil protection practitioners to work together across geographical and organisational boundaries in the preparation, response and recovery phases of an event or emergency.

The use of Resilience Direct will enable various recommendations to be addressed as outlined in the London Resilience Partnership Debrief Report.

Note 35 in Annex B states "the Partnership needs a way to collectively and quickly capture data held by all partners to ensure that efforts are directed towards areas most in need, this could also include actions / issues taken by partners at each location."

Resilience Direct is a tool that can log and map incident data as necessary to help build a shared awareness of what is happening in the response or recovery to an event. Resilience Direct can share files and maps to all partners to ensure incident data is accessible, and partners can also edit or add to these maps to continually build situational awareness.

The application of Resilience Direct also supports meeting Recommendation 11. This recommendation states a project should be commissioned to "develop a partnership-wide approach to the fast-time collation of information about the location and extent of flooding impacts". An appointed agency or person can be assigned to this task on Resilience Direct to help reference the extend or potential for flooding.

Resilience Direct can also be used to log calls from the general public (see also section 10.7). A theme emerged in the Debriefing Report that the public may call either Local Authorities, the Environment Agency, Thames Water and/or LFB on flooded locations and

68 Surface Water Flood Risk Management in London | London Councils

impacts. Calls logged on Resilience Direct can support shared situational awareness and join knowledge in this area.

It should be acknowledged that while Resilience Direct is a useful tool for sharing information, access within organisations across the London Resilience Partnership is often limited, if these organisations can access the system at all. Consideration will also need to be given to colleagues and organisations who cannot access the system. A process would need to be developed across the Partnership, as would a single set of critical infrastructure maps containing all the relevant information to all agencies concerned.

10.10.3 Checklists

A number of recommendations were outlined in the London Resilience Partnership Debrief Report that regarded defining roles, responsibilities, and triggers for specific actions in the preparation and response to flood incidents.

The recommendations we consider to be of note from the Debrief Report are:

- Recommendation 18: Local authorities (Lead Local Flood Authorities) to work with Environment Agency, Thames Water and Transport for London to confirm roles, responsibilities, and arrangements in place for the clearance of trash screens and gullies ahead of and/or during heavy rainfall events.
- Recommendation 20: Local authorities would like clarification on the legislation / duties that apply to Thames Water in response to surface water flooding and surcharging into/from the sewage network, this will help clarify Thames Water's responsibilities for response arrangements, decontamination / recovery, and insurance liability.
- Note 5 in Annex B: Longer-term action for individual organisations to review the actions it takes in response to the triggers / levels of weather and flood warnings in the London Strategic Flood Response Framework and Severe Weather & Natural Hazards Framework.

Checklists are one of the structures that can be used to confirm and record these actions. Checklists are helpful reference points in emergency plans as they summarise key priorities in various stages of the lifecycle of the incident. Our recommendations for checklists are as follows:

- Considerations should be made to the potential impacts that may emerge if specific actions are not completed. This allows for contingency arrangements to be outlined and implemented ahead of the risk emerging.
- Risk factors can be outlined in the checklists, one critical factor being the risk profile of surface water flooding at different times of day. During the day, occupants are likely to be awake or out from their homes at work lowering the risk to life.
- Actions for specific flood warnings can be outlined. Partnership calls continually emerged as an area for consideration in the Debrief Report. Timelines can be included on when these actions are to be implemented following weather warnings. At a local level, an equivalent process could be used through the establishment of a Local Strategic Partnership Group to allow strategic discussions.
- Finally, checklists should be placed at the start of any emergency planning document. Plans are less likely to be followed, opened, or referred to if critical information is not available immediately. Checklists can help responders as actions are immediately available and can change the course of an incident.

10.10.4 Critical infrastructure

Recommendation 27 in the London Resilience Partnership Debrief Report states Local Authorities, and the British Red Cross are to "work together to establish suitable standards for Rest Centres, including disabled access and accessibility toilets". RBKC will work to support this at a regional level.

RBKC should collaborate with flood action groups who may be able to provide community lots as evacuation locations. Working with local communities can also identify broader diversity needs that need to be accommodated.

Rest centres are a form of critical infrastructure for the immediate response to an incident. The location of these sites, and the resources required to maintain and protect them are included in the Multi-Agency Flood Plan.

Alongside this, recommendation 16 states "infrastructure sites at risk of flooding should be included in the next revision of Multi-Agency Flood Plans and referenced in the next revision of the London Strategic Flood Response Framework".

This critical infrastructure list should have:

- A point of contact,
- Impacts should the site be lost,
- Contingency plans,
- Resources required to protect the location,
- Business continuity implications to the multi-agency response should the site be lost, including contingency plans to minimise disruptions to the incident response efforts.

10.11 Review and update of the Multi-Agency Flood Plan (MAFP)

An update of the MAFPs is already in progress by Royal Borough of Kensington and Chelsea. The three existing plans (which cover different sources of flooding) are being combined into a single Multi-Agency Flood Plan. The updated MAFP should be consistent with the findings of the London Resilience partnership debrief and Task and Finish Group (see section 10.10).

The new Multi-Agency Flood Plan should be reviewed annually and following any flood event to ensure it is up to date.

10.11.1 Training and exercising

A training and exercising framework should be introduced into the Multi-Agency Flood Plan. This framework can help to ensure consistent reviews and testing of the plan.

The training and exercising framework can be scheduled for specific times of the year (i.e., a training session every 6 months, tabletop exercise once a year, simulation exercise once every 3 years etc.). This system will also help with post-incident inquiries if the plan is ever challenged.

A track record of these training and exercise sessions can also be included as an Appendix of the plan. Although not helpful in the response to an incident, any learning and subsequent updates to the plan can be recorded in a formal location and shows the consistent approach taken to keep the plan current.

Exercise scenarios should be adaptive to different events and needs of responders. Other scenarios can explore climate change incidents and wider scale flooding events.

11 Discussion and recommendations for community and residents

11.1 Flood reporting

Thames Water is the Risk Management Authority for sewer flooding. To help Thames Water to understand the scale of the flooding, and recommend the best solutions, residents are asked to report a flood in their property directly to Thames Water (see section 10.7).

All residents who have not yet reported directly to Thames Water should do so as soon as possible via this link: Thames Water Flooding questionnaire.

11.2 Flood Action Groups

Flood Action Groups are voluntary groups of residents who meet on a regular basis to work on behalf of the wider community to help try and reduce the impact of future flood events. These groups will build an understanding of the local flood risk and impacts which will help in determining appropriate actions to build the communities resilience. The National Flood Forum[69] and RBKC's Resilience team have resources to assist communities with forming Flood Action Groups.

These Flood Action Groups will be the main point of contact between the community and responding agencies. This group will support in the creation of community flood plans, and it may consider developing a community flood scheme.

Within RBKC there is an existing Residents Flooding Steering Group. If there is appetite within the community, this group should form the starting point for the formation of one or more Flood Action Groups. There may be a need for different Flood Action Groups across different wards or neighbourhoods depending on the size and varying impacts from flooding.

Flood Action Groups would work to:

- Raise awareness of flood risk within the community.
- Monitor local conditions e.g. community volunteers keeping an eye out for blocked drains.
- Develop and review a community flood plan (more detail outlined in Section 8.2.3).
- Look out for vulnerable members of the community.
- Prepare for and take action during a flood event.
- Identify key flooding issues within the community.
- Build relationships and lines of communication with key RMAs.
- Influencing the development of future flood scheme opportunities to better manage flood risk.

Flood wardens can be appointed within the Flood Action Groups, potentially for each Ward. Flood wardens will have a key role on raising awareness of any flood risk to the community and will be a key individual at helping pass on flood warnings as they are issued, will help people prepare for flooding, especially vulnerable people both during and after the flooding event.

It is important that Flood Action Groups are given ownership of how it manage its own resilience, as these measures are likely to be in response to specific challenges at the local level.

An important consideration with flood action groups is that all religions, cultures, disabilities, backgrounds and needs of the community are accounted for. The flood action group will only be effective if it can be open-minded and considerate to the whole community that lives in the area.

69 National Flood Forum: https://nationalfloodforum.org.uk/working-together/communities/what-is-a-flood-action-group/

11.2.1 Flood Plans

Once formed, Flood Action Groups should develop community Flood Plans. National Flood Forum and RBKC's Resilience team can support in the development of these plans.

Resources are available to signpost and give additional guidance on what is to be included in a community flood plan, the Environment Agency have a community flood plan template that can be downloaded and used by the community, along with a guide on how to use the template.

Specific things that might need to be considered, and where National Flood Forum and RBKC can support is on:

- Advising on safe areas for flood wardens to walk when doing door to door knocking.
- Communication lines and points of contact should the community group need to update emergency responders on activities and risks.
- Training and exercising arrangements. Flood action groups should engage in training and exercising programmes to test their plan and make sure it is effective for an incident. Local authorities may wish to attend to gain an understanding on how the plan works in practice and aligns to other emergency response plans.
- Review the plan and advise on any areas that need amending.
- Advise on resource availability and work with the flood action group to outline how resources may be provided.
- Advise on immediate recovery actions.

When preparing flood plans, considering the high risk to life for those who live in basement flats, the rapid onset of flooding that can arise with surface water and sewer flooding, and the possibility that the flood could happen at night is particularly important in RBKC.

As well as community flood plans, management committees for individual buildings of flats and apartments should consider developing their own specific flood plans.

For individual households, the Environment Agency have a personal flood plan template that is free to download and use. Emergency Flood Kits are also recommended to ensure that persons have emergency equipment and key items stored and ready should they be needed in an evacuation – or if they are to stay for an extended period in a safe part of the home. Items include:

Personal Flood Plan	Phone and charger / powerbank
Cash	First Aid Kit
Spare house and car keys	Notebook and pen / pencil
Torch (wind up or carry batteries) and portable radio	Tools for fitting PFR measures and turning off utilities
Supplies for babies (comforter, sterilised bottles and spoons, etc.)	Camera to record damage for insurance purposes
Wash kit and essential toiletries	Non-perishable food items
Bottled water	Blankets and warm clothing

All flood plans (community, building or individual household) should be reviewed at least annually and following every flood event to ensure they are up to date.

11.3 Insurance

Flood Re is a re-insurance scheme that makes flood cover more widely available and affordable as part of home insurance. It works to keep insurance affordable for households

at the highest risk of flooding, and provides support for properties at risk of fluvial, coastal, surface water and groundwater flooding.

A joint initiative between the Government and insurers, every insurer offering home insurance in the UK must pay into the Flood Re Scheme. The levy raised is then used to cover the flood risks in home insurance policies. When a property is flooded and an insurer needs to pay out, they are later reimbursed from the Flood Re fund. There are certain eligibility requirements for accessing Flood Re, for example it only covers homes built prior to 2009.

Under the Flood Re scheme you can buy your insurance as normal through a wide range of providers. You can use the online Flood Re Tool to find out if your property qualifies for Flood Re. Some useful links are given below:

- The Association of British Insurers – Advises on how to access flood insurance, provides a flood insurance directory, offers advice on priorities when preparing for and recovering from a flooding event.
- Flood Re - Flood Re is a re-insurance Scheme that makes flood cover more widely available and affordable as part of a residents home insurance.
- Flood Re Tool - to find out if your property qualifies for Flood Re.

11.4 Property Flood Resilience

Residents can address risk to their property independently and self-fund the installation of PFR measures (see more information on PFR in section 10.5). This approach can offer greater certainty for the resident as they do not have to wait for the relevant Risk Management Authority to secure funding for a scheme, and the process of having PFR measures installed can be quicker than if the works were procured through a scheme covering a large number of properties. Privately funding PFR measures also allows greater flexibility in selecting the resistance and resilience measures and where they are installed, whereas funding within schemes is usually restricted to habitable spaces and resistance measures alone.

However, a lot of onus is placed on the homeowner in funding the measures and ensuring that measures of a sufficient quality are installed correctly, often at a time when they are still recovering from the financial and emotional impacts of flooding. It is also a piecemeal approach to improving the flood resilience of properties within a community. Unless neighbouring residents can fund and coordinate installation of measures at their properties at the same time, there is no consistent standard of protection across the properties at risk of flooding. This can allow properties with PFR measures installed to remain at risk of flooding from water entering through the adjacent walls of neighbouring unprotected properties.

11.5 Disconnecting roof water drainage

Disconnecting existing rainwater downpipes and redirecting surface water runoff into property level SuDS such as SuDS planters and rain gardens, above ground water butts or underground rainwater harvesting tanks, could contribute towards relieving pressure on the existing combined sewer network during small to medium rainfall events throughout RBKC and provide sustainability benefits as a result of water re-use[70].

Rainwater can be reused for non-potable purposes such as gardening, toilet flushing and car washing through the use of water butts. They can be provided in different shapes and sizes, and can be incorporated into a variety of settings. Rainwater harvesting tanks are typically larger and stored underground with a pumped system to allow water re-use. As

70 Above-ground storage is unlikely to make a significant impact upon severe events such as 12 July 2021. For example, to store the c. 70mm of rainfall which fell, a typical terraced property with a 50m2 roof area would need 3.5m3 of storage, which is not feasible to provide above-ground in small yards or gardens.

their capacity is dependent on the re-use of water, both systems should be designed with an overflow to discharge excess water through infiltration or connection to a downstream drainage component.

11.6 Resources for residents

The following sections provide links to website and documents that may help residents to understand their flood risk, and prepare for and respond to flooding.

11.6.1 Understanding your flood risk

- Long term flood risk website – Gov.uk website where you can check flood risk from river, tidal, surface water and reservoirs for your postcode and view it on a map.
- Check for flooding – Gov.uk website where you can check for flood warnings and sign up to receive them. Note these flood warnings only cover rivers and the sea. You can also view live rainfall and river levels at gauges.
- The National Flood Forum – An independent charity who provide resources and advice on flood risk to enable people to take control of their own flooding concerns.

11.6.2 Preparing for a flood

- Be Flood Ready – Provides guidance and information on Property Flood Resilience, helping homes, businesses and communities be prepared for an event.
- Communities Prepared – A national community resilience programme that works equip communities with the knowledge and confidence to manage a range of emergencies, including flooding. Website provides a range of downloadable resources and offers support with the development of community flood plans.
- The Blue Pages – A directory of property flood products and services.
- Flood Toolkit – An interactive and user-friendly website that offers immediate actions and guidance on the prevention, response and recovery to flooding events. Can be of support when developing individual flood plans.
- Know your flood risk – pdf developed by FloodRe breaking down the process to building our resilience and understanding to flooding.
- Flood Guidance – offers advice on the different steps and consideration in the preparation for, response to a recovery from a flooding incident. Can be of support when developing individual flood plans.
- London Prepared – London Resilience Partnership website with pages on preparing yourself, your business and planning for emergencies of all kinds

11.6.3 What to do during and after a flood

- Dealing with flooding – RBKC advice on what to do and who to contact during a flood
- After a flood – RBKC advice on what to do and who to contact after a flood
- What to do if sewer flooding affects your home – Thames Water advice on how to contact them and what to do in the event of sewer flooding.
- How to recover after a flood – Gov.uk advice on recovering from a flood
- What should I do? – National Flood Forum advice on how to recover from a flood

12 Conclusion

The flooding that occurred on 12 July 2021 impacted at least 76 streets and over 340 properties in RBKC. The Royal Borough of Kensington and Chelsea, as the Lead Local Flood Authority for Kensington and Chelsea, has exercised its power to undertake a Section 19 investigation as this fulfilled its criteria of 'significant flooding' (Section 1.1).

Analysis of the rainfall and river levels recorded during the event (Section 7) indicated that the return period of the storm event varied significantly across RBKC depending on the location and the storm duration. In the south of the Borough, the return period of the storm based on the radar data was less than 1 in 2 years. The maximum return period of the storm event, based on the radar data in Notting Hill, indicates that the storm event was likely to be up to a 1 in 185-year event (rounded to the nearest 5 years) in the areas that experienced the heaviest rainfall. This is comparable with the estimates from the Met Office across London of return periods of up to 179 years for the amount of rain that fell in one hour[71].

The Chelsea tide gauge located on the River Thames shows that high tide coincided with the heavy rainfall. It is likely that the observed flooding was caused by extreme rainfall falling on a heavily urbanised catchment which was exacerbated by high tide levels in the River Thames impeding sewer drainage.

The main source of flooding was the intense rainfall during the event. This then flowed overland and drained into highways gullies and the combined sewer system. However, because of the high volume of intense rainfall, many sewers surcharged, with drains overflowing on the streets. This, combined with the continuing large amount of rainfall, created a large amount of overland flow which then collected in basement properties or at the ground floor level. The high flow volumes in the sewers also flooded properties internally by backing up through domestic wastewater pipes and coming up through toilets and shower drains, primarily if the property was at the basement level.

Multiple organisations responded to the event (Section 8). There were thousands of calls across London to various organisations, including London Fire Brigade and Thames Water. In RBKC, the Council also took several calls from flooded residents and dispatched on-call liaison officers to the sites, while establishing the Borough Emergency Control Centre. The control centre took calls from residents while coordinating with the on-site teams, the police, London Fire Brigade, and was the contact point for other agencies outside of the borough.

Thames Water and London Fire Brigade also sent their own teams to various areas across London, but with the number of events occurring across the city, their resources were stretched thinly. While the rain mostly stopped at around 18:00, many properties in RBKC still had floodwater which had to be removed. At 19:15, London Fire Brigade declared a major incident and requested resources such as sandbags and water pumps from organisations and boroughs across London, including the Environment Agency. London Fire Brigade at 23:09 then sent a stand down message for the major incident, but continued to work throughout the night across London to remove the floodwater still in properties.

In RBKC, the Council and Thames Water were involved in cleaning properties and organising temporary accommodation. After one week, some flooded residents had returned home, while the majority remained in hotels. Those in privately rented accommodation had their landlords and insurance take up the cost of temporary accommodation.

71 Thames Water (2021). Internal Review into 12 and 25 July 2021 storms in London: https://www.thameswater.co.uk/media-library/home/about-us/investing-in-our-region/flooding-review/july-flooding-internal-review.pdf

A list of possible recommendations for RMAs (Section 10) and the community/individual property owners (Section 11) have been developed and discussed and are summarised below:

Recommendation	Owner(s)
Carry out an independent review of sewer flooding and implement the recommendations	Thames Water (in progress)
Engage with and scrutinise the findings of the Thames Water independent review	RBKC (in progress)
Opportunities to retrofit SuDS should be prioritised wherever possible whether that be through specific schemes with Thames Water or government funding or through routine incorporation into urban regeneration and highways projects	RBKC, Thames Water
SuDS opportunity mapping	RBKC (in progress)
Joint campaign of community engagement and information to residents on how to prepare for a flood, who to contact during a flood, what to do after a flood. Repeat annually. Clear and consistent signposting on websites.	RBKC, Thames Water
Investigate the feasibility of a government funded PFR scheme in RBKC, or in partnership across a wider London area using the Environment Agency Flood Resilience Framework	RBKC (in progress)
Develop and implement an independent forecasting system for surface water flooding	RBKC (in progress)
Share sewer forecasts with other RMAs	Thames Water
Work together to streamline and triage the flood reporting process	RBKC, Thames Water and wider London Boroughs
Review and improve the accuracy of tipping bucket rain gauge at Holland Park or install high capacity rain gauge to more accurately record periods of intense rainfall	Environment Agency
Consider increasing frequency of highway gully cleaning in flooding hotspots	RBKC
Regular review of Critical Drainage Areas	RBKC
Review and update Multi-Agency Flood Plan and implement a process of review annually and after any flood event	RBKC (in progress)
Implement a training and exercising framework for the Multi-Agency Flood Plan	RBKC
Implement recommendations of the London Resilience Partnership Debrief and Surface Water Flooding Task and Finish Group	RBKC and wider London RMAs
Formation of community Flood Action Groups	Community
Production of community Flood Plans	Community
Report past sewer flooding to Thames Water	Individual property owners
Personal or building-level Flood Plans	Individual property owners/management committees

Use of Flood Re insurance scheme	Individual property owners
Disconnecting roof water drainage / property level SuDS	Individual property owners

THE ROYAL BOROUGH OF
KENSINGTON
AND CHELSEA

JBA consulting

Offices at

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

Registered Office
1 Broughton Park
Old Lane North
Broughton
SKIPTON
North Yorkshire
BD23 3FD
United Kingdom

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

Jeremy Benn Associates Limited

Registered in England 3246693

JBA Group Ltd is certified to:
ISO 9001:2015
ISO 14001:2015
ISO 27001:2013
ISO 45001:2018