Counters Creek
Understanding Flood Risk and Long-Term Strategy
(Main Report)

Table of Contents

List of figures:

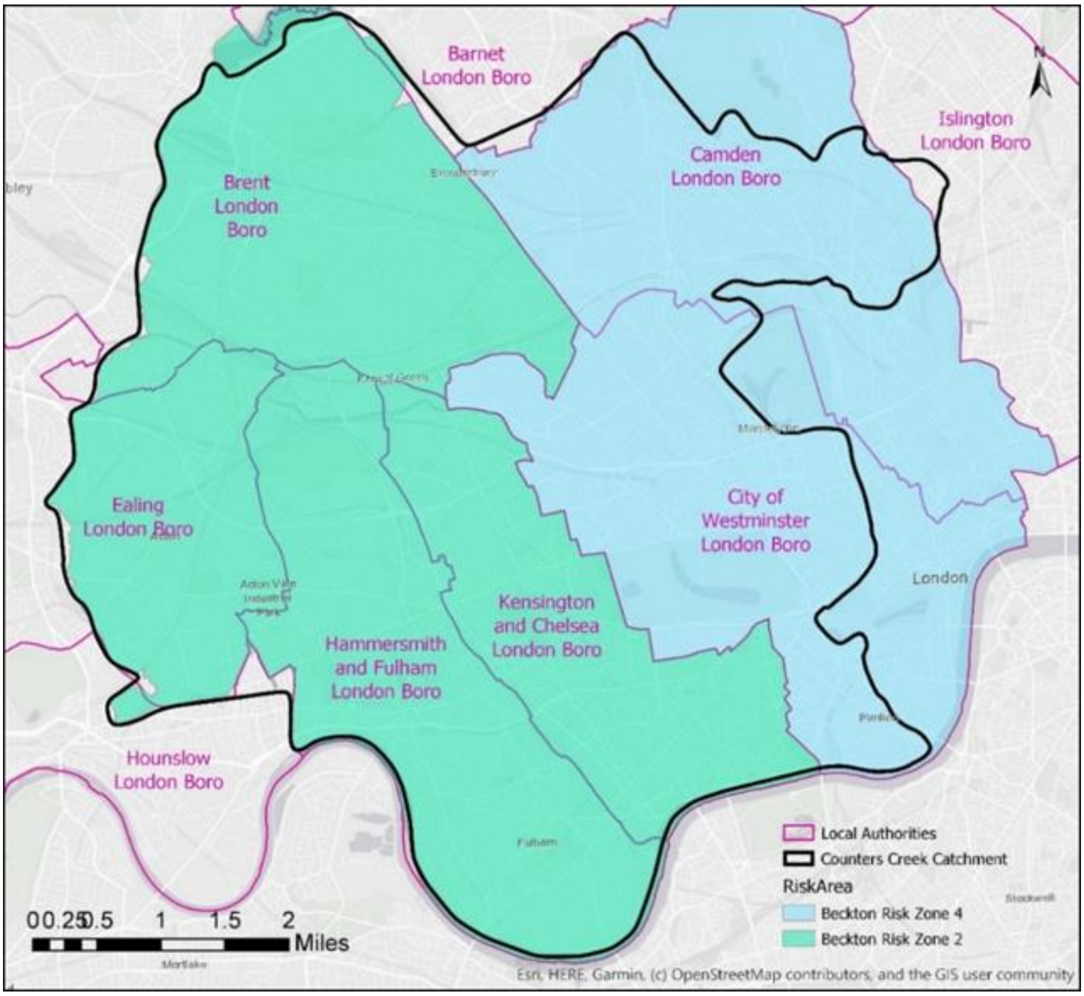
List of tables:

Section 1

Introduction

1.1 The Counters Creek Catchment runs through the boroughs of Kensington and Chelsea, Hammersmith and Fulham, City of Westminster, Camden, Brent and Ealing as shown in Figure 1.

Figure 1: Counters Creek area (black boundary)



1.2 Following concerns from stakeholders, Ofwat introduced a performance commitment for AMP7[1]: by the end of July 2023 we must deliver a fully assured report for the Counters Creek catchment which sets out our understanding of flood risk to customers and the level of flood resilience within the catchment. We must also outline our long-term strategy for alleviating flooding in the area.

[1] Performance Commitment PR19TMS_CC: Understanding the risk of flooding and level of resilience within the Counters Creek Catchment

1.3 Within the performance commitment Ofwat also set out some detailed technical questions for us to answer. Each of the sub-headings in this report relate to these questions.

1.4 The purpose of this report is to explain the work we have done to address the performance commitment to our customers. Section 2 of our report outlines the activities we have undertaken and the progress we have made in understanding the risk of flooding to our customers. Section 3 describes our short-, medium- and long-term strategy for addressing flood risk within the catchment. Section 4 lists out the clauses of the performance commitment and signposts the supporting evidence contained in sections of this report including technical appendices, our London Flood Review Report, our Drainage and Wastewater Management Plan (DWMP) for 2025-2050 and our Operating Techniques for the Thames Tideway Tunnel.

1.5 Our increased understanding of flood risk and resilience has been developed within the statutory DWMP Framework and in conjunction with representatives from 18 different affected stakeholder groups. Within the DWMP Framework Counters Creek is part of the Beckton Catchment Strategy Plan (CSP) which will be published on our company website in June 2023.

1.6 On 12 July 2021 over a month's rainfall fell in under an hour, with Kensington, Westminster and Hammersmith being the most affected. Over 80mm of rain fell (170% of July's average rainfall) in a few hours over the course of the storm. The Met Office has confirmed return periods of up to 179 years for the amount of rain that fell in one hour. This coincided with a peak in high tide, which meant that the water in the combined sewer could not escape into the Thames. To put this into context, the joint probability of this magnitude of storm occurring at the same time as a peak high tide is 1 in 716 years[2]. While this is highly unlikely it has enabled us to supplement our understanding of the risk of flooding in a 1 in 30-year and 1 in 50-year rainfall event alongside a more extreme event.

1.7 The scale of the flooding from the July 2021 storms and the need to address this growing risk prompted us to commission an independent review into the causes and strategic solutions to flash flooding. This has allowed us to better understand the changing impacts of flood risk from climate change and put actions in place to improve resilience.

1.8 We have worked with an Independent Experts Group, consisting of three experts with industry-leading knowledge and experience in drainage modelling, flood risk management and legislation/regulation. They ensure independent challenge to our approaches and rate of progress. This Technical Report and supporting evidence has been fully assured as required by our assurance processes including our external assurer Mike Woolgar.

[2] A probability of 716 years has taken account of storm return period of 179 years coinciding with the probability of a high tide (6 hours in a 24-hr period preventing discharge into the Thames).

Section 2

Improvements in understanding flood risk

A Improvements in information available to us

2.1 We recognise that there was a need for us to improve the depth, scale and quality of information available to us to assess flood risk and develop a long-term strategy for resolving flooding in the Counters Creek area. Over the last three years, we have significantly improved the information available to us through application of the Drainage and Wastewater Management Planning Framework and by learning from historic events. Key improvements include:

- Learning from historic events: following the London Floods in 2021 we collated an additional 28 types of data, 13 of which were from third parties (Technical Appendix for Information). Examples include asset data (from us and third parties), operational and monitoring data, tide levels, rainfall, effectiveness of past projects, flooding instances (5 sources), and basement[3] data.
- Learning from historic events: surveying of basement property levels to improve our understanding of flood risk to customers (section 2.52) and the data we collect on root cause as part of investigations (section 2G and Technical Appendix for Flooding Investigations).
- Collation and analysis of third-party asset data in order to assess the impact on flood risk (section 2C and Technical Appendix for Information) and third-party reports of flooding (Technical Appendix for Information).
- Surveys to verify connections with other catchments contributing flows to Counters Creek (section 2D and Technical Appendix for Connectivity).
- Ongoing monitoring data to ensure our hydraulic model is replicating storm events (section 2B and Technical Appendix for Modelling).
- Assessment of long-term emerging risks such as population change, urban and climate change (section 2H).
- The operation of strategic pumping stations to prevent flooding (section 2I) and operational data to manage the network on a daily basis (Section 3E).
- Event duration monitor data, pump run times, depth monitors and treatment works influent monitors to help us understand the impact of tides, groundwater and infiltration on flooding and how different rainfall intensities affect flooding across a widespread area (sections 2F, 2E and Technical Appendix for Resilience).
- Mapping of our vulnerable customer database to properties which have flooded, so we can take this into account when prioritising remedial work (Section 3E).

[3] A basement is part of a building that is partly or entirely below ground level.

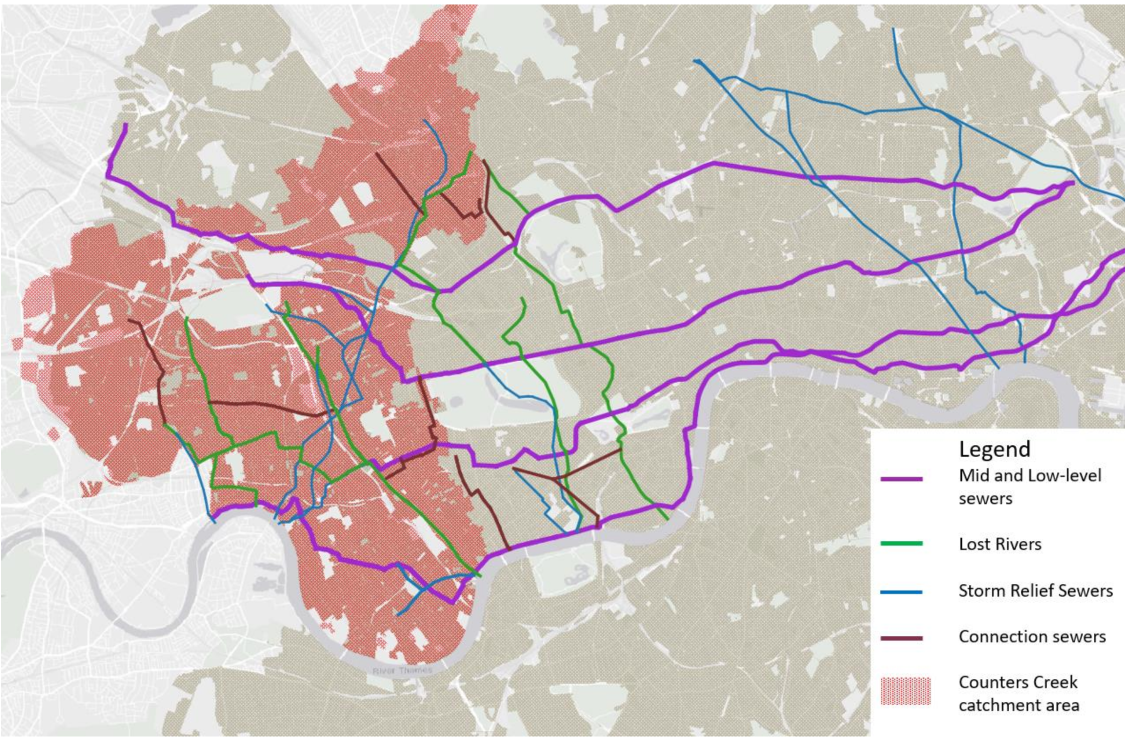
2.2 We pursue a co-operative approach working with and sharing knowledge with our stakeholders as required by section 13 of the Flood and Water Management Act (2010). As part of our DWMP process we have undertaken significant engagement with the Lead Local Flood Authorities, Catchment Partnerships, Thames Regional Flood and Coastal Committee Strategic Partnerships.

2.3 Our DWMP stakeholder community is substantial, with 54 Lead Local Flood Authorities (LLFA), 27 Catchment Partnerships, and 13 Thames Regional Flood and Coastal Committee Strategic Partnership areas, who represent our 15 million wastewater customers. Our approach to engagement, the channels used and the subjects discussed, and the frequency of engagement are described in our DWMP for 2025-2050 Appendix F – Stakeholder Engagement[4]. This also captures the key lessons learned from stakeholders which have been taken into our DWMP process.

B Developments in modelling to assess flood risk

2.4 We recognise that we did not provide sufficient transparency of the granularity of our hydraulic model, and the extent to which it is integrated with other catchment models when we submitted evidence for our AMP6 performance commitment. Therefore, we have provided a detailed explanation of how our model has evolved over time in the Technical Appendix for Modelling.

Figure 2: Map of Counters Creek catchment showing main sewer connections with surrounding catchments



2.5 London catchments are unusually large and complex. Counters Creek forms part of the Beckton catchment and borders Mogden and Deephams catchments. We model the

[4] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-f-stakeholder-engagement.pdf

interrelationships with the Mogden and Crossness catchments so that the risk of flooding in Counters Creek and upstream/downstream, including the interaction with the Thames Tideway Tunnel, is well understood. The Deephams catchment does not connect into the Counters Creek area. Figure 2 shows a map of the Counters Creek catchment and the sewers connecting with other catchments.

2.6 Our hydraulic model has been audited and is compliant with the latest adopted industry modelling guidance.[5] It meets the recommended granularity for estimating the level of flood risk[6], and where we undertake investigation or design work, we understand how customers' individual properties are affected[7].

2.7 Our model for Beckton has been evolving over the last 30 years, so that it is the largest, most detailed, and complex model at Thames Water and possibly in the UK. We undertake regular calibration, verification, and on-site investigations to ensure it reflects actual flooding and current operational practices. It is the most monitored and understood network in our area.

2.8 The maturity of the modelling has been demonstrated by effectively replicating the large storm events and resulting flooding such as occurred in the extreme weather events on 12 and 25 July 2021. The model can be used in a live manner, providing insight to the hydraulic performance of major assets, key interactions across the network and to validate root causes of flooding soon after it is reported. Close comparison of modelled and automatically monitored sewer water levels demonstrates the representativeness of the model across a range of storm events.

2.9 Since the beginning of AMP7 (2020) we have made a number of improvements to our modelling approach to better understand the risk of flooding to our customers from our network.

- We have updated the model to 1) account for the beneficial impact of the sustainable urban drainage solutions that have been implemented in five streets in the London Borough of Hammersmith and Fulham; 2) ensure the model replicates all reported flooding and information from household surveys arising from the significant storms in July 2021.
- We have worked with our Independent Expert Group to develop the best possible method for our models to reflect the risk of flooding of basements, taking into account the acknowledged limitations of the most advanced modelling software available. The relationship between basement connectivity and flood risk is complex. Even though basements exist it does not mean they are connected because they may not contain a basin or toilet. Even if a basement is connected and may be modelled as at risk, the homeowner may have taken steps to mitigate the risk. Basements that are not connected can still be flooded through overland flow entering through the light well, air bricks, doors and windows. Therefore, it is not as straight forward as to whether a property is or is not connected and it is a continually changing picture as homeowners undertake renovations which they are not required to notify us of. Therefore, surveys in

[5] CIWEM Urban Drainage Group (UDG) (2017) Code of Practice for the Hydraulic Modelling of Urban Drainage Systems (COP)).
[6] Type II Model as defined by CIWEM Urban Drainage Group (2017) Code of Practice
[7] Type III Model as defined by CIWEM Urban Drainage Group (2017) Code of Practice

response to flooding and learning from historic events will remain key to us having an as full as possible picture of customer flooding risk.

- We have combined our Beckton and Crossness strategic models with our detailed Beckton model in order to assess the risk of flooding up to 2050 taking into account growth, climate change and the commissioning of the Tideway Tunnel in 2025. The output of this work is shown in section 2H.
- A current limitation of the recommended DWMP[8] modelling approach is that it assumes rainfall falls uniformly over a catchment. Our analysis of flood risk sensitivity to different rainfall intensities, durations and locations demonstrates that in a catchment the size of Beckton or Mogden that is rarely the case (see section 2E), with the nominal rainfall intensity threshold reached only in parts of these large catchments. Therefore, the risk of flooding set out in the DWMP as shown in section 2.60 is likely to be an overestimation.
- Our ICMLive tool allows us to simulate storm events based on Met Office forecasts to provide an early warning for storm flows. This allows us to improve our response to customers and provides information to verify and continually improve our hydraulic model.

2.10 Further technical supporting evidence on these points is included in the Technical Appendix for Modelling.

2.11 We recognise that refinement of the hydraulic model and data collation is a continuous process. Over the next six months, 50 further depth loggers will be installed at key trunk sewer intersections across the Beckton catchment as part of our Smart Network Programme aimed at reducing blockages, as explained in section 3.58~~3.~~. The extension of the network of loggers has been selected to give a broad whole-catchment coverage of the main flow paths between the trunk sewer and storm relief systems to understand better how flows move from one section of the network to another. This will continue to improve insight to understand the interaction between trunk system arteries and inform future performance of the network.

2.12 In addition to the model validation, field surveys and system monitoring, we intend to make improvements in the following areas:

- Increase the proportion of 2D modelling in areas which have been modelled to replicate the flow paths for above ground (surface) water entering the sewerage system, so we better understand customer flood risk root causes.
- Move our modelling to the cloud, which will overcome some of the current limitations we have on run times and our ability to extend the current model.
- Investigate opportunities for optimisation and variable control of the network once the Tideway Tunnel is commissioned in 2025.
- Undertake more real-time modelling to improve the effectiveness of our customer response during, or immediately prior, to heavy rainfall events.

[8] Uses Design estimation rainfall events Flooding Estimation Handbook (FEH13)

C Improvement in our understanding of interaction with third party assets

2.13 We approached the Royal Borough of Kensington and Chelsea, the London Borough of Hammersmith and Fulham, Highways Agencies, Transport for London, the Environment Agency, and Network Rail to request the sharing of asset data with the aim of mapping this against the reported flood problems to reveal what, if any, interactions there are with our assets.

2.14 We have an emerging picture of whether Network Rail's drainage assets contribute to increasing flood risk. The main connections are associated with the Old Oak Common railway junction which has undergone significant redevelopment in the last 5-10 years. Crossrail and High Speed 2 operations have resulted in the old marshalling yards and track in the area being redeveloped. We have carried out detailed flow monitoring and impact assessment studies and have confirmed that new development is not expected to increase the risk of flooding (section 2.61).

2.15 The tidal flood defence walls of the Environment Agency do not significantly interact with our network as our outfalls cut through these walls. Although in theory surface water (overland flow) could become trapped behind flood walls in periods of heavy rainfall, we have not been able to find any evidence to support that this is increasing flood risk.

2.16 We have actively engaged with the Lead Local Flood Authorities (Royal Borough of Kensington and Chelsea, London Borough of Hammersmith and Fulham and City of Westminster), who have provided further information on locations and instances of flooding which we have used to improve our model accuracy. We have supplemented this with information from social media and moved our sewer flooding questionnaire online, so it is easier to complete and submit. There is also the option to report sewer flooding by phone.

2.17 The majority of the Counters Creek catchment has a combined sewerage system so surface water runoff from road gullies and roof drainage goes into the sewerage system. This increases the risk of sewer flooding during heavy rainfall. Section 2.53 shows four maps where surface water contributed to the root cause of flooding in July 2021.

2.18 Our existing hydraulic models already take account of the flows from all known lost rivers, which have been incorporated into the sewerage system, and of the impact of flow from downpipes and highway drainage from gully maps. By placing monitors at specific locations within the catchment we have proved that the hydraulic model sufficiently replicates the rise, fall and response of the sewer network to rainfall which includes the impact from roof and road drainage. Therefore, these flows are already taken account of in our assessment of flood risk.

2.19 To gain a better understanding of the risk of flooding from surface water (overland flow) we have undertaken analysis to understand how much surface water enters the sewers during storms and how much remains above ground. This analysis used our rainfall data, sewer flooding reports and sewer monitor data. We concluded that for the 12 July event approximately 30% of rainfall was unable to enter the combined sewer systems, due to blocked gullies, downpipes or the flow rate exceeding the capacity of road gullies. Therefore, any work to unblock or increase the capacity of road gullies draining to a combined sewer may increase the risk of sewage flooding to customers.

2.20 Further technical supporting evidence on these points and a description of the new information sources is included in the Technical Appendix for Information.

D Improvement in our understanding of interaction with other catchments

2.21 As described in the modelling section, our models cover a widespread area, and we model the impact of interlinked catchments on each other. We have also modelled the impact of how flood risk will change when the Tideway Tunnel becomes operational in 2025.

2.22 The Beckton catchment flows from west to east. Counters Creek forms the northwest part of the Beckton catchment. It borders the Mogden catchment which takes flows to the west and Deephams to the north. The connections between the Beckton and the Deephams networks are downstream of the Counters Creek area, so the Deephams catchment does not contribute to flood risk in Counters Creek.

2.23 During the last two years, we have undertaken a number of additional surveys to better understand the four points of interactions with the Mogden catchment. Review of this improved information has concluded that there is no discernible increase in flood risk from the interaction with the Mogden catchments. One of the cross connections was never constructed and the other three are via small, 150mm diameter pipes so contribute a very small proportion of the total volume in connected areas.

2.24 The risk of flooding downstream of the Counters Creek area is low because there is available sewer capacity downstream in Westminster in the Beckton catchment. There is some backing up from downstream catchments, but this is localised and occurs when the storm relief sewers don't have capacity. This does not result in flooding.

2.25 There is a risk of flooding upstream of Counters Creek in Acton, which varies depending on the magnitude and position of the rainfall event. Acton flows are largely controlled by the Acton storm tanks and the new Tideway connection on this site. In this area it is known that the hydraulic model over predicts the risk of flooding, so further investigations will be undertaken as part of our CSP.

2.26 Further technical supporting evidence on these points is included in the Technical Appendix for Catchment Connectivity.

E Improvement in our understanding of rainfall return periods and resilience

2.27 In the last two years we have undertaken additional sensitivity analysis to enhance our understanding of how rainfall of different intensities, durations and spatial distribution affects flood risk across a widespread area. This complements the work that we did at the time of the original Counters Creek tunnel scheme design in AMP5.

2.28 Our current approach goes beyond the CIWEM Urban Drainage Group (2017) Code of Practice, as we have prepared guidance on how to simulate rainfall on large catchments by using three different profiles instead of one. Our approach and rationale for choosing this is explained in section 2.4.2 of the Stage 3 Report of the London Flood Review.

2.29 In the recent analysis we used historical rainfall data to determine how rainfall falling over a different part of the catchment would affect maximum water levels in sewers and resulting flood risk. By moving the rainfall 2km in each direction (north, south, east and west) we were able to conclude that:

- When rain is centred over the northwest of the catchment, flood risk to customers is higher than when rainfall falls to the southeast of the catchment.

- Rainfall to the west creates a higher risk of flooding to customers in Shepherds Bush and Hammersmith as the capacity in this area is reduced due to increased flows from the upstream areas of Stamford Brook and Acton.
- Rainfall to the north increases the risk of flooding to customers in Kensington and Notting Hill as the capacity is reduced due to increased flows from the upstream areas via the Counters Creek mainline sewer and the Northwest Storm Relief sewers.
- When rainfall falls to the south and east, downstream of Counters Creek, the flood risk to customers is significantly reduced as there is more sewer capacity in the downstream network for flows to discharge.

2.30 If the rainfall on 12 July 2021 had occurred further east, our modelling estimates there would have been approximately 14% more customers (properties) affected by flooding. This is due to the density of the properties rather than the interconnectivity between the Counters Creek catchment and the downstream network. Shifts in other directions predicted a difference of 5-6% which is considered small and likely due to variances in property density.

2.31 Typically, we use a 1 in 30-year return period design standard for new flood protection schemes with a range of duration storm events.

2.32 Further technical supporting evidence is included in section 3 of the Stage 2 London Flood Review report.

F Improvement in our understanding of resilience to tide/river levels and groundwater/infiltration

Infiltration and groundwater

2.33 Due to the number of ditches, streams and lost rivers that have been incorporated into the London sewerage system since Victorian times, there is a baseflow which represents about 33% of the peak dry weather flow in the Counters Creek Catchment. This is a small contribution compared with storm flows and therefore has a negligible impact on the risk of flooding. In the last two years we have improved our understanding of resilience through an assessment of ground water infiltration using 4 different data sources:

- Analysis of long-term pumping station run times
- Event duration monitors (EDM)
- Depth logger data from sewers within the Counters Creek catchment to review the local seasonal variation in baseflows
- Flows arriving at Beckton STW to determine catchment-wide seasonal variations in flows

2.34 Seasonal variation in pump run times, or changes in flows particularly in very wet weather would be a good indicator that groundwater infiltration may seasonally affect flood risk. Our analysis set out in the Technical Appendix for Resilience shows that we did not find any evidence of seasonal variations in groundwater infiltration or storm induced infiltrations and therefore we do not consider these to be factors affecting flood risk.

Tide and river levels

2.35 There are 34 combined sewer overflows which will discharge to the Tideway Tunnel instead of the river Thames in 2025. Currently during high tides, the flap valves on the combined sewer overflows close to prevent the tide from entering the sewer system. Only pumped sewage can enter the river Thames. Pumping against the tide reduces pump capacity causing sewers to back up resulting in an increased flood risk in Hammersmith. This risk will reduce significantly when the Tideway Tunnel becomes operational, as shown in Tables 1 and 2, because the sewers can discharge into the Tunnel.

2.36 At Western Pumping Station outfall capacity is thought to be reduced for about 3 hours around the high tide peak, through pumping against the tide. This potentially increases flood risk as flow backs up depending on the sensitivity of particular areas to changes in water levels.

2.37 Our analysis shows properties that drain to gravity sewers have a higher risk of flooding than properties whose flow is pumped by pumping stations. Those closest to the river have a higher risk than those further away. The area of Hammersmith has a higher risk of flooding due to the concentration of storm relief sewers and its low-lying nature.

2.38 Our DWMP modelling assumed that the Thames Barrier is operational and able to cope with the increased tidal ranges. The Thames Barrier is being operated more frequently than first anticipated, but the upstream levels will be protected for as long as the Barrier is being operated effectively. We use latest available tidal predictions from the Port of London Authority to feed into our modelling.

2.39 Further technical supporting evidence on these points is included in the Technical Appendix for Resilience.

G Improvements to our understanding of historic flood risk and investigation of future flood risk

2.40 We have processes in place to record and investigate instances of flooding, which are reported either directly to us or via the Lead Local Flood Authorities. Our Sewer Flooding Methodology Supporting Guidance document details the processes used to capture and investigate reports of flooding events. Extracts of the guidance including a list of the information we collect are contained in our Technical Appendix for Flooding Investigations. Each report of flooding is investigated (desktop and/or site visit).

2.41 We regularly undertake reviews to learn from and further our understanding of the root causes of flooding. The most comprehensive review was the London Flood Review following the extreme weather events on 12 and 25 July 2021. We have committed £10 million to understand the risk of sewer flooding in Counters Creek and improve the resilience of customers at higher risk of being flooded again in the future.

2.42 The review was completed and published on 12 July 2022. The purpose of the review was to understand why the flooding in July 2021 was so severe, whether the historic design of our sewer systems had an impact on the locations and extent of reported flooding and how the operation of the system impacted flooding. It consisted of four reports, which we have included as Technical Appendices.

- Stage 1 – An objective review of the available data relating to the flooding on 12 and 25 July 2021.
- Stage 2 – An investigation into the catchment response and root causes that led to flooding on 12 and 25 July 2021.
- Stage 3 – An assessment of the performance of Thames Water assets including flood alleviation schemes, critical pumping stations and operational performance of the network during the flooding events on 12 and 25 July 2021.
- Stage 4 – A summary of the lessons learned and recommendations to improve resilience to future flooding events.

2.43 To ensure a fully transparent and impartial process, we commissioned an Independent Expert Group consisting of three experts with industry-leading knowledge and experience in sewerage and drainage modelling, legislation and regulation, and flood risk management, to lead the review.

2.44 A Strategic Stakeholder Panel comprising representatives from the key strategic organisations in London with a responsibility for, and interest in, surface water and sewers was established to review the scope and objectives, and to endorse, promote and enact the findings.

2.45 The recommendations from the review and our actions taken are set out in our DWMP 2025-2050 in Appendix P: Our response to London Flooding 2021- June 2023[9].

2.46 The remainder of section 2 sets out the actions relevant to Counters Creek that we have adopted following the review which have improved our understanding of flood risk.

2.47 We have analysed customer contact data to identify properties which were flooded either for the first time or as a repeat flood. We identified additional flooded properties from our discussions with the Lead Local Flooding Authorities and from social media and news articles. Each of these properties was sent a letter offering a survey.

2.48 We have written to 3,402 properties we know or think may have flooded in Hammersmith and Fulham, Kensington and Chelsea, Westminster Camden and Brent. Of the 3,402 properties:

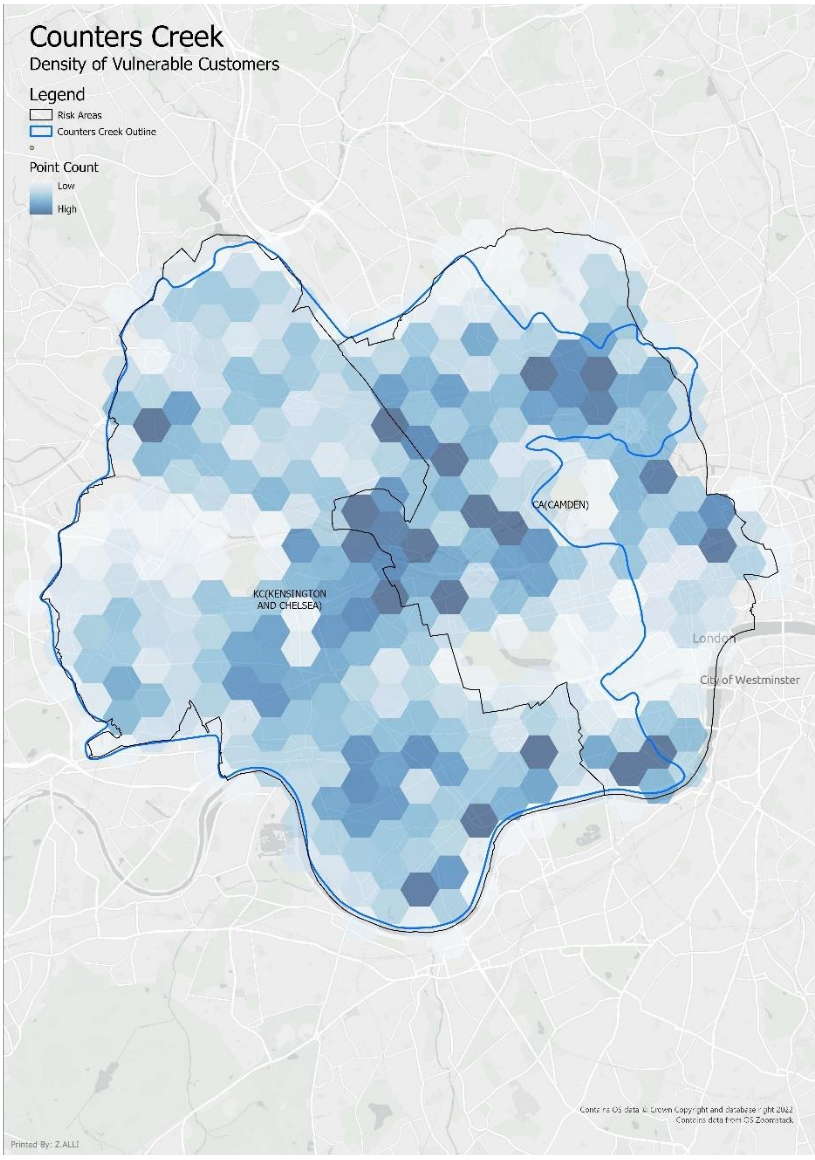
- 773 properties have reported their flooding either directly to Thames Water or to a stakeholder who then shared this with us (e.g. a Borough).
- 2,629 properties are those which we think may have flooded but have not reported it.
- Of the 2,629, 782 customers have now confirmed their property has flooded and their property has been added to the flooding register.
- All 1,555 (773+782) properties that have previously reported or confirmed their flooding have been contacted to arrange a survey.

[9] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-p-response-to-july-2021-floods.pdf

- As at the beginning of April 2023, 911 (59%) of these properties have booked a survey and 903 (99%) of those surveys booked have been completed.

2.49 To improve our understanding of whether vulnerable customers have been affected by flooding we have overlaid our register of vulnerable customers onto our register of customer flooding. This data has been used to ensure we prioritise operational responses, investigations, and mitigations to our vulnerable customers. Figure 3 shows the locations of where the highest density of vulnerable customers are in the Counters Creek area.

Figure 3: Density of vulnerable customers in the Counters Creek area



2.50 We have reached out to our vulnerable customers by ‘door-knocking’. To ensure we focused on our most vulnerable customers first, we set three levels of priority for surveys: 1) vulnerable customers who live in basements, 2) customers who were non-contactable during the delivery of the Counters Creek scheme and surrounded by properties which have been flooded before and have mitigation measures in place, 3) customers who have been identified as at risk from flooding as predicted by the hydraulic model.

2.51 In parallel, we have promoted the need to report flooding and book a survey through local media, social media, and faith groups. Where customers have reported flooding but not booked a survey, we have followed up with them three times via email, letter and door knocking. We have worked with Borough officers to share with them lists of areas where we have low numbers of responses.

2.52 We combined the following information to understand why a property flooded and to assess its future flood risk:

- Property survey information
  - How the property connects to our sewer and which sewer/s it connects to and its size
  - The depth of the connection vs the lowest point of the property's drainage system
  - The impermeable area of the property
  - Details about the property type and customer vulnerability
- Flood history
  - Review of the information from the Sewer Flooding Questionnaire
  - Any previous reported flooding and from what severity of storm
- Modelled flood depth – the maximum water level in the sewer in a 'major' storm (3.3% AEP storm)

2.53 Figure 4 Figures 4 to 7 show examples of the analysis that is undertaken to understand flooding hotspots. These figures relate to the flooding on 12 and 25 July 2021 and show the locations of properties that flooded and root causes.

2.54 Sections 2 and 4 of the Stage 2 London Flood Review Report provide a full description of the analysis undertaken and include reference to previous flooding events, the replication of the modelled flooding vs actual flooding and the impact of factors such as flooding coinciding with operational pump failures and high tides. It also includes analysis of the impact of surface water entering the system.

2.55 It should be noted that many customers do not know who to report their flooding to and many more are reluctant to report flooding due to concerns about the potential impact on their property's value, rental income and insurance costs. Therefore, reported flooding significantly under-represents actual flooding.

Figure 4: London Borough of Hammersmith and Fulham flooding root causes July 2021 as identified in March 2022

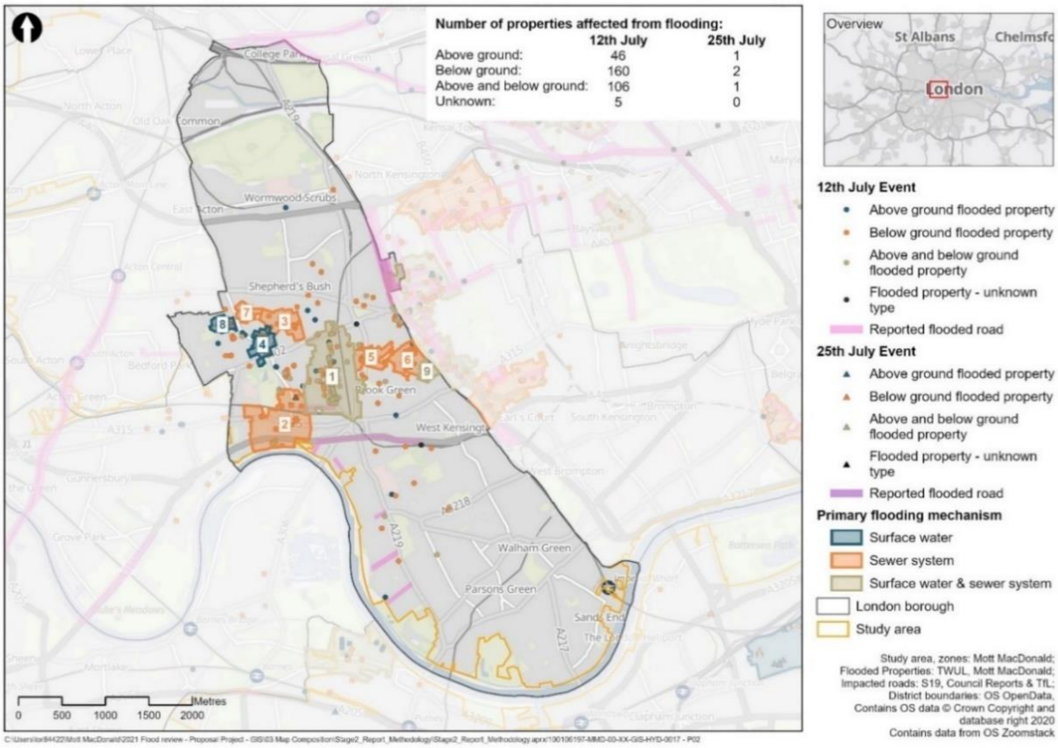


Figure 5: Royal Borough of Kensington and Chelsea flooding root causes July 2021 as identified in March 2022

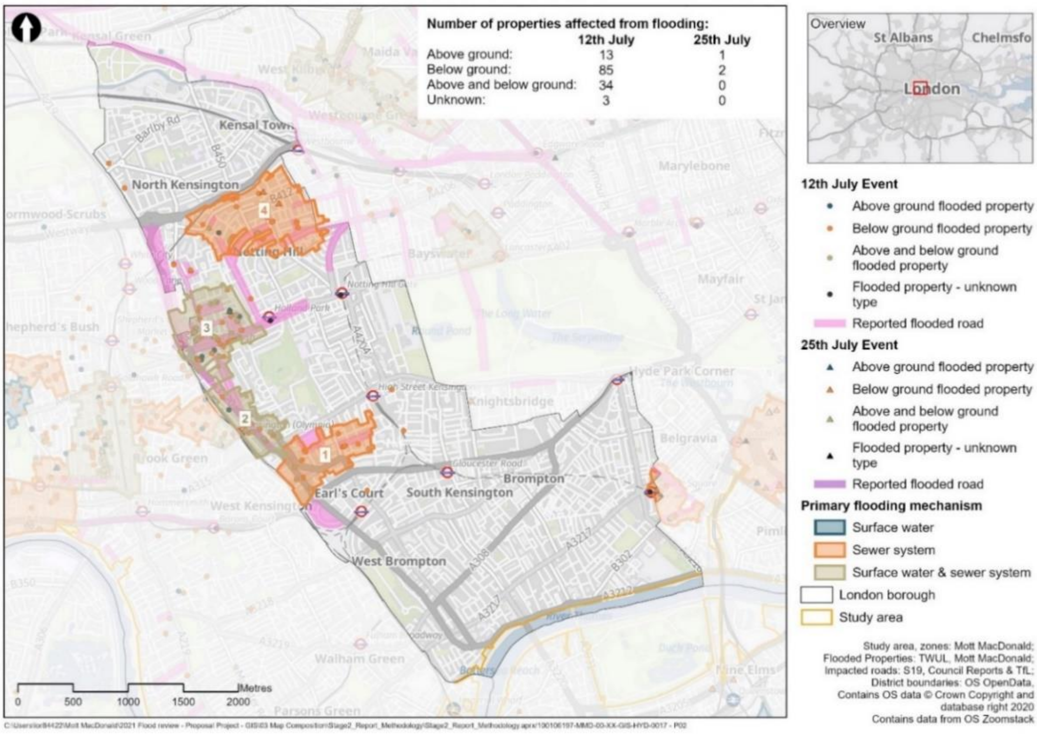


Figure 6: City of Westminster flooding root causes July 2021 as identified in March 2022

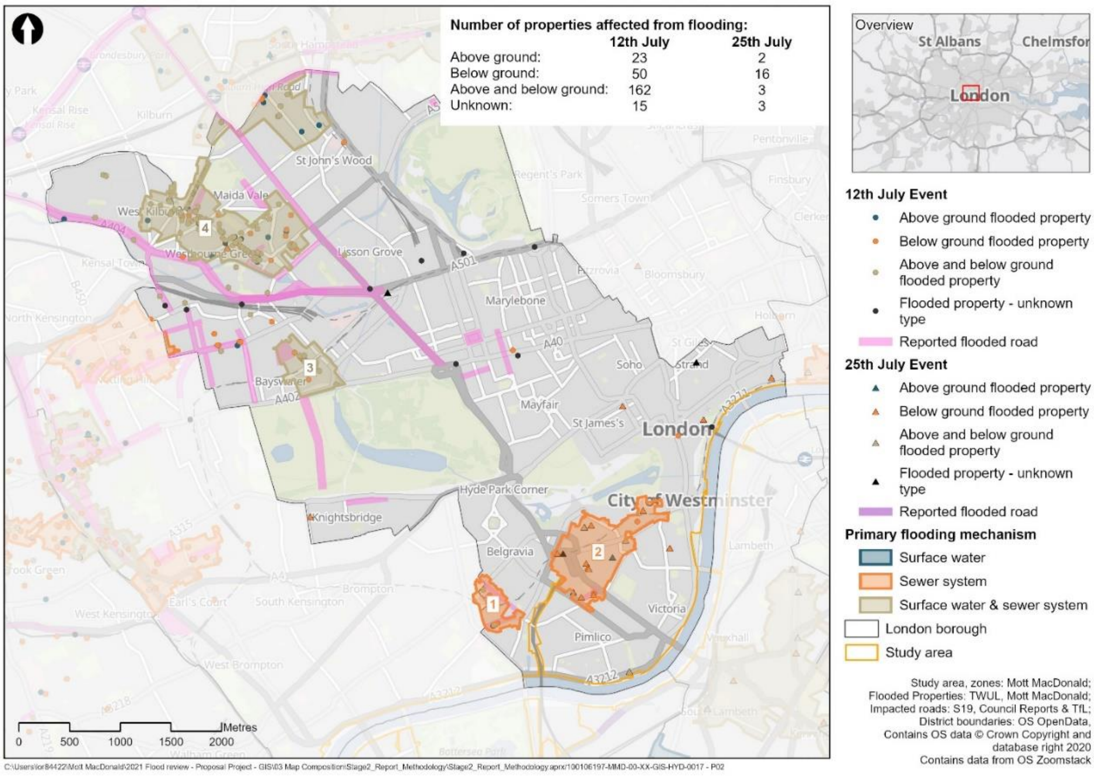
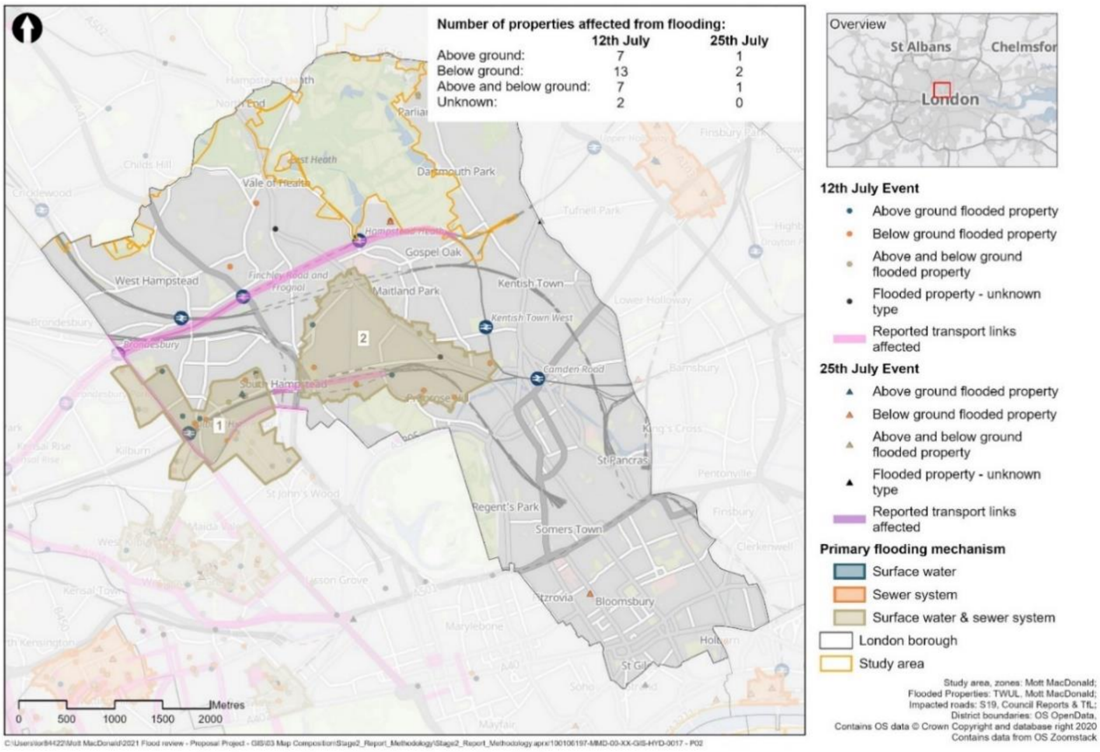
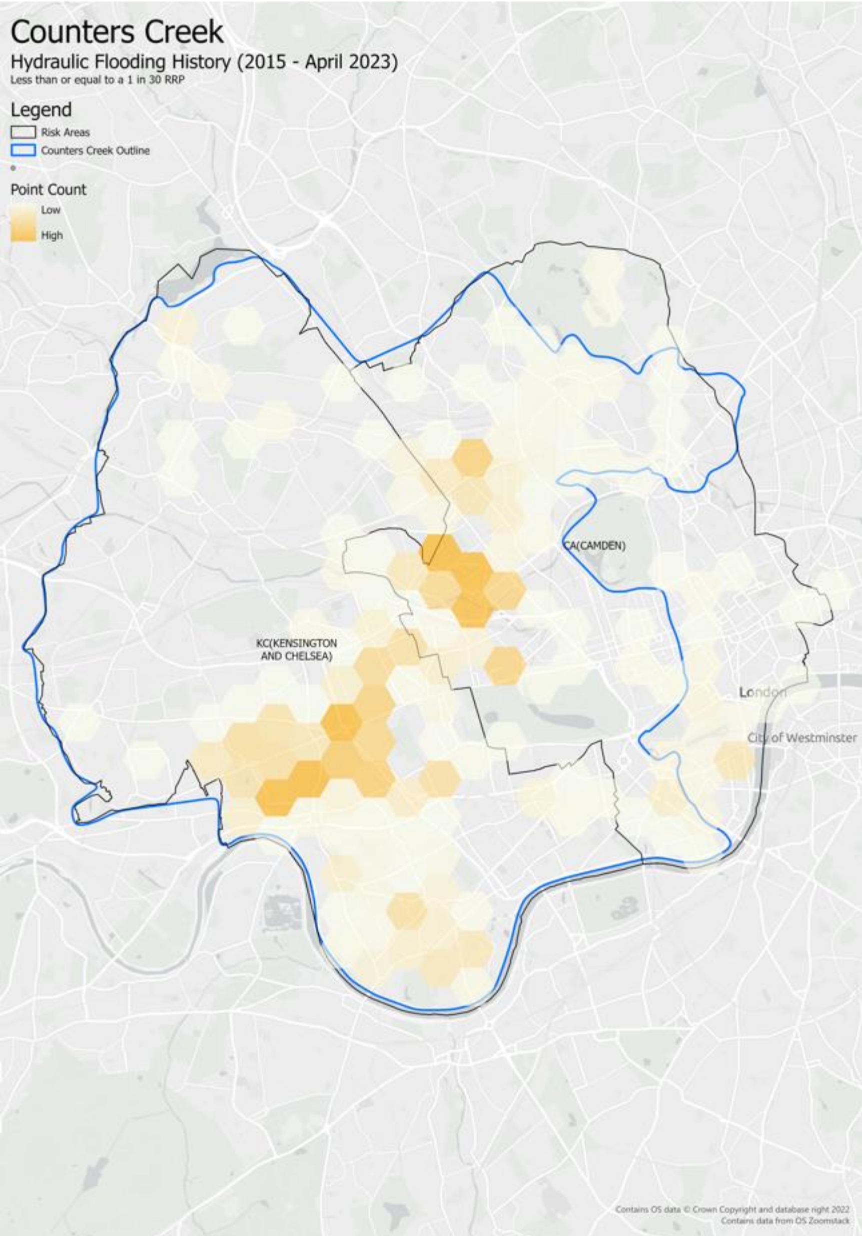


Figure 7: London Borough of Camden flooding root causes July 2021 as identified in March 2022



2.56 Figure 8 shows the location of customers who experienced hydraulic flooding between April 2015 and April 2023 from a 1 in 30, or lower, return period rainfall event. 1:30 is the design standard which we typically use for new flood protection schemes. The blue boundary relates to the Counters Creek area and the black boundary to the modelling areas in the DWMP.

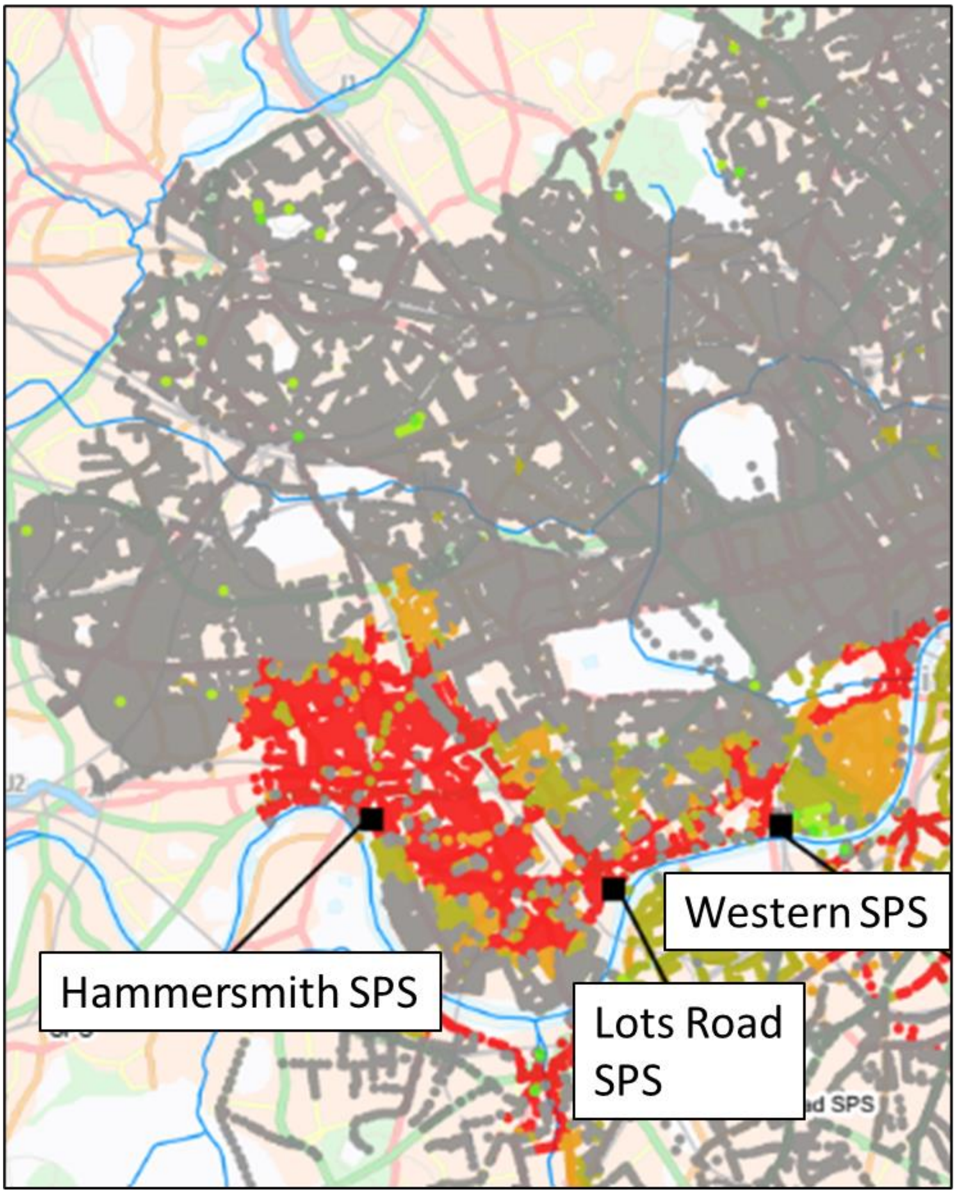
Figure 8: 1 in 30 flooding in Counters Creek as at April 2023 (Source Flooding History Database)



H Improvements to how we assess emerging flood risk

2.57 In addition to flooding that has occurred in the past, we have also assessed how flood risk will change in the future. Emerging flood risk relates to flooding which has not yet materialised and at the time of the final determination we had not completed our assessment for flood risk up to 2050. We have assessed risk in two stages, the first shows the impact of the Tideway Tunnel which will be commissioned in 2025 (Figure 9) and the second that the impact of the emerging risks up to 2050.

Figure 9: Reduction in flood levels post implementation of Tideway Tunnel at high tide



2.58 Figure 9 shows the modelled change in flow levels in sewers at high tide once the Tideway Tunnel is operational. The areas shown in red have the greatest predicted reduction in water levels in sewers compared with the baseline. Red reduces the water levels by >0.5m, orange by 0.3 – 0.5m, olive by 0.1 – 0.3m and grey and green by < 0.1m. Therefore, the risk of flooding around Hammersmith and the areas closest to the Thames near Lots Road and Western Pumping Stations have the greatest reduction in flood risk. Figure 10, which shows the modelled risk of flooding in 2050 taking into account the impact of the Tideway Tunnel, shows that the risk of flooding in Hammersmith will substantially reduce.

2.59 We have then assessed the impact of the emerging risks of population growth, urban creep and climate change on customer flood risk up to 2050. This has been assessed as part of DWMP. Appendix B of our DWMP explains how we have undertaken a Risk Based

Catchment Screening[10] approach to assess each of the zones within the Beckton catchment.

2.60 Our DWMP subdivides London's sewage treatment catchments into a number of risk zones based on hydraulic modelling areas as shown in Figure 1. Risk zone 2 covering Royal Borough of Kensington and Chelsea, Hammersmith and Fulham, Brent and Ealing was taken forward for a full further risk and resilience assessment. Our approach is outlined in Appendix C of our DWMP in our Baseline Risk and Vulnerability Assessment (BRAVA)[11]. Our BRAVA assessment uses the combined hydraulic model for Beckton and Crossness catchments which simulates rainfall using 1 in 30- and 1 in 50-year design storms in 2030, 2035 and 2050. Table 1 and Table 2 show the impact of emerging flood risk to customers and Figure 10 shows the indicative locations for a 1 in 30-year or less return period design standard in 2050.

Table 1: Output of BRAVA assessment for Risk Zone[12] 2 – Royal Borough of Kensington and Chelsea, Hammersmith and Fulham, Brent and Ealing.

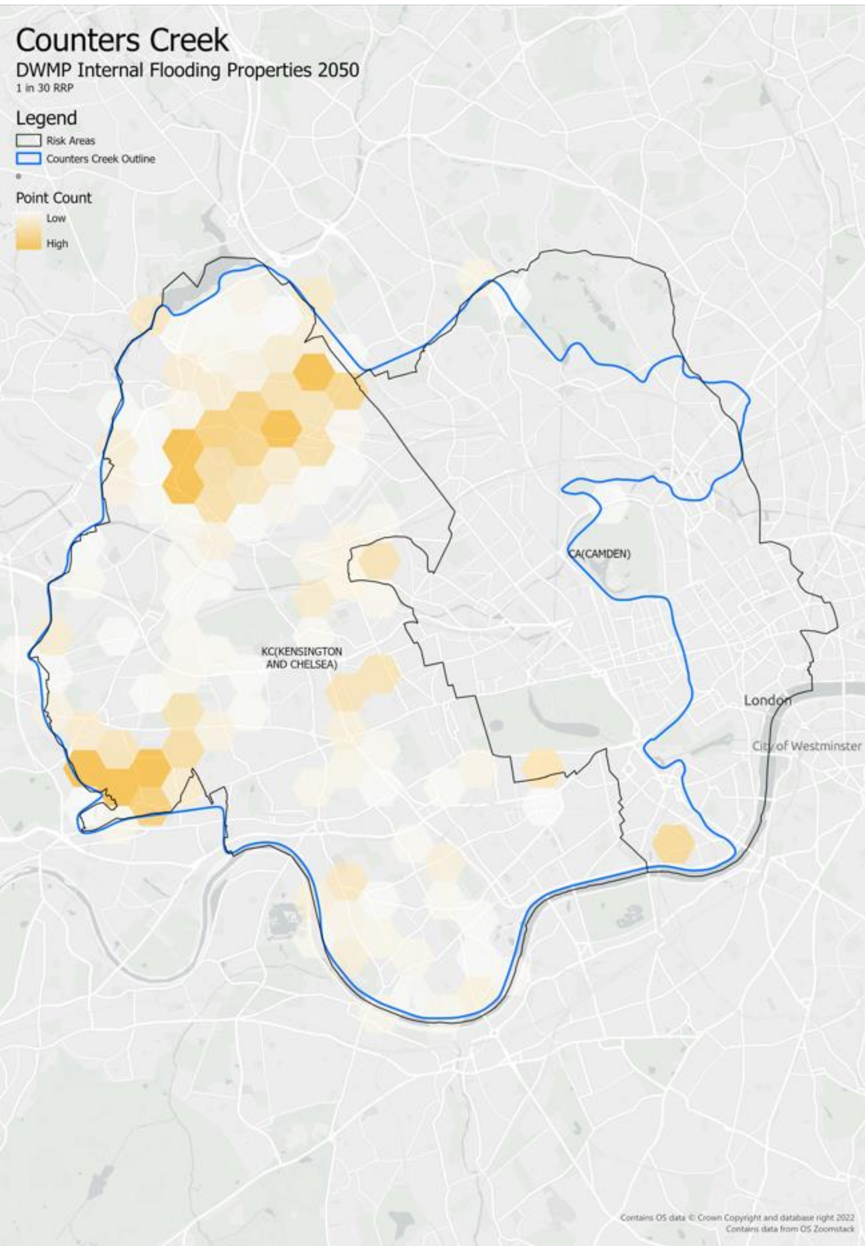
	2025	2035	2050
No. of residential homes at risk of 1:30 internal sewer flooding	8,606 (2.9%)	9,351 (3.1%)	10,633 (3.6%)
No. of residential homes at risk of 1:30 external sewer flooding	12,204 (4.1%)	11,230 (3.8%)	11,794 (4.0%)
No. of residential homes at risk of 1:50 internal and external sewer flooding.	26,134 (8.8%)	24,758 (8.3%)	27,604 (9.3%)

Table 2: Output of BRAVA assessment for Risk Zone 4 – covering parts of City of Westminster and Camden.

	2025	2035	2050
No. of residential homes at risk of 1:30 internal sewer flooding	369 (0.2%)	63 (0.03%)	91 (0.04%)
No. of residential homes at risk of 1:30 external sewer flooding	816 (0.3%)	253 (0.1%)	253 (0.1%)
No. of residential homes at risk of 1:50 internal and external sewer flooding.	2569 (1.1%)	389 (0.2%)	416 (0.2%)

[10] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-b-risk-based-catchment-screening.pdf
[11] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-c-baseline-risk-and-vulnerability-assessment-and-problem-characterisation.pdf
[12] Our catchment is divided into a number of risk zones which relate to hydraulic modelling areas.

Figure 10: 1 in 30-year flooding in Counters Creek as 2050 (Source DWMP)



2.61 Our assessment of growth used Local Authority forecasts for short term growth and the Office of National Statistics' population projections for longer term forecasts up to 2050. We identified three large development areas affecting Counters Creek, the Old Oak Common Marshalling Yard, which is currently under construction, the Old Oak Common new residential redevelopment and the O2 development in Camden.

2.62 For the Old Oak Common Marshalling Yard we have undertaken a detailed impact assessment and the development site is not expected to increase the risk of flooding. The Old Oak Common new residential development is a complete redevelopment of the area and will therefore be served by a separate surface water sewer and the development will include sustainable urban drainage systems (SuDS). These will remove existing surface water from the network, creating additional capacity in that area. The O2 development incorporates surface water runoff reduction through SuDS and attenuation tanks. Therefore, these sites in the Counters Creek catchment are likely to reduce flood risk.

2.63 Urban creep (small infill) development is not a significant factor in increasing flood risk in Counters Creek since the area is already heavily urbanised and because the urban creep is expected to be mitigated through the installation of SuDS. This is why projections of risk of external flooding are decreasing in the long term.

2.64 We have assessed the impact of climate change on the Counters Creek area, and this is likely to be the most significant emerging risk affecting internal flooding in the long term as shown in Table 1 and Table 2 and Figure 10. This means that there is likely to be a higher volume of surface water in the network from overland flow in the future.

2.65 We want to make sure we increase the resilience of our assets so that we can protect our customers, communities, and the environment from the impacts of these challenges. As part of our adaptive planning approach, we have tested our proposed plan against a range of plausible futures. We have assessed the impact of different climate change, population forecasts and technology changes to understand how and when our investment plan might change in response to different levels of flood risk. Our approach is set out in Appendix G[13] of our DWMP.

2.66 We also assess emerging flood risk using our hydraulic models in conjunction with near real time depth monitors across the network. We are installing further depth monitors increasing coverage and granularity of the data, which continues to improve our understanding of real-time performance of the network. Further detail is contained our operational strategy in section 3E of this report.

I Improvements to our understanding of where flood prevention is dependent on the operation of pumps or other assets

2.67 The correct operation of pumps and other assets is critical to ensure the risk of flooding to customers is minimised. There are three strategic pumping stations which could impact the risk of flooding within the catchment, Western Pumping Station, Lots Road Pumping Station and Hammersmith Pumping Station, the locations of which are shown in Figure 9.

2.68 Western Pumping Station has three dry weather pumps which discharge to the downstream Low Level Sewer No. 1, which are operated automatically depending on the levels in the wet well.

2.69 The station provides an invaluable role in flood protection by discharging storm flows to the river when the sewerage network has reached capacity. The site has four manually operated storm pumps. If all storm pumps are in full operation, they discharge up to 13.5m3/s to the river Thames. It should be noted that the pumping station output may be affected by tide. Should high flows occur at the same time as high tide, it takes one storm pump to balance the flows by pumping against the tide. This effectively means that the

[13] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/ appendix-g-adaptive-pathway-planning.pdf

capacity of the storm pumps is reduced. Operational capacity is modelled at 9m^3/s (one pump out of operation and one at half capacity).

2.70 The pumps are switched from dry weather to storm pumps depending on the following levels:

- The level in the Low-Level Sewer No. 1 downstream of Western Pumping Station (greater than 2m depth, or pipe-full)
- The level in the Low-Level Sewer No.1 upstream of Western Pumping Station reaches 6 foot or is considered to be rising rapidly.

2.71 Also at the same site is the Western Deep Pumping Station, which empties the Western Deep Sewer. There are four pumps related to the emptying of Western Deep, but only three pumps operate concurrently (one operates as a standby pump in the event of failure). The pumps are switched on manually and drain down is started once the levels in the Low-Level Sewer No.1 have returned to normal dry weather operation.

2.72 Lots Road Pumping Station is made up of five diesel pumps and three electric pumps, all of which are manually controlled. The pumping station receives flows from three directions: the Counters Creek main line sewer which goes to the electric pumps wet well, the Low-Level Sewer No.1 which goes to the diesel pumps, and the Walham Green Storm Relief Sewer which goes to the diesel pumps. The fifth diesel pump can switch operation so that it drains down both the Counters Creek Main Line and the Walham Green Storm Relief Sewer. The pumps are switched on manually under two conditions:

- When the level in the Counters Creek (Electric) inlet reaches 1.069m (3ft 6 inches) the first pump is switched on. Subsequent pumps are switched on if the level continues to rise. Once the level drops below 0.457m (1ft 6 inches) the pumps are switched off.
- When the level in the Walham Green (Diesel) inlet reaches 3.048m (10ft) the first diesel pump is started if the vacuum pump is online; otherwise, the pump will be started at 4.267m (14ft). Subsequent pumps are switched on if the level continues to rise. The last pump is switched off when the level in the Walham Green Storm Relief Sewer drops below 3.048m (10ft).

2.73 Hammersmith Pumping Station consists of nine operational pumps. There is one pump which returns low flows to the Low-Level Sewer No. 1, and eight which pump flows to the river in a duty/assist operation. The operating protocols are achieved if seven river pumps are operational, as one pump is routinely unavailable for maintenance purposes. The maximum output of flows from the pumping station is 25m^3/s, although the design capacity of the pumping station is 22m^3/s, to allow for maintenance.

2.74 In order to assess the impact of pump operation on flood risk there are a very large number of variables that can be modelled such as individual pump failures in isolation or in combination, the impact of that occurring with different levels of rainfall intensities in different locations, the impact of pump failure coinciding with high and low tides and the impact both before and after the implementation of the Tideway Tunnel. We have therefore modelled twelve different scenarios as shown in Table 3.

Table 3: Scenarios for the operation of strategic pumping stations

Pump scenario	High Tide	Low Tide
Pumping stations operating at 50% capacity	With and without Thames Tideway Tunnel Flooding is likely to occur around Hammersmith and Lots Road pumping stations at high tide.	With and without Thames Tideway Tunnel Flooding is likely to occur around Lots Road pumping station at low tide.
All pumps failed at Western PS, Lots Road PS and Hammersmith PS	With and without Thames Tideway Tunnel Flooding is likely to occur around Hammersmith and Lots Road pumping stations at high tide. When Tideway is not yet commissioned, flooding is likely to occur at Western pumping station as well.	With and without Thames Tideway Tunnel Flooding is likely to occur around Hammersmith and Lots Road pumping stations at low tide. When Tideway is not yet commissioned, flooding is likely to occur at Western pumping station as well.
Lots Road PS operating at 50% capacity, all other PSs fully operational	With and without Thames Tideway Tunnel Flooding is likely to occur around Lots Road pumping station at high tide.	With and without Thames Tideway Tunnel Flooding is likely to occur around Lots Road pumping station at low tide.
All pumps failed at Lots Road PS; all other PSs fully operational	With and without Thames Tideway Tunnel Flooding is likely to occur around Hammersmith and Lots Road pumping stations at high tide.	With and without Thames Tideway Tunnel Flooding is likely to occur around Hammersmith and Lots Road pumping stations at low tide.

2.75 The output of our modelling is shown in section 4 of the Technical Appendix for Resilience. It shows the impact of increased water levels in the sewer ranges from <0.1m to >0.5m, which is used to indicate where flooding could occur. This is taken into account when we assess the criticality of these pumping stations in our operational and maintenance assessments.

J Summary of key factors affecting flood risk and resilience

2.76 The additional work we have undertaken to understand the risk flood and resilience has concluded that:

- The main factors influencing flood risk in the Counters Creek area are rainfall, surface water and climate change.
- The number of customer properties affected depends on the location and intensity of the rainfall, the density of properties and the number of basements.
- Flood risk currently increases if rainfall coincides with a high tide, but this will reduce after Tideway Tunnel becomes operational.
- The impact of infiltration, ground water and connectivity to other areas on flood risk is negligible.
- Work to unblock or increase capacity of road gullies could increase flood risk due to increase in surface water entering the system.
- Growth and urban creep are likely to reduce flood risk when SuDS or dedicated surface water sewers are implemented.
- Correct operation of Thames Water assets is required to prevent flooding.

2.77 A partnership approach is required to remove surface water to reduce flood risk.

Section 3

Our long-term strategy for alleviating flooding risk

A Our overall approach

3.1 Our long-term strategy for alleviating flood risk in Counters Creek has the following key elements:

- Commissioning of the Tideway Tunnel in 2025.
- Provision of protection to basement properties in the Counters Creek area which flooded in the 2021 severe flooding event, where we are investing over £10m.
- Encouraging more SuDS with over 7,000 hectares of impermeable area drained into SuDS, across London including rainwater harvesting, rain gardens, green roofs and rewilding projects.
- Investing up to £1.7bn in risk zones 2 and 4 (covering Counters Creek) to reduce the risk of flooding of customers to 1.5% (internal) and 3% (external) up to a 1 in 30-year storm event in any given year by 2050, ensuring 95% of properties are not at risk of a 1 in 50-year storm event.
- Updating our asset base so that it is reliable, resilient to climate change and able to support London's growth.
- Digitising the tunnel and our existing trunk sewer system to use real-time data (rainfall, sewer levels, flow, storm discharges etc.) alongside predictive models (rainfall, hydraulic, operational resources etc.) to reduce discharges to the tidal River Thames by up to 95%.
- Reducing the risk of sewer flooding in homes by building resilience in the network, working in partnerships with public, private, non-governmental and community partners, and using the new Thames Tideway Tunnel to its full potential to support the reduction of risk.
- Ongoing operation of our network - using smart controls and sensors to track how our system performs under pressure, enabling improvements and enhancing our response to and recovery from significant weather events.

3.2 Our intent is to manage surface water before providing upgrades to sewerage system. We cannot solve the sewer flooding issues without all stakeholders with a responsibility for surface water collaborating to manage and remove surface water from the sewerage system.

3.3 One of the findings from the London Flood Review was that there was a lack of strategic co-ordination and collaboration between risk management agencies and the need for a strategic-level plan to co-ordinate activity at supra-borough level. Collectively, these led to the formation of the London Surface Water Strategic Group ('LSWSG'), which met for the first time in December 2022. The aim of this group is to ensure the collaboration of the key flood risk management organisations and drive the development and delivery of a London-level surface water management strategy and action plan. We are members of the LSWSG and co-funding the development of the strategy, which should be complete in early 2024.

3.4 Our strategy is for alleviating flood risk is described in further detail in Sections 3B to 3E.

B Our strategy for the Tideway Tunnel

3.5 The Tideway Tunnel is due to be commissioned in 2025. Over a typical year 95% of the predicted combined sewer overflow discharge volume will be captured in the tunnel allowing the network to drain more quickly and reduce the volume of storm water backing up which currently causes flooding in low-lying areas close to the River Thames. The reduction in flood risk is accounted for in the 2025 numbers in Tables 1 and 2 and the impact shown in Figure 9.

3.6 The ability to discharge via the combined sewer overflows remains when excessive rainfall-runoff occurs or when planned or emergency work is being undertaken.

3.7 The risk of flooding will be considerably lower than currently, but it could occur if the tunnel reaches capacity at the same time as a high tide and the rainfall is sustained over a 2-day period. In this instance the tidal flaps would be closed reducing discharge into the Thames and the tunnel would not be able to fully drain causing some backing up of the sewers.

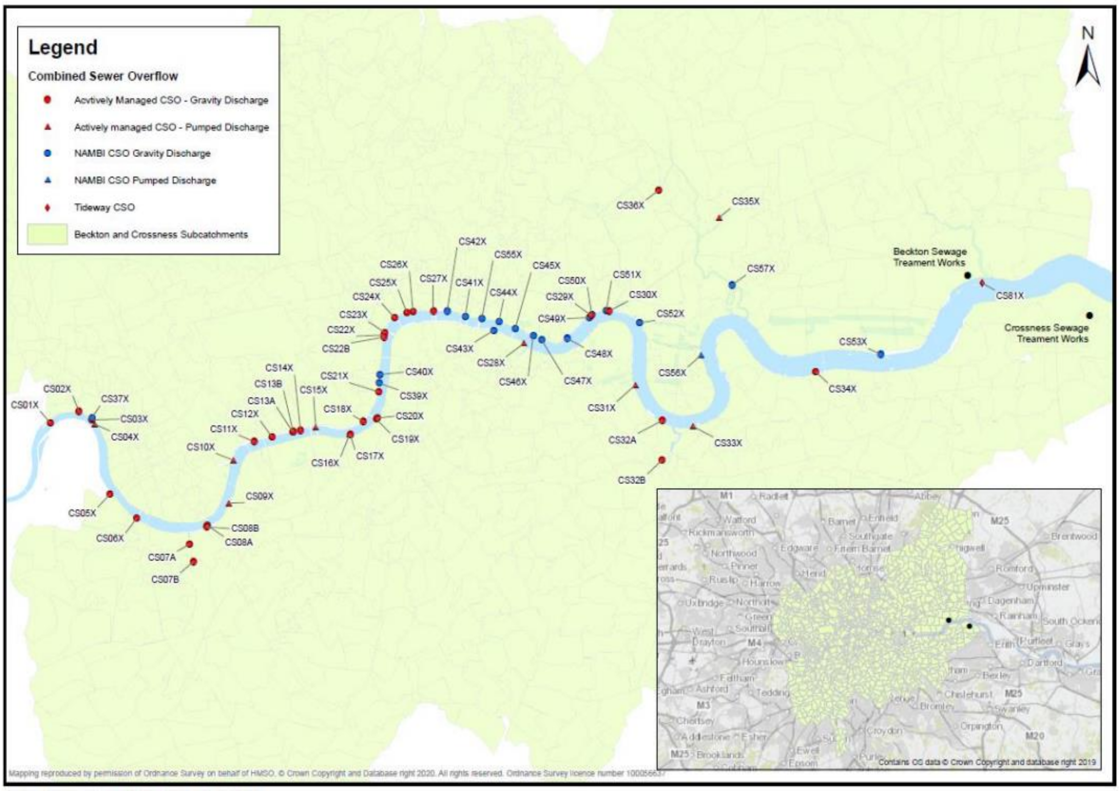
3.8 Our strategy for the operation of the Tideway Tunnel[14] was developed with the Environment Agency and published in November 2012.

3.9 In March 2020 we completed an update to consolidate our learning from operating and optimising the tunnel performance, following the commissioning of the Lee Tunnel. We will complete a further update after the Tideway Tunnel is commissioned.

3.10 The implementation of the Tideway Tunnel allows us a greater level of control over the network; sections 3 and 4 of the Operating Techniques set out the combined sewer overflows which are actively managed by the Tideway Tunnels as shown in Figure 11.

[14] London Tideway Tunnels Operating Techniques Version 1 November 2012

Figure 11: Actively managed combined sewer overflows discharging to the London Tideway Tunnels



3.11 Section 5 of the operating techniques sets out the different modes of operation for wet weather and extreme wet weather and the key control factors governing the operation of the Tideway Tunnel. These include the target water control levels, the inflow control limits, the hydraulic throughput of Beckton and Crossness sewage treatment works and the operational contingencies.

3.12 Section 7 of the operating techniques describes the circumstances under which sewage will continue to discharge via the combined sewer overflows into the Thames and level of agreement required by the Environment Agency for this to occur. Examples of circumstances include planned or emergency inspections and maintenance, and commissioning of the Tunnel in 2025.

3.13 Sections 8 and 9 of the operating techniques describe the monitoring requirements for combined sewer overflows and flow and water level monitoring to ensure the tunnel is managed effectively to reduce the risk of flooding occurring.

C Our strategy for protection of properties following the London 2021 flooding

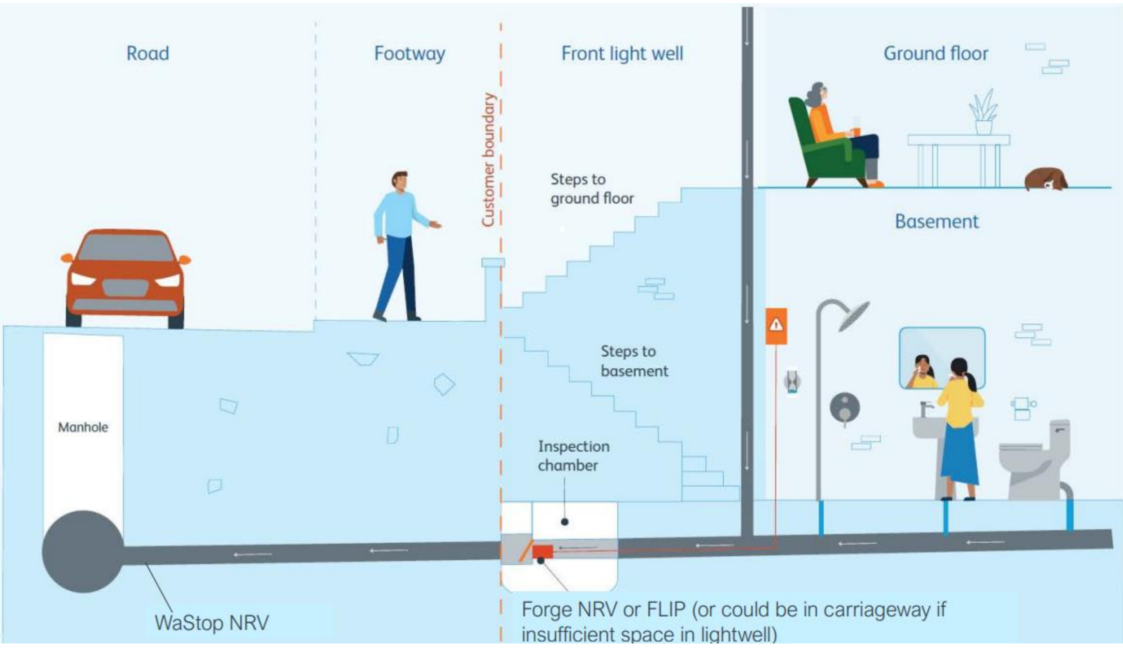
3.14 Due to the high number of properties identified from our surveys following the London 2021 floods, we have taken a risk-based approach to prioritising the delivery. As at the beginning of April 2023, 903 surveys were complete. For the purposes of flooding investment prioritisation, we have created four main risk groups, which are used in our flooding prioritisation tool:

3.15

- Higher risk of internal flooding – these are properties that may experience significant depth of internal flooding from a 'major' (1 in 30-year / 3.3% AEP) storm. We are sub-prioritising delivery in properties where we know that there are a) highly-vulnerability customers in self-contained basement flats, then b) all self-contained basement flats, then c) multi-storey properties with basements. We have started work on 28 properties and aim to complete by end of June 2023.
- Lower risk of internal flooding – these are properties where the risk of internal flooding is less than "higher risk" properties. They may experience some internal flooding from a major storm, but not as severely as the higher risk properties.
- Low risk of flooding – these are properties not identified at risk of internal and/or external flooding from a 'major' storm. Properties at 1 in 30- to 1 in 50-year risk will be part of our AMP8 business plan.
- Overland flood risk – these are properties that are not at risk of flooding through their sewer connection (usually because they don't have a basement) but may be at risk of flooding from overland flow from a surcharging sewer.

3.16 Our delivery plan is based around customers' vulnerability and prioritising those who are at a greater risk of flooding if a major storm occurs. We aim to sequentially work through the risk groups across all Boroughs, in a rolling programme. We will also start with properties where we can install devices in their lightwells whilst applying for permission from Boroughs/Transport for London to install devices in the carriageway.

Figure 12: Protection measures for customers' properties



3.17 Figure 12 shows the locations of different protection measures which can be installed to protect customers from flooding. Our default protection measure is to install a non-return valve ('NRV'), either a 'WaStop' NRV for properties connected to a large diameter trunk sewer or a 'Forge' NRV for properties not connected to a large trunk sewer.

3.18 For properties that would experience significant self-flooding[15] if protected by a non-return valve we will install a 'FLIP' which is a non-return valve with a pump that can push flows from a customer's property into a full sewer when the non-return valve is closed. Prior to installing a 'FLIP' we will undertake a risk assessment of the upstream and downstream impact to ensure the risk of flooding is not transferred elsewhere. We are working with Local Authorities to ensure planning policies reflect the type of devices that are appropriate for installation.

3.19 In some locations, protection can be most efficiently provided at a street or neighbourhood scale by using a trunk sewer non-return valve rather than installing individual devices to a customer's property.

3.20 For properties with high surface water run-off volumes, from large impermeable areas, we are investigating the opportunity to provide discounted water butts to help address the flood risk.

3.21 As at the beginning of April 2023 we have installed measures protecting 243 properties, 7 of which were in properties with highly vulnerable customers, 119 WaStop NRVs protecting 119 properties and trunk sewer flaps protecting 117 properties. We have sent letters to book installation dates at 186 properties in Royal Borough of Kensington and Chelsea and 240 properties in London Borough of Hammersmith and Fulham. We have also arranged customer drop-in sessions in the Boroughs. Next, we will be moving to the London Boroughs of Westminster and Camden.

D Our strategy for managing emerging flood risk as set out in our DWMP

3.22 Our long-term strategy for the Counters Creek Catchment is set out in our Beckton CSP which is due to be published in June 2023.

3.23 We have developed our strategy for the next 25 years to meet the future challenges which are impacting our region such as climate change, population growth and urban creep.

3.24 Our Beckton CSP sets out:

- How we've worked in partnership to develop our strategic plan.
- Our predictions for the future challenges we face in this region.
- How this plan is expected to address these challenges and who else is involved.
- Our shared strategy for reducing flooding both in the short and long term.
- Our approach for adaptive planning for different plausible futures.

3.25 Our plan outlines our shared vision for the future and details how, through working together, we can improve and enhance our wastewater services in this area to ensure 95% of properties are not at risk of flooding in a 1 in 50-year storm by 2050. We plan to reduce property hydraulic sewer flooding to 1.5% (internal) and 3% (external) up to a one in 30-year storm event in any given year by 2050.

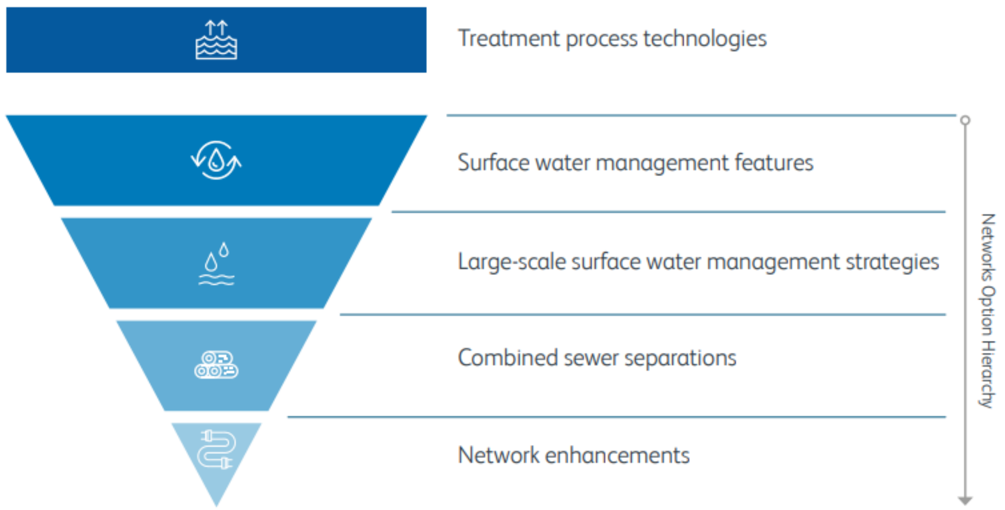
[15] Flows can back up behind the flap valve, when it is closed and result in flooding, if the runoff from property drainage is bigger than the capacity of the pipework.

3.26 We have worked with a range of stakeholders to identify the key aspects of Local Flood Risk Management Strategies, Surface Water Management Plans, Local Plans, Sustainable Urban Drainage design and evaluation, Blue/Green Infrastructure Plan and Climate Change Action Plans that align with our DWMP. A full list of key aspects that relate to flood risk is included within our final DWMP.

3.27 We estimate that > 1/3 of customer properties we surveyed following the London 2021 floods were not flooded via their sewer connection, but via overland flow (or overland flow was the main cause of their flooding). We understand that in some areas our surcharging sewers amplified existing surface water flooding. We are liaising with London Borough officers to identify where surcharging sewers create new or exacerbate existing risk hotspots and to identify options to reduce the volume of water trying to enter the sewer upstream of these hotspots.

3.28 Our strategy for resolving flooding focuses on removal of surface water before consideration of separation of combined sewers and upsizing of sewers. This ensures we are selecting the least customer disruptive and most environmentally sustainable options first. Our network options hierarchy is shown in Figure 13 and explained in paragraphs 3.293. to 3.373..

Figure 13: Network options hierarchy



3.29 Our strategy for **surface water management** reinforces the fundamental basis of our surface water and foul sewerage systems being separate by addressing property misconnections of surface water into the foul sewer system or foul to surface water. It includes working with partners to facilitate the installation of features to collect, store and/or infiltrate surface water from buildings and impermeable areas, such as driveways and carparks, as part of enhancing the surface water management system.

3.30 A key part of our strategy for surface water management is the installation of SuDS which are sustainable drainage features to help reduce flooding from rainfall and storms. They manage surface water run-off from buildings and hardstanding in a way that reduces the total volume, flow and rate of surface water that runs directly into drains and sewers. They can also be referred to as 'nature-based solutions' (NbS) where the local environment has been utilised effectively, without harm, to reduce flood risk.

3.31 There are different types of SuDS; green, which include installing features such as rainwater gardens and tree pits or grey, which are engineered solutions such as attenuation (underground) storage tanks.

3.32 There are many benefits to SuDS[16] which are considered more sustainable than traditional drainage methods:

- Managing run-off volumes and flow rates from hard surfaces, reducing the consequences of urbanisation on flooding
- Providing opportunities for using run-off where it falls
- Protecting or enhancing water quality (reducing pollution from runoff)
- Protecting natural flow regimes in watercourses
- Being sympathetic to the environment and the needs of the local community
- Providing an attractive habitat for wildlife in urban watercourses
- Providing opportunities for evapotranspiration from vegetation and surface water
- Encouraging natural groundwater/aquifer recharge (where appropriate)
- Creating better places to live, work and play

3.33 SuDS can also provide shade and evaporative cooling, reducing the urban heat island effect, where urban areas are hotter than surrounding rural areas. They may also trap air pollutants, improving air quality and have further positive effect on the health and wellbeing of our customers.

3.34 We have undertaken a review of the acceptability of SuDS to our customers and incorporated learning from other organisations in our DWMP 2025-2050 Appendix R – Sustainable Urban Drainage Systems and Nature Base Solutions[17]. Key messages include:

- Stakeholder feedback on the practicality of implementing SuDS where 7 in 10 consultation responses supported our target for increasing the use of SuDS.
- How we have refined our SuDS delivery programme following engagement with City Officials from Copenhagen, New York, Rotterdam and Amsterdam. We have adopted best practice from Copenhagen's Cloudburst Management Plan, Philadelphia's Green Stormwater Infrastructure Strategic Framework, Washington's Climate Ready DC and Rotterdam's Resilience Strategy.
- Our participation in the London Strategic SuDS pilot where two of the pilot areas, Camden and City of Westminster, were in the Counters Creek area. The project demonstrated that retrofitting small SuDS features can deliver greater benefits when using improved understanding from hydraulic modelling to target key locations. The pilot

[16] The SusDrain Website (a community that provides resources for organisations involved in the delivery of SuDS).
[17] https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/ appendix-r-delivery-of-suds-and-nature-based-solutions.pdf

was supported by the Thames Regional Flood and Coastal Committee levy funding which demonstrated how additional benefits can be delivered through co-funding.

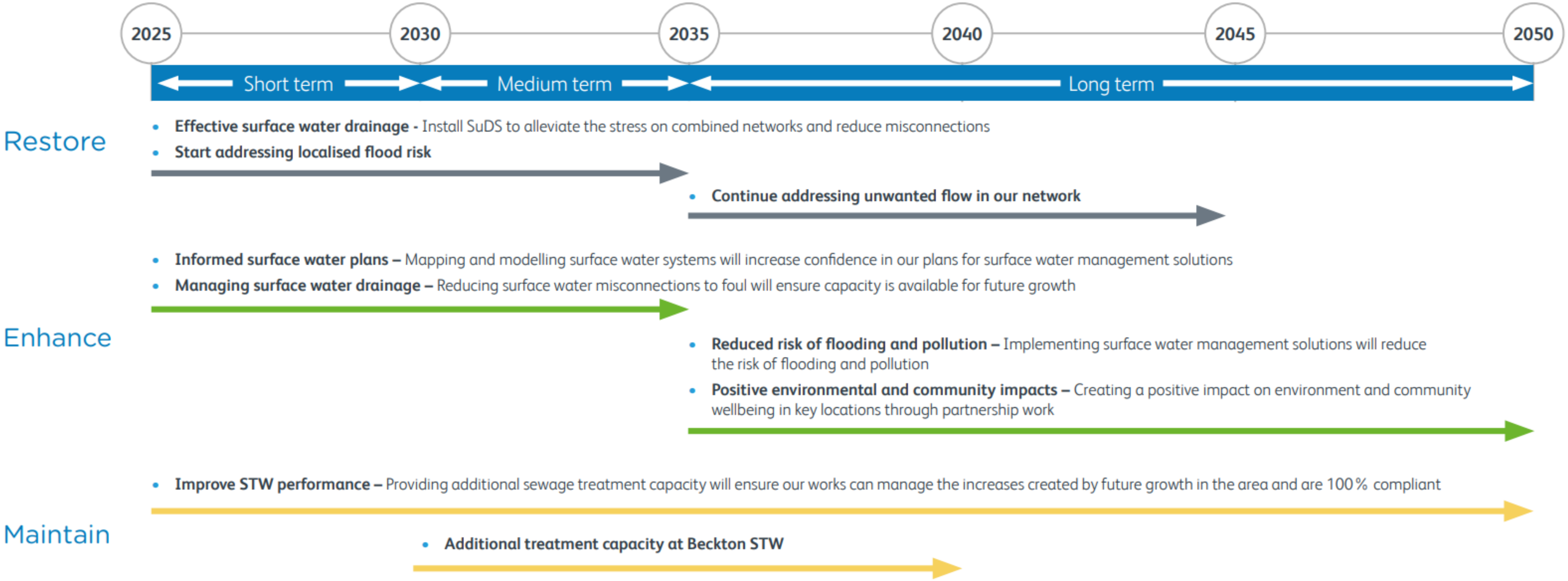
3.35 **Large-scale surface water management strategies** involve the delivery of surface water management strategies across the risk zones to significantly reduce or remove the rainfall runoff entering the foul sewer system at these locations.

3.36 **Combined sewer separation** involves converting existing combined sewers into dedicated surface water and foul water sewers. The partitioning of the systems will provide capacity relief at times of high rainfall for the foul sewers. Surface water can be managed on the surface using sustainable urban drainage systems.

3.37 **Network enhancements** involve managing the impact of surface water on the sewerage system through the identification of network improvements to address deficiencies in the sewerage network capacity and a high risk of sewer flooding now or in the future. This includes the construction of large attenuation sewers, new surface water sewers and foul water sewers.

3.38 Our Beckton CSP for 2025-2050 sets out a phased approach to delivery as shown in Figure 14.

Figure 14: Phased approach to delivery 2025-2050



3.39 Our Beckton CSP sets out the details of the proposed key areas of focus. Table 4 shows our planned deliverables up to 2050 which relate to risk zones 2 and 4 covering the Counters Creek area. These are subject to funding through the price review process.

Table 4: Planned deliverables by 2050

Deliverables	Number of deliverables by 2050
Modelled properties no longer at risk from Internal Flooding 1 in 30-year	6,727
Modelled properties no longer at risk from Internal Flooding 1 in 30-year	6,317
Modelled properties no longer at risk from 1 in 50-year	16,572
SuDs	£1.2bn
Fouls sewers	£570m

3.40 Our preferred plan comprises options that have been developed to meet medium term (2035) and long term (2050) performance targets. Our hierarchy of solution types commences with and seeks to maximise the implementation of benefits from SuDS. In risk zones 2 and 4 of the Beckton Catchment the plan that represents the best value for customers would require a spend of over £1.7bn. In addition to the traditional solutions are a number of partnership opportunities where we could work together with our stakeholders, for example:

- Earls Court and Holland Road in Hammersmith and Fulham. In Earls Court we have previously installed property level flood protection measures, but network modelling has indicated flooding of customer properties is still a risk. In Holland Road flooding is due to sewer incapacity. For both locations there is the potential for reducing flood risk to customers through collaboration with LB Hammersmith and Fulham. We will be investigating measures to slow down surface water entering sewers while providing wider environmental and amenity benefits.
- Willesden Green and Chamberlayne Road in Brent where flooding exists and may be exacerbated by surface water ponding. We will be investigating the potential for targeted surface water management measures to replace existing non-permeable surfaces, along with the identification of space for rain gardens or potential for swales.
- South and West Hampstead which has a history of sewer and surface water flooding in 2021 with extensive property flooding in 1991. A collaborative investigation is proposed to consider surface water management solutions and the wider environmental, water reuse and amenity benefits in this densely urbanised area. Stakeholders involved include the Environment Agency, Transport for London, residents' groups and HS2.

E Our operational strategy

Variable Control Strategies

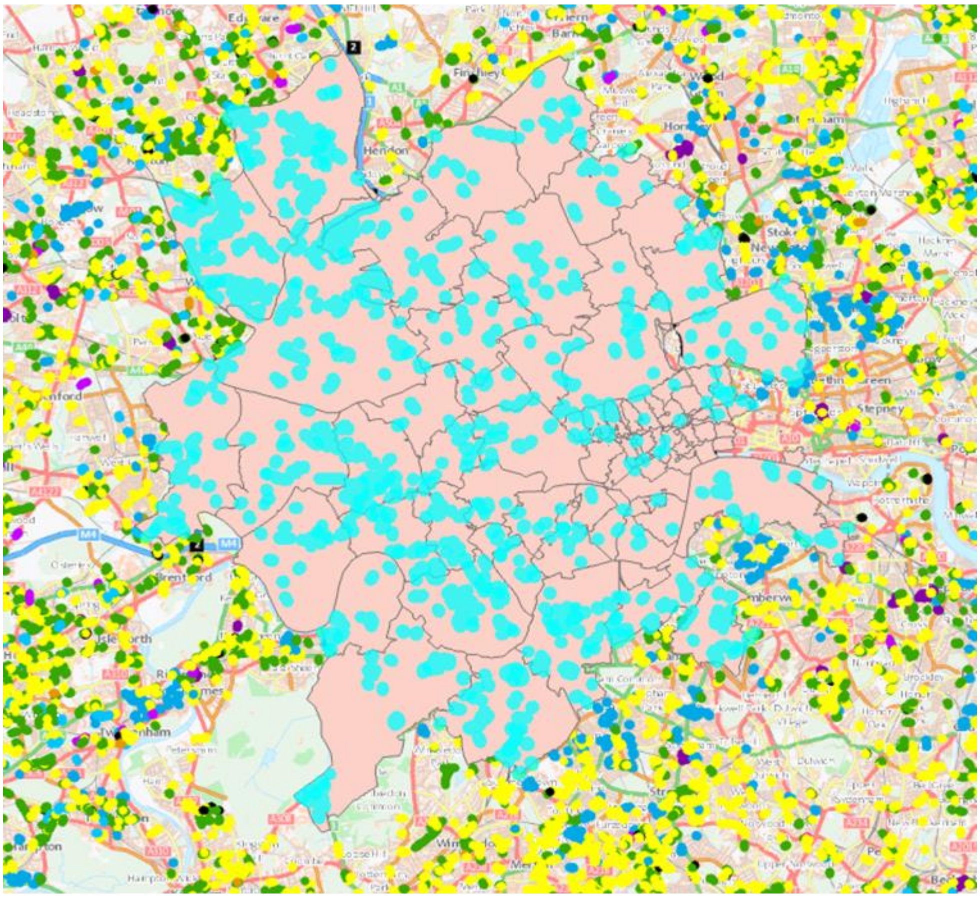
3.41 Unlike the water network, the London sewerage system was not designed to work with variable controls allowing flow to be moved to where there is spare capacity. In simple terms, the London sewerage system is designed so that additional pumps automatically switch on when water levels in the system rise to trigger levels as a result of rainfall. When the sewerage system is full, excess water is discharged into the river Thames via the combined sewer overflows. If this coincides with a high tide event, the flaps close, gravity sewers cannot discharge and pumped sewers discharge at a reduced rate because they are pumping against the tide. The sewerage system backs up and flooding of customers' properties may occur.

3.42 The opportunities for variable control increase when the Tideway Tunnel becomes operational (see section 3.10).

3.43 We cannot control the location or intensity of the rainfall, but we can collaborate with stakeholders and customers to better manage the volume of surface water entering the system and exacerbating flood risk.

Operation and maintenance of sewers

Figure 15: Snapshot of planned sewer maintenance programmes within postcodes related to Counters Creek (light blue dots)



3.44 Hydraulic flooding can be exacerbated by poor operation of the network; therefore, it is important that we have strategies in place to ensure that blockages, silt, and fats, oils and grease (which can form fatbergs) do not reduce the capacity of the network and that collapses do not cause sewerage escapes. Silt is not currently a significant factor in increasing flood risk in the Counters Creek catchment, due to the volume of surface water entering the system, which flushes out the silt.

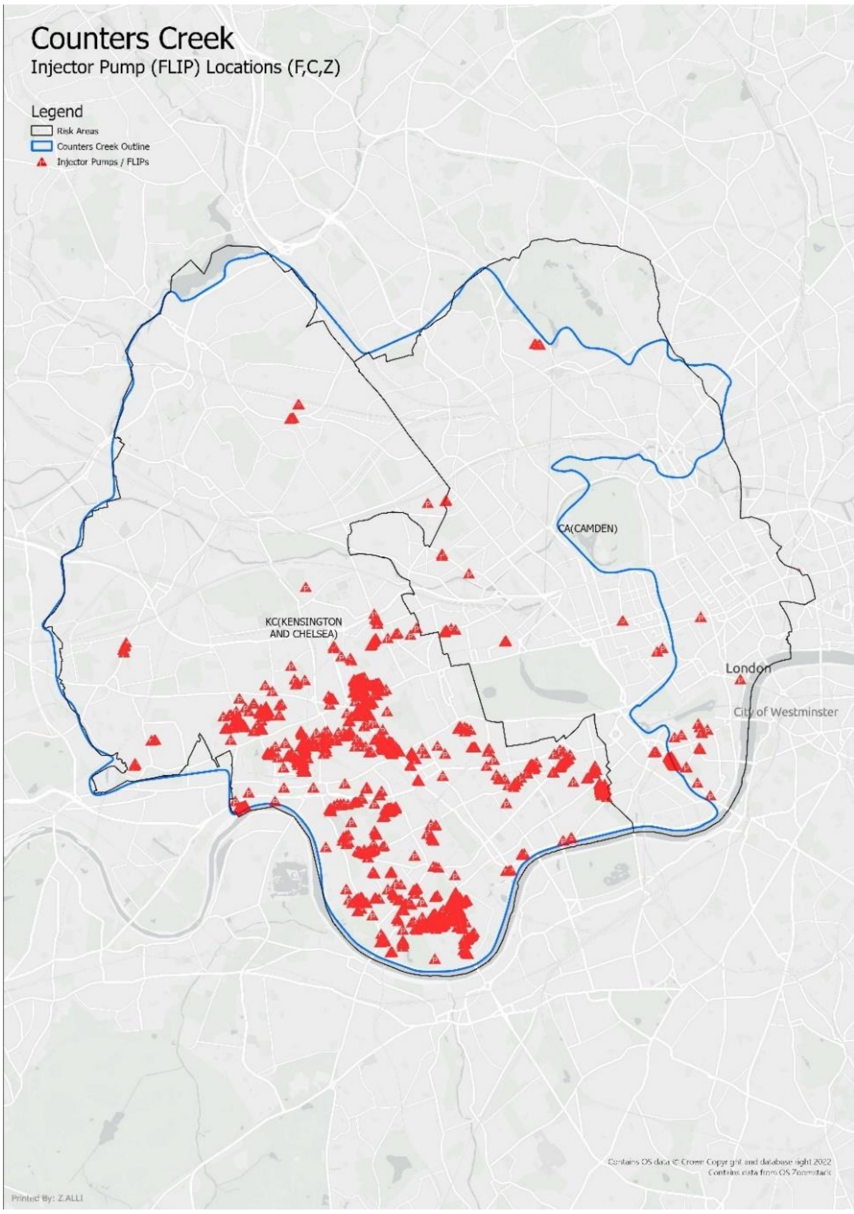
3.45 Figure 15 shows a snapshot of our proactive cleaning and CCTV programme for 2022/23 affecting Counters Creek postcodes (pink area) which is based on our sewer blockage, sewer collapse, pollution and flooding hotspots represented by light blue dots. This is refined on an ongoing basis by performance data which is collected from our daily operations and from incidents. In addition, every flooding incident is investigated; this may include cleaning and CCTV surveys.

3.46 We also undertake regular customer information campaigns on the impact of customers putting fats, oils and grease, and wet wipes into sewers.

Operation and maintenance of FLIPs, pumping stations and legacy flap valves

3.47 We have asset standards in place for the maintenance and operation of pumping stations and FLIPs. Our maintenance frequency for FLIPs is either annually or 6 monthly depending on the type of equipment installed. The frequency of planned maintenance for pumping stations depends on the criticality of individual stations but strategic pumping stations such as Hammersmith, Lots Road and Western will be visited daily. Figure 16 shows the location of FLIPS in the catchment as at the end of April 2023.

Figure 16: Location of FLIPs in the Counters Creek catchment



3.48 Since the severe flooding that occurred in July 2021, we have undertaken some additional sensitivity testing to understand the impact that Hammersmith and Lots Road Pumping Stations, the Thames Barrier closure and blockages within the catchment might have had in increasing the flooding at ten locations.

3.49 At the time of the event one of the nine pumps at Hammersmith did not switch on and there was a slight delay at Lots Road as those pumps are manually switched on when certain levels are reached. Our full analysis is set out in section 3 of the Stage 2 report of the London Flooding Review. It concluded that none of these factors had a significant impact on flooding as the most significant factor was the location and intensity of the rainfall to the north and west of the catchment.

3.50 Lots Road Pumping Station has recently had a new high voltage supply installed, which will enable us to replace the existing diesel pumps with electric pumps and new control systems. We plan to install automatic pump activation by 2030.

3.51 Legacy flap valves: Following a customer reporting flooding of their property, we routinely carry out an investigation by lifting manholes within a customer's property to understand the cause of flooding. Depending on the cause and the future risk to the property, we decide whether we can undertake any mitigation measures. Some flap valves are difficult to access as they sit inside a trunk sewer and inspection requires significant planning, flow diversions and traffic management. Investigations for these will be carried out as part of our trunk sewer investigations.

3.52 We are proposing to move from a reactive to a proactive approach for the operation and maintenance of legacy flap valves. Our approach will be risk based. We will continue to improve the data we hold on our asset registers recording both the locations of valves and details of equipment failures which will be used in future targeting of operational and maintenance programmes.

Control centre monitoring

3.53 Our control centres receive regular data from sewer and pumping station level monitors, event duration monitors and pump run times. We are able to set a range of operating parameters and receive an alarm when operation falls outside of these parameters. Depending on the criticality of the alarm, we will send out an operator to investigate the cause, with the aim of correcting issues and errors before flooding of any properties occurs.

3.54 Our operational strategy is underpinned by a number of decision-making tools. As part of our Smart Waste Network programme, we are developing these tools with a view to integrating data streams to build a holistic understanding of our catchments. We are also developing real-time algorithmic analysis to increasingly allow for proactive intervention as risks emerge. Our Operational Control Centre currently uses three new or extended capability tools to better understand the risk of flooding in real-time.

ICMLive tool

3.55 ICMLive allows us to simulate storm events based on Met Office forecasts to provide an early warning for storm flows. This allows us to improve our response to customers and provides information to verify and continually improve our hydraulic models.

3.56 An example of this was the recent flooding of the North London Flood Relief sewer (NLRS) (outside of the Counters Creek area) in heavy rainfall. The model was simulated with radar rainfall data for the dates where flooding was reported. One date replicated the flooding well, where another date did not result in flooding. Further investigation work in the network was undertaken to improve the understanding of the performance. Two penstocks which limit flows in the High-Level Sewer and divert flows to the NLRS were investigated. Whilst these are in the model, they were modelled as fully open, whereas in reality they are partially open, thereby diverting more flows to the NLRS. This was then updated in the model to reflect the current operation leading to better replication of the timing and locations of the reported flooding.

3.57 ICMLive was also used to provide a safe system of work before allowing operators to enter the storm relief lines to undertake maintenance at Hammersmith Pumping Station. ICMLive was used in real-time with forecast rainfall from the Met Office to provide an early warning for storm flows that could arrive at the works site. Depth monitors were installed and maintained at key overflow points upstream, and the calibration of the model checked regularly. A twice daily safe system of work required a check against the ICMLive model forecast flows and the live depth logger data at key points.

Sewer Level Alert Manager (SLAM)

3.58 This is a spatial risk model which allows us to review sewer level monitors in real time. We intend to install 18,500 of these monitors across the Thames region during AMP7, with the final 5000 being installed this year. Further monitors will be installed in AMP8. The programme is targeted at blockage hotspot areas and Counters Creek has a low level of blockages compared to Mogden and East Beckton. The tool is used to identify and allow clearance of sewer blockages before they affect customers, helping to prevent property flooding and environmental pollution. It also helps us understand how the network performs during flooding events.

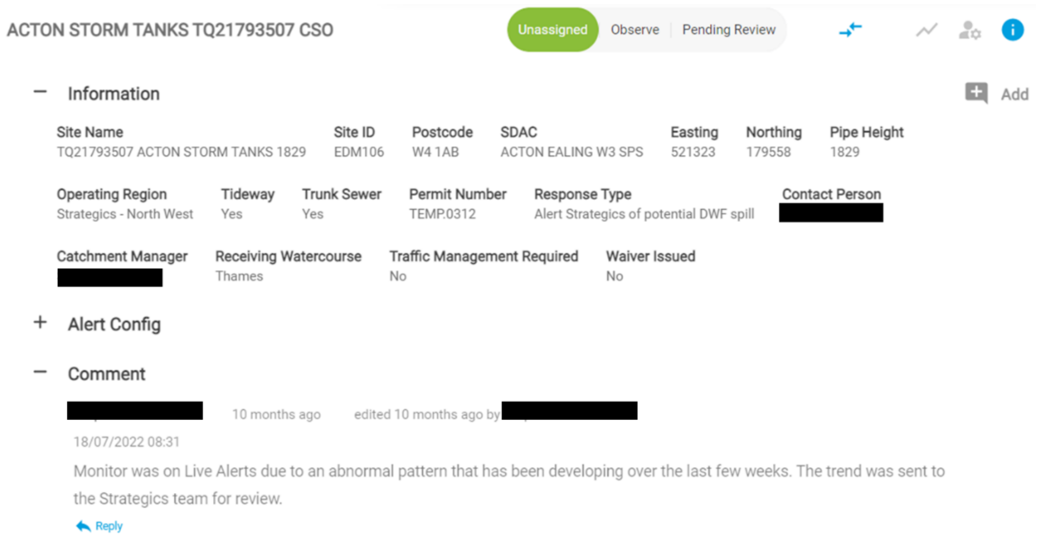
3.59 Figure 17 shows the logger data from one site within the Counters Creek Catchment. The blue bars represent rainfall, the orange/brown bars are the recorded sewer levels. The grey is the upper and lower operating range for the site. The red and green dots represent the jobs raised by the control room to respond when the levels change from their normal patterns. The example below found a blockage, which was then cleared before it impacted customers avoiding the need to call us to report a problem.

Figure 17: Sewer level alert data from logger in Counters Creek catchment

Discharge Alert Manager (DAM)

3.60 Our Discharge Alert Manager (DAM) tool uses Event Duration Monitor (EDM) data on Combined Sewer Overflows and storm tanks to improve how we manage flow in the wastewater systems. It provides insight into the day-to-day operation of the sewerage network and the key discharge points to the environment. We use the DAM tool in the Counters Creek catchment to monitor the flows arriving at Acton storm tanks.

Figure 18: Screen shot of the DAM tool



3.61 Figure 18 shows that the control centre received an alarm due to unusual flow patterns which may have meant there was an increased risk of flooding. The software is able to 'learn' what we consider to be normal flows and sets upper and lower bands. If the observed data moves out of these normal bands, the software places the site in alert and operational teams can investigate. This happened in July last year and Operations teams were sent out to investigate.

F Conclusions

3.62 The performance commitment stated that by the end of July 2023 we must deliver a fully assured report for the Counters Creek catchment which sets out our understanding of flood risk to customers and the level of flood resilience within the catchment. We must also outline our long-term strategy for alleviating flooding in the area.

3.63 Our report sets out the work we have undertaken to improve our understanding of flood risk to customers and the level of flood resilience within the catchment. This includes the work we have undertaken since the performance commitment was set and we have more clearly articulated our previous modelling work. We are able to state with confidence that the main factors affecting flood risk within the Counters Creek catchment are rainfall, surface water and climate change.

3.64 Our report and the Catchment Strategy Plan for Beckton set out the strategy for resolving flooding in the Counters Creek catchment in the short, medium, and long term. We intend to invest up to £1.7bn in risk zones 2 and 4 (covering Counters Creek) to reduce the risk of flooding of customers to 1.5% (internal) and 3% (external) up to a 1 in 30-year storm event in any given year by 2050, ensuring 95% of properties are not at risk of a 1 in 50-year storm event.

3.65 Our plan is subject to funding via the relevant price reviews. Our report has been independently assured by Mike Woolgar.

3.66 We have discussed the content of this report with the Boroughs of Hammersmith and Fulham, Kensington and Chelsea, City of Westminster and Camden and incorporated their feedback into the report.

3.67 We recognise that resolving flooding within the Counters Creek area requires a multi-organisation approach which will be coordinated via the London Surface Water Strategic Group. We will continue to work with Local Authorities to identify and implement sustainable urban drainage solutions as part of our Catchment Strategy Plan for the area.

Section 4

Performance commitment to evidence mapping

4.1 Table 5 sets out where to find the supporting evidence to demonstrate we have met the requirement for the performance commitment, starting with the main report which then references out to other reported information.

Table 5: Performance Commitment to evidence mapping

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
A general improvement in the depth, scale and quality of information available to the company, making use of information from both its own datasets as well as from third party stakeholders and organisations	Section 2A	Information	Stage 1	
Further model build and verification work, applying industry best practice throughout, to improve its understanding of the risk of flooding in the Counters Creek catchment as a whole and in localised flooding areas. It is considered likely that this would include an improved understanding of both localised as well as more strategic catchment wide flooding mechanisms, following guidance from the CIWEM UDG (2017) Code of Practice for the Hydraulic Modelling of Urban Drainage Systems (COP) or successors as well as other guidance where required	Section 2B	Modelling		

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
Consideration of the risk of flooding from rainfall across a widespread area, both within and external to, the Counters Creek catchment. It is expected this would demonstrate understanding of how rainfall of different event types across a widespread area impacts upon the effectual drainage of and flooding within the Counters Creek catchment. Best practice should be applied in line with the CIWEM UDG (2016) Rainfall Guide or successor or recognised equivalent, to assist any further verification, within the Counters Creek catchment and surrounding regions, where necessary	Section 2E		Stage 2 report section 3	
A sufficient level of understanding in regard to the interaction of the company's drainage assets with Lead Local Flooding Authority (LLFA) and third-party assets, where relevant, in relation to flood prevention in the Counters Creek catchment.	Section 2C	Information		
A sufficient level of understanding of historic flooding within the Counters Creek catchment and how the company will ensure it has processes in place to allow it to investigate and understand future flooding incidents when they occur. This applies to flooding incidents, whether reported to the LLFA, Thames Water and/or any other body.	Section 2G	Investigations	London Flood Report Stages 1-4	DWMP 2025-2050, Appendix F – Stakeholder Engagement https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-f-stakeholder-engagement.pdf Our DWMP 2025-2050 Appendix P – Our response to London Flooding 2021- June 2023.

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
It is expected the company will pursue a co-operative approach working with and sharing knowledge with stakeholders required by section 13 of the Flood and Water Management Act (2010).				https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-p-response-to-july-2021-floods.pdf
The inclusion in the model of basements and domestic connections at key flooding locations, to a Type III level of detail, as per the COP, where necessary, to predict the onset of flooding at property level.	Section 2B	Modelling	London Flood Risk report	
Sufficient understanding and representation within the model of any variable control strategies within the catchment - in particular, any new interactions, such as those presented by the Thames Tideway Tunnel (TTT). In regard to the TTT, there should be a sufficient level of understanding regarding how the current system (and any future changes to that system) will interact with the TTT and what impacts it may have, if any, upon resilience and flood risk within the Counters Creek Catchment	Section 3B	London Tideway Tunnels Operating Techniques Version 2		
Assessment of the impact tide/river levels and groundwater / infiltration have upon the effectual drainage and flooding within the Counters Creek catchment to ensure a network resilient to these risks.	Section 2F	Resilience		

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
A full understanding of where flood prevention within the catchment is highly dependent upon the operation of pumps and/or other assets.	Section 2I Section 3E		Stage 2	
A sufficient understanding of predicted flooding and flows in the extremities of, and external to, the Counters Creek catchment so that any transfer of flows or risk from outside the Counters Creek catchment to within the Counters Creek catchment are fully understood.	Section 2ESection 2D	Catchment Connectivity		
A sufficient level of understanding and confidence regarding operational issues and how factors like silt are likely to influence the risk of flooding within the network.	Section 3E		London Flood Risk Report	
A sufficient level of understanding regarding legacy flap valves or other control devices within the network and the impact they are having, or may have, on flooding.	Section 3E			
Emerging risks.	Section 2H			DWMP for Beckton 2025-2050 https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/beckton-catchment-strategic-plan.pdf Appendix B Risk Based Catchment Screening https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-b-risk-based-catchment-screening.pdf

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
				Appendix C Baseline Risk and Vulnerability Assessment https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-c-baseline-risk-and-vulnerability-assessment-and-problem-characterisation.pdf
The limitations of any resultant model should be clearly stated. In particular it should be stated, at headline level, the conditions under which the model cannot be used with confidence to provide a sufficient level of understanding regarding the risk of flooding in the Counters Creek catchment.	2.9, 2.12 and 2.25	Modelling		
Strategy for addressing flood risk	3A – E			Beckton CSP 2025-2050 https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/beckton-catchment-strategic-plan.pdf Appendix G Adaptive Planning https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-wastewater/appendix-g-adaptive-pathway-planning.pdf Appendix R Sustainable Urban Drainage Systems and Nature Based Solutions https://www.thameswater.co.uk/media-library/home/about-us/regulation/drainage-and-

Performance commitment requirement	Section of the main report	This report appendix	London Flooding Review Technical Report	Drainage and Wastewater Management Plan
				wastewater/appendix-r-delivery-of-suds-and-nature-based-solutions.pdf