MOTT MACDONALD

London Flooding Review

Non-Technical Summary - Stage 3 Report

May 2022

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Non-Technical Summary - Stage 3 Report

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	May 2022	S Wilcockson	L Bowyer/ E Flores Diaz	K Macpherson	Stage 3 Non-Technical Summary
B	May 2022	S Wilcockson	E Flores Diaz	F Barbour	Updated following IEG review

Information class: Standard

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1 Introduction

On 12 July and 25 July 2021, several London boroughs experienced severe flooding, causing damage to property and infrastructure, and disrupting people's lives and livelihoods. To establish why this flooding happened, and how similar events may be managed in the future, Thames Water commissioned an independent expert group (IEG) to lead an Independent Review into the flooding.

The review consists of four key stages:

– *Stage 1: What?* – An objective review of the available data relating to the flooding on 12 and 25 July 2021
– *Stage 2: Why?* – An investigation into the flooding mechanisms and root causes that led to flooding on 12 and 25 July 2021
– *Stage 3: How?* – An assessment of how well Thames Water's assets, including flooding alleviation schemes, critical pumping stations and the overall sewer network, performed on 12 and 25 July 2021
– *Stage 4: What next?* – Recommendations to improve current flood mitigation processes and improve resilience to future flooding events

2 Stage 3 – what did we do?

Stage 3 builds on the activities we undertook in Stages 1 and 2. During Stage 3, we took a closer look at how the various assets that were involved in managing the extreme rainfall on 12 and 25 July 2021 performed. These assets included sewers, pumping stations and flood alleviation schemes.

We looked specifically at:

- Return periods and design standards
- Performance of critical assets during the events
- Performance of recent and future capital schemes
- Interaction between multiple flooding assets, such as the sewer network and gully systems

2.1 Return periods and design standards

Return periods

A return period is associated to the probability of events such as floods occurring.

A return period is usually described in terms of a '1-in-10 year' or '1-in-100 year' event. Despite how it sounds, this does not mean that such an event will only occur once in 10 or 100 years, or that once it has happened it won't happen again for another 10 or 100 years.

A return period gives the estimated time interval between events of a similar size or intensity. For example, if the return period of a flood is 1-in-10 years, this means it has a 10/100, or 10%, probability (or chance) of occurring in any given year, regardless of when the last similar event occurred.

While, on average, there will be one 1-in-10 year event in ten years, in any given ten-year period there may or may not be an event of this magnitude. It is also possible for there to be more than one such event, or for there to be events of a higher magnitude in the same period. For a more detailed explanation of return periods, click here.

A notable characteristic of summer storms of this nature is high intensity of rainfall over a small area. These are called convective storms[1]. It was not possible to provide a single return period for each flooding event as the intensity of the rainfall was very different across different parts of the city. The high tide on the days in question would also have had an effect on the return period as this can prevent sewers draining effectively into the River Thames.

However, what we can say from our calculations is that 69km^2 of the catchment (the area being studied) exceeded a rainfall return period of 1-in-30 years on 12 July 2021; and 123km^2 of the catchment exceeded a rainfall return period of 1-in-30 years on 25 July 2021. This is out of a total catchment area of 1,292km^2. At its peak intensity, over a small area of Bayswater, the event on 12 July exceeded a 1-in-200 year return period.

It was important to understand the range of return periods of the flooding events so that we could compare these with the design standards for the sewer system.

[1] Convective Storms | Royal Meteorological Society (rmets.org)

Design standards

Design standards refer to how much flow (wastewater and rainfall) sewer systems are designed to accommodate.

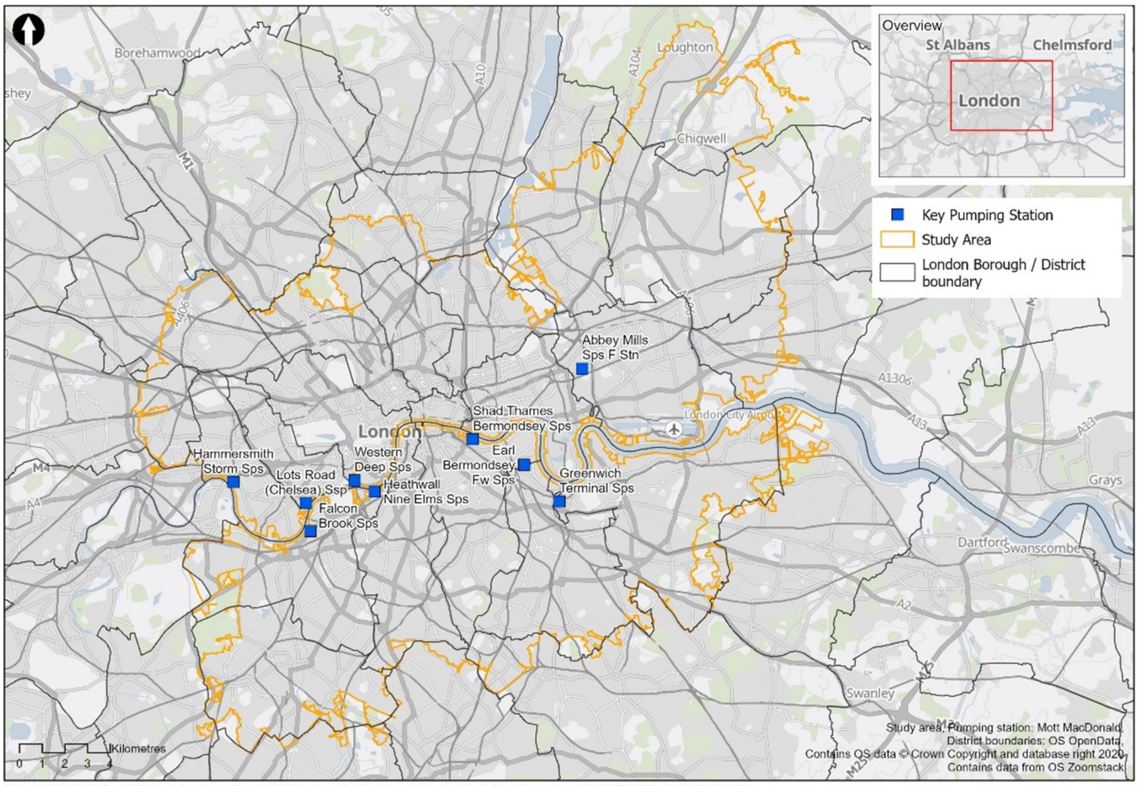
New sewer systems are usually designed so that all flows (sewage and surface water run-off) are contained within the sewer up to a 1-in-30 year return period, which means there won't be flooding at ground level during rainfall up to that intensity. Older sewer systems were not designed to the same standard, and therefore often have a capacity much less than the 1-in-30 year event. While the Victorian sewer system for London had ample capacity at the time of its construction, the growth of the city has had an effect on the ability of the sewer system to cope with the current flows that drain into it.

Further information about the design of sewers, and other flood risk assets, is given in the CIRIA C635 guidance document 'Designing for Exceedance' and Codes for Adoption, produced by WaterUK.

2.2 Performance of critical assets during the events

We looked at how key pumping stations performed during the flooding events to see if they performed as designed or if their operation had an impact on the flooding. There are nine strategic pumping stations operated by Thames Water situated across London. Six pumping stations have the purpose of pumping storm flows to the river, and three pumping stations play a critical role in lifting flows and transferring them eastwards to the sewage treatment works at Beckton and Crossness. There are over 200 designated pumping stations in the Beckton and Crossness drainage catchments. The nine selected for assessment are most critical to transferring flows from one catchment to another.

Figure 2.1: Key pumping station locations in Beckton and Crossness



During the July 2021 events, Lots Road Pumping Station and Hammersmith Pumping Station experienced some reductions in capacity as a result of operational issues, due to the pumping stations not having all pumps available and a delay to manual switch-on of pumps. In Stage 2 we found that, while these operational issues increased water levels locally, they did not play a significant role in flooding during the July events. This is because the systems were overwhelmed by the high intensity rainfall, which far exceeded the capacity they were designed for.

The Stage 3 report presents descriptions of each of the strategic pumping stations, how they are modelled and how they performed during the July 2021 events.

Flooding was also attributed to Abbey Mills Pumping Station I, however this was because the maximum pump rate was exceeded. This means that the pump couldn't work any harder than it did, as it was designed to cope with a certain amount of rainfall, which was exceeded on 12 and 25 July. So, rather than the capacity being reduced at Abbey Mills Pumping Station I, the design meant it didn't have the capacity to cope with the amount of rainfall flowing to this pumping station during these extreme events.

Table 2.1: Performance of strategic pumping stations

Pumping station	Operational issues	Performance on 12/25 July 2021
Hammersmith Pumping Station	Pumping station not operating at full capacity on 12 July	Performed as designed, minor impact on flooding
Lots Road Pumping Station	Delay to manual switch-on of pump	Performed as designed, minor impact on flooding
Falcon Brook Pumping Station	None	Performed as designed
Western Pumping Station	One pump out of operation, one pump at half capacity	Performed as designed
Heathwall Pumping Station	None	Performed as designed
Shad Pumping Station	None	Performed as designed
Earl Pumping Station	None	Performed as designed
Greenwich Pumping Station	None	Performed as designed
Abbey Mills Pumping Station I	None	Performed as designed, minor impact on flooding

2.3 Performance of recent and future capital schemes

We analysed four capital schemes (these are projects developed and built by Thames Water to manage flood risk up to a 1-in-30 year design standard) to see how they performed during the July 2021 flooding events. These included three flood alleviation schemes. A flood alleviation scheme (FAS) is a series of structures and methods put in place in an area to limit damage that may be caused by flooding. In particular at-risk areas, flood alleviation schemes can be supplemented by Flooding Local Improvement Projects (FLIPs). These are additional protection measures designed to provide resilience to flooding for a single property, normally by means of stopping water entering a property via the sewer system. We also looked at whether the Thames Tideway Tunnel (due to be completed in 2025) would have had an impact on the flooding if it had been operational in July 2021.

We used a 1D (one-dimensional) hydraulic model to simulate rain falling on the catchment and flowing through the sewer system, and compared this with the observed rainfall data from rain gauges on 12 and 25 July. This was to see if more or less water drained into the sewer system than was originally calculated and whether the flood alleviation schemes worked as designed. A 1D model predicts how much rainfall goes into a manhole or road drain from roof drains, paved drives, patios, road surfaces, etc, and then into the sewers.

1D modelling of the flood alleviation schemes found:

- Westbourne Grove FAS: the scheme operated as designed, by diverting flows into a storage tank. The tank nearly reached full capacity. Levels in the main sewer were reduced by 400mm, reducing flood risk in the area. Four properties which were protected through the scheme, to the 1-in-30 year design standard, experienced flooding in July. Evidence suggests at least two properties had a FLIP installed. Therefore, there is a risk the FLIP failed, or was overwhelmed through other sources, such as surface water which was not able to enter the sewer system. Further investigations are recommended.

  Result: the scheme performed as designed – of the 120 properties protected to the 1-in-30 year return period event, seven flooded during this event, one of which could have been from a secondary flood mechanism and not necessarily as a result of failure of the system.

- Maida Vale FAS: the scheme covers three separate areas:
  - Tamplin Mews: performed as designed by reducing the water levels locally. However, there were a number of properties which were expected to be covered by this FAS that reported flooding for the first time. This is likely to be because these properties are still connected to the trunk sewer, which was overwhelmed during the event.
  - Formosa Street: performed as designed by reducing the water levels locally. However, the principle of the scheme is to divert flows away from locations which previously reported flooding. As a result, water levels are increased in other areas. Some properties which reported flooding in July were likely to have normally drained to sewers which, during the storms, already had increased flows due to the diversion. However, it is not possible to confirm if flooding would be experienced as a result of high levels in the network regardless of changes to flow routes. We recommend that Thames Water investigates these areas of detriment (possible negative effects of a FAS) further to determine potential solutions.
  - Cambridge Gardens: consists of FLIPs. None of the properties reported flooding in July, suggesting the FLIPs performed as designed. No nearby properties reported flooding either.

  Result: the scheme performed as designed – eight properties were protected during the storms as a result.

- Thames Tideway Tunnel: construction not yet completed. The purpose of the tunnel is to reduce spills to the River Thames from the sewer network to improve water quality, rather than to act as a flood risk asset. However, we carried out the analysis to demonstrate any benefits that the tunnel system, and associated improvements, may provide during similar events in the future. The tunnel was predicted to fill to maximum during the 25 July 2021 event. During the 12 July 2021 event, the rainfall was more localised so the impact across the whole drainage network was reduced. In both events, there was a minor improvement in reducing levels near to interceptions (points at which the existing sewer system diverts flows to the new scheme) but, overall, the tunnel will not make a major difference to flood risk for extreme events once connected.

Result: With the completion of the London Tideway Tunnel (LTT) system, during significant or extreme storms, some limited benefit to network sewers adjacent to the LTT interception can be expected when the tunnel is available to accept flows.

- Counters Creek Flood Alleviation Scheme (FAS) (as constructed): The scheme consists predominantly of FLIPs, plus some local schemes that provide street level isolation from the sewer network once the pipes become full. The area covered by Counters Creek also includes permeable paving schemes, which were built to offset potential detriment caused by installing several FLIPs in a localised area. As the schemes affect very localised areas, there is little impact catchment-wide on reducing top water levels. No properties protected by local schemes reported flooding in the July event. Some properties with FLIPs did report flooding but it is not known if this is related to a failure of the FLIP or from being overwhelmed from surface water. There is no evidence that top water levels were increased as a result of diverting flows to other parts of the catchment.

  Result: the scheme as constructed performed as designed – when compared with the reported flooding properties in July 2021, 21 out of 1300 (1.6%) of these FLIP properties reported below ground flooding. This demonstrates that the FLIPs provided protection for the majority of properties above the 1 in 30yr rainfall return period level for which they were designed. Additionally, 44 properties were protected during July 2021 by local schemes that were separate to FLIP installation.

In addition, we modelled a historical tunnel route that was proposed when the Counters Creek FAS was originally designed. The proposed tunnel design was eventually rejected in 2017 in favour of installing FLIPs. We did this to determine the effects the Counters Creek tunnel may have had on catchment water levels if it had been progressed as originally planned. This was in response to questions from stakeholders and members of the public after the events about the potential impact of the rejected tunnel design.

- Counters Creek Tunnel (reference design): The reference design consists of four interception sites, and assumes a connection to London Tideway Tunnel (via the Thames Tideway Tunnel, TTT) at Lots Road Pumping Station. Obviously, the scheme could not have had an effect on the July 2021 floods as the TTT is yet to be built, but once the hypothetical tunnel is connected in the model, it predicts that future similar events would benefit. There was a large reduction in top water levels close to the interception sites. There was also a moderate reduction across the Shepherd’s Bush, Fulham, Holland Park, Brook Green and Hammersmith areas. The further away from interception sites, the less benefit was observed. However, the flows into LTT from the tunnel exceeded the agreed $18m^3/s$ design flow rate from Lots Road Pumping Station to the TTT, and this might have a negative impact on the performance of the hydraulic control structures.

  Result: More than 2000 properties were the original focus of the Counters Creek FAS design solution. Of these, 64 properties reported flooding in July 2021. We found that 31 of the 64 properties that reported flooding may have benefited from the tunnel solution if it had formed part of the Counters Creek FAS design.

2.4 Interaction between multiple flooding assets, such as the sewer network and gully systems

We used two focus areas or flooding ‘hotspots’ – Waltham Forest and Maida Vale – to test the interaction between above-ground assets (road gullies that drain water from the surface) and below-ground assets (sewer pipes). We used computer models to see whether:

a. Blocked gullies could have inhibited flows entering the sewer system, making surface flooding worse;

b. Flows from neighbouring areas could have exacerbated flooding and affected the performance of the sewer assets.

To demonstrate these, we created localised linked 1D-2D models, which represented the overland flow routes and the below-ground sewer network (click here for a more detailed explanation of 1D and 2D modelling in this context).

In Waltham Forest, we were testing the performance of gullies. We identified that the intensity of the rainfall was so great, flows into the below-ground network were restricted. A large amount of flow was retained on the surface, but some flows were able to enter the sewer network. Therefore, it is likely that the water retained on the surface was not solely due to gullies being blocked. Even without blockages, gullies may have filled with water making them unable to accept the flow, causing it to run past them rather than into them.

In Maida Vale, we were testing the Tamplin Mews tank and its associated system. Observed data suggested the level in the tank reached a much higher level than expected, using the current 1D model. We ran a number of simulations using 2D models to see how water flowed over the different surfaces in the catchment and the effects of rainfall on neighbouring areas such as parkland. These scenarios are not possible with 1D modelling alone.

We found that the high level in the tank was caused predominantly by flooding from the trunk sewer network draining overland and entering the new sewer system constructed as part of the Maida Vale FAS, and then entering the tank. A second scenario demonstrated that flooding along Kilburn Park Road was better replicated when overland flows from Paddington Recreation Grounds were taken into account. The analysis shows that the interaction between the above-ground and below-ground systems is important when designing new flooding schemes.

The tests on these focus areas suggest that the current use of 1D only models is inadequate in understanding flood risk and the performance of flood schemes. We will discuss this further in the Stage 4 report.

3 What happens next?

In Stage 4, we will summarise our findings and make recommendations to improve current flood mitigation processes and improve resilience to future flooding events.

We will publish the Stage 4 report, along with a non-technical summary like this one, in the next step of the London Flood Review.

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