Counters Creek Technical Appendix Flooding Resilience

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Section 1 Introduction

1.1 This is a technical appendix which provides supplementary information to the main Counters Creek Understanding of Flood Risk and Long-Term Strategy report. Table 1 shows the clauses in the performance commitment to which the supporting evidence relates.

Table 1: Relevant clauses of the performance commitment

Requirement	Appendix section
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.	2 and 3
A full understanding of where flood prevention within the catchment is highly dependent upon the operation of pumps and/or other assets.	4

Section 2

Resilience to groundwater and infiltration

A Methods of assessment

2.1 This section describes the analysis we have undertaken to assess the impact that groundwater and infiltration have upon the effectual drainage and flooding within the Counters Creek catchment to assess whether the network is resilient to these risks.

2.2 We assess flood risk from groundwater infiltration based on the ratio of baseflow to storm flow and the significance of seasonal variation in baseflow.

2.3 In the main report we explained that we looked at four different ways of assessing whether seasonal variation in groundwater infiltration is likely to impact the risk of flooding:

- 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

B Baseflow represented in the model

2.4 We assess the flood risk resulting from the baseflow (constant flows within the sewer system referred to as unaccounted-for flows) through historical flow surveys and long-term monitors in the catchment.

2.5 The source of the unaccounted-for flows could be from multiple locations, such as groundwater, an impact of the lost river system, or misconnections from other drainage systems. Table 2 shows that the baseflow is a low percentage of the storm flows, therefore it has a low impact on flood risk. The greatest proportion of flow during a rainfall event originates from urban runoff and rainfall responses. As this is a combined sewerage system, this will have the greatest impact on the system and its risk of flooding.

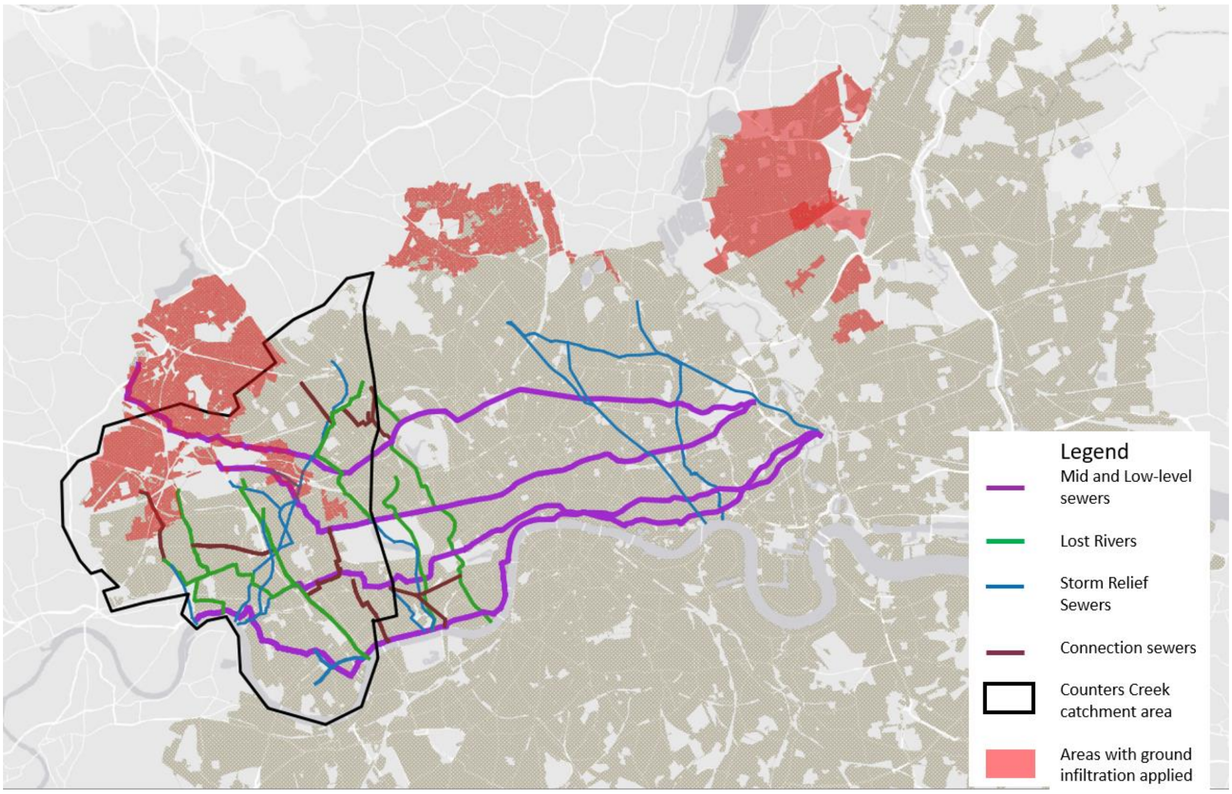
Table 2: Comparison of the base flow, peak dry weather flow and storm flows

Trunk Sewer	Average baseflow	Peak dry weather flow	1 in 30-year storm flows	Baseflow/Storm flow %
Counters Creek Mainline	85l/s	210l/s	6,200l/s	1.37%
Brook Green Sewer	25l/s	120l/s	1,200l/s	2.08%
Low Level 1 sewer (Hammersmith)	150l/s	260l/s	2,100l/s	7.10%
Low Level 1 sewer (Chelsea Foreshore)	570l/s	1,335l/s	3,900l/s	14.6%

2.6 Our long-term plan as set out in drainage and wastewater management plan will tackle attenuating or separating storm flows to reduce the impact of storm response runoff, either by slowing the flows, attenuating them to reduce the peak flow, or separating surface water runoff from the current combined sewer network.

C Groundwater infiltration represented in the hydraulic model

Figure 1: Beckton Catchment showing where slow response rainfall runoff is included in the hydraulic model



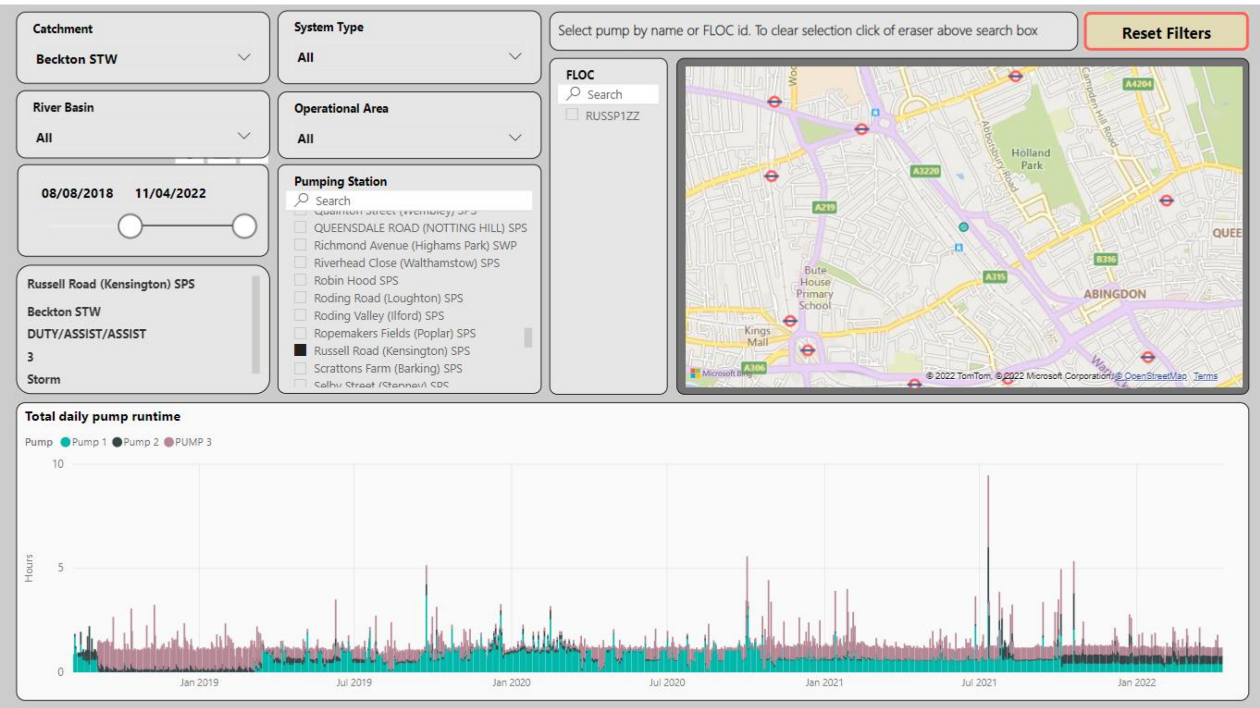
2.7 We represent the risk of groundwater infiltration, or the extremely slow response of the system draining down following rainfall (using the infiltration module), in the hydraulic model by using historical flow survey data. Therefore, it is accounted for in our BRAVA assessment. Figure 1**Error! Reference source not found.** shows the application of this slow response runoff is on the periphery of the catchment, and only affects a small part of the Counters Creek catchment. There was insufficient evidence during historical flow surveys and the long-term monitors to indicate slow response runoff in the Counters Creek catchment.

D Pumping station run time analysis

2.8 Seasonal variation in pump run times, or changes in flows particularly following prolonged periods of wet weather could indicate that groundwater infiltration may affect flood risk. We selected a number of pumping stations across the Counters Creek catchment which we considered to be good indicators of potential infiltration impact as explained below.

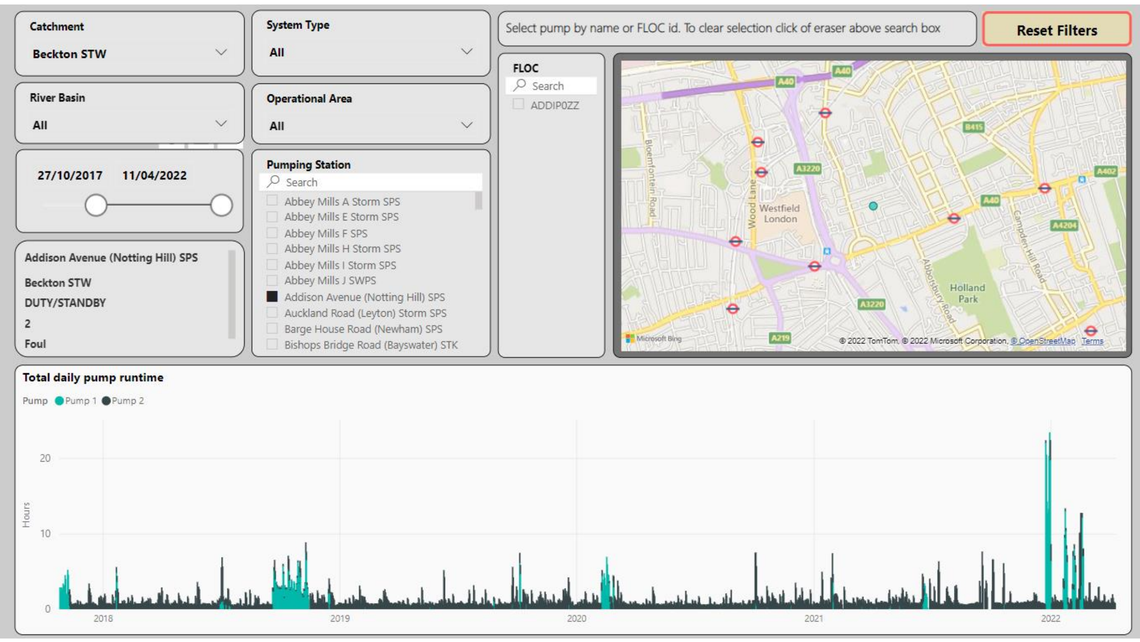
2.9 Russell Road Pumping Station is located just off Holland Park Road and serves a catchment isolated by the pumping station from the Counters Creek sewer. It is considered a good indicator as it does not take flows from elsewhere. Figure 2 shows the long-term pump run times have no seasonal variation (a combination of the three pumps at this station, shown in green, black and brown values on the graph), despite the winters of 2019/20 and 2020/21 being very wet. The peaks in the graphs relate to key storm events where large amounts of rainfall enter the sewers. The daily run times remain very constant apart from these storm events, and there is no change to the hours of operation during the winter that would suggest increased flows from infiltration or groundwater. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 2: Pump run hours for Russell Road Pumping Station



2.10 Figure 3 shows the pump hours run for Addison Avenue Pumping Station in Notting Hill, located within the Counters Creek catchment. It provides an indication of similar rainfall conditions and the response in the sewer system. Again, the peaks in the graph coincide with storm events, but there is no change to the winter operation that would suggest increased flows from infiltration or groundwater. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 3: Pump run hours for Addison Avenue Pumping Station, Notting Hill



2.11 Hammersmith Storm Pumping Station serves the storm relief network draining much of the Counters Creek catchment. If groundwater was entering the storm relief network, then we would expect to see greater operation of the pumps during the wet winter periods in Figure 4. However, operation is intermittent and associated with key storm events.

2.12 Hammersmith Storm Pumping Station has a set of drain pumps that return baseflows to the Low-Level No.1 at approximately 200l/s. This takes, on average, 24 hours to drain the upstream storm relief sewers back to the Low-Level Sewer No.1. The operation of this pump can be seen in Figure 5. The operation matches the key storm events shown in the main storm pump operation graph. Only excess storm flows are discharged to the river, and once the rainfall stops the system stores, and then returns flows, using the drain set pumps. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 4: Pump run hours for Hammersmith Storm Pumping Station

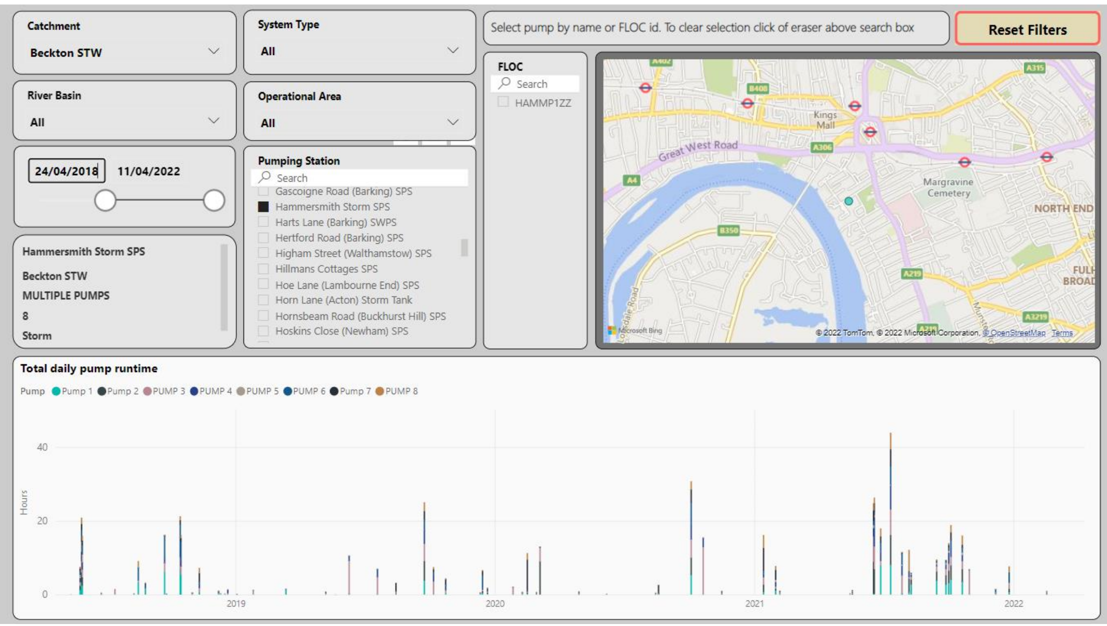
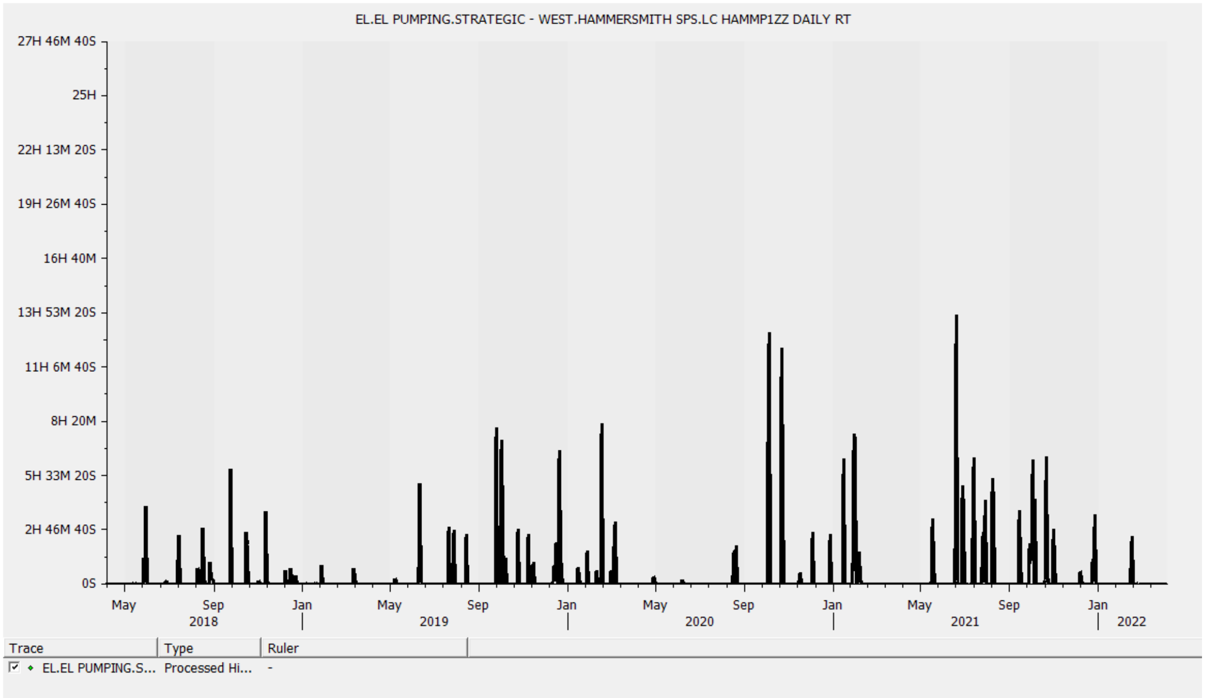


Figure 5: Run times for drain pump at Hammersmith Pumping Station



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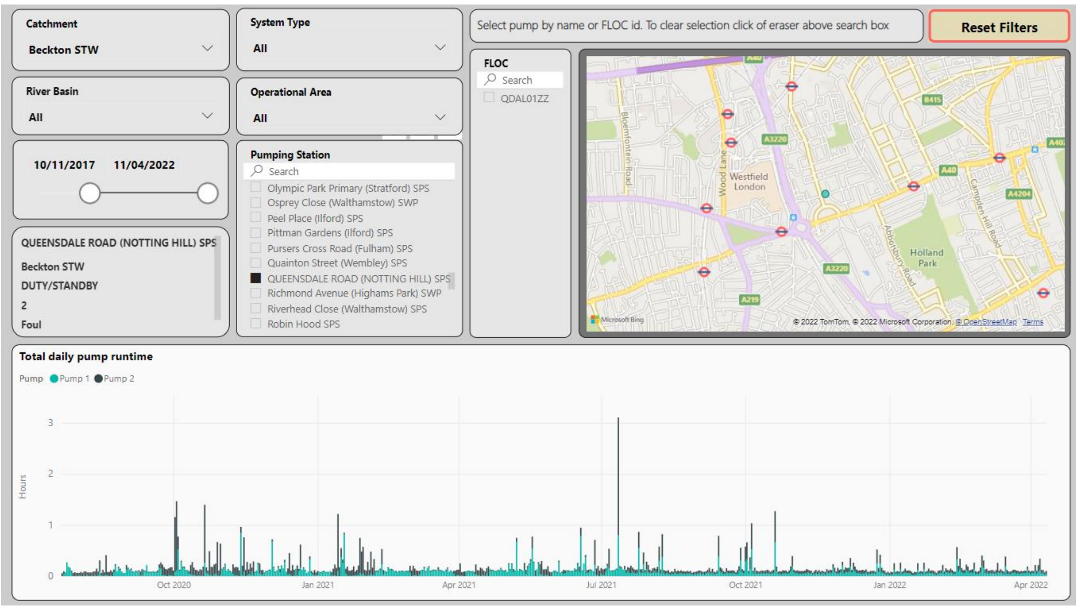
2.13 Figure 6 shows the pump run hours for Queensdale Road Pumping Station in Notting Hill, which was installed as part of the AMP6 scheme and is situated within the Counters Creek catchment. The peaks in the graph relate to key storm events but there is no change to the winter operation that would suggest increased flows from infiltration or groundwater. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 6: Pump run hours for Queensdale Road Pumping Station

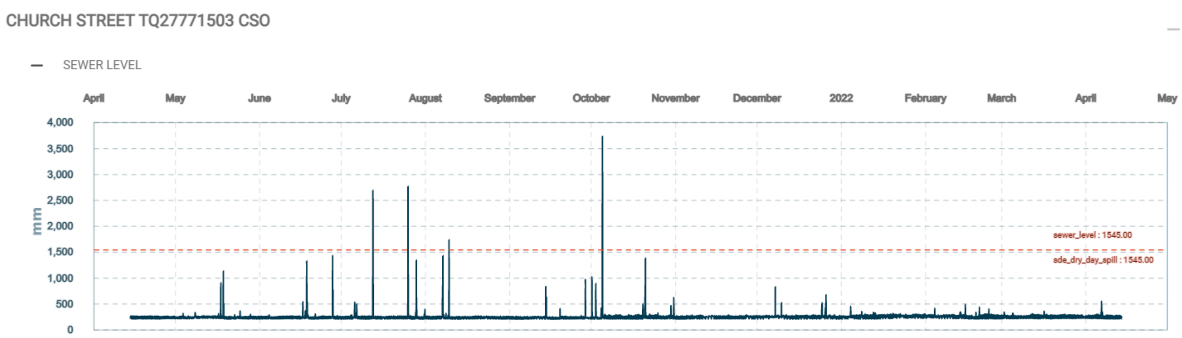


2.14 The key findings of our analysis are that there is no seasonal variation relating to groundwater and pump response times relate more closely to rainfall responsive runoff.

E Event duration monitor and depth logger analysis

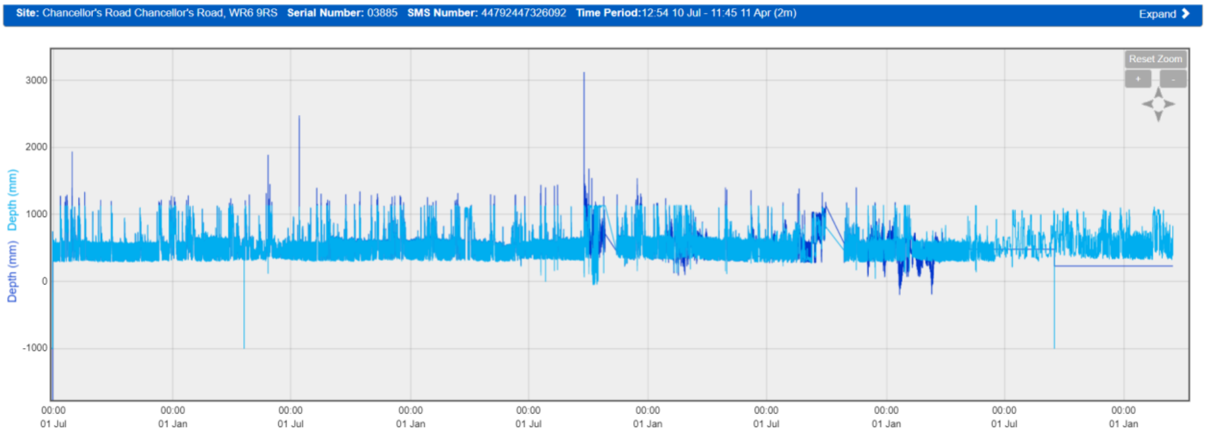
2.15 We have reviewed event duration monitor (EDM) and depth logger monitoring data within the main trunk sewers across the Counters Creek Catchment as this shows long term trends in the sewer system, and available capacity in the sewer. This would show a variation in baseflows if infiltration and groundwater were impacting the sewerage system. The examples below show the long-term trends for several cross connections between trunk sewers and storm relief sewers in the catchment.

Figure 7: Church Street sewer EDM – April 2021 to April 2022



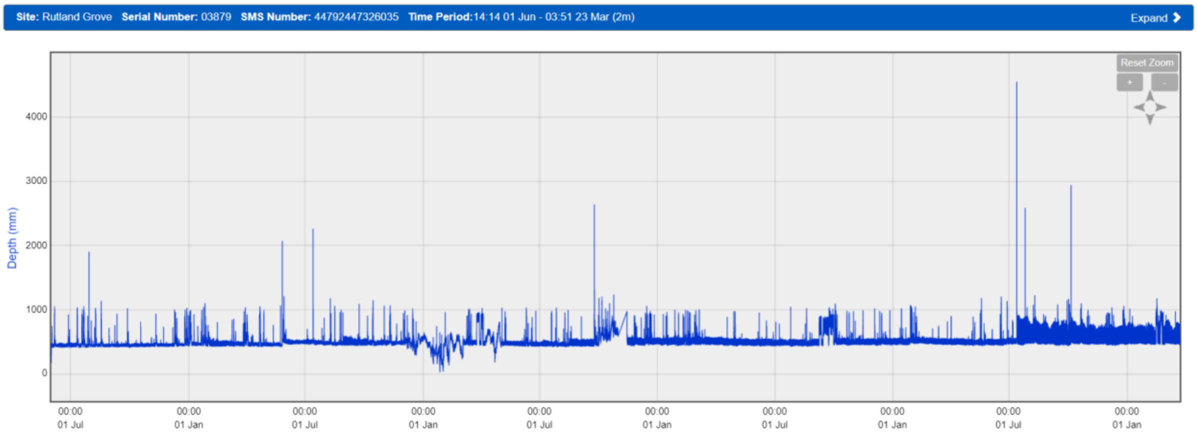
2.16 Figure 7 shows the data from Church Street EDM. It has a very stable baseline flow and no seasonal variation that could be attributed to groundwater infiltration, therefore, this is not likely to affect flood risk.

Figure 8: Chancellors Road depth logger data – July 2017 to April 2022



2.17 Figure 8 shows data from the Chancellors Road logger, located in the Low-Level No.1 sewer outside Hammersmith Pumping Station. This shows that since 2017 there has been no discernible change to the base flows and no seasonal variations despite there being two wet winters during this time. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

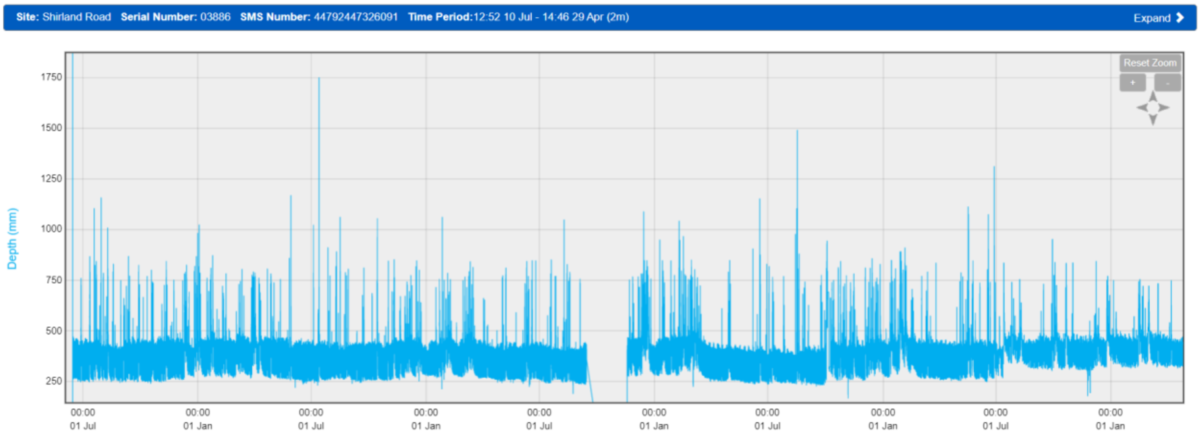
Figure 9: Rutland Grove depth logger data – July 2017 to April 2022



2.18 The data for Rutland Grove in Figure 9 appears to show that there is more flow in the sewer after the extreme weather event in July 2021. Investigations determined that is due to damaged tide flap gates at the outfall which means a small amount of river water is entering the sewer at high tides. This increase isn't seen at the downstream logger on Chancellors Road and so the volumes are small. The damaged tide flap gates have now been repaired and the levels are now back to pre-July 21 levels.

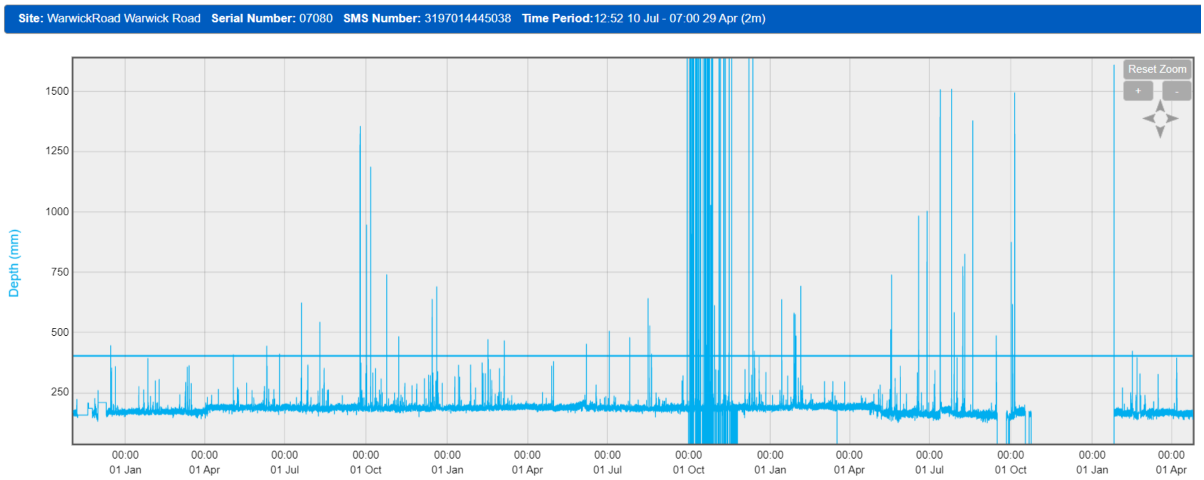
2.19 There are no discernible changes to base flow and no seasonal variation that would suggest groundwater infiltration and therefore it is not likely to increase flood risk.

Figure 10: Shirland Road depth logger data – June 2017 to April 2022



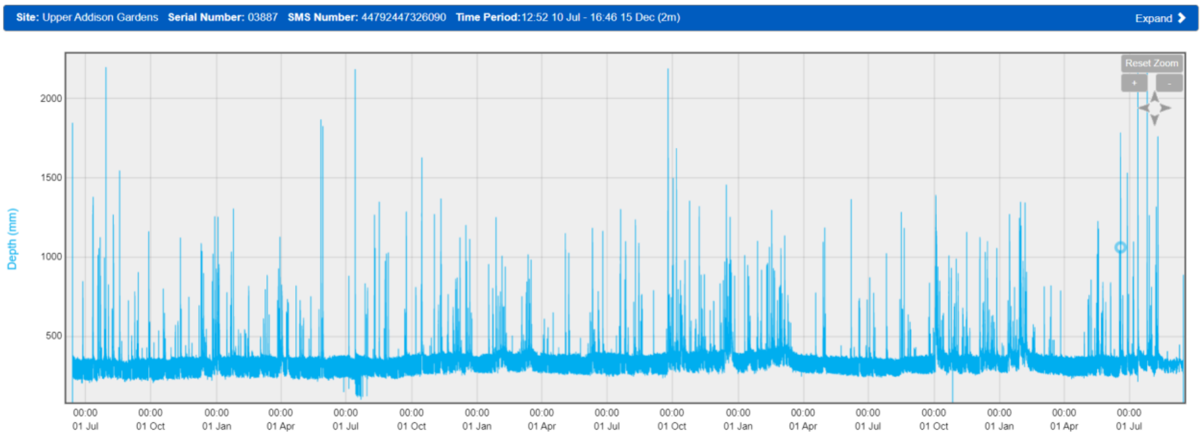
2.20 The Shirland Road logger is located within the Ranelagh sewer. The data in Figure 10 shows a slight increase in base levels during Jan 2020 and Jan 2021 but this is thought to be due to the increased number of rainfall events and the time it takes the system to drain down rather than any longer term baseflow elements. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 11: Warwick Road depth logger– September 2018 to April 2022



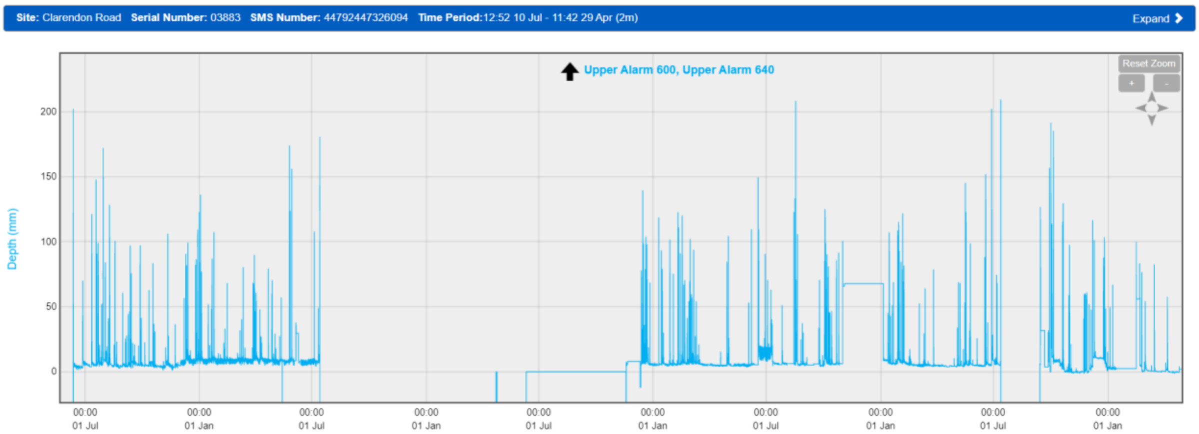
2.21 The Warwick Road depth logger is located at the junction of the Counters Creek sewer and the Low-Level No.2 sewer and has been recording data since September 2018. Figure 11 shows that, apart from a few periods of noisy data in October 2020 following Storm Alex and missing data from October 2021 to January 2022, the baseflow levels at this key junction have been very consistent. There are no seasonal groundwater influences seen at this central part of the Counters Creek catchment.

Figure 12: Upper Addison Gardens depth logger– June 2017 to November 2021



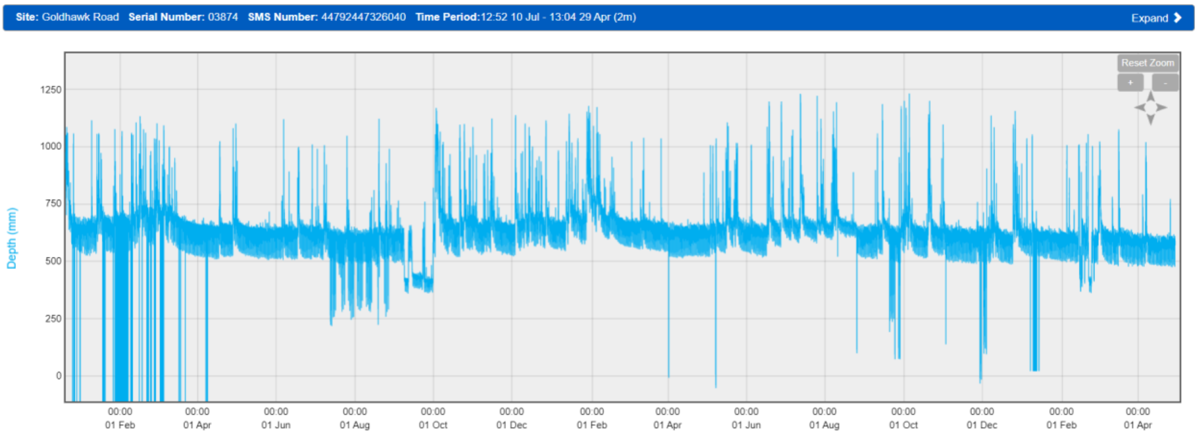
2.22 The Upper Addison Gardens depth logger is located at the top end of the Counters Creek sewer. The data in Figure 12 shows how storm responsive the combined sewerage system is with each spike representing a rainfall event. The baseflow levels remain constant throughout the 4 years with some slight increases during prolonged wet periods. This reflects the time taken for the system to drain down and successive rainfall events rather than any groundwater influences on the system. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

Figure 13: Clarendon Road depth logger – June 2017 to April 2022



2.23 The Clarendon Road depth logger is located in the chamber where the North Kensington Storm Relief sewer and the Northwest Storm Relief sewers cross. The data in Figure 13 is missing for periods due to equipment failures but the underlying baseflow in these storm relief sewers that bring flow down into the Counters Creek catchment is stable and shows no seasonal variation that would suggest any groundwater interaction with the network. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

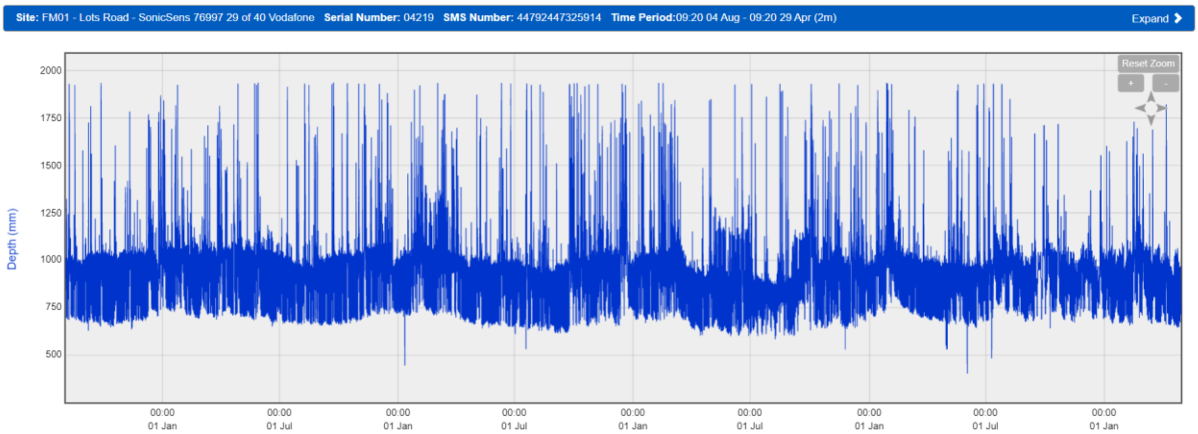
Figure 14: Goldhawk Road depth logger – December 2018 to April 2022



2.24 Goldhawk Road logger is on the Stamford Brook sewer that brings flows into the Counters Creek catchment from the west and Acton areas. The data shown in Figure 14 covers the wet winters of 2019/20 and 2020/21. The baseflow levels from these periods is only 50mm greater than the dry winter of 2021/22. Periods of higher flows are associated with successive storm events on the catchment and the drain down of Acton Storm Tanks returning storm flows back to the network once the storm event has passed.

2.25 Acton storm tanks have a pre-Tideway volume of approximately 19,200m^3. Returning this flow to the sewer network following large rainfall events prolongs the flows in the network and the levels recorded in the sewer at this location. The variation in flow found here is, therefore, attributed to variation in rainfall and storm tank drain down periods rather than groundwater infiltration into the system. Therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

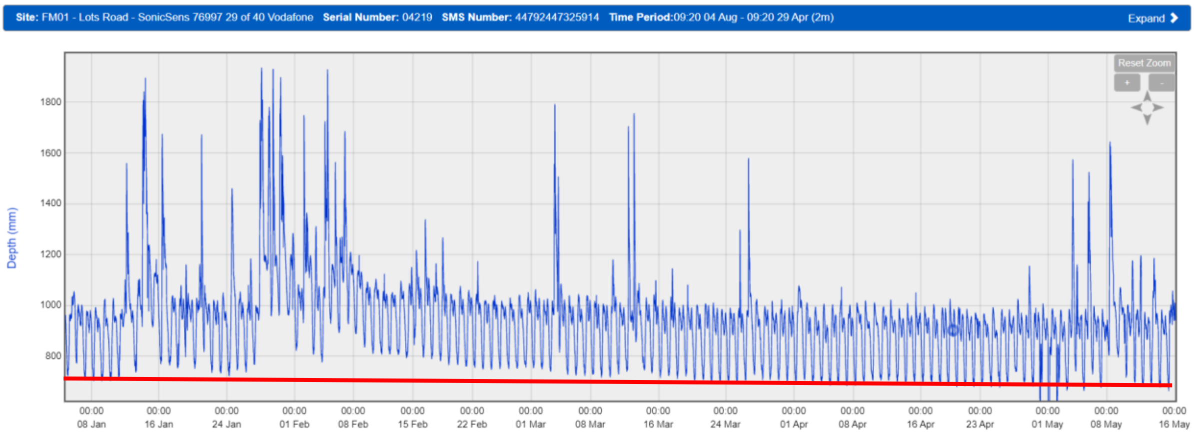
Figure 15: Lots Road depth logger – August 2017 to April 2022



2.26 The Lots Road logger is in the Low-Level No.1 sewer outside Lots Road Pumping Station. The data in Figure 15 shows a relatively stable baseflow of between 700mm and 750mm. There does appear to be a slight uptick during the winter period, but this is thought to be due to increased rainfall activity and the time it takes the network to drain down following each event rather than any groundwater associated inflows. The large storm relief system upstream of Hammersmith Pumping Station can take 24 hours to drain down using pumps delivering flows back to the system at 200l/s. This equates to a drain down volume of 17,280m^3 contained within the storm relief sewers.

2.27 Figure 16 shows the typical response to increased rainfall and the gradual return to normal dry weather flow conditions. This period is from January 2021 to May 2021 and covers the wet winter period with successive rainfall events topping up the system. Further events in March raise the levels once again, but by April the levels are consistently back to prewinter levels.

Figure 16: Lots Road depth logger – January 2021 to May 2021



2.28 The key findings of our analysis for EDMs and loggers is that there is no seasonal variation relating to groundwater and infiltration. Data is more closely related to rainfall responsive runoff. Therefore, groundwater and infiltration are not thought to significantly increase flood risk.

2.29 One area mentioned in our final drainage and wastewater management plan which has had a history of sewer and groundwater flooding in 1975, 2002 and 2021 is South and West Hampstead. We are currently proposing a collaborative investigation to consider surface water management solutions with the Environment Agency, Transport for London, Residents Groups and High Speed 2.

F Analysis of flows arriving at Beckton sewage treatment works

2.30 If groundwater and infiltration were entering the sewerage system this would be most evident at the sewage treatment works inlet. Figure 17 shows a year's worth of Flow To Full Treatment data which has a very consistent baseflow level. The storm events throughout this period can be seen in Figure 18. At Hammersmith PS the system can take 24 hours to drain down following a large rainfall event. Across the whole Beckton catchment there are many more storm relief sewers and storm tanks that all drain back to the network once the storm has passed, resulting in a gradual return to dry weather flow conditions.

Figure 17: Beckton STW Flow to Full Treatment

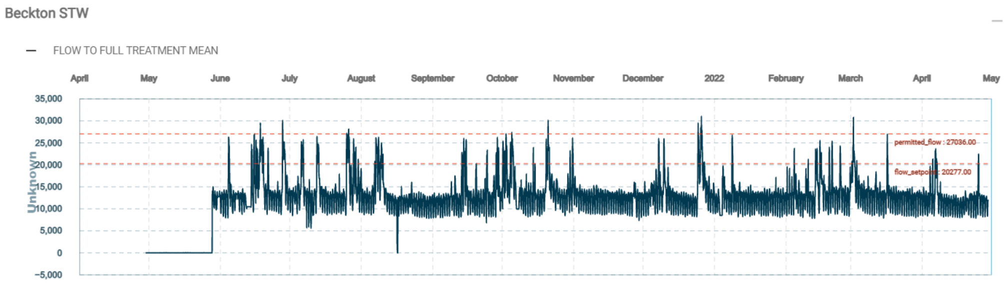
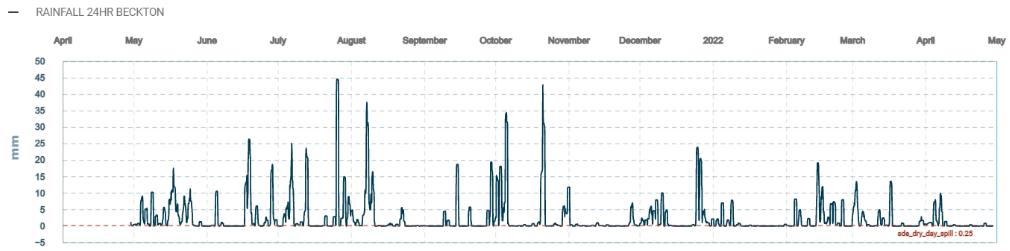


Figure 18: Beckton Daily Rainfall



2.31 We have not found seasonal variations in the baseflow level, therefore, infiltration and groundwater are unlikely to have an impact on flood risk.

G Geology of London

2.32 The majority of the Counters Creek area is underlain by London Clay and there is likely to be some infiltration (less than compared to sands) which varies over time and locations. In terms of data, the British Geological Survey data is too coarse for a meaningful assessment of how it might impact infiltration in the Counters Creek area as it is only available on a regional scale.

2.33 Our analysis concludes that infiltration and groundwater are unlikely to have an impact on increasing flood risk. We have accounted for any flows through historical flow surveys and ongoing monitoring. This has been taken account of in our BRAVA assessment.

Section 3

Resilience to river levels and tides

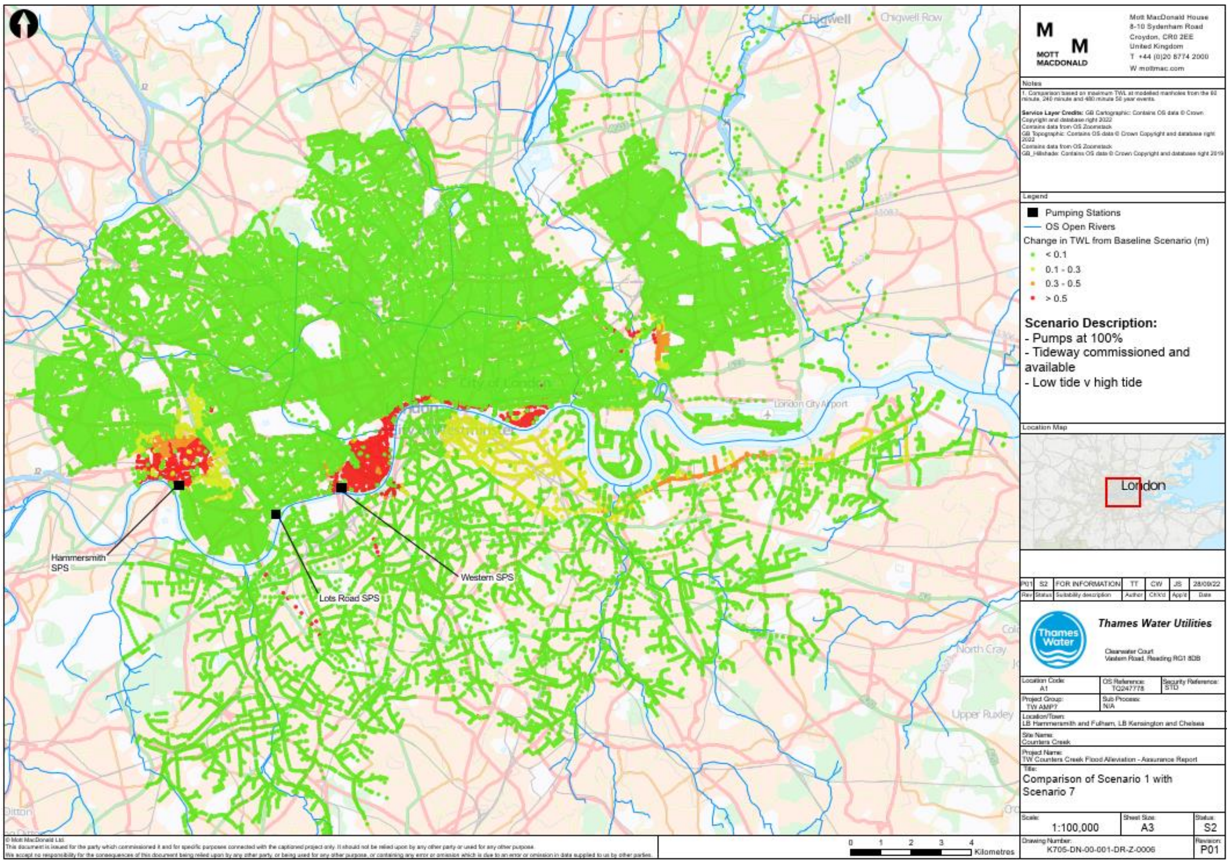
3.1 This section describes the impact that river and tide levels have upon the effectual drainage and flooding within the Counters Creek catchment to confirm that the network is resilient to these risks.

Sensitivity of system to high tide

3.2 There are numerous combined sewer overflows which discharge to the River Thames from the Beckton sewerage catchment. These are modelled as outfalls along the foreshore and are influenced by the tidal Thames. During high tides, the flaps on the combined sewer overflows discharging into the Thames close to prevent the tide from entering the sewer system. The outfalls will be unable to discharge until either the levels in the sewerage system exceed the tide levels or the tide levels recede. This is referred to as tide-locking.

3.3 If tide-locking coincides with a severe rainfall event (as occurred on the 12 and 25 July 2021) the sewers cannot freely overflow into the Thames, so the wastewater backs up, potentially increasing the extent of the sewer flooding. Figure 19 shows the areas in red where levels in the network increase as a result of high tide. The increase in levels is more evident upstream of Hammersmith Pumping Station and immediately downstream of Western Pumping Station. These are areas where there are a higher number of surface water outfalls that discharge via gravity. When the outfalls cannot discharge, flows are conveyed to the pumping station in order to be pumped to the river. This can result in an increased risk of flooding due to high tides.

Figure 19: Area influenced by high tide – showing modelled difference in levels due to tide-locking



3.4 Some outfalls are situated downstream of pumping stations which can, therefore, pump against a high tide. All storm pumping stations which discharge to the river will have to operate, on occasion, against a high tide. During times at which the pumps are pumping against a higher head, their efficiency reduces for approximately 3hrs around the high-tide peak. Anecdotal evidence from Operators from Western Pumping Station (and others) is that this reduces the output of the station by the equivalent of one storm pump, so this potentially increases the risk of flooding upstream as shown in the output of the sensitivity testing.

3.5 In Hammersmith, there is a larger concentration of storm relief sewers, reflecting the natural contours and low-lying nature of the catchment in this area. When flows reach the pumping station, if there is a high tide, pump efficiency may be reduced as discussed above.

3.6 The Independent Flooding Review found that tide-locking did have an impact on increasing maximum water levels. However, the intensity of the rainfall event in July 2021 was such that flooding would likely have occurred regardless of whether the outfalls were tide-locked or not, but some of the flood depths may have been higher due to the tidal locking. Areas such as Kilburn and Holland Park have a lower sensitivity to tide levels as they are further inland from the tide-locked outfalls.

3.7 In future, the Thames Tideway Tunnel, once it is operational, will improve the performance of the catchment and the impact of tide-locking on flood risk because the flows from Hammersmith PS will flow into the Tunnel. There are also gravity interceptions along the Low-Level Sewer No. 1 at Ranelagh, which will allow flows to spill into the Thames Tideway Tunnel instead of into the river, increasing further the resilience in the catchment when tide-locking is likely. The Thames Tideway Tunnel will also improve performance of the catchment where successive storm events occur. The storm relief network upstream of Hammersmith currently takes 24 hours to drain down. With the gravity connection to the Tunnel in place the system will drain much more quickly reducing the risk of the network backing up.

Section 4

Operational resilience of pumps

4.1 This section describes the impact that pump failures at the strategic pumping stations have upon the effectual drainage and flooding within the Counters Creek catchment to confirm that the network is resilient to these risks.

4.2 In the main report we explained how the strategic pumping stations of Western Pumping Station, Lots Road Pumping Station and Hammersmith Pumping Station operate and the number of pumps required to prevent flooding.

4.3 We explained how we have modelled the following scenarios to test the risk of flooding in case of pump failures. These represent fairly extreme scenarios so provide an envelope of risk impacts:

- All three pumping stations operating at 50% capacity
- All pumps failed at Western PS, Lots Road PS and Hammersmith PS
- Lots Road PS operating at 50% capacity, all other PSs fully operational
- All pumps failed at Lots Road PS, all other PSs fully operational

4.4 For each scenario, we have simulated the impact of high and low tides and the impact both before and after the implementation of the Tideway Tunnel. The results have been compared to a baseline scenario where all three pumping stations are fully operational. This appendix contains the full output of the modelling in Figure 20 to Figure 35.

4.5 Each figure 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.

Figure 20: Increase in TWL when all three SPSs are operating at 50% capacity – high tide – assuming Tideway is fully commissioned

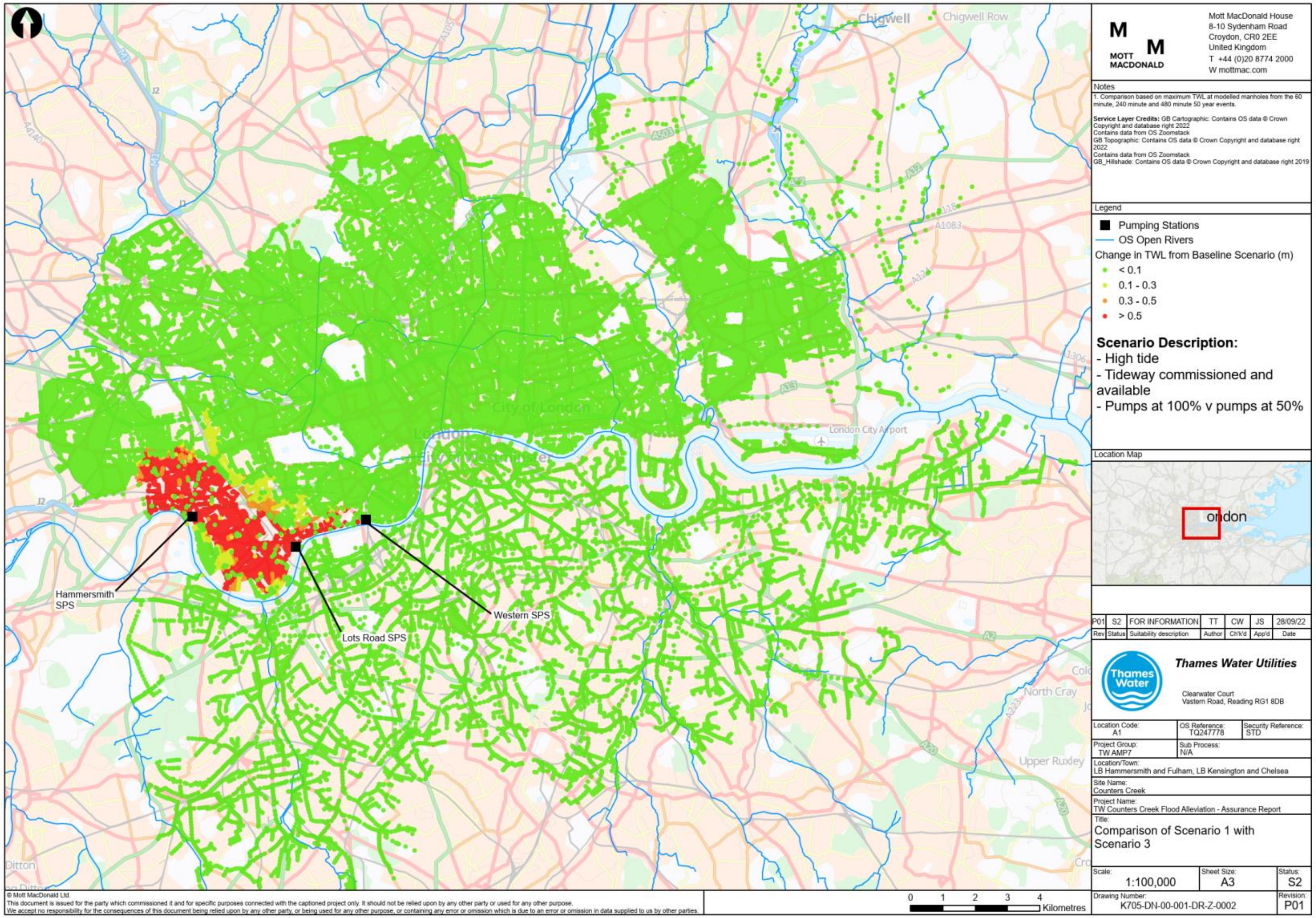


Figure 21: Increase in TWL when all three SPSs are operating at 50% capacity – high tide – assuming Tideway not yet commissioned

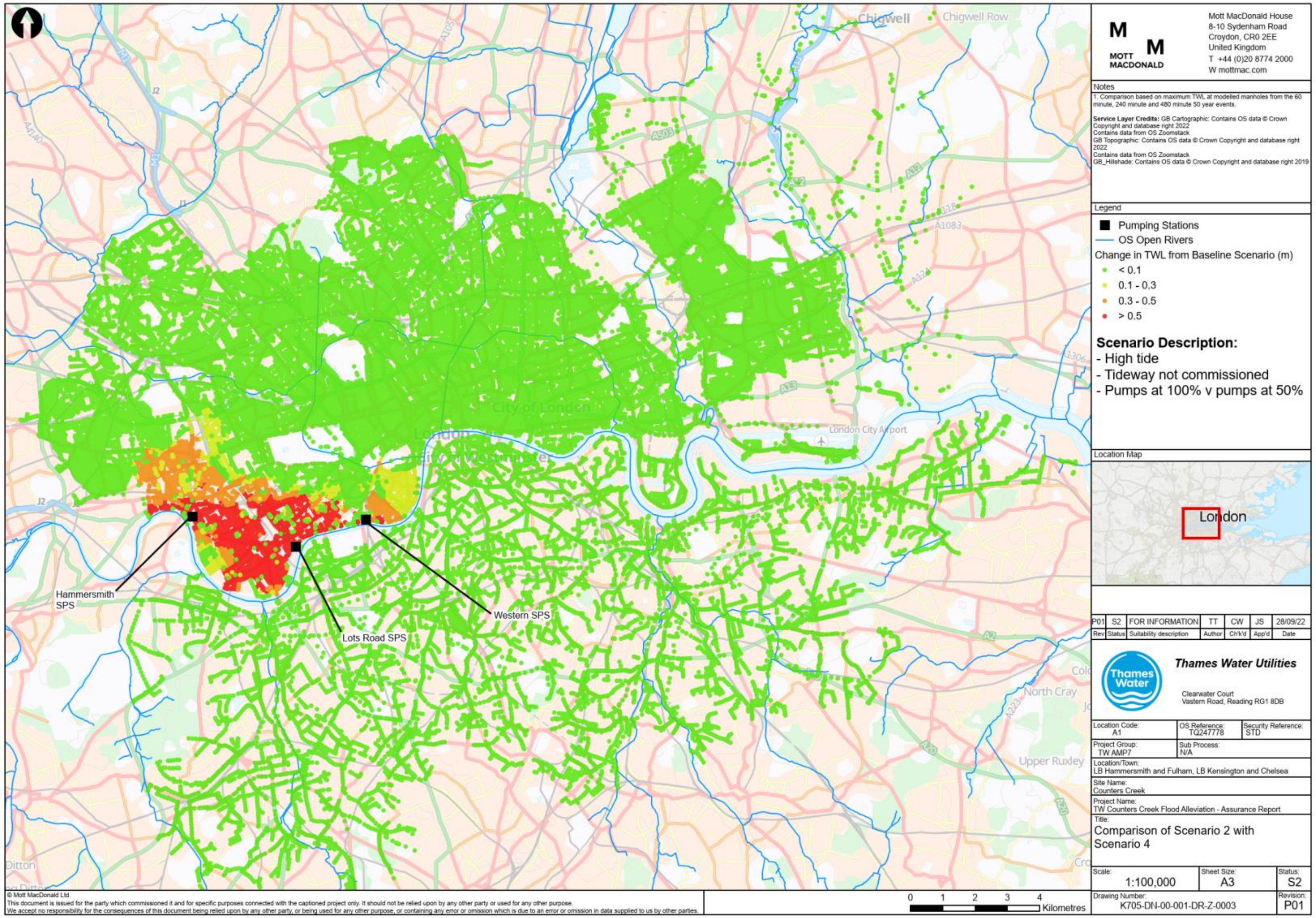


Figure 22: Increase in TWL when all three SPSs are operating at 50% capacity – low tide – assuming Tideway is fully commissioned

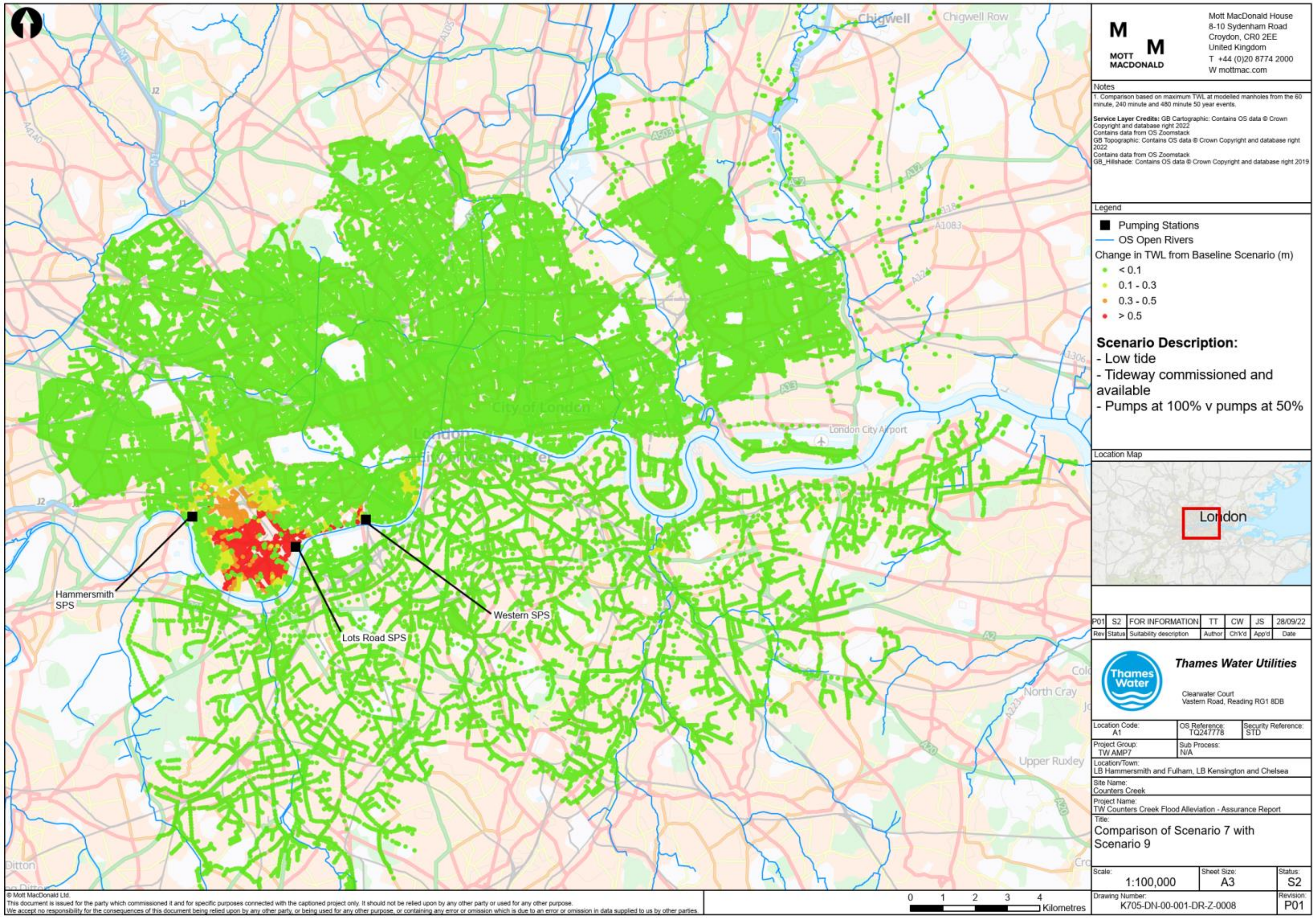


Figure 23: Increase in TWL when all three SPSs are operating at 50% capacity – low tide – assuming Tideway not yet commissioned

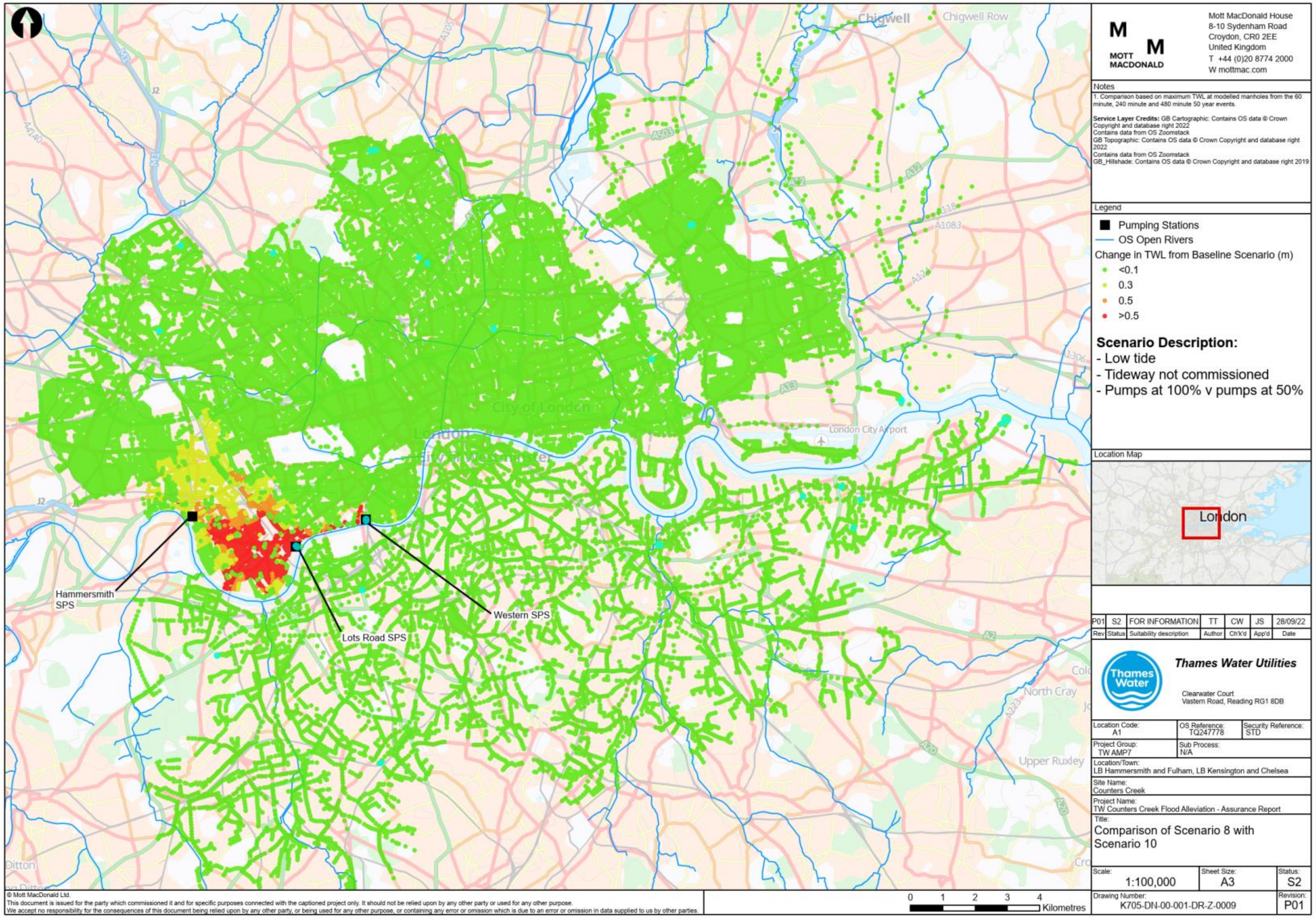


Figure 24: Increase in TWL when pumps failed at all three SPSs – high tide – assuming Tideway is fully commissioned

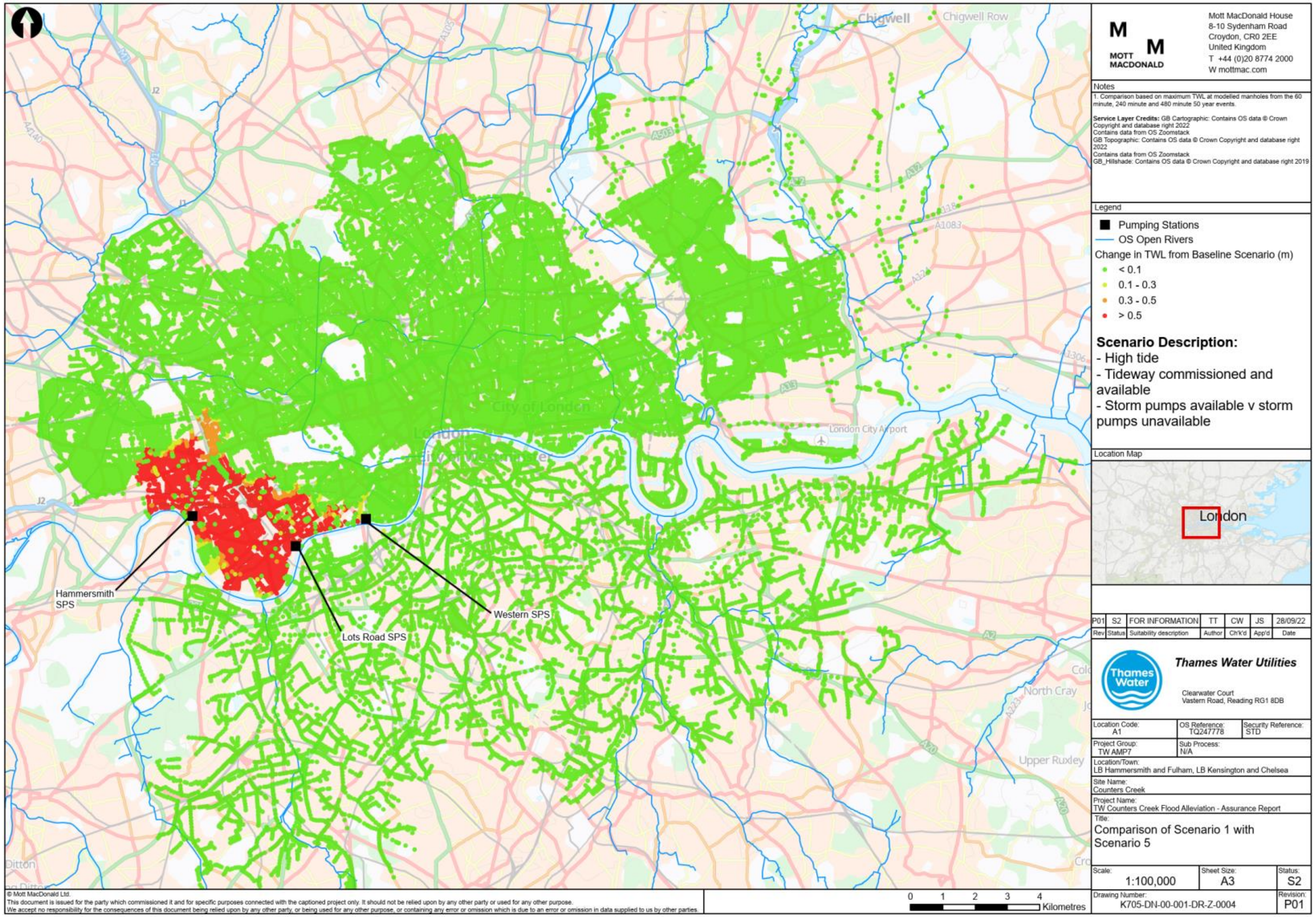


Figure 25: Increase in TWL when pumps failed at all three SPSs – high tide – assuming Tideway not yet commissioned

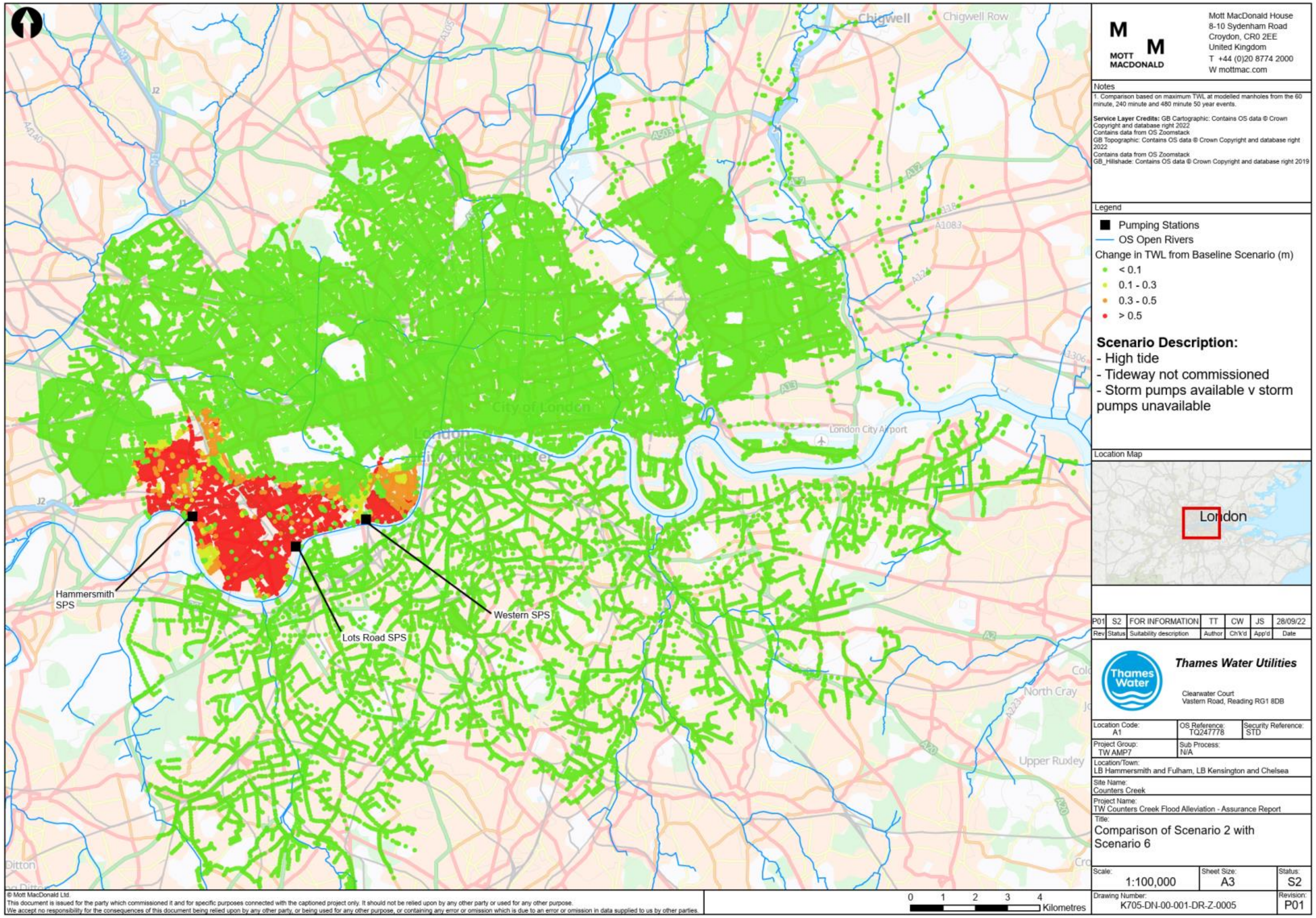


Figure 26: Increase in TWL when pumps failed at all three SPSs – low tide – assuming Tideway is fully commissioned

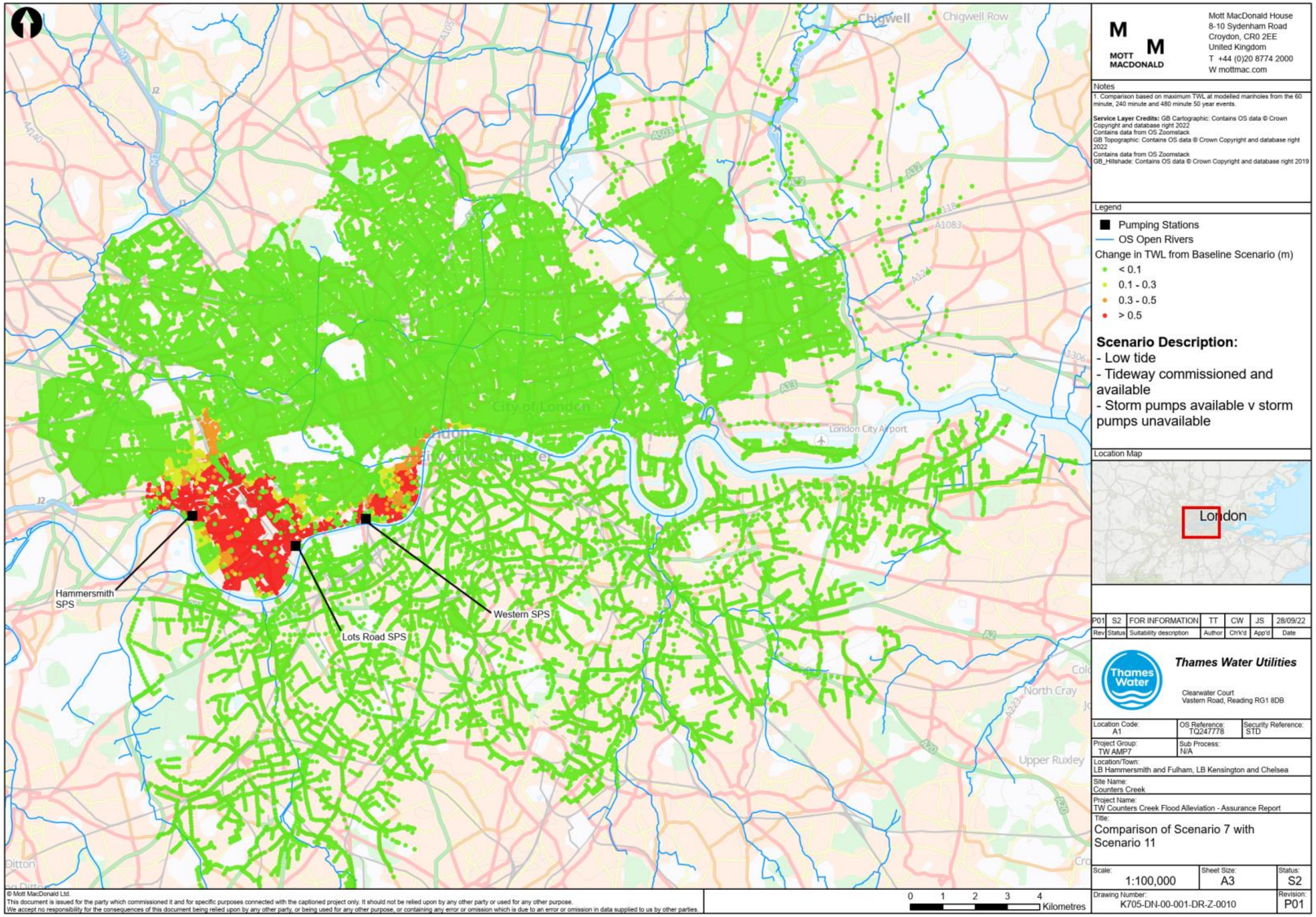


Figure 27: Increase in TWL when pumps failed at all three SPSs – low tide – assuming Tideway not yet commissioned

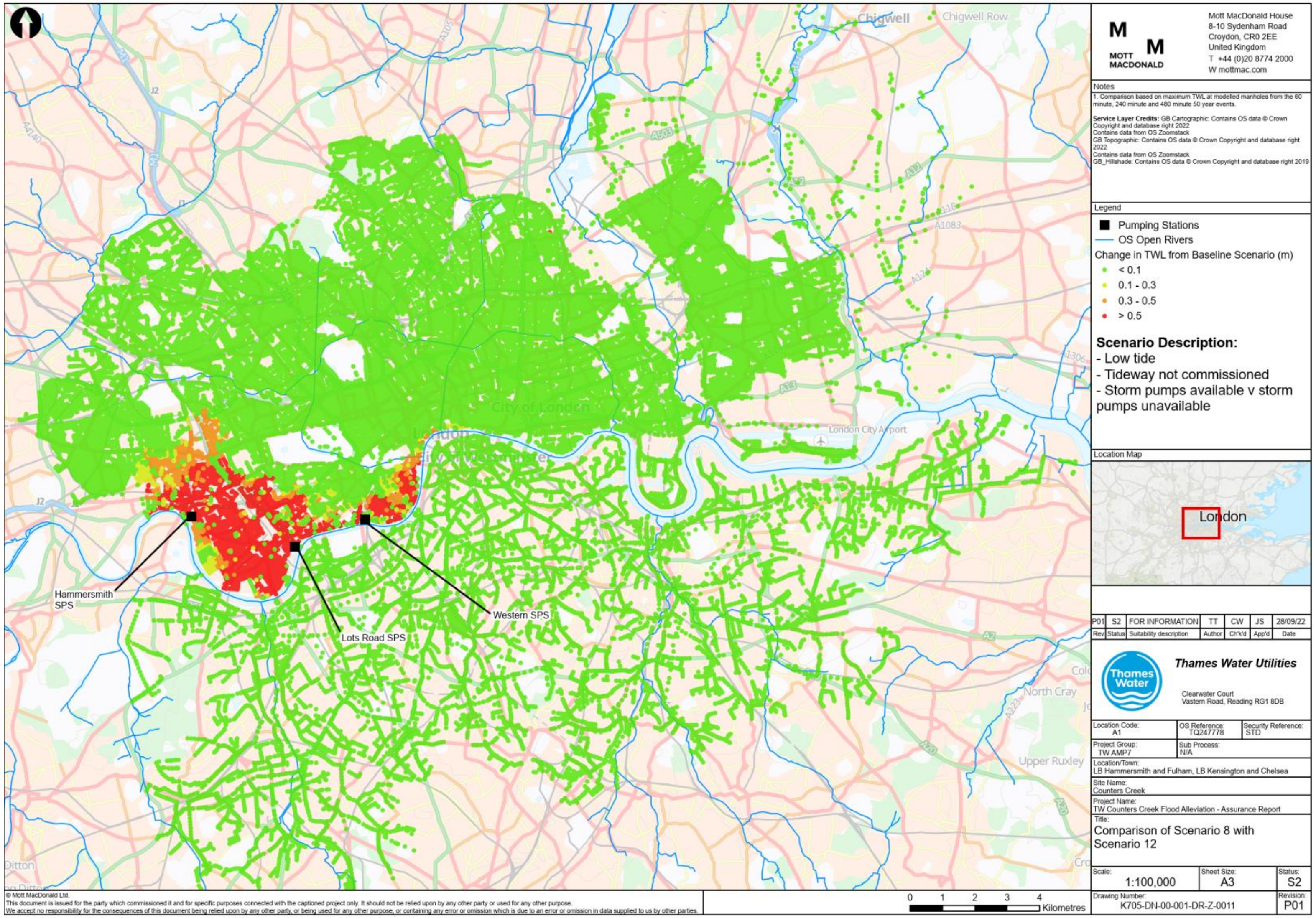


Figure 28: Increase in TWL Lots Road PS is operating at 50% capacity – high tide – assuming Tideway is fully commissioned

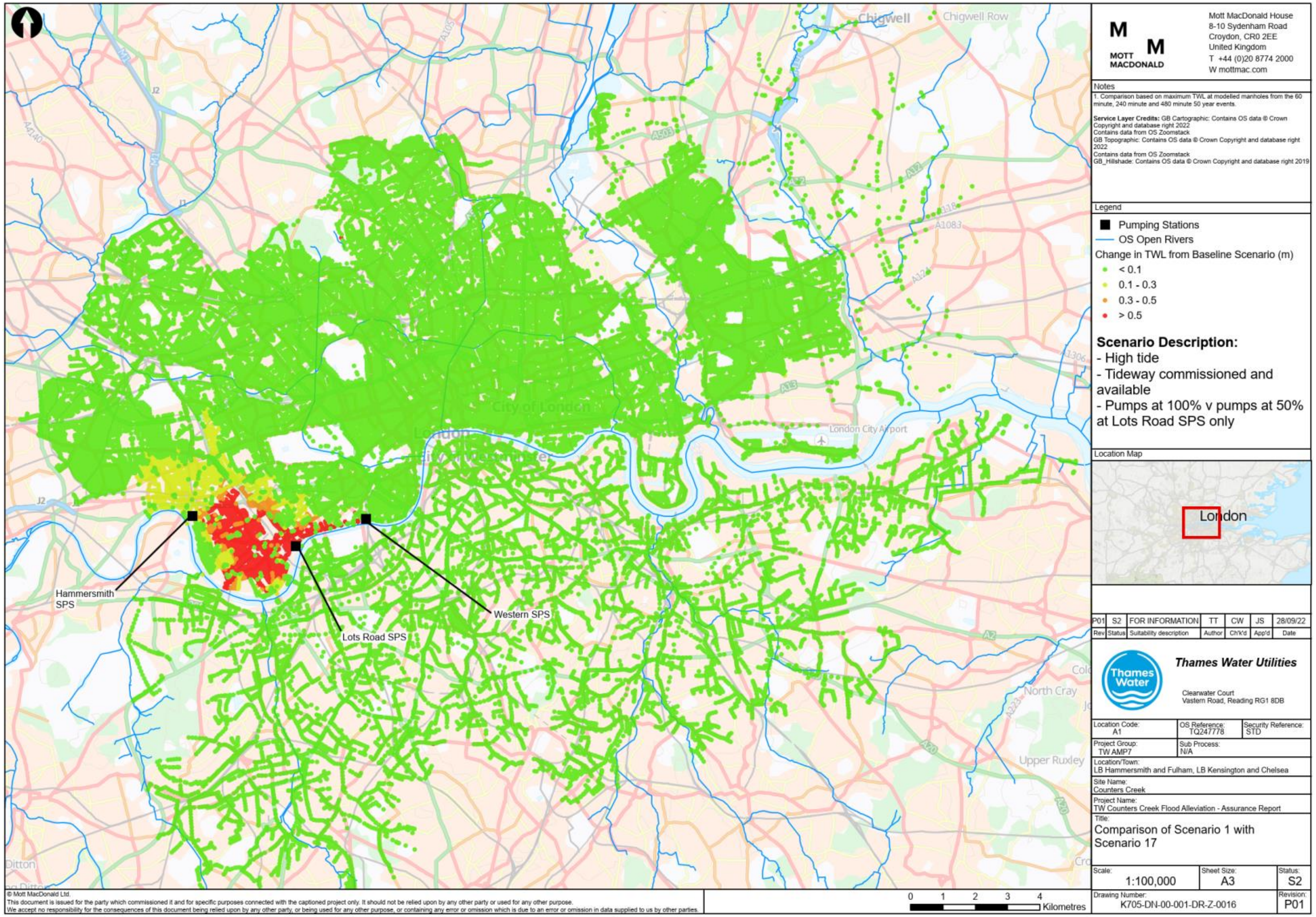
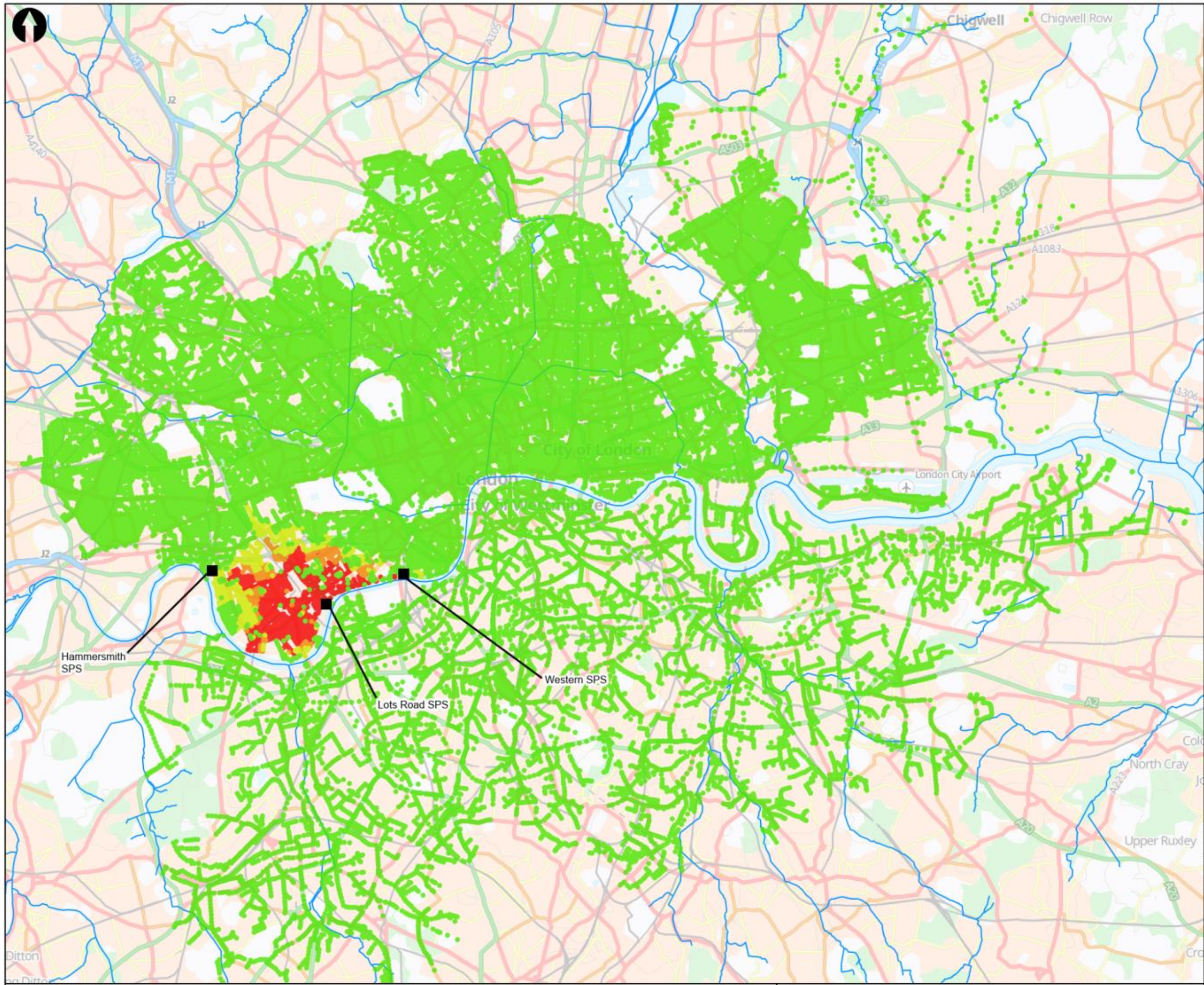


Figure 29: Increase in TWL Lots Road PS is operating at 50% capacity – high tide – assuming Tideway not yet commissioned



Mott MacDonald House
8-10 Sydenham Road
Croydon, CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
W mottmac.com

Notes

1. Comparison based on maximum TWL at modelled manholes from the 60 minute, 240 minute and 480 minute 50 year events.

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Contains data from OS Zoomstack
GB_Hillshade: Contains OS data © Crown Copyright and database right 2019

Legend

- Pumping Stations
- OS Open Rivers

Change in TWL from Baseline Scenario (m)

- < 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Scenario Description:
- High tide
- Tideway not commissioned
- Pumps at 100% v pumps at 50% at Lots Road SPS only

Location Map

Rev	Status	Suitability description	Author	Ch'k'd	App'd	Date
P01	S2	FOR INFORMATION	TT	CW	JS	28/09/22

Thames Water Utilities
Clearwater Court
Vastern Road, Reading RG1 8DB

Location Code: A1
OS Reference: TQ247778
Security Reference: STD
Project Group: TW AMP7
Sub Process: N/A
Location/Town: LB Hammersmith and Fulham, LB Kensington and Chelsea
Site Name: Counters Creek
Project Name: TW Counters Creek Flood Alleviation - Assurance Report
Title: Comparison of Scenario 2 with Scenario 18
Scale: 1:100,000
Sheet Size: A3
Status: S2
Drawing Number: K705-DN-00-001-DR-Z-0017
Revision: P01

Figure 30: Increase in TWL Lots Road PS is operating at 50% capacity – low tide – assuming Tideway is fully commissioned

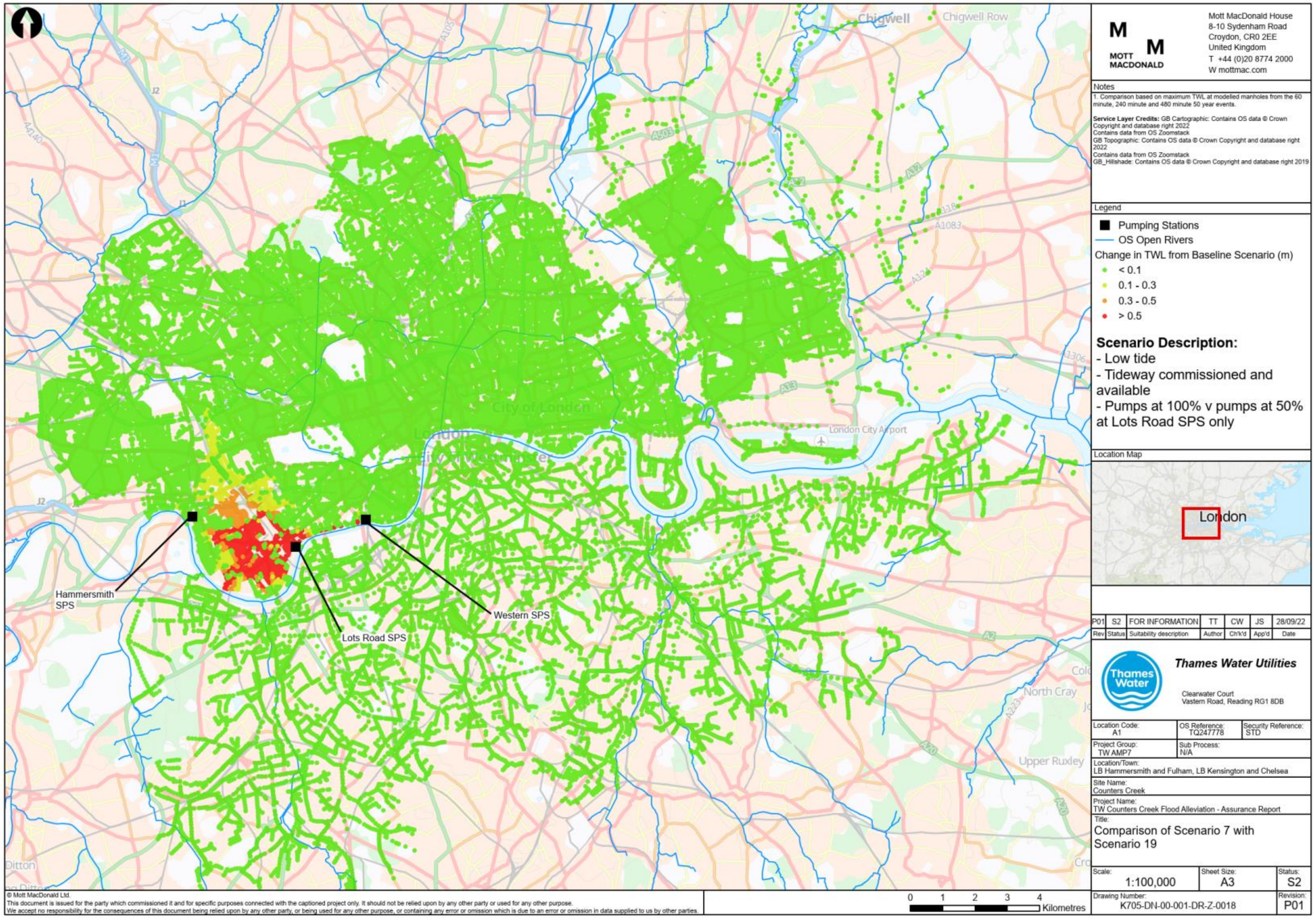

Figure 31: Increase in TWL Lots Road PS is operating at 50% capacity – low tide – assuming Tideway not yet commissioned

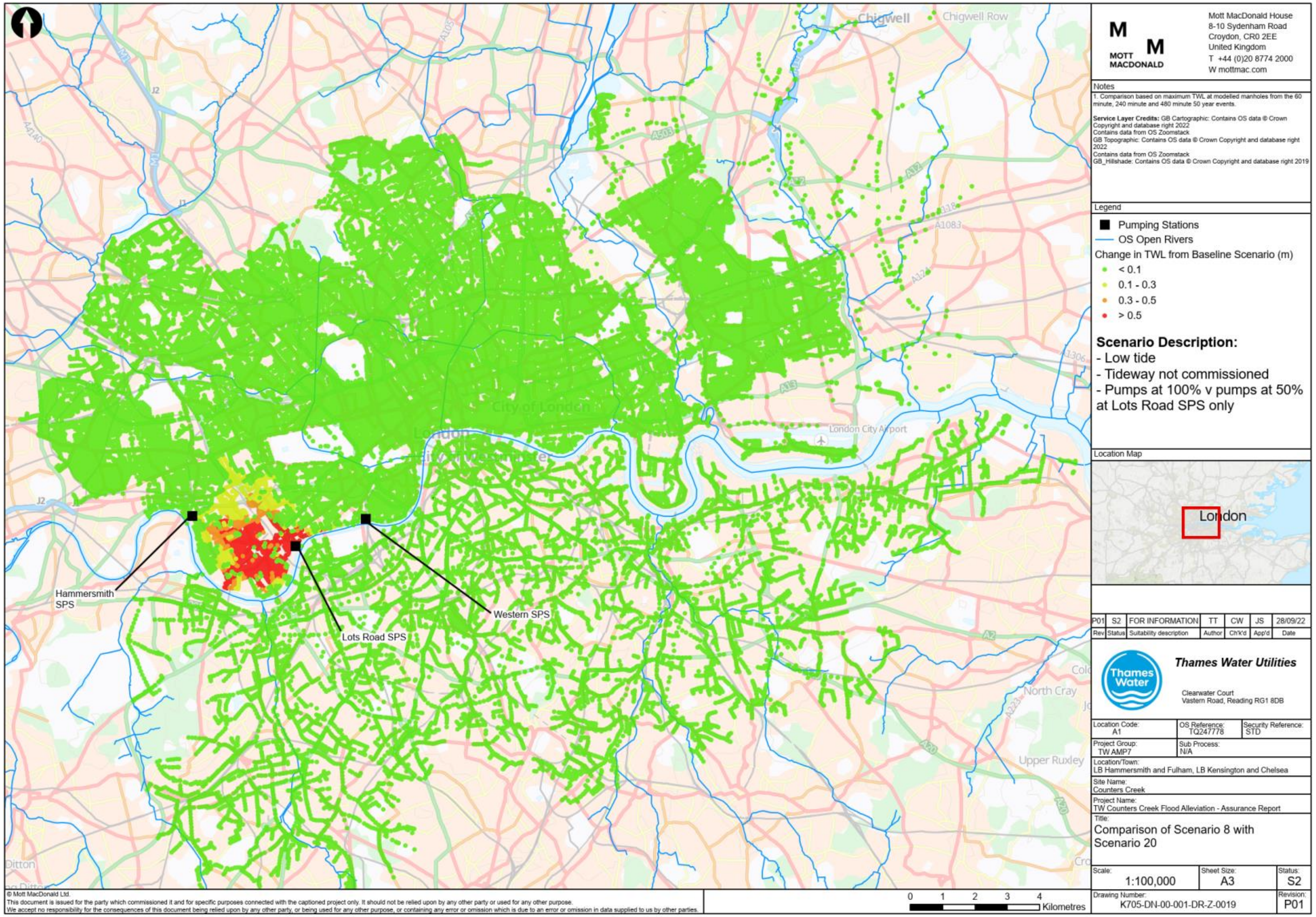

Figure 32: Increase in TWL when all pumps failed at Lots Road PS – high tide – assuming Tideway is fully commissioned

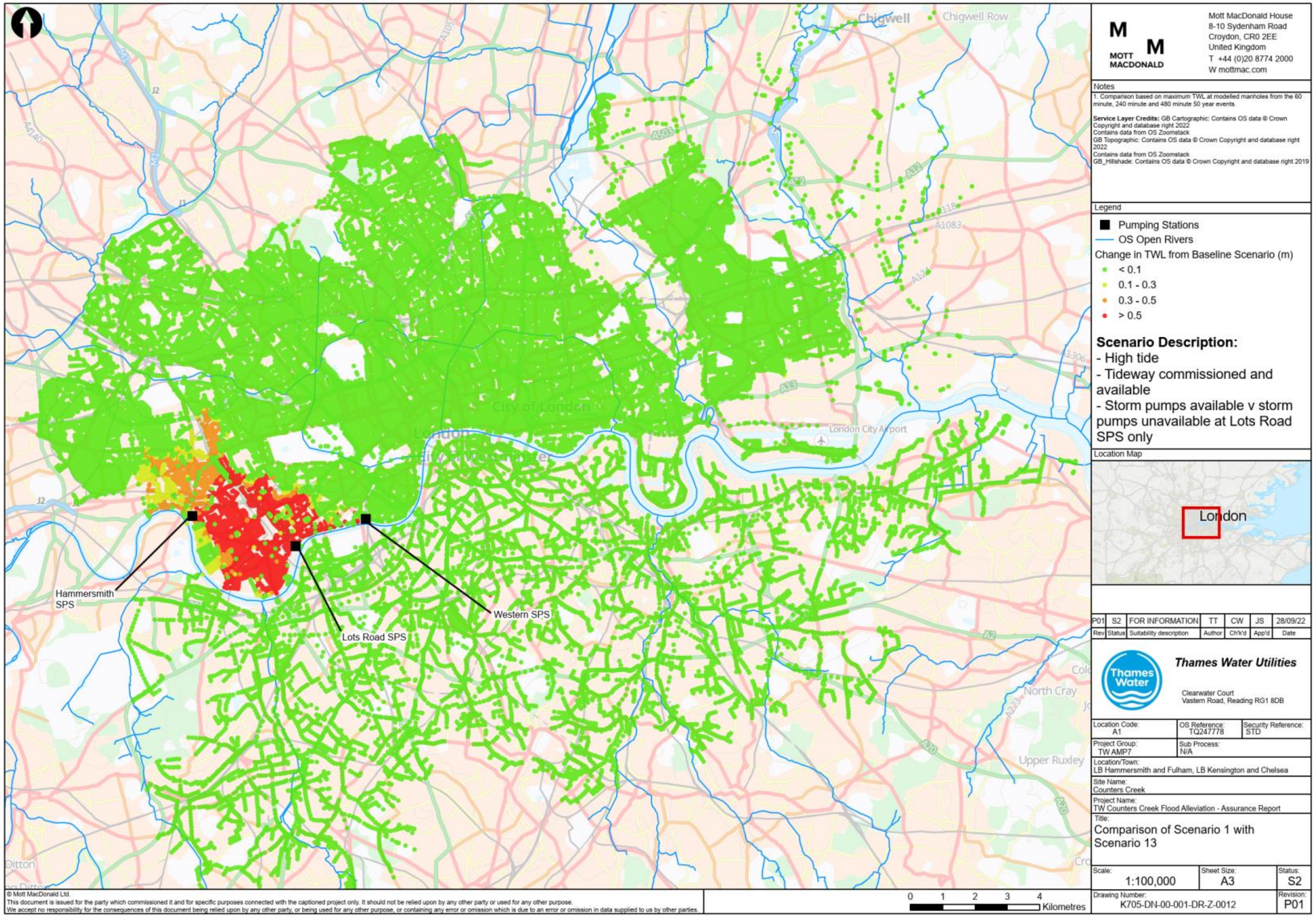

Figure 33: Increase in TWL when all pumps failed at Lots Road PS – high tide – assuming Tideway not yet commissioned

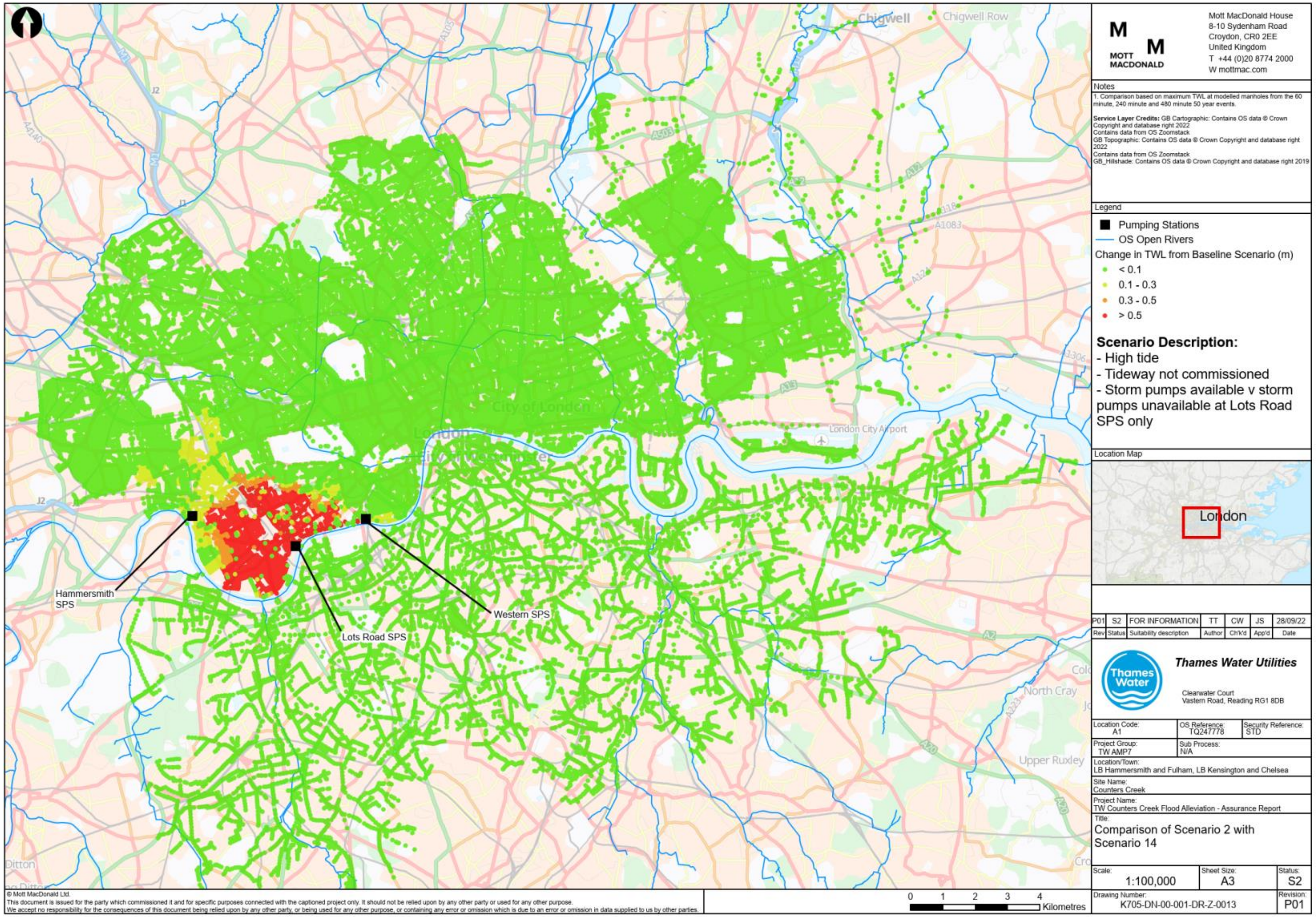

Figure 34: Increase in TWL when all pumps failed at Lots Road PS – low tide – assuming Tideway is fully commissioned

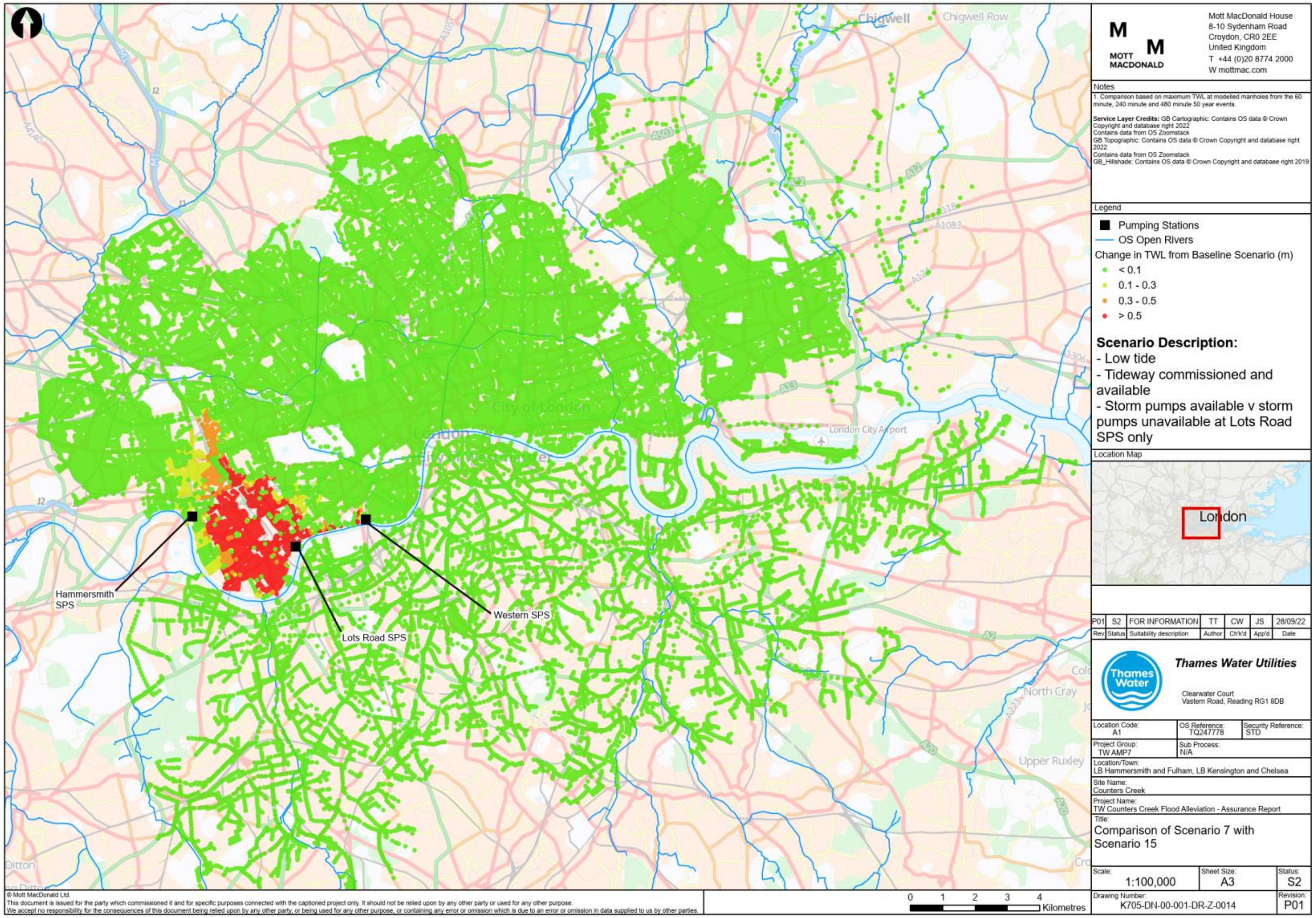

Figure 35: Increase in TWL when all pumps failed at Lots Road PS – low tide – assuming Tideway not yet commissioned