RICHMOND SECTION 19 FLOOD INVESTIGATION

PREPARED FOR LONDON BOROUGH OF RICHMOND UPON THAMES

Authored by	Michael McCarthy
Reviewed by:	Tom Whitworth
Approved by	Mike Mair
Date	June 2023
Version	2.0

Metis Consultants Ltd.
2 Sheen Road, Richmond
London, TW9 1AE
United Kingdom
t. 020 8948 0249
e. info@metisconsultants.co.uk
w. metisconsultants.co.uk

Revision History

Version	Date	Description	Prepared	Approved
1.0	February 2023	Draft for Client Review	MMC	MM
2.0	June 2023	Final following Stakeholder Review	MMC	MM

Limitations

Metis Consultants Limited (Metis) have prepared this Report for the sole use of the Client. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by Metis. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of Metis.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by Metis has not been independently verified by Metis, unless otherwise stated in the Report.

The work described in this Report is based on the conditions encountered and the information available during the period of production. The scope of this Report and the services are accordingly factually limited by these circumstances.

Metis disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to Metis' attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. Metis specifically does not guarantee or warrant any estimate or projections contained in this Report.

The Client should take appropriate professional legal advice prior to implementing any recommendations made within this Report that may impact on the legal exposure of the Client.

Copyright

Contact Details

Metis Consultants Ltd.
2 Sheen Road, Richmond
London, TW9 1AE
t. 020 8948 0249
e. info@metisconsultants.co.uk
w. metisconsultants.co.uk

Executive Summary

This flood risk investigation report was written as part of the London Borough of Richmond upon Thames (Richmond)'s duty as Lead Local Flood Authority (LLFA) under Section 19 of the Flood and Water Management Act (2010). Heavy rainfall over London on the 12th of July 2021 triggered significant flooding across London, with Richmond experiencing a range of between a 1 in 10 year and greater than a 1 in 100 year magnitude rainfall event. Richmond received ten reports of flooding at eight different locations. Six of these reports were of internal flooding, spread across five different locations; at Chestnut Road, Eleanor Grove, Lower Mortlake Road, The Quadrant, and two reports at Halcyon Close; while the remaining four reports were of a combination of highways and external flooding. The internal reports were the main focal point for the investigation since they met the thresholds of Richmond's Section 19 criteria.

This report has been carried out in response to these significant flooding events and aims to investigate the causes of flooding, as well as the actions of the Risk Management Authorities (RMAs) who have different roles in response to flood events. The RMAs include Richmond, the Environment Agency (EA), Thames Water Utilities Limited (TWUL) and Transport for London (TfL).

The hydrological catchments used in the analysis of the flood events in this report were produced as part of Richmond's Surface Water Management Plan (SWMP) (2021). There are 12 hydrological catchments in Richmond, while the flooding reports from the 12th of July event are distributed between four of these catchments.

The reported flood incidents were mapped for each separate flooding event, while a site visit was also conducted to view each of the affected locations and collect data to supplement the information already received. For each event, the flood incident details were analysed, flooding mechanisms and various flood risks were assessed, the actions of RMAs before, during and after the flooding were recorded (where known), and recommendations are given. Every effort has been made to clarify any unknowns as part of the scope of this report from which conclusions have been drawn from as part of this investigation, however some inaccuracies may exist within the original datasets used. For example, through analysing the existing TWUL drainage asset data received, it appears that some assets may have been mislabelled at some of the locations investigated within this report. This includes the TWUL sewer network layout at the Quadrant, where there are two larger sewer pipes shown to be feeding into a smaller pipe. TWUL drainage asset data is not always complete and may require for key network areas to be raised for further investigation.

The investigation identified that sewer flooding and surface water flooding were the most frequent source of flooding during the 12th of July 2021 event. The significant volume of rainfall falling upon hard surfaces led to some surface water flooding across Richmond. The TWUL sewer network likely became overwhelmed at many locations leading to sewer surcharge, any blockages to gullies and within sewers would have accelerated this process. Topographical factors exacerbated the flooding experienced at the investigated locations, which were largely located at topographical low points.

Since the flooding in July 2021, Richmond have set up an internal flood group, updated their Local Flood Risk Management Strategy (LFRMS) and SWMP, and have installed approximately 12 gully sensors across Richmond in areas where there have been historical or known surface water flooding issues. Similarly, TWUL have conducted their independent London Flood Review which assessed the

London floods in the summer of 2021. Based on the conclusions of the source and cause of the flooding experienced, the following recommendations were drawn up as part of this report:

Chestnut Road

- Richmond to liaise with TWUL to investigate a potential blockage or capacity issue to the surface water sewer on Chestnut Road.
- Richmond should check the gullies on Chestnut Road and review the gully maintenance schedule.

Eleanor Grove

- Richmond to liaise with TWUL to investigate the combined and foul sewers on Eleanor Grove for blockages.
- Richmond should collaborate with TWUL to inform residents of their Bin it - Don't Block it campaign – for example through leaflet distribution on Eleanor Grove. This should reduce the frequency of blockages to the foul / combined sewer systems.
- Eleanor Grove has a high risk of foul / combined sewer surcharge, as indicated by their Capacity Assessment Framework (CAF). This area should be investigated further by TWUL, including detailed hydraulic modelling and monitoring, to understand the risks better and identify what action is needed.

Halcyon Close

- Richmond to liaise with TWUL to investigate a potential blockage or capacity issue to the surface water sewer on Queen's Ride.
- Richmond should investigate methods to redirect surface water on Queen's Ride away from the dropped kerb access into Halcyon Close. Richmond should also investigate potential sustainable drainage systems (SuDS) opportunities on the western edge of the road.
- Richmond should educate the residents of Halcyon Close about the appropriate maintenance of privately owned SuDS to ensure that they will be operational during flooding events.

Lower Mortlake Road

- Richmond should check the gullies on Lower Mortlake Road and review the gully maintenance schedule.

The Quadrant

- Richmond, in collaboration with TWUL, should investigate some highways SuDS opportunities to reduce the risk of sewer surcharge at The Quadrant.
- TWUL to update its asset records for the surface water drainage network at The Quadrant and share this with Richmond. This will support with the appropriate identification of a solution to reduce flood risk at the quadrant.

Richmond general recommendations

- Richmond should continue to encourage the reporting of flooding incidents through the use of the flood reporting tool, such as at Barnes Green where there were a large number of anecdotal affected locations without specific reports received.
- Richmond should investigate the locations affected by external / highway flooding and collaborate with TWUL where necessary to reduce the risk of recurrence where possible. Further

to this Richmond should explore potential SuDS opportunities across the borough, from which potential schemes could be developed to resolve flooding issues.

TWUL general recommendations

- TWUL to review and act upon the recommendations provided within the independent London Flood Review which assessed the London floods in the summer of 2021. These recommendations can be found here.
- TWUL to publish the first Drainage and Wastewater Management Plans (DWMPs), which look at the current state of drainage and wastewater management. These plans factor in growth urban creep and climate change. TWUL should look at long-term actions needed for the DWMP areas in Richmond. Further information can be found here.
- TWUL to consider the recommendations of the London Flood Review and continue to prioritise inspection and sewer cleaning based on the behaviour and impact of the operation of the sewer network at all sites. TWUL will prioritise sites where the sewer is causing any issues for customers to ensure the best service possible.

CONTENTS

1 INTRODUCTION 1
1.1 BACKGROUND POLICY AND INFORMATION 1
1.2 METHODOLOGY 1
2 RISK MANAGEMENT AUTHORITIES 3
2.1 ENVIRONMENT AGENCY 3
2.2 LONDON BOROUGH OF RICHMOND UPON THAMES 3
2.3 THAMES WATER UTILITIES LIMITED 4
2.4 LANDOWNERS 4
2.5 CATEGORY ONE RESPONDERS 5
3 FLOOD INCIDENT DETAILS 6
3.1 12TH OF JULY RAINFALL EVENT 6
3.2 RAIN GAUGE DATA 7
3.3 AFFECTED LOCATIONS AND HYDROLOGICAL CATCHMENTS 7
4 FLOODED LOCATIONS 10
4.1 CHESTNUT ROAD 10
4.1.1 LOCAL DRAINAGE NETWORK 10
4.1.2 LOCAL FLOOD MECHANISM 11
4.1.3 LOCAL FLOOD RISK 11
4.1.3.1 Surface water flood risk 11
4.1.3.2 Groundwater flood risk 12
4.1.3.3 Sewer flood risk 13
4.1.4 SOURCE AND CAUSE 14
4.2 ELEANOR GROVE 15
4.2.1 LOCAL DRAINAGE NETWORK 15
4.2.2 LOCAL FLOOD MECHANISM 16
4.2.3 LOCAL FLOOD RISK 16
4.2.3.1 Surface water flood risk 17
4.2.3.2 Fluvial flood risk 17
4.2.3.3 Groundwater flood risk 19
4.2.3.4 Sewer flood risk 19
4.2.4 SOURCE AND CAUSE 19
4.3 HALCYON CLOSE 21
4.3.1 LOCAL DRAINAGE NETWORK 21
4.3.2 LOCAL FLOOD MECHANISM 21
4.3.3 LOCAL FLOOD RISK 22
4.3.3.1 Surface water flood risk 22
4.3.3.2 Groundwater flood risk 23
4.3.3.3 Sewer flood risk 24
4.3.4 SOURCE AND CAUSE 24

4.4 Lower Mortlake Road 26
4.4.1 Local drainage network 26
4.4.2 Local flood mechanism 27
4.4.3 Local flood risk 27
4.4.3.1 Surface water flood risk 27
4.4.3.2 Groundwater flood risk 28
4.4.3.3 Sewer flood risk 29
4.4.4 Source and Cause 29
4.5 The Quadrant 30
4.5.1 Local drainage network 30
4.5.2 Local flood mechanism 31
4.5.3 Local flood risk 31
4.5.3.1 Surface water flood risk 32
4.5.3.2 Groundwater flood risk 32
4.5.3.3 Sewer flood risk 33
4.5.4 Source and Cause 33
4.6 External / Highways flooding reports 35
4.7 Actions taken by relevant RMAs (and other stakeholders affected) 35
5 CONCLUSIONS AND RECOMMENDATIONS 38
5.1 Conclusions 38
5.2 Recommendations 38
5.2.1 Chestnut Road 38
5.2.2 Eleanor Grove 38
5.2.3 Halcyon Close 38
5.2.4 Lower Mortlake 39
5.2.5 The Quadrant 39
5.2.6 Richmond general recommendations 39
5.2.7 TWUL general recommendations 39

FIGURES AND TABLES

Figure 3-1 July 12th Rainfall return periods in Richmond 6
Figure 3-2 Rainfall at Putney Village on 12th of July 2021........ 7
Figure 3-3 Location of 12th of July 2021 flood reports 8
Figure 3-4 SWMP Hydrological Catchments and flood locations 9
Figure 4-1 Local drainage network in Chestnut Road........ 11
Figure 4-2 EA RoFSW (Chestnut Road)........ 12
Figure 4-3 Areas susceptible to groundwater flooding (Chestnut Road)........ 13
Figure 4-4 Local drainage network in Eleanor Grove........ 16
Figure 4-5 EA RoFSW (Eleanor Grove)........ 17
Figure 4-6 EA Fluvial flood risk (Eleanor Grove)........ 18
Figure 4-7 Areas susceptible to groundwater flooding (Eleanor Grove)........ 19
Figure 4-8 Local drainage network in Halcyon Close 21
Figure 4-9 EA RoFSW (Halcyon Close)........ 23
Figure 4-10 Areas susceptible to groundwater flooding (Halcyon Close)........ 24
Figure 4-11 Local drainage network in Lower Mortlake Road........ 26
Figure 4-12 EA RoFSW (Lower Mortlake Road)........ 28
Figure 4-13 Areas susceptible to groundwater flooding (Lower Mortlake Road)........ 29
Figure 4-14 Local drainage network in The Quadrant 31
Figure 4-15 EA RoFSW (The Quadrant)........ 32
Figure 4-16 Areas susceptible to groundwater flooding (The Quadrant)........ 33
Figure 4-17 Location of Highways / External flooding reports 35

Table 1-1: Data sources........ 2
Table 2-1: Borough level Risk Management Authorities 3
Table 3-1 Summary of flooded locations on 12th of July 2021 8
Table 4-1 Criteria for Risk of Flooding from Surface Water categories 12
Table 4-2 Criteria for areas at risk of flooding from rivers and the sea........ 17
Table 4-3 Risk Management Authority actions........ 35

Acronyms and Abbreviations

Acronym and Abbreviation	Definition
CAF	Capacity Assessment Framework
DWMP	Drainage and Wastewater Management Plan
EA	Environment Agency
FEH	Flood Estimation Handbook
FWMA	Flood and Water Management Act (2010)
GIS	Geographic Information System
LFB	London Fire Brigade
LFRMS	Local Flood Risk Management Strategy
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
MAFP	Multi-Agency Flood Plan
MPS	Metropolitan Police Service
RaRa	Rainfall Radar
Richmond	London Borough of Richmond upon Thames
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water
SWMP	Surface Water Management Plan
TWUL	Thames Water Utilities Limited

1 Introduction

1.1 Background Policy and Information

This flood risk investigation report has been prepared by Metis Consultants Ltd for the London Borough of Richmond upon Thames (Richmond). As a unitary authority, Richmond is a Lead Local Flood Authority (LLFA). LLFAs are defined as a Risk Management Authority (RMA) under Section 6 of the Flood and Water Management Act 2010 (FWMA). LLFAs are required to investigate significant flooding incidents under Section 19 of the FMWA and publish the results. A LLFA must, to the extent that they consider it necessary or appropriate, investigate:

- Which RMAs have relevant flood risk management functions, and
- Whether each of those RMAs has exercised, or is proposing to exercise, those functions in response to the flood.

LLFAs set out the criteria which defines what flood event should trigger a Section 19 investigation. For Richmond, the criteria are outlined in the Local Flood Risk Management Strategy (LFRMS) (2023). This is currently in the process of being updated however the criteria will be unchanged:

- If internal flooding* of a single residential property, business or office premises has occurred.
- Where a flooding incident has impacted on an identified item of critical infrastructure.

* Internal flooding: where water crosses the threshold of a commercial or residential building.

There was a significant rainfall event which took place in Richmond on the 12th of July 2021 which led to several flooding incidents. Many of these incidents met Richmond's Section 19 criteria which triggered the writing of this flood investigation report. On the 12th of July 2021 there were six reports of internal flooding and four reports of external / highways flooding, which impacted eight different locations in Richmond.

1.2 Methodology

To conduct this investigation, data was collected from the relevant RMAs; Richmond, Thames Water Utilities Limited (TWUL), and the Environment Agency (EA). A list of the data and their sources is compiled below in *Table 1-1*. To supplement the eight initial reports of flooding received from the RMAs, a search on social media platforms was conducted to obtain any additional reports from residents impacted by the flooding on the 12th of July 2021. The social media messaging returned two additional reports, although only one of these reports met Richmond's Section 19 criteria to be investigated in this report.

Table 1-1: Data sources

Data	Source
Actions taken before, during, and after the 12th of July Rainfall event	Richmond / TWUL
Detailed River Network	EA
Flooding reports	Richmond
Flood risk mapping from various sources	EA
Rainfall data	EA / TWUL
Return periods for each flood event	TWUL
Sewer network data	TWUL

The available historical flooding, topographical, drainage, and geological data was used to explore all potential flood risk sources throughout the flooded locations. The collated data from the RMAs was used to produce maps for each flood report location using a geographic information system (GIS). The hydrological catchment areas were defined using Richmond's Surface Water Management Plan (SWMP) (2021). A site visit was also conducted to view each of the affected locations and collect data to supplement the information already received. The responsibilities of the RMAs for each location for each event were identified.

The results of the investigation were compiled and are outlined in *5.1* of this report, while recommendations on flood risk mitigation and potential next steps are provided in *5.2*. Every effort has been made to clarify any unknowns as part of the scope of this report, including contacting TWUL about the potential mislabelling of their sewer network at the Quadrant.

Similarly, the map in *Figure 3-1*Figure 3-1 which is compiled of rainfall radar (RaRA) data from the Met Office using Flood Estimation Handbook (FEH) 99 calculations for the spatial visualisation lacks spatial accuracy. The 1 km^2 grid squares on the map can be misleading in cases where a reported location resides on the boundary of two vastly different return periods. The conclusions of the investigation have been drawn from the data provided, although further information would enhance the conclusions. Information on actions taken by RMAs prior to and during the flooding, along with information from TWUL on reported flooding incidents and actions before and after the events would enable more focus to the recommendations of this report. This has formed part of the recommendations.

2 Risk Management Authorities

There are multiple RMAs who are responsible for managing the risks of flooding, as referred to in *Introduction*. These are presented in *Table 2-1* where they are listed at a borough level. Further information on each RMA can be found throughout *2.1 to 2.5*.

Table 2-1: Borough level Risk Management Authorities

Risk Management Authority	Borough-specific Authority	Flood risk management responsibilities
Environment Agency (EA)	EA	Main rivers and reservoirs
LLFA	Richmond	Surface water, ordinary watercourses, and groundwater
Water and Sewerage Company	TWUL	Surface water, foul and combined sewer systems
Highway Authority	Richmond	Public highway drainage

2.1 Environment Agency

The EA are responsible for managing flood risk from main rivers, the sea, and reservoirs. As the national flood risk authority for the UK, they also supervise and work with other RMAs to manage the risk of flooding. The EA has an important role in advising Local Planning Authorities on how development proposals may influence flood risk and issuing consent for works that may be on or near main rivers. They also take part in emergency planning and response to flooding events.

The main rivers within the Richmond which the EA is responsible for managing and maintaining are:

- River Thames
- River Crane
- Beverley Brook
- Duke of Northumberland's River
- Whitton Brook
- Portlane Brook

2.2 London Borough of Richmond upon Thames

Richmond has multiple roles to perform as a principal RMA, predominantly as a LLFA, but also as a Highway Authority, landowner, and Category One Responder. The LLFA's main responsibility is to manage the risk of flooding from surface water, groundwater, and ordinary watercourses. Under the FWMA and Flood Risk Regulations (2009), they are responsible for, amongst other duties:

- Developing, maintaining and publishing a Local Flood Risk Management Strategy (LFRMS).
- Maintaining a register of assets and features that have a significant effect on flood risk in Richmond.
- Reviewing and acting as a statutory consultee on surface water drainage proposals for major developments under the Town and Country Planning Order (2015).
- Undertaking flood risk investigations.
- Prepare and maintain Preliminary Flood Risk Assessments (PFRAs), flood hazard and risk maps, and flood hazard plans.

Other RMAs have a duty to cooperate with LLFAs where necessary to carry out the above responsibilities. The LLFA can also carry out work to help alleviate surface water, groundwater, and ordinary watercourse flooding in collaboration with other RMAs.

As a Highway Authority, Richmond is responsible for providing and managing public highway assets that are not managed by Transport for London (TfL). The roads managed by TfL in Richmond are set out in the TFL Base Map and listed below:

- A205
- A316

Richmond is also responsible for the management of surface water drainage on council-managed highways, and maintenance of highway gullies, road surfaces and footpaths under their role as a Highway Authority.

As a landowner, Richmond has a responsibility to safeguard their own land and property against flooding. Common law also requires that they do not increase the risk of flooding to a neighbouring property through carrying out tasks such as drain clearing and maintaining any existing flood defences.

As a Category One Responder under the Civil Contingencies Act (2004), Richmond plays a lead role in emergency planning and recovery after a flood event. They are therefore required to have plans in place ready to respond to any emergency, such as a flooding event, and make sure that they can manage or reduce the impact of the event by liaising with relevant stakeholders (including other Category One Responders). These stakeholders are listed in Richmond's MAFP (Multi-Agency Flood Plan) which includes: the EA, Metropolitan Police Service (MPS), Richmond, London Fire Brigade (LFB), London Ambulance Service, TfL, National Grid: gas and electricity distribution & transmission, UK Power Network, British Red Cross, UK Health Security Agency, and TWUL.

2.3 Thames Water Utilities Limited

TWUL is the regional water and sewerage company and is the RMA responsible for managing the risk of flooding from public sewers including surface water, foul and combined sewer systems. They must manage and maintain their water supply and sewerage systems and make sure that they are resilient to flooding. They have a duty under Section 94 of the Water Industry Act (1991) to make sure that the area they serve is effectively drained and will continue to be effectively drained in the future. TWUL data has been used in this report to analyse local drainage networks.

As part of their responsibility for ensuring flood resilience, TWUL commissioned an independent London Flood Review following the Summer 2021 floods, which resulted in 28 recommendations being provided to reduce the future impact of such storms. These 28 recommendations are listed within Chapter 3 of the London Flood Review's Stage 4 Summary Report, and are discussed in detail within Chapter 4 of the full Stage 4 Technical Report.

2.4 Landowners

Landowners have the primary responsibility of safeguarding their own land and property against flooding, this includes private roads. Under common law they are also required to ensure that they do not develop their land or property in a way that increases the risk of flooding to a neighbouring property. Common law also empowers landowners to take reasonable measures to protect their property from flooding, provided that the measures do not bring about harm to others. Riparian owners are responsible for ensuring that any structure(s) on their land linked to a neighbouring watercourse is kept clear of debris and the watercourse can flow naturally. Typically, they are also responsible for maintaining the banks and bed of an ordinary watercourse or main river as it passes through or adjacent to their land, up to halfway across the watercourse.

2.5 Category One Responders

Schedule 1 of the Civil Contingencies Act (2004) categorises all Local Authorities and all blue light emergency services as Category One Responders. For flood incidents within the borough, the most relevant services are the LFB, the MPS and the EA. MPS co-ordinates emergency services and assists with evacuations, and LFB is responsible for saving lives, but may also pump out floodwater.

3 Flood Incident Details

3.1 12th of July Rainfall Event

The rainfall event that occurred on 12th of July 2021 caused widespread flooding across the South-East of England and London, including in Richmond. Thames Water's 'Rainfall Return Period and Reported Flooding Incidents' data shown in the map in *Figure 3-1* demonstrates the general trend that the North-East and the West of Richmond experienced higher return periods of (greater than 1 in 20 year) on average. In particular, Barnes (North-East) and Hampton (South-East) had the greatest return periods from the event (greater than 1 in 100 year). Central Richmond generally experienced less intense rainfall as shown by the lower return periods of (less than 1 in 10 year). The maps were produced using RaRA data from the Met Office using Flood Estimation Handbook (FEH) 99 calculations for the spatial visualisation. Some limitations to the accuracy of this map were explored in *1.2*.

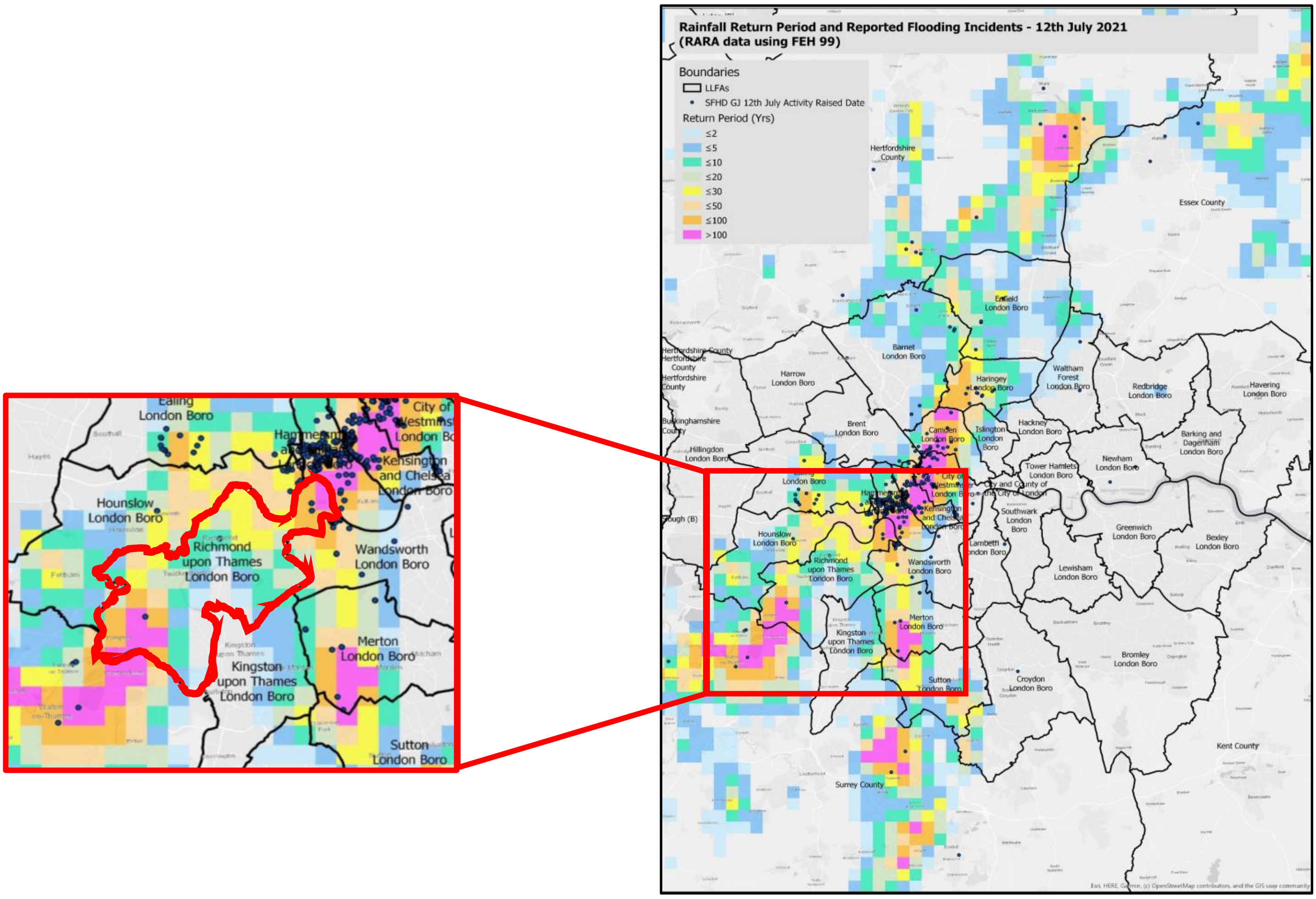

Figure 3-1 July 12th Rainfall return periods in Richmond

3.2 Rain Gauge Data

Rainfall data as recorded by a nearby rain gauge in Putney Heath has been collated for the rainfall event by the EA. The location of the Putney Village rain gauge lies to the East, outside of the Richmond boundary, and can be seen in *Figure 3-3.* There was no available rain gauge data from within Richmond. The rain gauge provided rainfall data at 15-minute intervals throughout the 12th of July 2021. The graph in *Figure 3-2.* shows that the rainfall began intensifying at approximately 14:45 before peaking over Putney Village at approximately 15:30 for a brief period. It then quickly subsided by approximately 16:00. At its peak the rain gauge recorded 16mm of rainfall, while there was a prolonged period of lighter rainfall between 16:00 and 20:00.

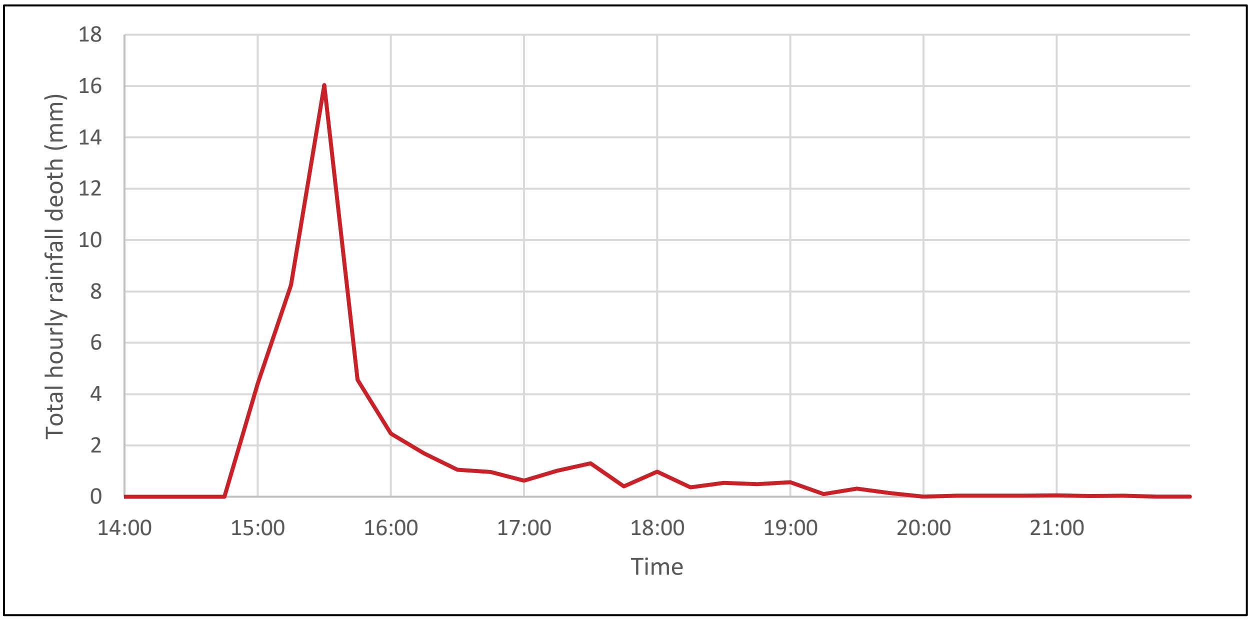

Figure 3-2 Rainfall at Putney Village on 12th of July 2021

3.3 Affected Locations and Hydrological Catchments

On the 12th of July 2021 Richmond was subject to widespread surface water 'flash' flooding. Richmond has received a total of ten flooding reports from the event, which were classified into internal and external / highway flooding as defined below:

- Internal flooding: flooding inside of the building, including basement.
- External flooding: flooding within property boundaries but not to buildings, this includes gardens, garages and driveways.
- Highway flooding: flooding on public roads.

The classification of external flooding and highway flooding has been combined since some of the non-internal reports included both these types of flooding.

There were six reported incidents of internal flooding, spread across five locations: Chestnut Road, Eleanor Grove, Lower Mortlake Road, The Quadrant, and two incidents at Halcyon Close. There were also four reported incidents of external / highways flooding, spread across three locations: Chester Close, Strawberry Vale, and two incidents at Lincoln Avenue. Most of these reports were of highways flooding, although there was a report of external flooding beneath the house and to the driveway of a property on Lincoln Avenue. This can also be seen below in *Table 3-1*.

Table 3-1 Summary of flooded locations on 12th of July 2021

Location	Internal	External / Highway
Chester Close	0	1
Chestnut Road	1	0
Eleanor Grove	1	0
Halcyon Close	2	0
Lincoln Avenue	0	2
Lower Mortlake Road	1	0
Strawberry Vale	0	1
The Quadrant	1	0

The LFB received a total of 36 calls from properties within Richmond regarding flooding, although some of these calls may have been duplicate calls from the same address. The most affected area was SW13 in Barnes, where the LFB attended ten addresses to assist with flooding on the 12th of July 2021. Once the rain had subsided and the gullies and sewers were able to cope the LFB received calls to cancel their attendance.

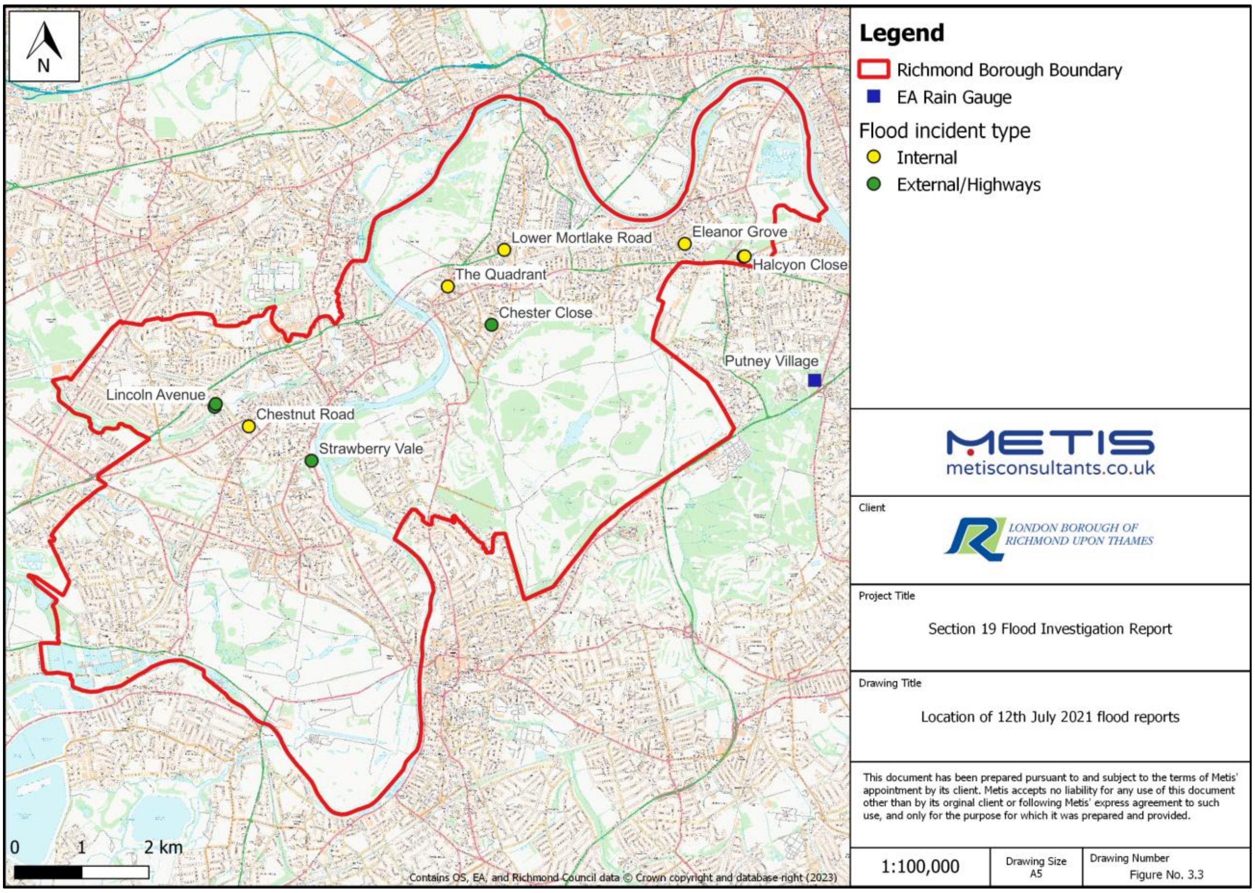

Figure 3-3 Location of 12th of July 2021 flood reports

Hydrological catchments have been defined within Richmond to understand the potential causes of flooding to each location. A catchment area is an area of land where rain falls and drains towards the same waterbody, flow path or topographical low point. The hydrological catchments used herein were defined in Richmond's Surface Water Management Plan (SWMP) (2021), using a combination of topographic and sewer data. There are 12 hydrological catchments identified within Richmond's boundary, several of which are largely situated within with Richmond's neighbouring boroughs: The

London Borough of Hounslow, The London Borough of Wandsworth (Wandsworth), and the Royal Borough of Kingston upon Thames, but share an overlapping area with Richmond. The flooding reports from the 12th of July event are distributed between four catchments, as seen in *Figure 3-4.* Chestnut Road is located in the Hanworth and South Twickenham catchment, The Quadrant and Lower Mortlake Road are both located within the Kew catchment, Eleanor Grove is located within the Putney Heath Catchment, and Halcyon Close is located within the Putney catchment.

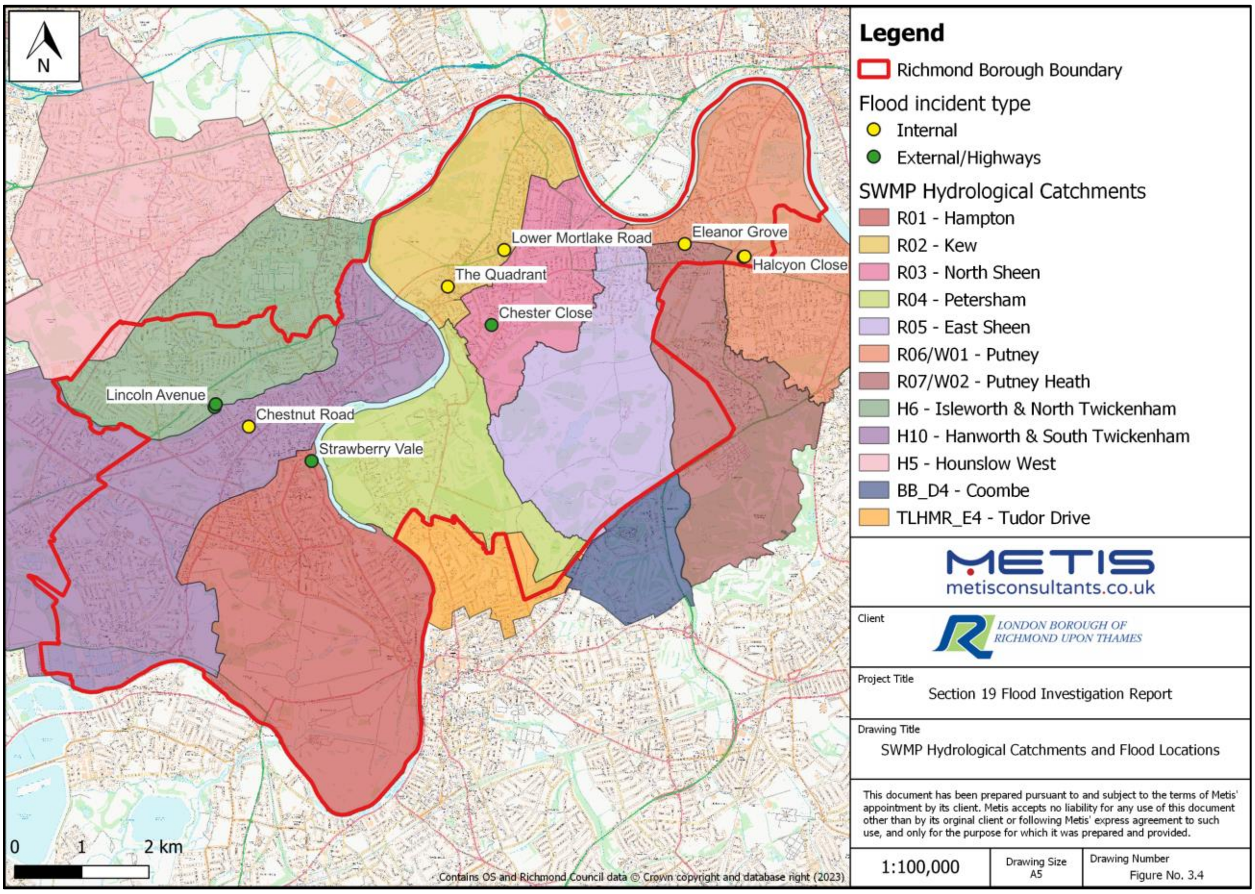

Figure 3-4 SWMP Hydrological Catchments and flood locations

The four external / highways reports are also spread across a further three catchments: Isleworth and North Twickenham, Hampton, and North Sheen. It should be noted however, that since the Richmond Section 19 criteria (defined in *1.1*) does not account for external / highways flooding unless it impacts on an identified item of critical infrastructure, the external / highways flooding reports at Chester Close, Lincoln Avenue and Strawberry Vale will not be individually investigated within this report. For completeness, the external / highways flooding reports which did not meet the Section 19 criteria are summarised in *4.6* of this report because they are part of the same storm event.

4 Flooded Locations

4.1 Chestnut Road

On the 12th of July 2021, large parts of London were affected by intense rainfall which resulted in widespread flooding, including in Richmond. At Chestnut Road the estimated return period was a 1 in 20 year event as seen in *Figure 4-1.* which led to a single report of internal flooding. However, it should be noted that the return period at this location may have been greater since Chestnut Road is located close to the border of the 1 in 50 year return period grid square to the South. The limitations to data such as the RaRa data is further discussed in the methodology in *1.2.* It was implied within the resident's flooding report that Chestnut Road had flooded "on a number of other occasions", and that the "drains" back up very quickly during heavy rain. There were also anecdotal reports of flooding at Second Cross Road within the resident's report, however no further details of this flooding have been received. Second Cross Road and any other anecdotal reports of flooding within this report are also referenced to in *4.6* which explores the External / Highway flooding reports which did not meet Richmond's Section 19 criteria.

4.1.1 Local drainage network

Surface water on Chestnut Road and its surrounding roads all drain to the local TWUL surface water drainage network as shown below in *Figure 4-1.* Chestnut Road is a cul-de-sac which has no upstream surface water drainage inputs joining it. All surface water on Chestnut Road drains to a 225mm diameter pipe which then drains North-West and joins a larger Eastward flowing 375mm diameter pipe on Staines Road.

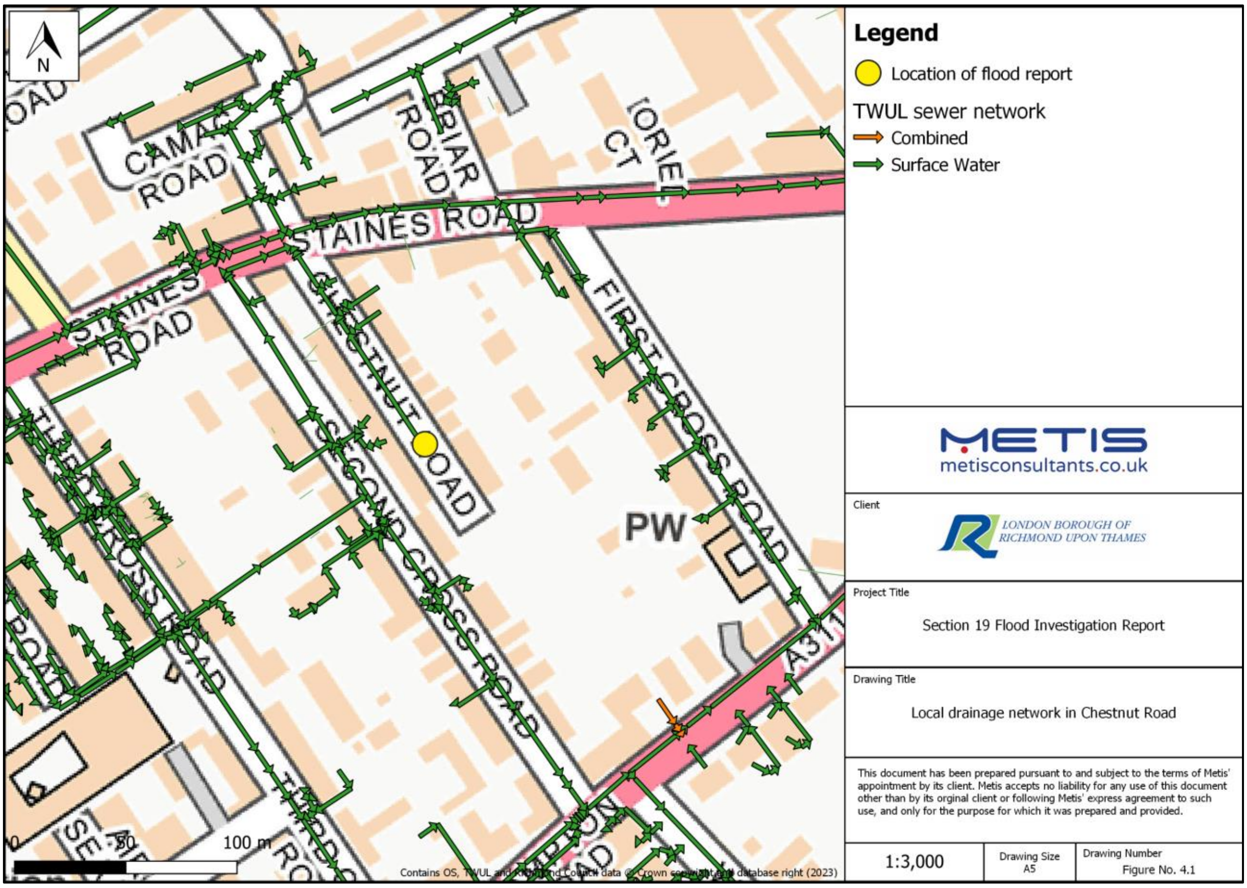

Figure 4-1 Local drainage network in Chestnut Road

4.1.2 Local flood mechanism

Light Detection and Ranging (LiDAR) data from the EA provides elevation data to 1m spatial resolution. The LiDAR data indicates that Chestnut Road is a relatively flat area without any steep gradients and was also reflected through the topography experienced when visiting the site. It was noted that there was a slight gradient falling away from Staines Road and down Chestnut Road, which is reflected by a 0.25m decrease in elevation. This suggests that surface water on Staines Road would flow down Chestnut Road to lower elevation and could contribute to- flooding.

4.1.3 Local flood risk

In order to understand the flood mechanisms that caused the flooding events on the 12th of July, it is important to consider the risk of flooding from surface water, ordinary watercourses, main rivers (fluvial), groundwater, sewers, and any other sources. This helps to determine what the main causes were and therefore to propose any mitigation strategies. At Chestnut Road there are no ordinary watercourses or main rivers in the vicinity which could pose a fluvial risk of flooding, therefore these types of flood risk have not been investigated for this location. Similarly, there were no other potential sources of flooding identified beyond surface water, groundwater or sewer flooding.

4.1.3.1 Surface water flood risk

Flooding from surface water occurs when the volume of rainwater received at a certain location exceeds the capacity of the existing drainage network and is also unable to drain into the ground via infiltration. This results in ponding and overland flows and often occurs during periods of intense rainfall, as experienced on the 12th of July. This is exacerbated in urban areas by the large area of impermeable surfacing. The EA defines an area's Risk of Flooding from Surface Water (RoFSW) within three categories as shown in *Table 4-1* below:

Table 4-1 Criteria for Risk of Flooding from Surface Water categories

Low Risk	This area is at risk of flooding from a 1 in 1000 year rainfall event, which means this area has a chance of flooding of between 0.1% and 1% each year.
Medium Risk	This area is at risk of flooding from a 1 in 100 year rainfall event, which means this area has a chance of flooding of between 1% and 3.3% each year.
High Risk	This area is at risk of flooding from a 1 in 30 year rainfall event, which means this area has a chance of flooding of greater than 3.3% each year.

The EA's RoFSW mapping in *Figure 4-2* predicts Chestnut Road to be at medium to low risk of surface water flooding. The mapping also predicts that Second Cross Road which runs parallel to Chestnut Road is at higher risk of surface water flooding, while Staines Road is at low risk.

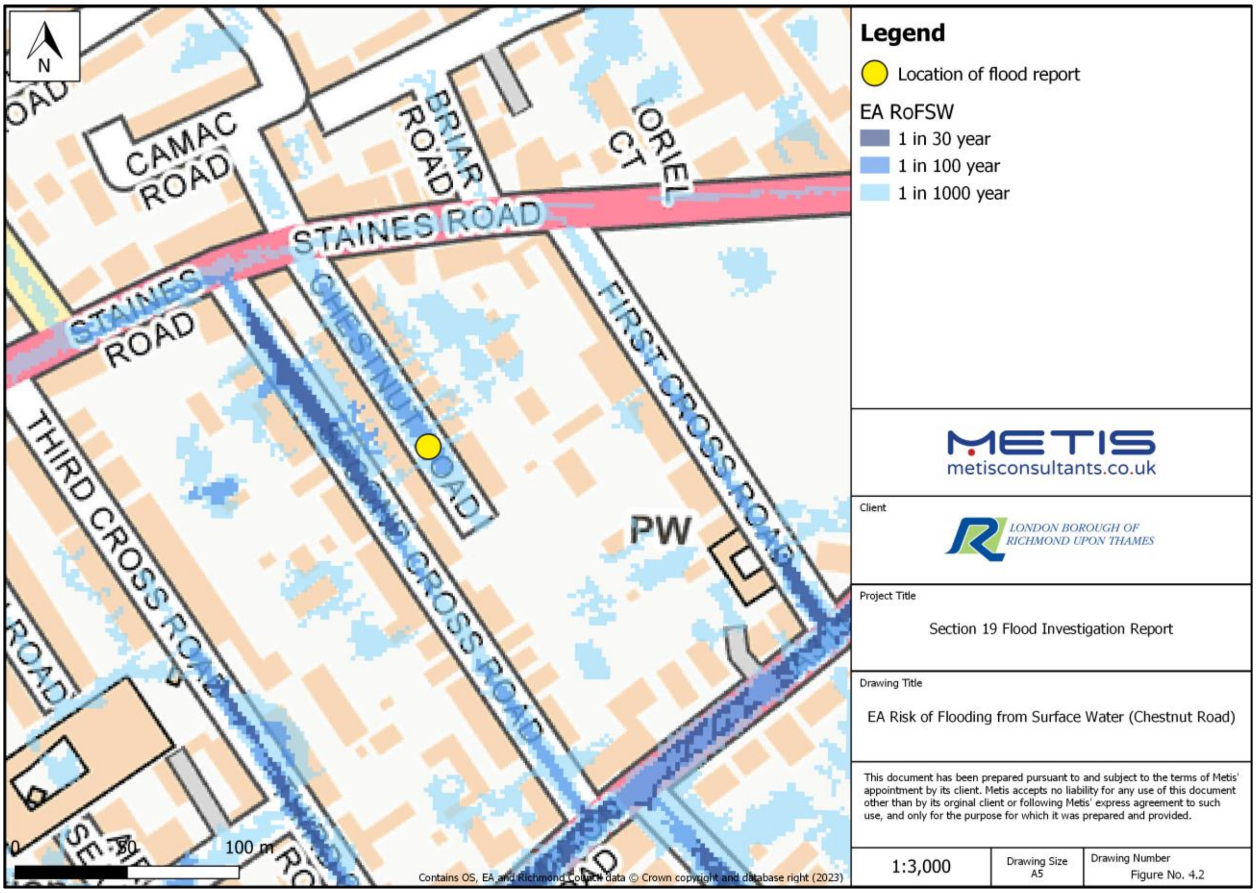

Figure 4-2 EA RoFSW (Chestnut Road)

4.1.3.2 Groundwater flood risk

Flooding from groundwater occurs when the underground water table rises above the surface of the ground. This can further exacerbate flooding on the surface, as the saturated ground prevents infiltration from taking place. Normally, this type of flooding occurs following prolonged periods of heavy rain, however the response time to rainfall may vary with the local geology. Mapping data from the EA, termed Areas Susceptible to Groundwater Flooding, shows the susceptibility of each 1km^2 to the emergence of groundwater. Chestnut Road is situated within an area of medium to high susceptibility of groundwater emergence (between 50% and 75% susceptibility) as shown in *Figure 4-3.* Chestnut Road also falls within the Strawberry Hill Throughflow Catchment as defined in Richmond's Further Groundwater Investigations report. Throughflow Catchment areas are catchments that change geographically with the change in Topography.

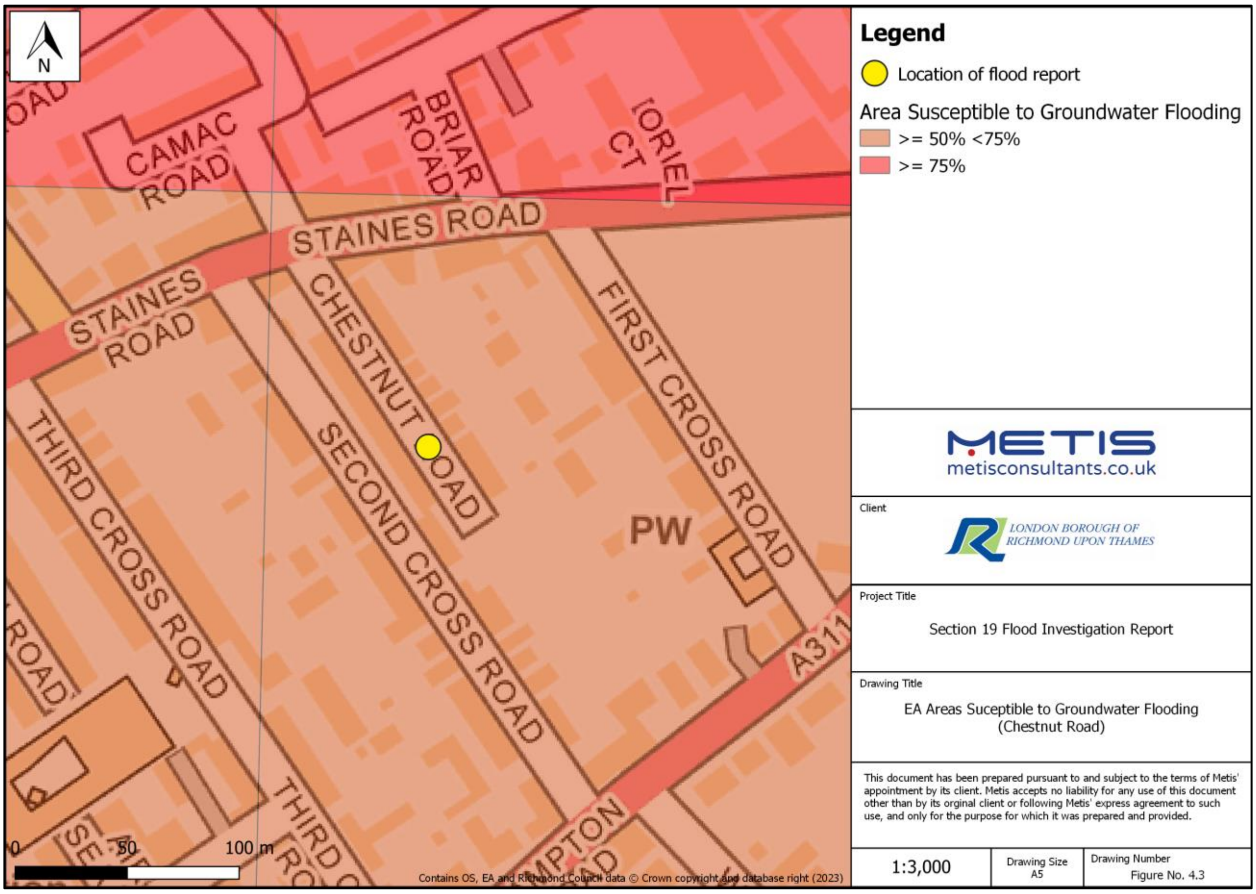

Figure 4-3 Areas susceptible to groundwater flooding (Chestnut Road)

4.1.3.3 Sewer flood risk

Flooding from sewers occurs when the volume of rainfall draining to the sewers exceeds the capacity of the network. This can be because the rainfall event exceeds the designed limits of the sewer or as a result of a blockage in the system. This results in the sewers backing up, surcharging, and generating overland flow, leading to flooding. The surface water sewers serving Chestnut Road are not serving any other roads upstream, which would convey additional volumes of sewage to Chestnut Road. The Capacity Assessment Framework (CAF) gives an indication of combined and foul sewer capacity and overflow performance through an index of risk. Chestnut Road is not included in TWUL's CAF modelling and thus it is unclear what the level of risk would be. There is potential that flooding could occur if the condition of the TWUL surface water sewer or highway gullies on Chestnut Road were not appropriately maintained. A blockage to the surface water sewer or gullies serving Chestnut Road could lead to the backing up of sewage as described in the resident report. No information has been provided by TWUL or Richmond to ascertain the condition of the sewer or gullies on the 12th of July 2021.

4.1.4 Source and Cause

The most likely source of flooding on Chestnut Road during the 12th of July 2021 was sewer flooding. The estimated return period at Chestnut Road was a 1 in 20 year event as seen in *Figure 3-1*. However, it should be noted that the return period at this location may have been greater since Chestnut Road is located close to the border of the 1 in 50 year return period grid square to the South. The limitations to data such as the RaRa data is further discussed in the methodology in *1.2*. The flooding report made to Richmond by a resident living on Chestnut Road suggested that the "drains" on Chestnut Road back up quickly during heavy rain, implying that either the surface water sewer on Chestnut Road was surcharging, or that the gullies on Chestnut Road were not free flowing. TWUL surface water sewers are typically designed with a return period of up to a 1 in 30 year event, therefore it should be less likely to surcharge in a 1 in 20 year rainfall event. However, without any specific design records available for the sewer network Chestnut Road this is not possible to confirm either way. Therefore, it is likely that the flooding to Chestnut Road stemmed from a blockage or capacity issue within the surface water sewer or to gullies on the surface. As mentioned in *4.1.2*, the topography of Chestnut Road slopes away from Staines Road which suggests that surface water would pond on the surface of the road and not dissipate until the sewer system could receive it, exacerbating the flooding. The resident's report did not provide details to suggest that groundwater would have contributed as a source of flooding to Chestnut Road in this event. However, Chestnut Road is located in an area of medium to high susceptibility to groundwater flooding, and as mentioned in *4.1.3.2*, Chestnut Road is located in the Strawberry Hill Throughflow Catchment, which may have implications to groundwater flooding. Further investigation into the geology and groundwater flow paths is required to quantify the risk of groundwater flooding at Chestnut Road. Whilst it is not possible to conclude with certainty that sewer flooding was the source of flooding at Chestnut Road, the local flood risk information discussed, in combination with the details from the flooding report, suggest that a blockage or capacity issue within the sewer is likely to be the cause.

4.2 Eleanor Grove

At Eleanor Grove the estimated return period was a 1 in 100 year event as seen in *Figure 3-1,* which led to a single report of internal flooding. The flooding report received from the resident on Eleanor Grove describes that the "drains" on the street were not coping, which resulted in flooding to their garden and also 30mm deep flooding to their below street level kitchen. The report also described that water was coming up through the shower drain, and that the water was contaminated. However, it is not explicitly clear which source of flooding to their property was contaminated. There were also anecdotal reports of flooding at Rosslyn Avenue, however no further details of this flooding have been received. As previously mentioned in *4.1*, Rosslyn Avenue and any other anecdotal reports of flooding within this report are also referenced to in *4.6* which explores the External / Highway flooding reports which did not meet Richmond's Section 19 criteria.

4.2.1 Local drainage network

The local drainage network on Eleanor Grove consists of a 150mm diameter surface water pipe which runs the length of the cul-de-sac from East to West. This pipe then joins a larger 225mm surface water pipe on White Hart Lane which flows South, as seen below in *Figure 4-4.* There are also three combined sewer pipes which appear to join a foul sewer pipe which runs to White Hart Lane. The foul sewer pipe is not included in *Figure 4-4* since it should not have been directly influenced by the rainfall on 12th of July 2021, and including the foul network would overcomplicate the mapping. However, foul flooding is considered within this report since the combined sewer pipes serving the foul sewer would be storm responsive, and thus likely would influence the volume of water within the foul sewer during extreme rainfall events.

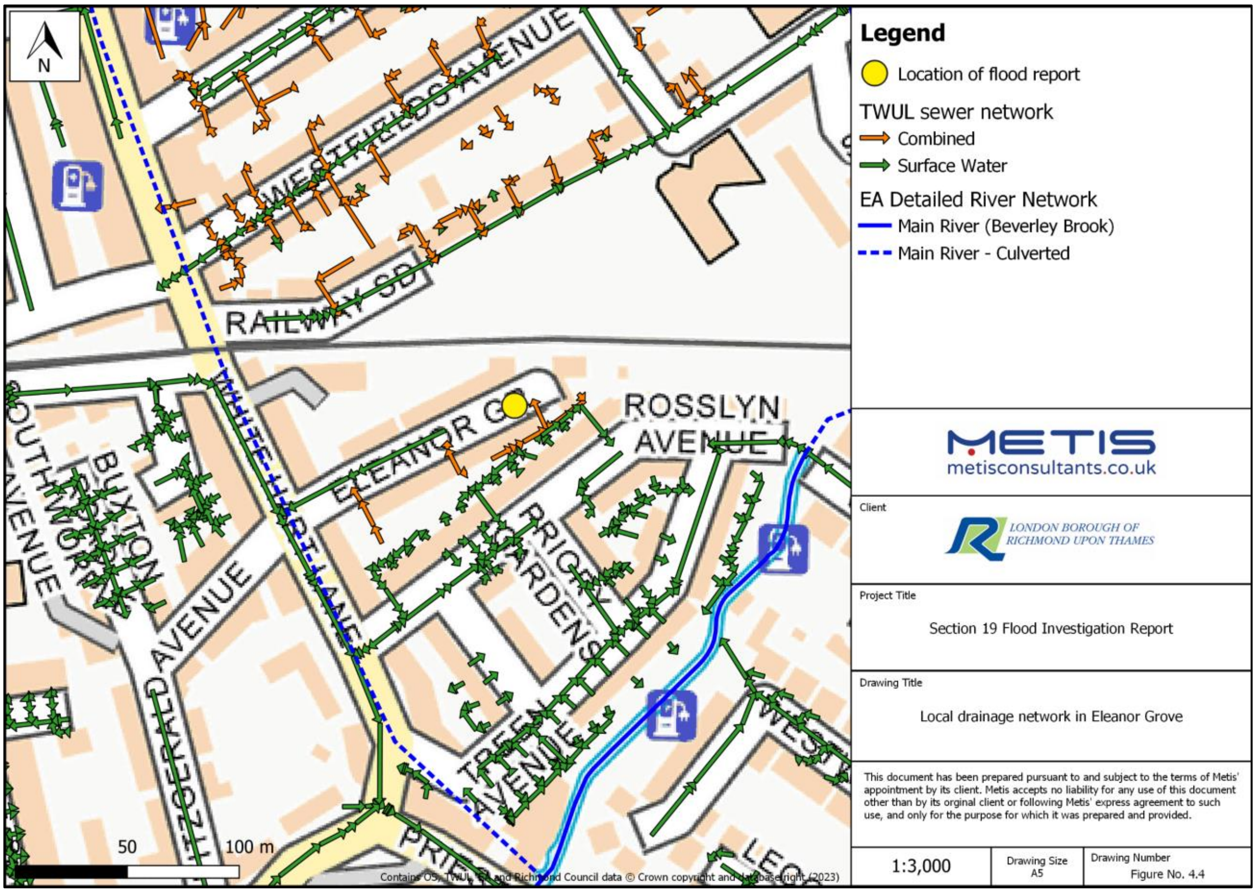

Figure 4-4 Local drainage network in Eleanor Grove

4.2.2 Local flood mechanism

The LiDAR data shows a 0.5m decrease in elevation from White Hart Lane to the bottom of Eleanor Grove. This implies that surface water is likely to flow down Eleanor Grove from White Hart Lane.

4.2.3 Local flood risk

In order to understand the flood mechanisms that caused the flooding events on the 12th of July, it is important to consider the risks of flooding from various sources. This helps to determine what the main causes were and therefore help to verify any mitigation strategies. At Eleanor Grove the potential sources of flooding identified were surface water, fluvial, groundwater and sewer flooding.

4.2.3.1 *Surface water flood risk*

As defined earlier in *4.1.3.1* surface water flooding occurs when the volume and intensity of rainfall exceeds both the capacity of the local drainage network and the ability of the ground to infiltrate. The EA's RoFSW mapping shown below in *Figure 4-5* predicts that Eleanor Grove is largely at low risk of surface water flooding, with some patches at medium risk. There are however areas of very high risk of surface water flooding to the South-West of Eleanor Grove in the vicinity of the Beverley Brook.

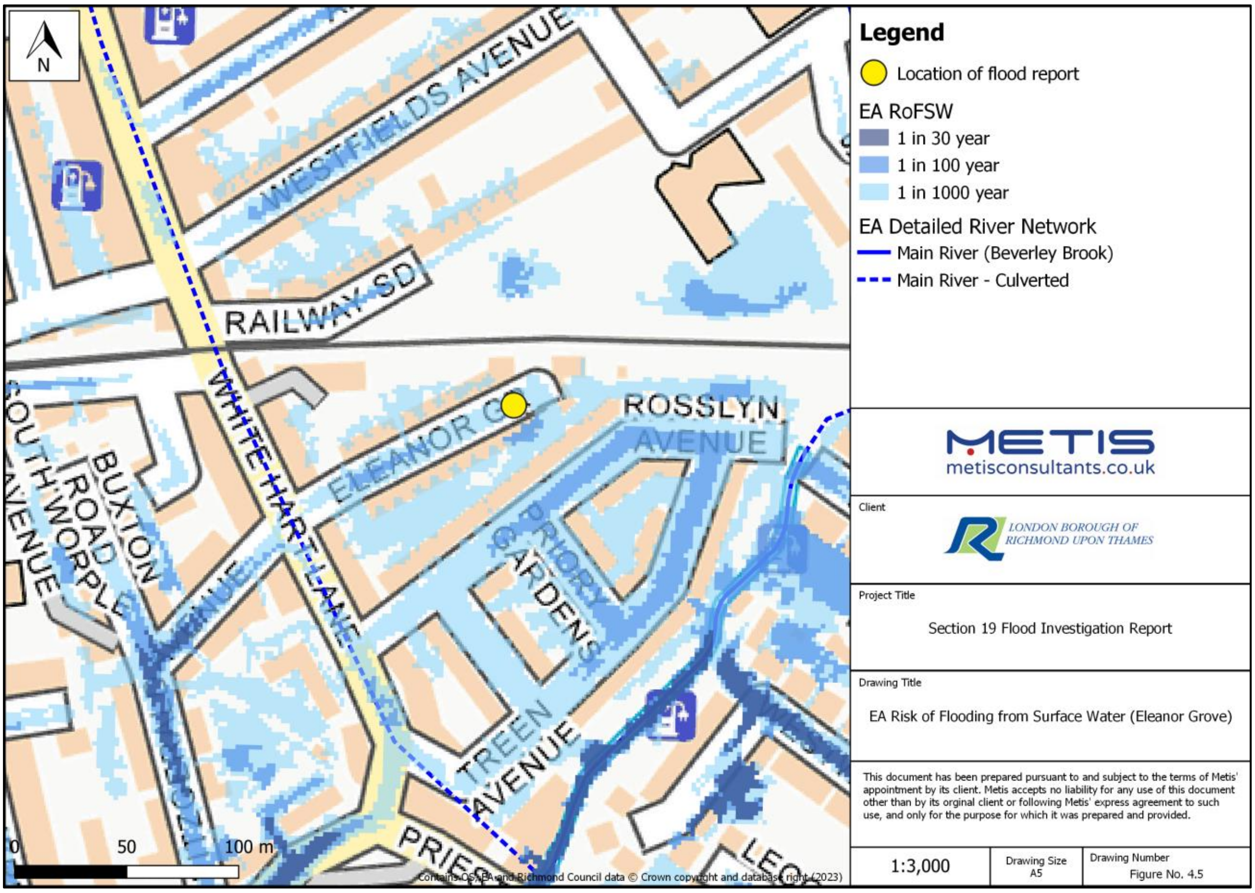

Figure 4-5 EA RoFSW (Eleanor Grove)

4.2.3.2 *Fluvial flood risk*

Fluvial flooding occurs when the capacity of a main river is exceeded causing the banks to be breached and resulting in overflow of the banks. Areas at risk of fluvial flooding are again also divided into three categories by the EA, and incorporate risk of flooding from the sea, as shown below in *Table 4-2*:

Table 4-2 Criteria for areas at risk of flooding from rivers and the sea

Flood Zone 1	Land at less than 0.1% chance of flooding each year.
Flood Zone 2	Land with between 0.1% and 1% chance of flooding each year.
Flood Zone 3	Land with greater than 1% chance of flooding each year.

As seen in *Figure 4-6*, Eleanor Grove is not located within Flood Zone 2 or Flood Zone 3, despite the Beverley Brook flowing nearby (approximately 100m to the South-East of Eleanor Grove). Its location within Flood Zone 1 implies that the site is predicted to be at very low risk of fluvial flooding. A culverted watercourse is shown to run from South to North beneath White Hart Lane. This could lead to flooding if not appropriately maintained, albeit this would likely increase risk of flooding at the openings of the culvert by the River Thames to the North, or at the Beverly Brook to the South, rather than at Eleanor Grove. Richmond is a tidally influenced borough, however none of the locations considered in this investigation are influenced or impacted by tidal flood risk.

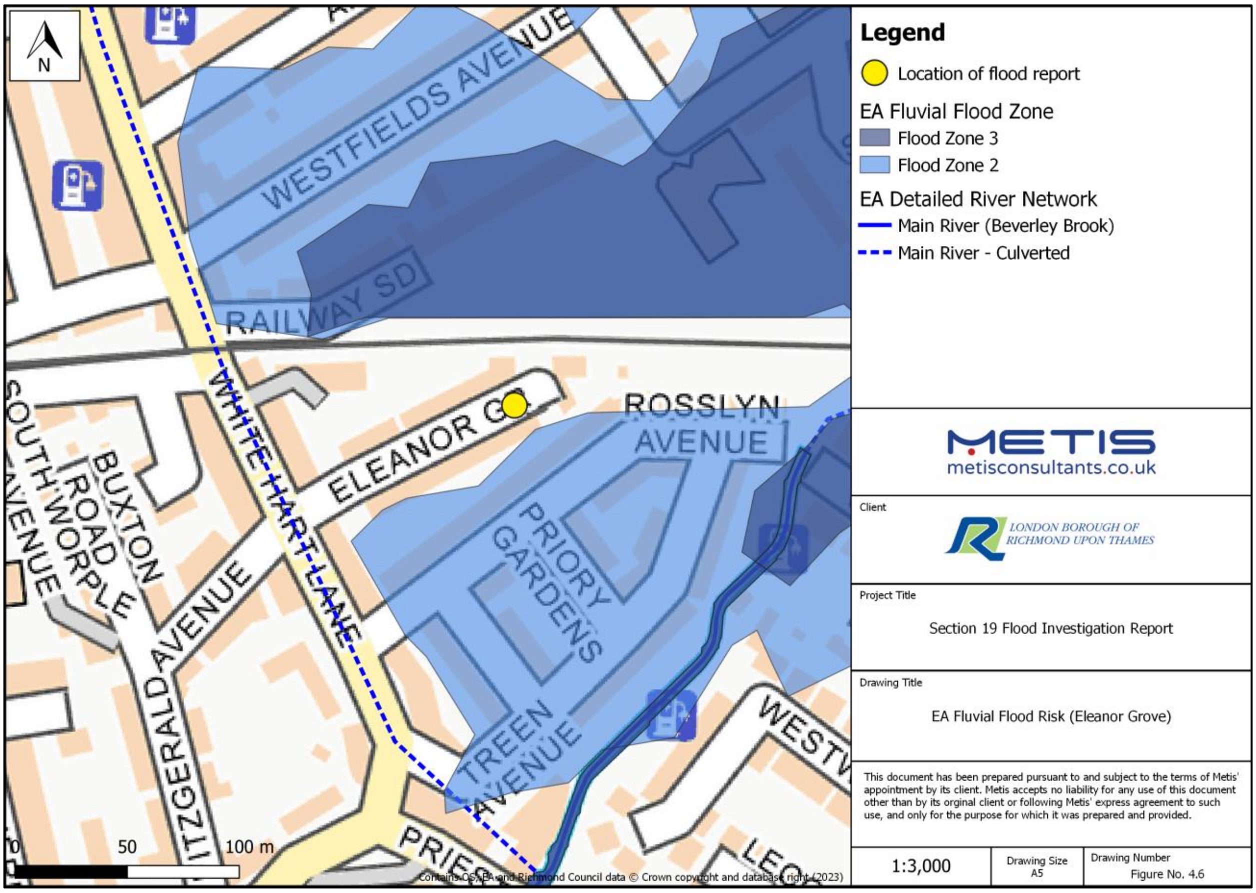

Figure 4-6 EA Fluvial flood risk (Eleanor Grove)

The Richmond Strategic Flood Risk Assessment (SFRA) also confirms that Eleanor Grove is not located within "Fluvial Flood Zone 3b" or within an area of Tidal Breach Inundation. This hence predicts that there would be no tidal influence on flooding at Eleanor Grove.

4.2.3.3 Groundwater flood risk

As previously described in *4.1.3.2*, flooding from groundwater occurs when the underground water table rises above the surface of the ground. The EA's Areas Susceptible to Groundwater Flooding mapping shown below in *Figure 4-7* predicts that Eleanor Grove is highly susceptible to groundwater emergence, with a predicted susceptibility of greater than or equal to 75%. The Further Groundwater Investigations Report shows that Eleanor Grove is not located within a Throughflow Catchment.

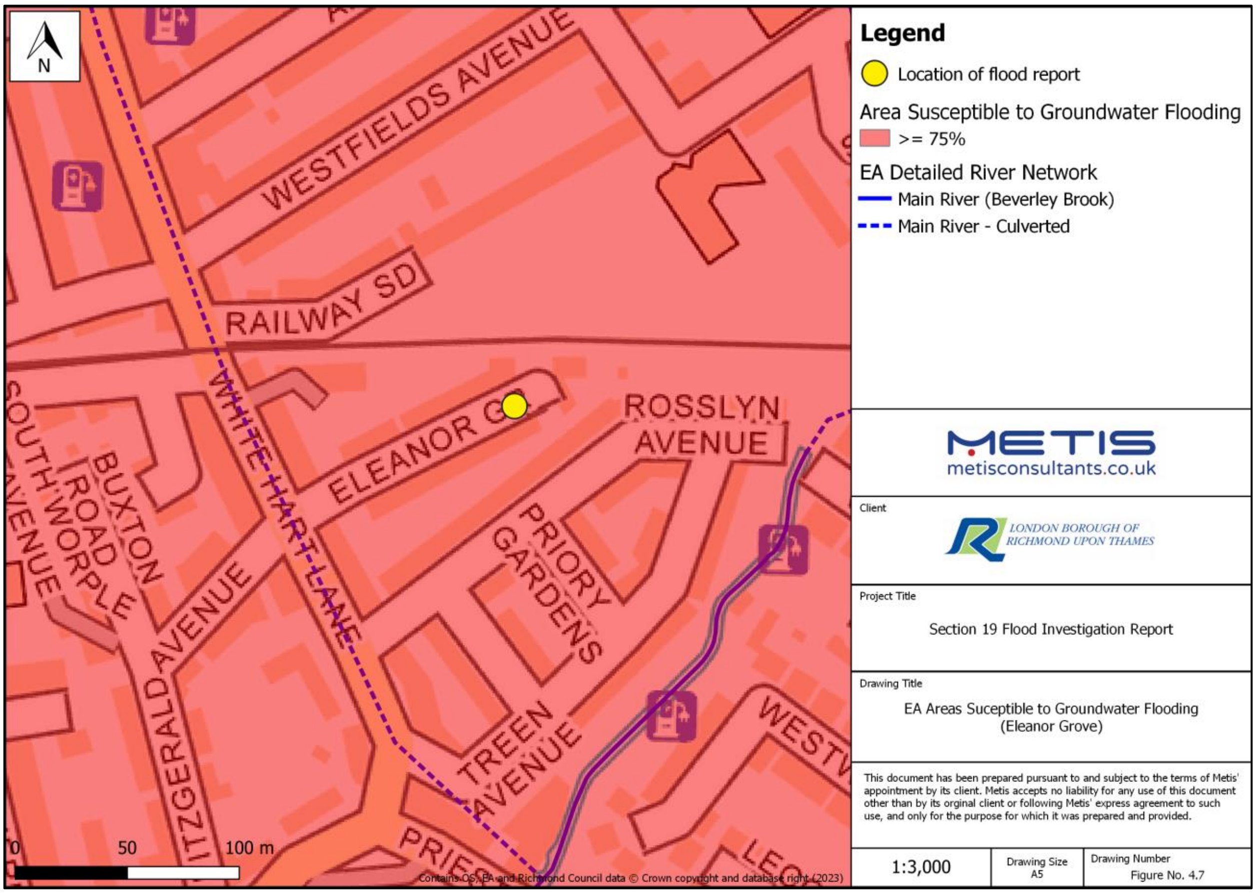

Figure 4-7 Areas susceptible to groundwater flooding (Eleanor Grove)

4.2.3.4 Sewer flood risk

Flooding from sewers occurs when the volume of rainfall draining to the sewers exceeds the capacity of the network as stated in *4.1.3.3*. The map of the sewer network serving Eleanor Grove in *Figure 4-4,* shows that there are no other upstream roads feeding into the sewer network on Eleanor Grove. Despite this, the CAF shows that the Western end of Eleanor Grove is at risk of sewer surcharge in a 1 in 2 year rainfall event from 2020 onwards.

4.2.4 Source and Cause

Sewer flooding is the most likely cause of flooding to Eleanor Grove during the 12th of July 2021 rainfall event. *Figure 3-1* suggests that the return period at Eleanor Grove was a 1 in 100 year event. This substantial volume of rainfall would likely have overwhelmed the TWUL local sewer network which is not typically designed to retain such volumes. This would have resulted in surcharging of the surface water and combined sewers on Eleanor Road. The topography on Eleanor Road slopes away from White Hart Lane which leads to significant ponding further down the road. The CAF predicts that Eleanor Grove is at high risk of foul or combined sewer surcharge for a 1 in 2 year rainfall event, which could be supportive of the details from the resident's flood report which suggested that the "drains" on the highway were not coping and that the water was contaminated. The foul sewer on Eleanor Grove is fed by three combined sewers which would have been storm responsive during the 12^{th} of July 2021 flooding. In a 1 in 100yr event the combined sewers would have fed significant volumes of surface water into the foul sewer which may have led to surcharge of the sewer, as predicted by the CAF.

The resident report does not confirm whether the contaminated water was reaching the property from the highway, or from within where it was described that there was water coming up through the shower drain. It is possible that a blockage within, or a leak from the private drainage within the property boundary, or the TWUL combined sewers which serve the properties on Eleanor Grove, could have resulted in foul sewage backing up and flooding the property.

The resident report also mentions that there was 30mm deep flooding to the below ground kitchen. This flooding could have been caused by groundwater since Eleanor Grove is shown to be in an area of high susceptibility to groundwater emergence. However, there are no details within the report which describe how the water entered the below ground kitchen. A more likely explanation, in line with the suggestion that the highway "drains" were unable to cope, could be that surface water had entered the kitchen from one of the property entrances.

4.3 Halcyon Close

The estimated return period at Halcyon Close was a 1 in 100 year event as seen in *Figure 3-1,* which led to 100mm deep flooding which impacted 14 properties, two of which flooded internally. Anecdotal evidence given by a local community group describes that the privately owned soakaway located within Halcyon Close, which takes water from the carpark and roofs, had become overwhelmed during the flooding. Further anecdotal evidence from a Richmond Council Highways Engineer suggested that the flooding may have been exacerbated as a result of the tide flaps being shut due to high water levels, which would prevent any surface water from discharging into the Thames.

4.3.1 Local drainage network

The local drainage network in the vicinity of Halcyon Close consists of a single surface water sewer pipe to the South of Halcyon Close which flows from West to East along Queen's Ride (B306). This surface water pipe has a 150mm diameter to the West of Halcyon Close, although this increases to a 225mm diameter pipe continuing Eastward as it passes the entrance to Halcyon Close. As seen below in *Figure 4-8*, there are no recorded TWUL sewer assets within Halcyon Close, which suggests that Halcyon Close may be supplied by a private drainage network.

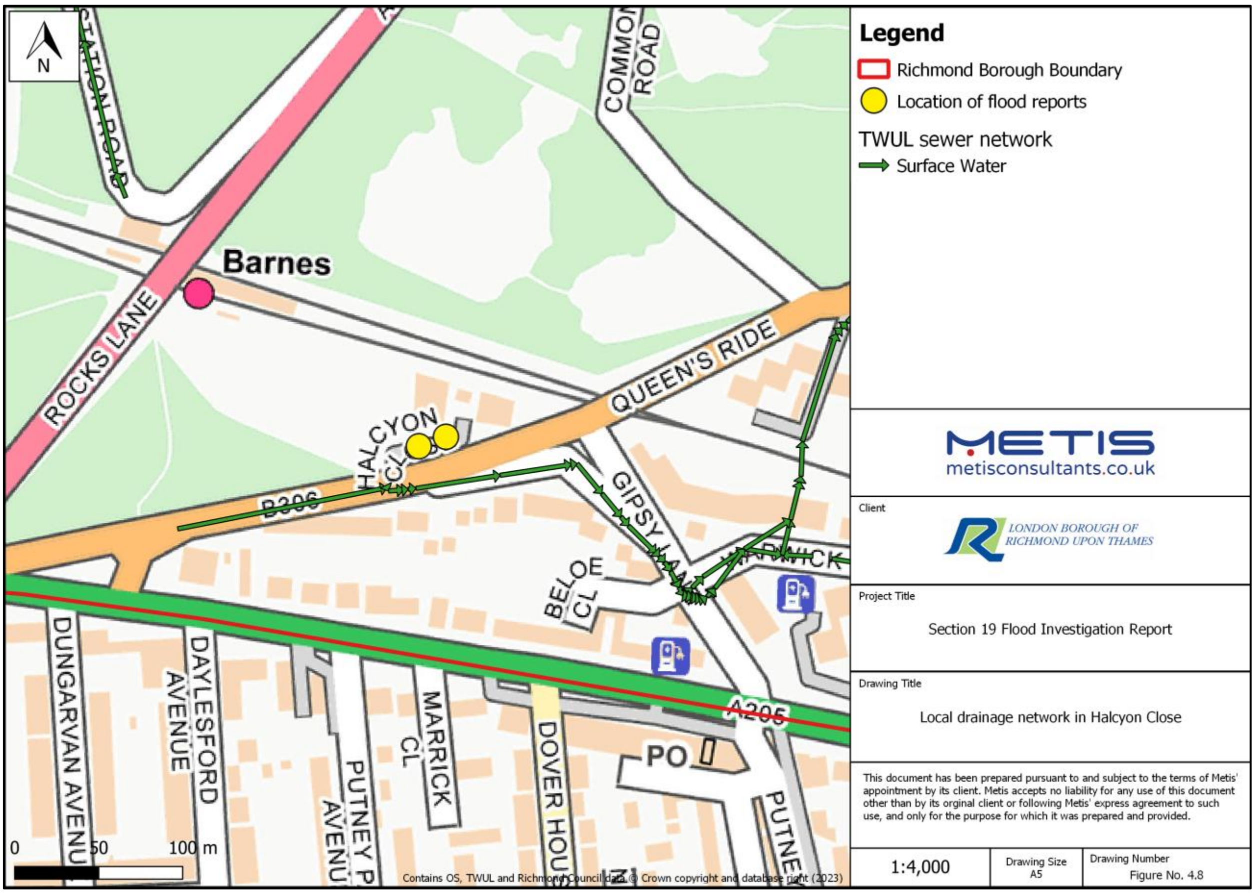

Figure 4-8 Local drainage network in Halcyon Close
***The pink circle is part of the base map and represents Barnes Train Station**

4.3.2 Local flood mechanism

The LiDAR data at Halcyon Close portrays a 0.5m decrease in elevation in comparison to Queen's Ride, which suggests why surface water would flow into Halcyon Close. The elevation of Queen's Ride is also lowest at the entrance to Halcyon Close and Queen's Court opposite. There is a particularly steep gradient where Queen’s Ride rises to cross the railway, with an elevation range of 0.35m. This suggests that surface water runoff on Queen’s Ride would convey towards to Halcyon Close, which is reflective of the description of flooding reported on the 12th of July 2021.

4.3.3 Local flood risk

In order to understand the flood mechanisms that caused the flooding events on the 12th of July, it is important to consider the risks of flooding from various sources. This helps to determine what the main causes were and therefore help to verify any mitigation strategies. At Halcyon Close there are no ordinary watercourses or main rivers in the vicinity which could pose a fluvial risk of flooding, therefore these types of flood risk have not been investigated for this location. Similarly, there were no other sources of flooding identified beyond surface water, groundwater, or sewer flooding.

4.3.3.1 Surface water flood risk

As defined earlier in *4.1.3.1* surface water flooding occurs when the volume and intensity of rainfall exceeds both the capacity of the local drainage network and the ability of the ground to infiltrate. The EA’s RoFSW mapping shown below in *Figure 4-9* predicts that Halcyon Close is at varied risk of surface water flooding. The majority of Halcyon Close is predicted to be at low to medium risk of surface water flooding, although the North-West corner is shown to be at high risk. Queen’s Ride (B306) is also shown to be at high risk of surface water flooding at the entrance and to the West of Halcyon Close, which is reflective of the topography discussed in *4.3.2*. There is also a high risk of surface water flooding predicted to the railway behind Halcyon Close, although this is at a significantly lower elevation than Halcyon Close and hence does not pose a risk to the properties here.

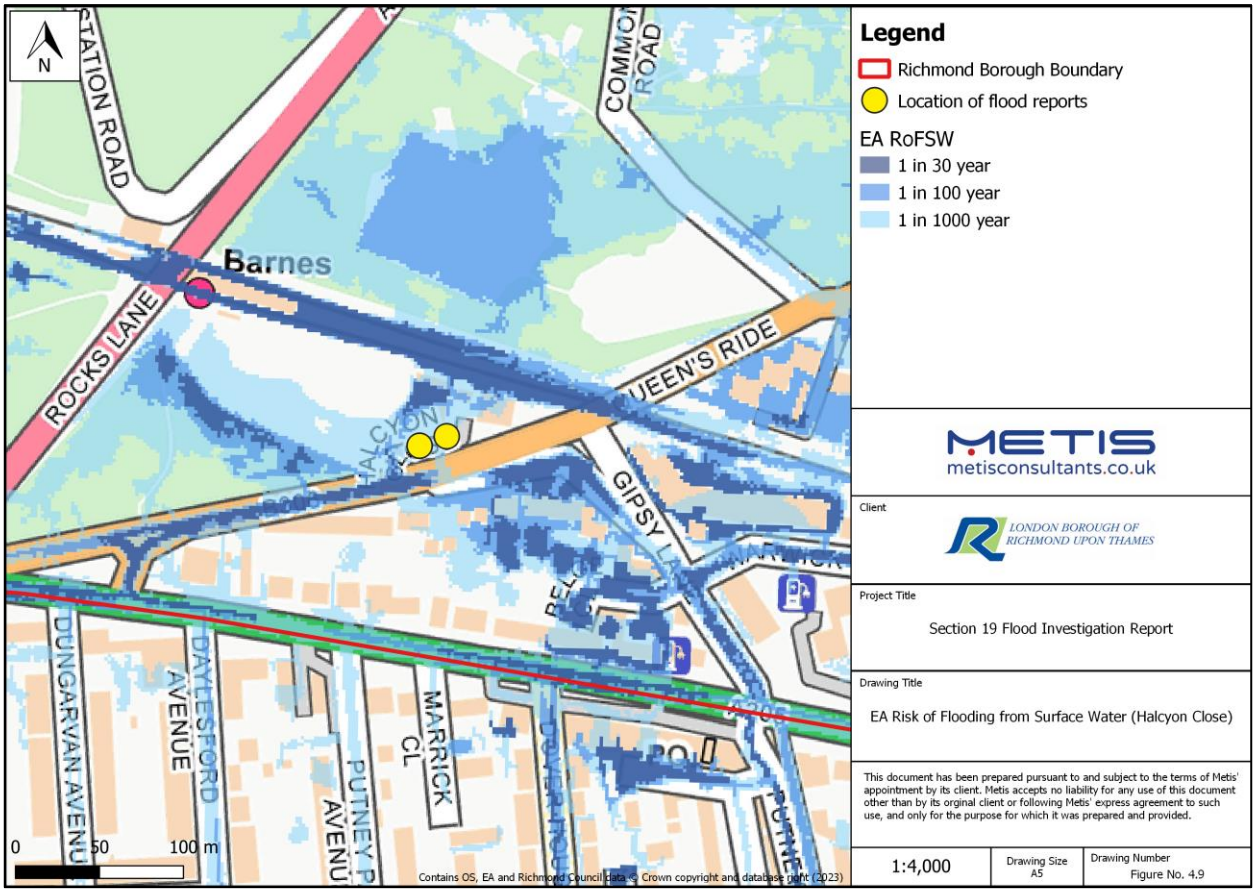

Figure 4-9 EA RoFSW (Halcyon Close)
***The pink circle is part of the base map and represents Barnes Train Station**

4.3.3.2 Groundwater flood risk

As previously described in *4.1.3.2*, flooding from groundwater occurs when the underground water table rises above the surface of the ground. The EA's Areas Susceptible to Groundwater Flooding mapping shown below in *Figure 4-10* predicts that Halcyon Close and the surrounding area are highly susceptible to groundwater emergence, with a susceptibility of greater than or equal to 75%.

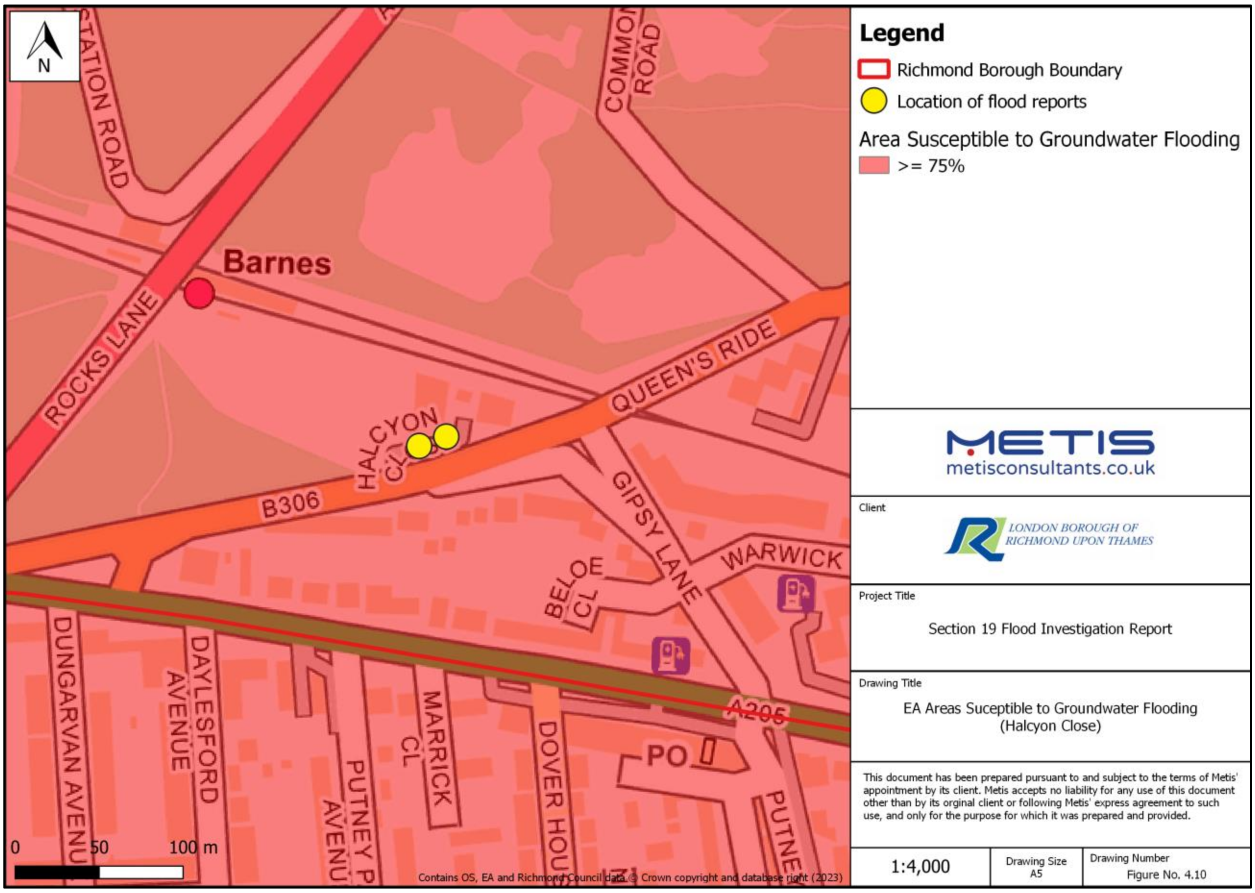

Figure 4-10 Areas susceptible to groundwater flooding (Halcyon Close)
***The pink circle is part of the base map and represents Barnes Train Station**

4.3.3.3 Sewer flood risk

As mentioned in *4.1.3.3*, flooding from sewers occurs when the volume of rainfall draining to the sewers exceeds the capacity of the network. There is a single surface water sewer on Queen's Ride which increases in capacity as it passes Halcyon Close, which should theoretically mitigate the risk of the sewer lacking capacity in an event which does not exceed a 1 in 30 year return period, which TWUL surface water sewers are typically designed to hold capacity for. The CAF does not suggest that there is a risk of surcharge from combined or foul water sewers on Queen's Ride or within Halcyon Close.

4.3.4 Source and Cause

The most likely cause of flooding to Halcyon Close on 12th of July 2021 was a combination of surface water conveyance from Queen's Ride, and sewer flooding. Halcyon Close is shown to be at medium to high risk of surface water flooding which implies that surface water would be a likely source of flooding during a 1 in 100 year rainfall event, as is suggested in *Figure 3-1*. Whilst the railway behind Halcyon Close is also at high risk of flooding there were no flooding reports received on the railway. In such a significant rainfall event surface water overflows from Queen's Ride would have conveyed substantial volumes of surface water into Halcyon Close, which resides at the low point of the road. It is likely that in a 1 in 100 year rainfall event the TWUL surface water sewer on Queens Ride would have been overwhelmed by the volume of rainfall and surcharge, which would have amplified the volumes of surface water flowing into Halcyon Close.

Anecdotal evidence from Richmond Council suggests that the tide flaps were shut due to high water levels during the event, which would prevent any surface water from discharging into The River Thames. This indicates it is likely that the surface water sewers would have backed up and potentially resulted in flooding onto the highway. It is also possible that a blockage within the sewer could have exacerbated the situation, however there was no evidence provided to support or disprove this theory.

Another account of anecdotal evidence from the community group suggested that the privately owned soakaway within Halcyon Close had become overwhelmed. This would imply that the significant volumes of overland flows from Queen's Ride had impeded the soakaway from being able to function to design, negating any infiltration to remove flooding from Halcyon Close.

Whilst these are all potential mechanisms involved in the flooding to Halcyon Close on 12th of July 2021, further investigation will be required to identify the cause and mitigate the risk of repeat flooding at Halcyon Close.

4.4 Lower Mortlake Road

The estimated return period at Lower Mortlake Road was a 1 in 30 year event as seen in *Figure 3-1,* which led to the internal flooding of a single property. The resident report states that blocked gullies in the main road caused water to back up over the pavement and into the property. There was no further information received about the flooding at this location.

4.4.1 Local drainage network

Lower Mortlake Road is managed by both surface water and combined sewers as shown by the TWUL drainage asset data in *Figure 4-11*. There is a 300mm diameter surface water pipe which flows from East to West beneath the Southern footway, which drains a number of surrounding roads from both the North and South. These roads include St George's Road, Bardolph Road and Trinity Road which contribute from the South, and Raleigh Road and the Southern half of Stanmore Gardens which contribute from the North. There is also another 225mm diameter surface water sewer which flows from East to West beneath the Northern footway of Lower Mortlake Road which carries water from the Manor Circus roundabout. The 760mm diameter combined sewer on Lower Mortlake Road flows beneath the highway in the opposite direction to the surface water sewers, from West to East. This combined sewer travels a significant distance, from as far as the River Thames almost 2km away in a South-Westerly direction.

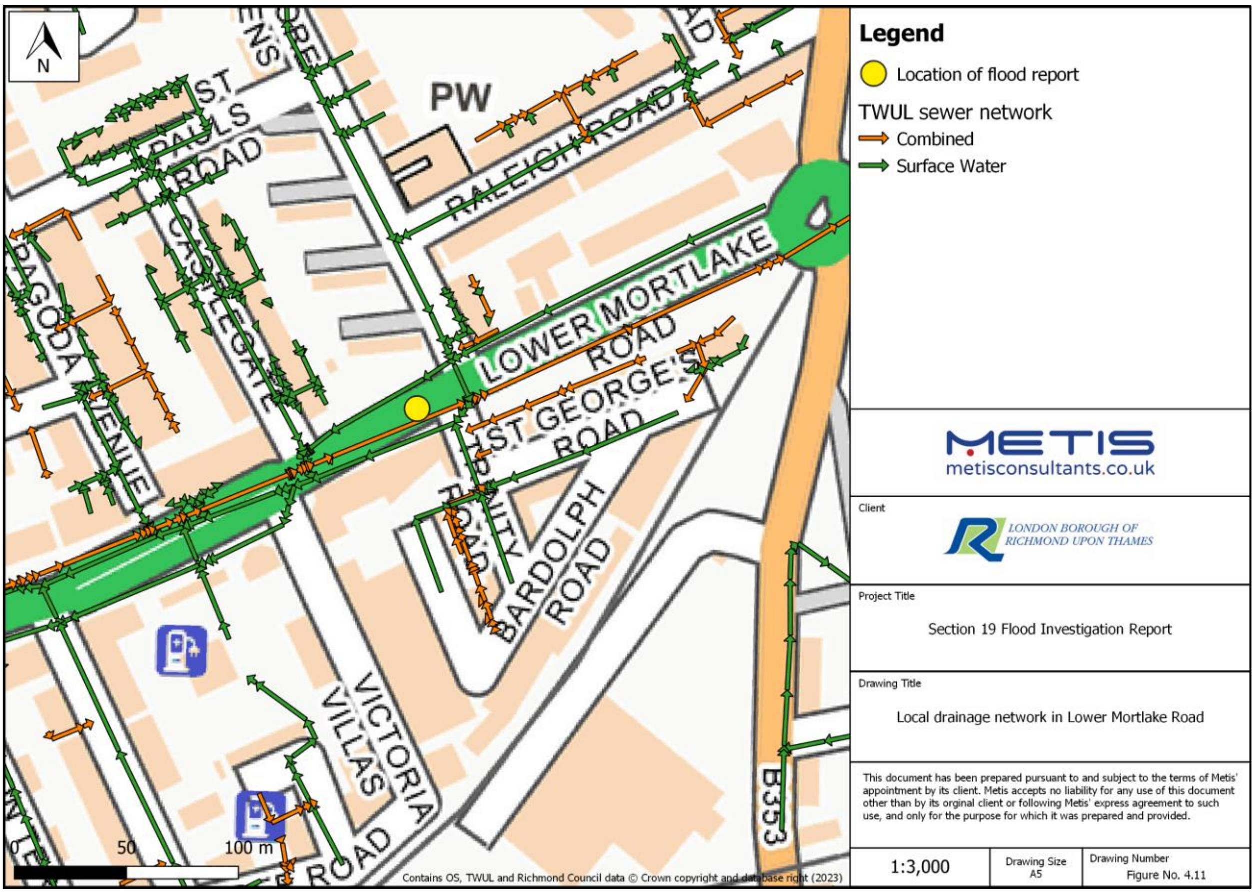

Figure 4-11 Local drainage network in Lower Mortlake Road

4.4.2 Local flood mechanism

The LiDAR data at Lower Mortlake Road shows that there is a steep gradient falling Westwards away from the Manor Circus roundabout, with an elevation decrease of approximately 0.5m to the lowest point, outside the Premier Inn. The adjoining roads including Raleigh Road and Trinity Road are relatively flat and do not markedly slope towards Lower Mortlake Road, which implies that they should not contribute to surface water flooding on Lower Mortlake Road.

4.4.3 Local flood risk

In order to understand the flood mechanisms that caused the flooding events on the 12th of July, it is important to consider the risks of flooding from various sources. This helps to determine what the main causes were and therefore help to verify any mitigation strategies. At Lower Mortlake Road there are no ordinary watercourses or main rivers in the vicinity which could pose a fluvial risk of flooding, therefore these types of flood risk have not been investigated for this location. Similarly, there were no other sources of flooding identified beyond surface water, groundwater or sewer flooding.

4.4.3.1 Surface water flood risk

As defined earlier in *4.1.3.1* surface water flooding occurs when the volume and intensity of rainfall exceeds both the capacity of the local drainage network and the ability of the ground to infiltrate. The EA's RoFSW mapping shown below in *Figure 4-12* predicts that Lower Mortlake Road and the majority of its neighbouring roads are at low risk of surface water flooding.

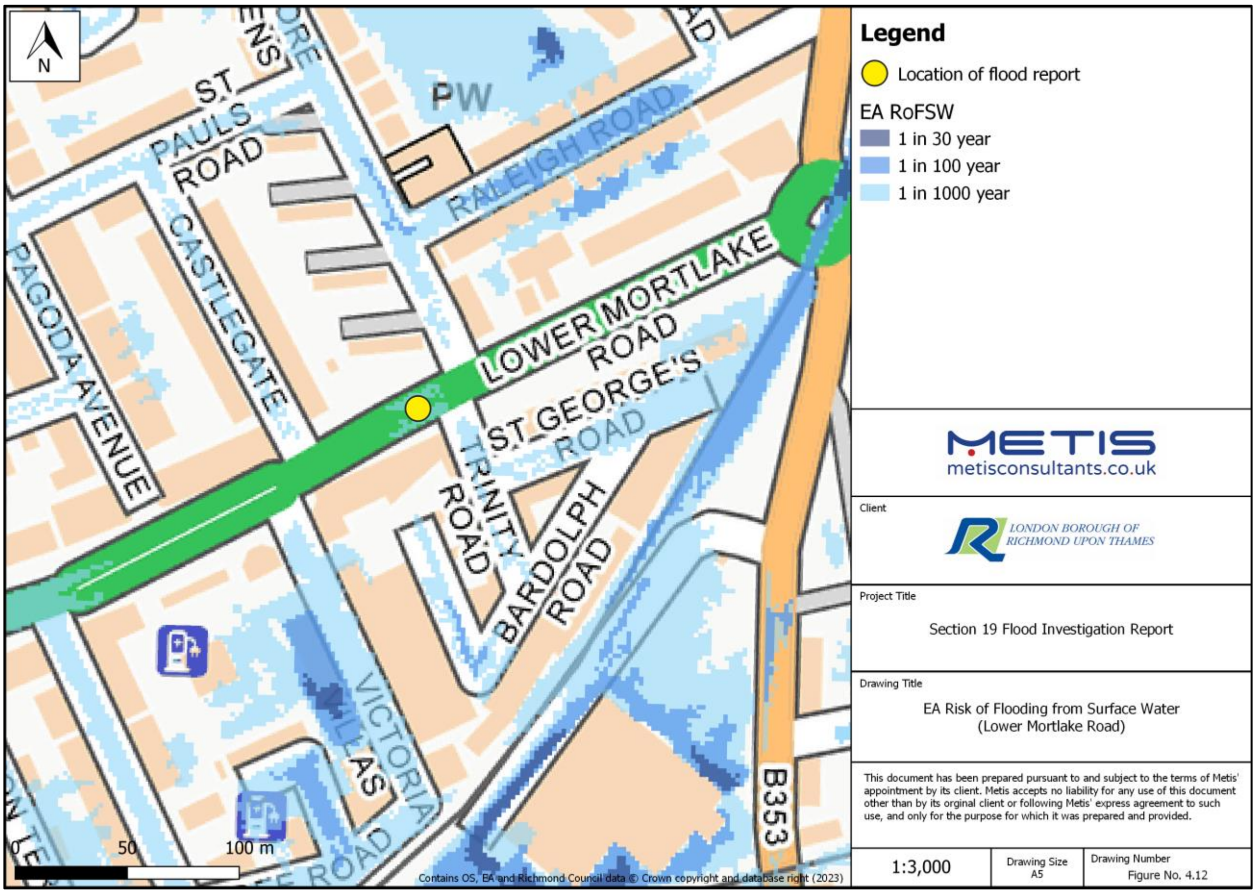

Figure 4-12 EA RoFSW (Lower Mortlake Road)

4.4.3.2 Groundwater flood risk

As previously described in *4.1.3.2*, flooding from groundwater occurs when the underground water table rises above the surface of the ground. The EA's Areas Susceptible to Groundwater Flooding mapping shown below in *Figure 4-13* predicts that Lower Mortlake Road and the surrounding area are highly susceptible to groundwater emergence, with a susceptibility of greater than or equal to 75%. Lower Mortlake Road also falls within the Richmond Hill Throughflow Catchment as defined in Richmond's Further Groundwater Investigations report. As previously described in *4.1.3.2*, Throughflow Catchment areas are catchments that change geographically with the change in Topography.

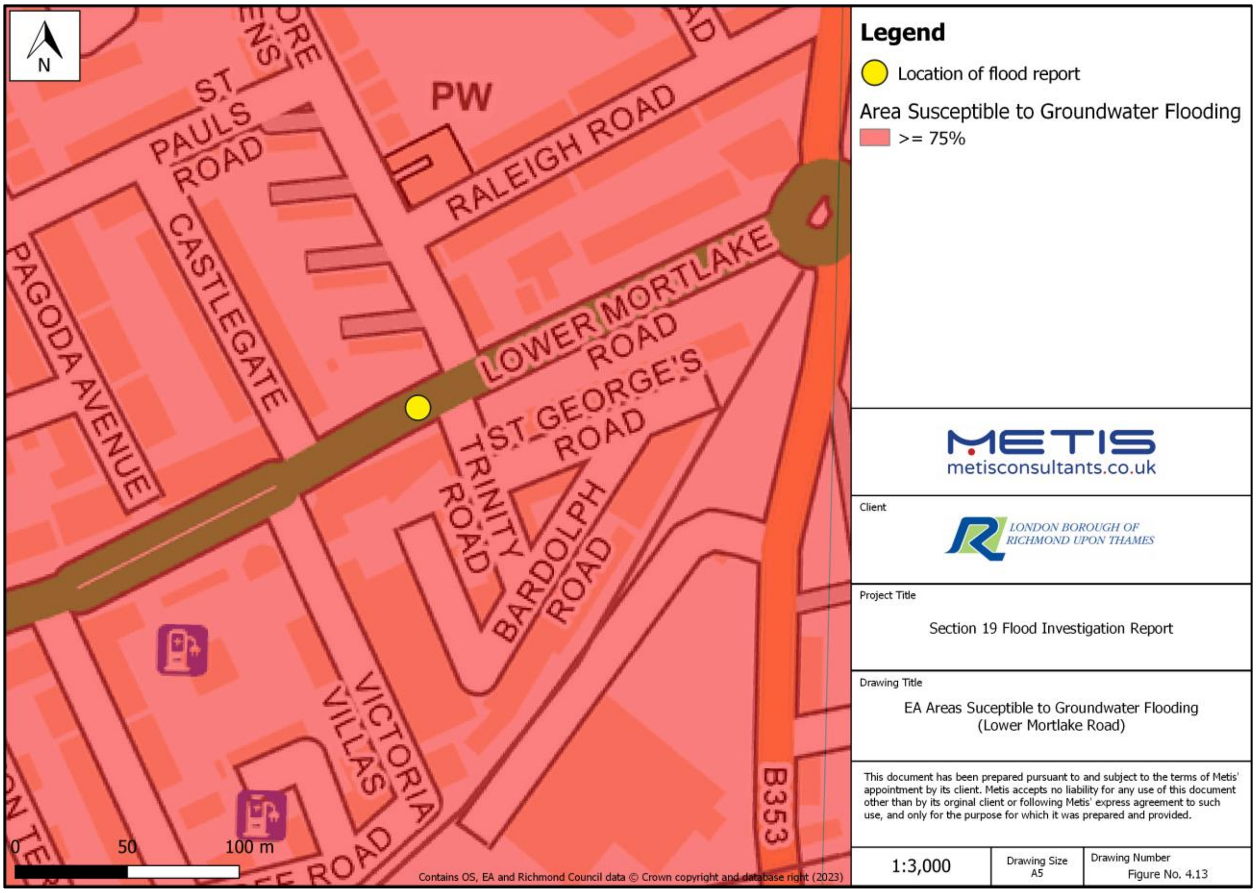

Figure 4-13 Areas susceptible to groundwater flooding (Lower Mortlake Road)

4.4.3.3 Sewer flood risk

As described in *4.4.1*, the TWUL sewer network on Lower Mortlake Road is complex, with several surface water sewers connecting to the main sewer line which runs beneath the road. The adjoining surface water pipes drain a large area of the local TWUL sewer network which could trigger significant flooding if there were to be a blockage and subsequent back up of sewage. Likewise, the combined sewer conveys sewage over a prolonged distance, and could result in a similar situation if not appropriately maintained. The CAF suggests that the combined and foul sewers serving Lower Mortlake Road are at risk of surcharging in a 1 in 2 year event from 2020 onwards, which could hold significant implication for sewer flooding on Lower Mortlake Road in the near future.

4.4.4 Source and Cause

The most likely source of flooding to Lower Mortlake Road was a combination of surface water and sewer flooding. The Met Office RaRa map in *Figure 3-1* shows that Lower Mortlake Road experienced a return period of greater than a 1 in 30 year event on the 12th of July 2021. This indicates that the TWUL surface water and combined sewers on Lower Mortlake Road could have become overwhelmed by the volume of rainfall since their design capacity for new sewers is for up to a 1 in 30 year event. The flooding report received by Richmond stated that there were blocked gullies on Lower Mortlake Road, causing water to back up over the pavement. Given the steep gradient sloping down Lower Mortlake Road away from Manor Circus Roundabout, and the potential for sewer flooding in an exceedance event, it is likely that a substantial volume of surface water would pond at low points on the highway. If the highway gullies were not performing appropriately this would have led to overflows onto the footway as described in the resident's flooding report.

4.5 The Quadrant

The estimated event return period at The Quadrant experienced on the 12th of July 2021 is uncertain, since *Figure 3-1* shows The Quadrant to reside on the border of an area which experienced between a 1 in 10 and 1 in 30 year return period and an area which experienced a greater than 1 in 30 year return period. The lack of clarity shown in *Figure 3-1* is further explored as a limitation in the methodology in *1.2*. The event led to the flooding of a single property located between The Quadrant and Quadrant Road. The resident report describes “8 inches” (~200mm) of water through the back of the property from Quadrant Road, which spread out to “5 inches” (~130mm) through the front and basement of the property. It should also be noted that from a previous flooding event on the 12th of August 2020, the resident had reported water coming up through a manhole and through the edges of the walls in the basement floor. This may complement evidence of the flooding which will be investigated in this report from the 12th of July 2021.

4.5.1 Local drainage network

The Quadrant is surrounded by both surface water and combined sewers as shown in *Figure 4-14.* A 225mm diameter surface water pipe flows North along The Quadrant, which appears to converge with another larger 450mm surface water pipe flowing in the opposite direction. A 225mm pipe then flows West and then South beneath Quadrant Road to the West of The Quadrant. There is also a junction of three 225mm diameter combined sewers behind the flooded property, which resides between The Quadrant and Quadrant Road. These combined sewers appear to serve the flooded property and other neighbouring properties on this stretch of The Quadrant.

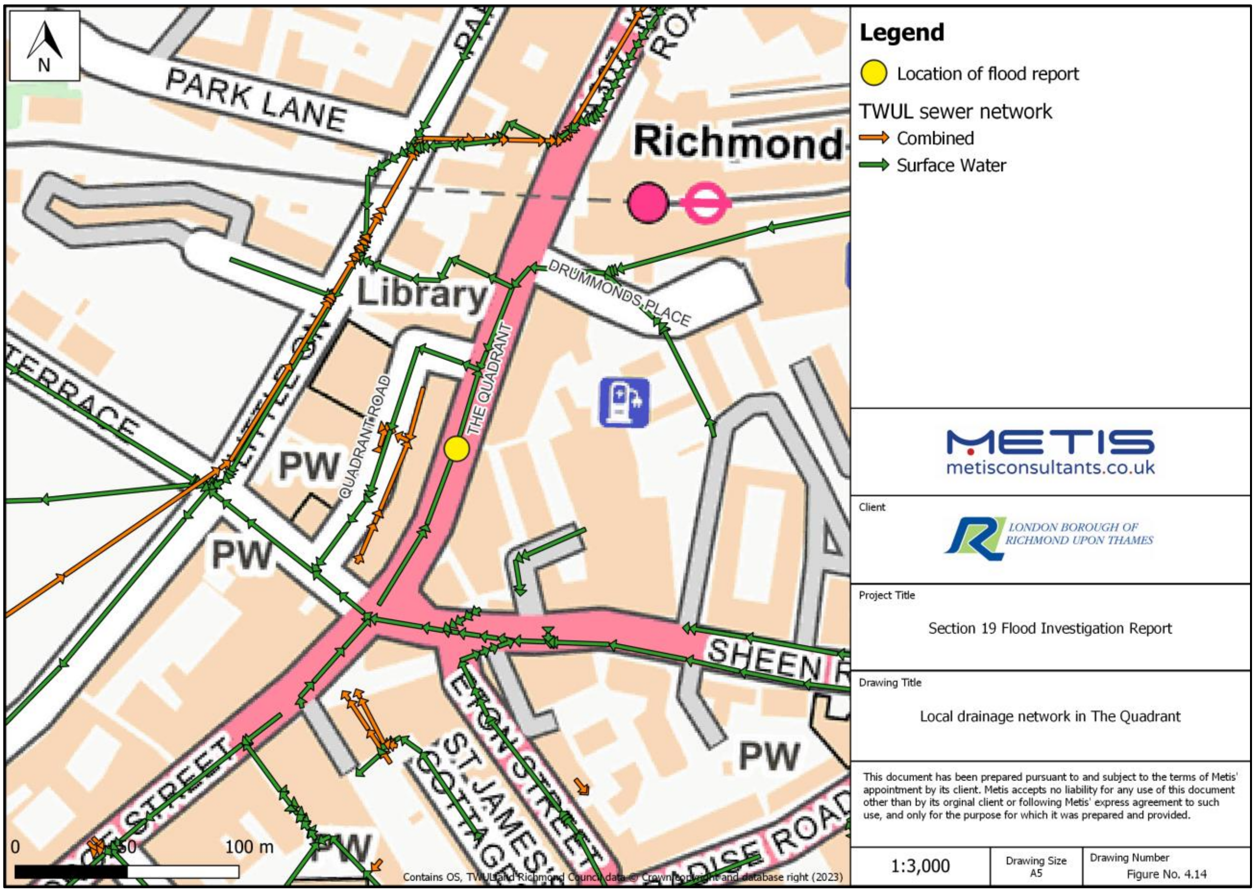

Figure 4-14 Local drainage network in The Quadrant
***The pink circle is part of the base map and represents Richmond Train Station**

This sewer network at The Quadrant appears to be incorrect, since it is unlikely that two larger sewers would converge to form a smaller sewer. It may be the case that the short section of surface water sewer between Quadrant Road and Drummonds Place is labelled to be travelling in the wrong direction. Or alternatively, that the surface water sewer on Quadrant Road is actually larger than the 225mm diameter it is labelled as. However, there are no recorded invert levels on the TWUL sewers or manholes to confirm either suggestion.

4.5.2 Local flood mechanism

The LiDAR data suggests that The Quadrant has a low point at the halfway point between the George Street / Sheen Road intersection and Richmond Station. There is a 0.75m elevation range between this low point and each end of The Quadrant which are of higher elevation. The elevation is 0.5m higher behind the flooded property on Quadrant Road, than outside the front of the property on The Quadrant.

4.5.3 Local flood risk

In order to understand the flood mechanisms that caused the flooding events on the 12th of July, it is important to consider the risks of flooding from various sources. This helps to determine what the main causes were and therefore help to verify any mitigation strategies. At The Quadrant there are no ordinary watercourses or main rivers in the vicinity which could pose a fluvial risk of flooding, therefore these types of flood risk have not been investigated for this location. Similarly, there were no other sources of flooding identified beyond surface water, groundwater or sewer flooding.

4.5.3.1 Surface water flood risk

As defined earlier in *4.1.3.1* surface water flooding occurs when the volume and intensity of rainfall exceeds both the capacity of the local drainage network and the ability of the ground to infiltrate. The EA's RoFSW mapping shown below in *Figure 4-15* shows that the section of The Quadrant outside the flooded property is predicted to be at high risk of surface water flooding. There is also a medium risk of surface water flooding along Quadrant Road to the West of The Quadrant and at the junction of The Quadrant with Sheen Road, George Street and Duke Street.

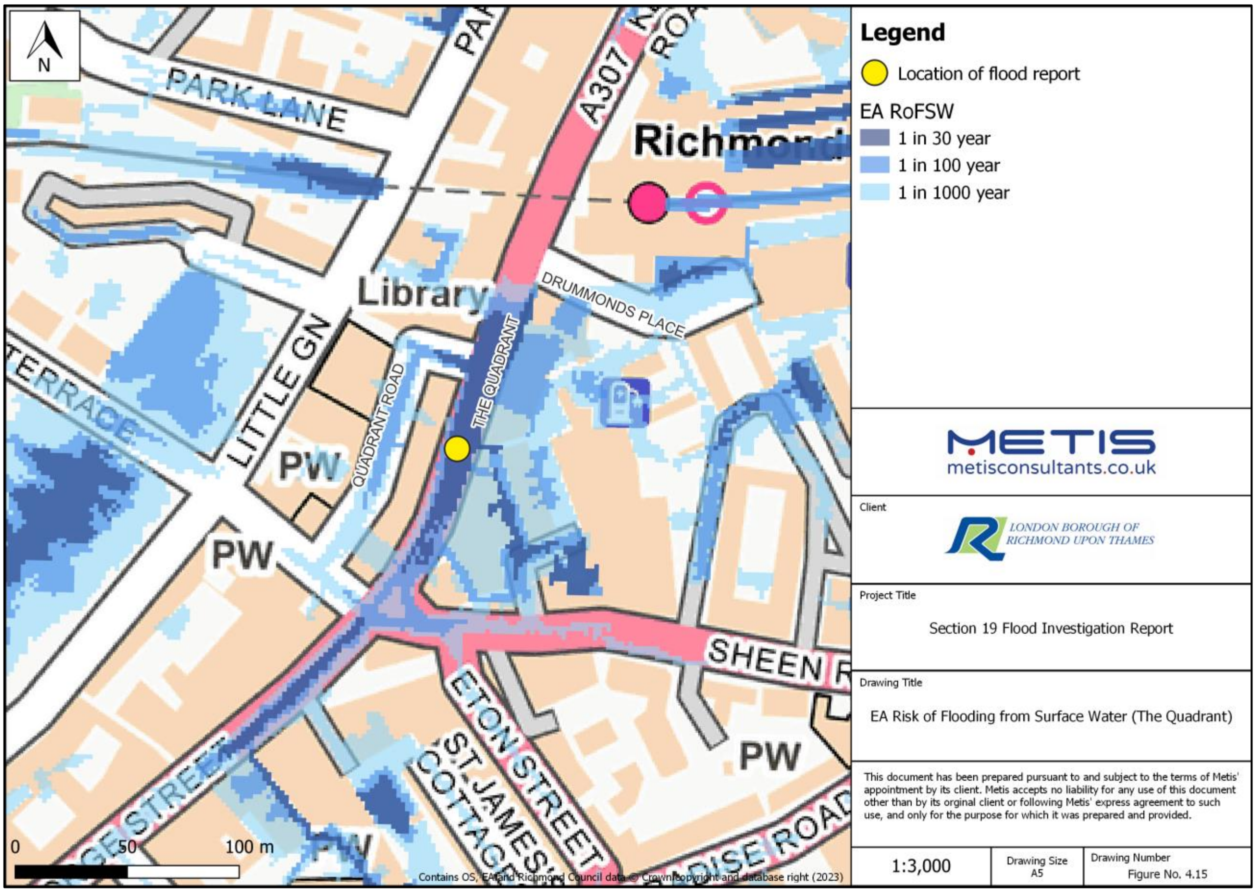

Figure 4-15 EA RoFSW (The Quadrant)
***The pink circle is part of the base map and represents Richmond Train Station**

4.5.3.2 Groundwater flood risk

As previously described in *4.1.3.2*, flooding from groundwater occurs when the underground water table rises above the surface of the ground. The EA's Areas Susceptible to Groundwater Flooding mapping shown below in *Figure 4-16* predicts that The Quadrant has a high susceptibility to groundwater emergence of greater than or equal to 75%. The susceptibility of groundwater emergence is less in the Southern end of the Quadrant where there is a medium susceptibility (between 50% and 75%). There is also a low susceptibility to groundwater emergence (less than 25%) to the South-East of The Quadrant. The Quadrant also falls within the Richmond Hill Throughflow Catchment as defined in Richmond's Further

Groundwater Investigations report. As previously described in *4.1.3.2*, Throughflow Catchment areas are catchments that change geographically with the change in Topography.

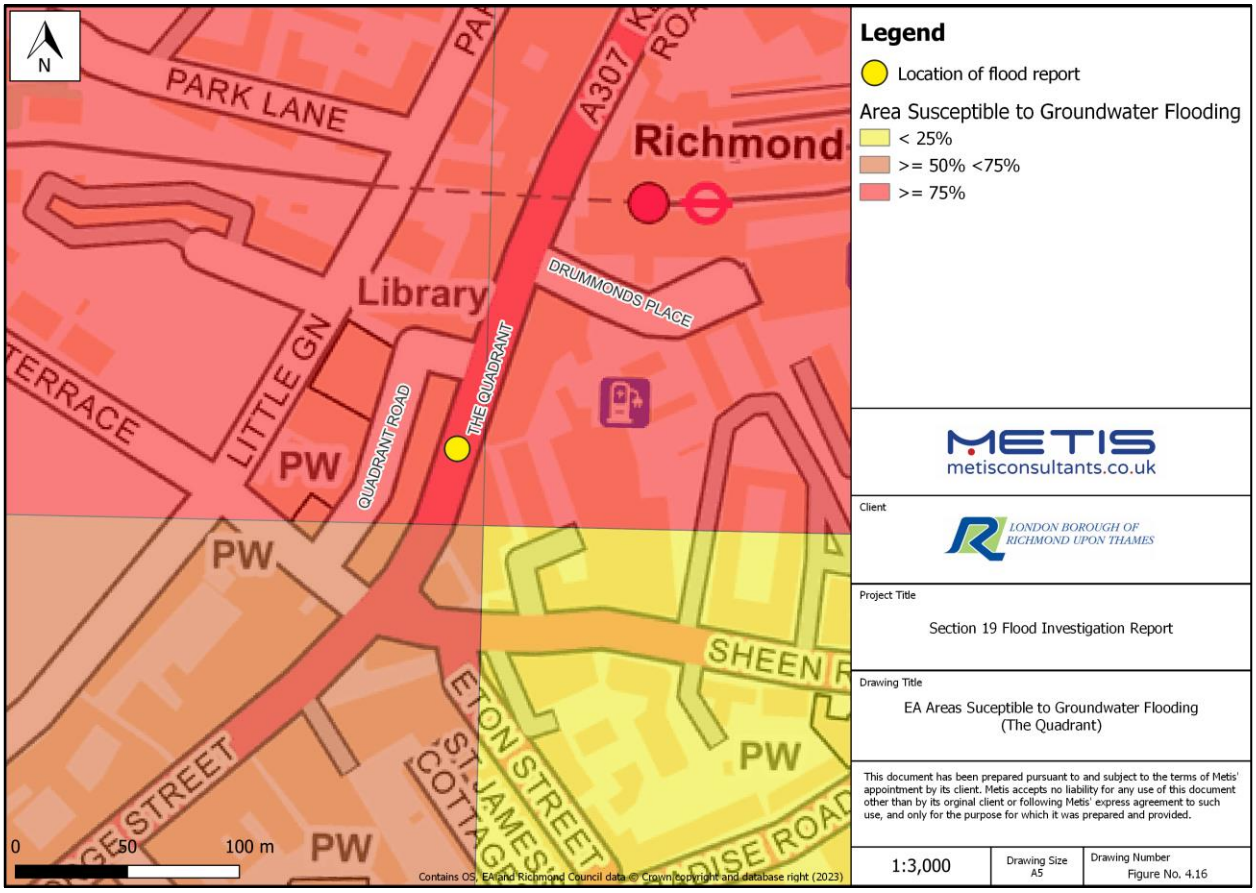

Figure 4-16 Areas susceptible to groundwater flooding (The Quadrant)
***The pink circle is part of the base map and represents Richmond Train Station**

4.5.3.3 Sewer flood risk

The TWUL sewer network implies that there are two converging 450mm diameter surface water sewers at the turning into Quadrant Road. However, the surface water sewer on Quadrant Road is of lesser capacity, only 225mm diameter. Therefore, with larger volumes of surface water being funnelled into a smaller pipe, it would suggest that sewer overflows at this location are likely. It should be noted however that the TWUL sewer network data may have inaccuracies. The CAF indicates that the Southern end of The Quadrant is at risk of foul sewer surcharge from 2030 onwards in line with the latest climate change projections.

4.5.4 Source and Cause

The most likely cause of flooding at The Quadrant is inconclusive, with several potential sources including surface water, groundwater and sewer flooding. As previously stated in *4.5.1*, the return period which The Quadrant experienced on the 12th of July 2021 is uncertain, since *Figure 3-1* shows The Quadrant to reside on the border of an area which experienced between a 1 in 10 and 1 in 30 year return period and an area which experienced a greater than 1 in 30 year return period. As investigated throughout *4.5.3*, The Quadrant is predicted to be at high risk of surface water flooding, and it is likely that surface water conveyance from the North and South of The Quadrant accumulated in the low point on the highway outside the parade of shops where the flooded property is located. The flooding report received by Richmond for the 12th of July 2021 event did not provide detail regarding the source of flooding but did state that there was flooding "through the back" of the property. It was not explicitly stated whether the property was also flooded from the front entrance on The Quadrant.

Previously reported flooding at the property from the 12th of August 2020 describes a surcharging manhole, and potentially groundwater entering through the walls of the basement. The TWUL sewer network in *Figure 4-14,* maps two larger 450mm diameter surface water sewers which converge at the turning into Quadrant Road, to form a smaller sewer of lesser capacity, only 225mm diameter. Based on this mapping, it is likely that a surface water manhole could have surcharged at this location, or another location along the Southern stretch of the 450mm surface water sewer. Where large volumes of surface water are funnelled into a smaller sewer, a significant backup of surface water would be generated during a 1 in 30 year rainfall event. However, it is likely that the TWUL sewer network is recorded incorrectly as previously suggested in *4.5.1*. Furthermore, this would not explain flooding to the back of the property from Quadrant Road, which is at a higher elevation. It is therefore extremely unlikely that any sewer surcharge from The Quadrant would cause flooding to Quadrant Road.

An alternative suggestion could be that the 225mm surface water sewer behind the property on Quadrant Road surcharged which caused flooding to the back of the property. It is possible that the reported surcharging manhole from the 2020 event may have been located on Quadrant Road behind the property, although this is not evidenced within the flooding report in August 2020. If this was the case, the flooding in July 2021 could have resulted from a blockage which had not been fully cleared since the August 2020 event. Alternatively, it may be indicative of a sewer capacity issue on Quadrant Road which has not yet been addressed.

The Quadrant is also predicted to be at a high risk of flooding from groundwater. The resident report from the 12th August 2020 event described water coming through the walls in the basement floor, and thus groundwater could be a source of flooding from the 12th of July 2021 event. However, this is inconclusive without receipt of further details from the resident describing the 12th of July 2021 flooding event. The Quadrant is also located within the Richmond Hill Throughflow Catchment which may have implications to groundwater flooding in The Quadrant. However further investigation would be required to quantify the risk of groundwater throughflow impacting properties on The Quadrant.

4.6 External / Highways flooding reports

Whilst Richmond's S19 criteria defined in *1.1* does not account for external / highways flooding unless it impacts on an identified item of critical infrastructure, there were four reports external / highways flooding as shown in *Figure 4-17*. There were individual reports at Chester Close, Strawberry Vale, and two reports at Lincoln Avenue. These locations are not individually investigated in detail within this report, however it is important to record that they flooded as a result of the 12th of July rainfall event. There was also anecdotal evidence of flooding on Barnes Green and to properties along the River Thames, although no official resident reports were received for these locations, hence their exclusion from this report. It is believed that flooding to the Barnes Green area occurred because of tide locking of the River Thames, and that the green acted as floodplain and flooded as intended. There were also mentions of highway flooding to Second Cross Road and Rosslyn Avenue within the reports Richmond had received for Chestnut Road and Eleanor Grove respectively. These roads may have been affected by the same sources discussed in this report, although further investigation will be required.

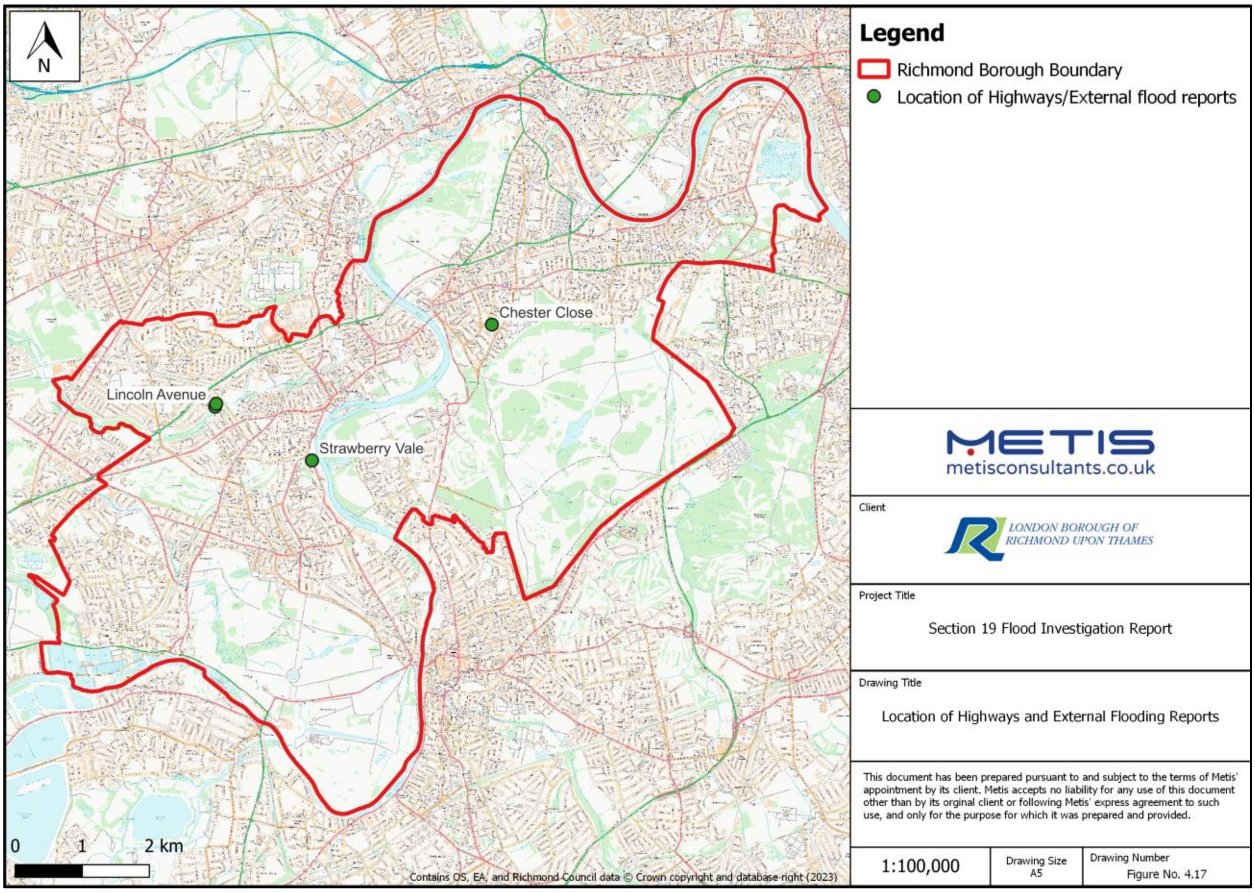

Figure 4-17 Location of Highways / External flooding reports

4.7 Actions taken by relevant RMAs (and other stakeholders affected)

The actions taken by relevant RMAs at all investigated locations before, during, and after the flood event of the 12th of July are summarised below in the table:

Table 4-3 Risk Management Authority actions

Authority	Authority Contributing Action to Flooding Incident
Richmond	***Before*** No information received.

Authority	Authority Contributing Action to Flooding Incident
	<u>During</u> No information received. ***<u>After</u>*** The LLFA reached out to residents who reported incidents to gather additional information. In addition to the regular cleansing regime, the Highways contractor visited gullies on Lincoln Avenue on the 13th, 15th and 28th of July 2021 to inspect and clear them. Lower Mortlake Road was visited on the 30th of July 2021. Approximately 12 gully sensors have been implemented across Richmond in areas where there have been historical or known surface water flooding issues. Highways staff will receive alerts for the gully levels and are able to access live data. There is potential for gully sensor information to be combined with forecasts or rainfall records to identify locations with sewer capacity issues. Richmond are setting up an internal flood group with the Richmond and the London Borough of Wandsworth (Wandsworth) officers. Richmond and Wandsworth's Local Flood Risk Management Strategy (LFRMS) and Surface Water Management Plan (SWMP) have been updated. Emergency Planning team are refreshing the flooding information on the website to make it clearer for residents what they should do before, during and after a flood. Flooding caused by intense heavy rain will be included as one of the scenarios in a Borough Resilience Forum (BRF) tabletop exercise with partners in June 2023, as part of hot weather preparations.
TWUL	***<u>Before</u>*** TWUL convened an 'adverse' weather meeting with Richmond's operational teams in response to the 'Yellow' Weather Warning issues by the Met Office. This meeting was to assess risk to services, customers, and the environment. ***<u>During</u>*** TWUL received more than double the number of daily expected telephone calls and contacts via social media, leading the Customer Contact Centre to be overwhelmed. Telephone lines were updated at 17:00 to include a message explaining that they were very busy. This was updated at 20:00 to explain that the delays were due to flooding in London. London Resilience Group convened a 'major incident call' and TWUL provided a list of vulnerable customers. There were no specific actions taken by TWUL in Richmond during the event on the 12th of July 2021 ***<u>After</u>***

Authority	Authority Contributing Action to Flooding Incident
	TWUL had 98-106 teams supporting customers across London. This was supplemented by 16 specialist crew from around the UK. TWUL operations team are not aware of any maintenance and or other flooding reports pre or post the 12th of July 2021 There were no specific actions taken by TWUL in Richmond after the event on the 12th of July 2021

5 Conclusions and Recommendations

5.1 Conclusions

This Section 19 investigation for Richmond was undertaken following the extreme rainfall event experienced on 12th of July 2021 which triggered the investigation criteria at five locations. There was a total of ten reports of flooding received by Richmond, six of which were internal flooding and four were external / highway flooding. The five locations investigated within this report were Chestnut Road, Eleanor Grove, Halcyon Close, Lower Mortlake Road, and The Quadrant. The external / highway flooding reports were outlined in *4.6*, although they were not investigated to the same level of detail as internal flooded locations as they did not meet Richmond's Section 19 criteria.

The investigation identified that the most frequent types of flooding during the 12th of July 2021 event were sewer flooding and surface water flooding. The significant volume of rainfall upon hard surfaces led to widespread surface water flooding across Richmond. The TWUL sewer network became overwhelmed at many locations leading to sewer surcharge, while there may have been blockages to sewers which accelerated this process in some locations. Topographical factors exacerbated the flooding experienced at the investigated locations, which were largely located at topographical low points. Based on the conclusions of the source and cause of the flooding experienced, the following recommendations have been drawn up.

5.2 Recommendations

This section details some recommended actions to be taken to reduce the risk of flooding at the investigated locations which experienced flooding during the 12th of July 2021 event:

5.2.1 Chestnut Road

- Richmond to liaise with TWUL to investigate a potential blockage or capacity issue to the surface water sewer on Chestnut Road.
- Richmond should check the gullies on Chestnut Road and review the gully maintenance schedule.

5.2.2 Eleanor Grove

- Richmond to liaise with TWUL to investigate the combined and foul sewers on Eleanor Grove for blockages.
- Richmond should collaborate with TWUL to inform residents of Bin it - Don't Block it - perhaps through leaflet distribution on Eleanor Grove. This should reduce the frequency of blockages to the foul / combined sewer systems.
- Eleanor Grove has a high risk of foul / combined sewer surcharge, as indicated by their CAF. This area should be investigated further by TWUL, including detailed modelling and monitoring, to understand the risks better and identify what action is needed.

5.2.3 Halcyon Close

- Richmond to liaise with TWUL to investigate a potential blockage or capacity issue to the surface water sewer on Queen's Ride.

- Richmond should investigate how to redirect surface water on Queen's Ride away from the dropped kerb access into Halcyon Close. Richmond should also investigate potential sustainable drainage systems (SuDS) opportunities on the Western edge of the road.
- Richmond should educate the residents of Halcyon Close about the appropriate maintenance of privately owned SuDS to ensure that they will be operational during flooding events.

5.2.4 Lower Mortlake

- Richmond should check the gullies on Lower Mortlake Road and review the gully maintenance schedule.

5.2.5 The Quadrant

- Richmond in collaboration with TWUL should investigate some highways SuDS opportunities to reduce the risk of sewer surcharge at The Quadrant.
- TWUL to update its information on the surface water drainage network at The Quadrant and share this with Richmond. This will support with the appropriate identification of a solution to reduce flood risk at the quadrant.

5.2.6 Richmond general recommendations

- Richmond should encourage the reporting of flooding incidents through the use of the flood reporting tool, such as at Barnes Green where there were a large number of affected locations without reports received.
- Richmond should investigate the locations affected by external / highway flooding and collaborate with TWUL where necessary to reduce the risk of recurrence where possible. Further to this Richmond should explore potential SuDS opportunities across the borough, from which potential schemes could be developed to resolve flooding issues.

5.2.7 TWUL general recommendations

- TWUL to review and act upon the recommendations provided within the independent London Flood Review which assessed the London floods in the summer of 2021. These recommendations can be found here.
- TWUL to publish the first Drainage and Wastewater Management Plans (DWMPs), which look at the current state of drainage and wastewater management. These Plans factor in growth urban creep and climate change. TWUL should look to implement long-term actions needed for the DWMP areas in Richmond. Further information can be found here.
- TWUL to consider the recommendations of the London Flood Review and continue to prioritise inspection and sewer cleaning based on the behaviour and impact of the operation of the sewer network at all sites. TWUL will prioritise sites where the sewer is causing any issues for customers to ensure the best service possible.