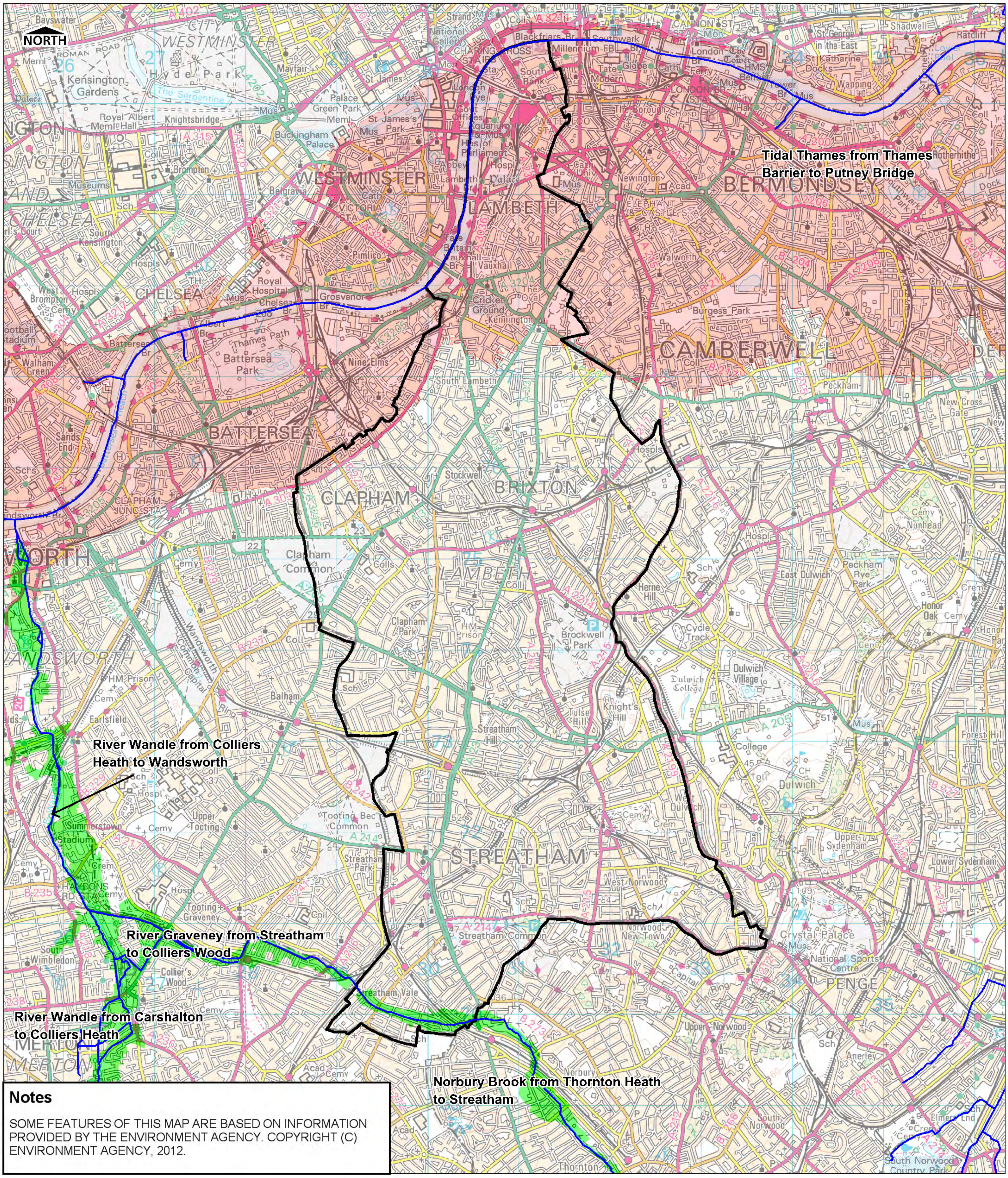

Notes

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Legend

- Main Rivers
- Lambeth Boundary
- Tidal Flood Warning Area
- Fluvial Flood Warning Area

Lambeth

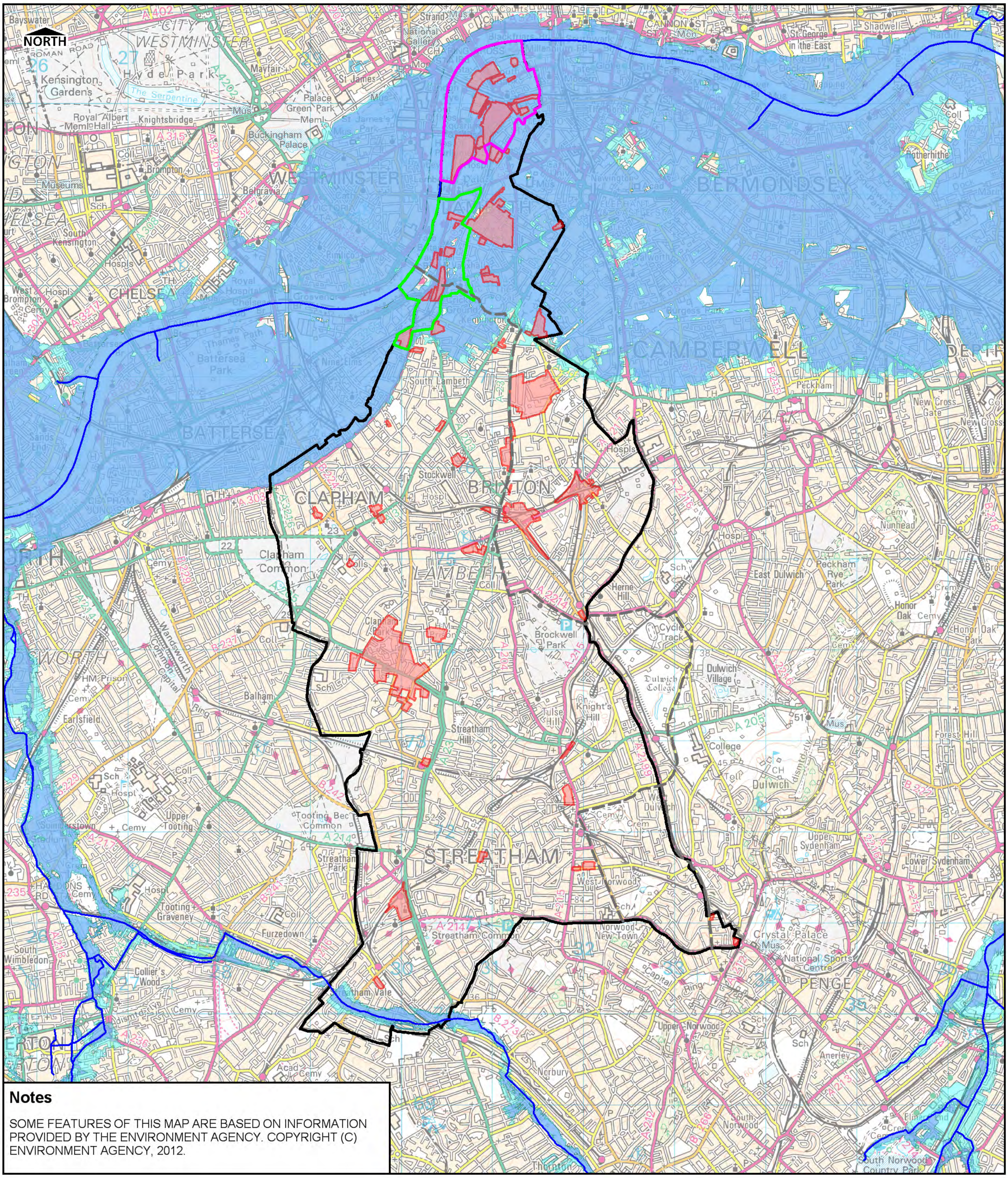
Lambeth SFRA

Environment Agency Flood Warning Areas

URS
The Crescent Centre
Temple Back
Bristol
BS1 6EZ
www.ursglobal.com

Scale at A3	Date	Drawn by	Approved by
1:40,000	Oct 2012	RM	TE

FIGURE 10



Notes

SOME FEATURES OF THIS MAP ARE BASED ON INFORMATION PROVIDED BY THE ENVIRONMENT AGENCY. COPYRIGHT (C) ENVIRONMENT AGENCY, 2012.

Legend

- Main River
- Effra Sewer
- Lambeth Boundary
- Potential Development Sites
- Waterloo Opportunity Area
- Vauxhall Opportunity Area
- Flood Zone 2
- Flood Zone 3a

Lambeth

Lambeth SFRA

Major Development Locations

URS

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Bristol
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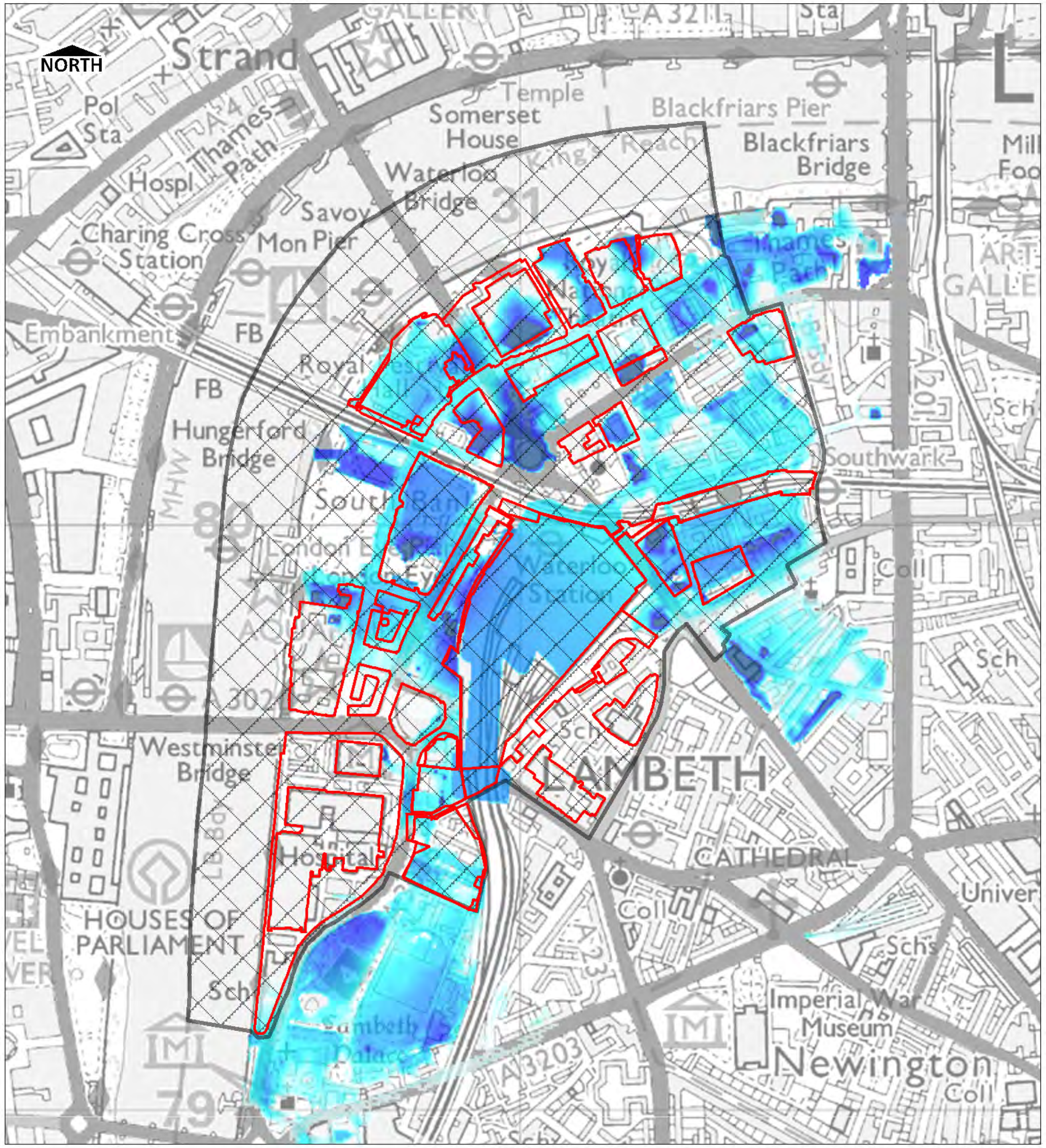
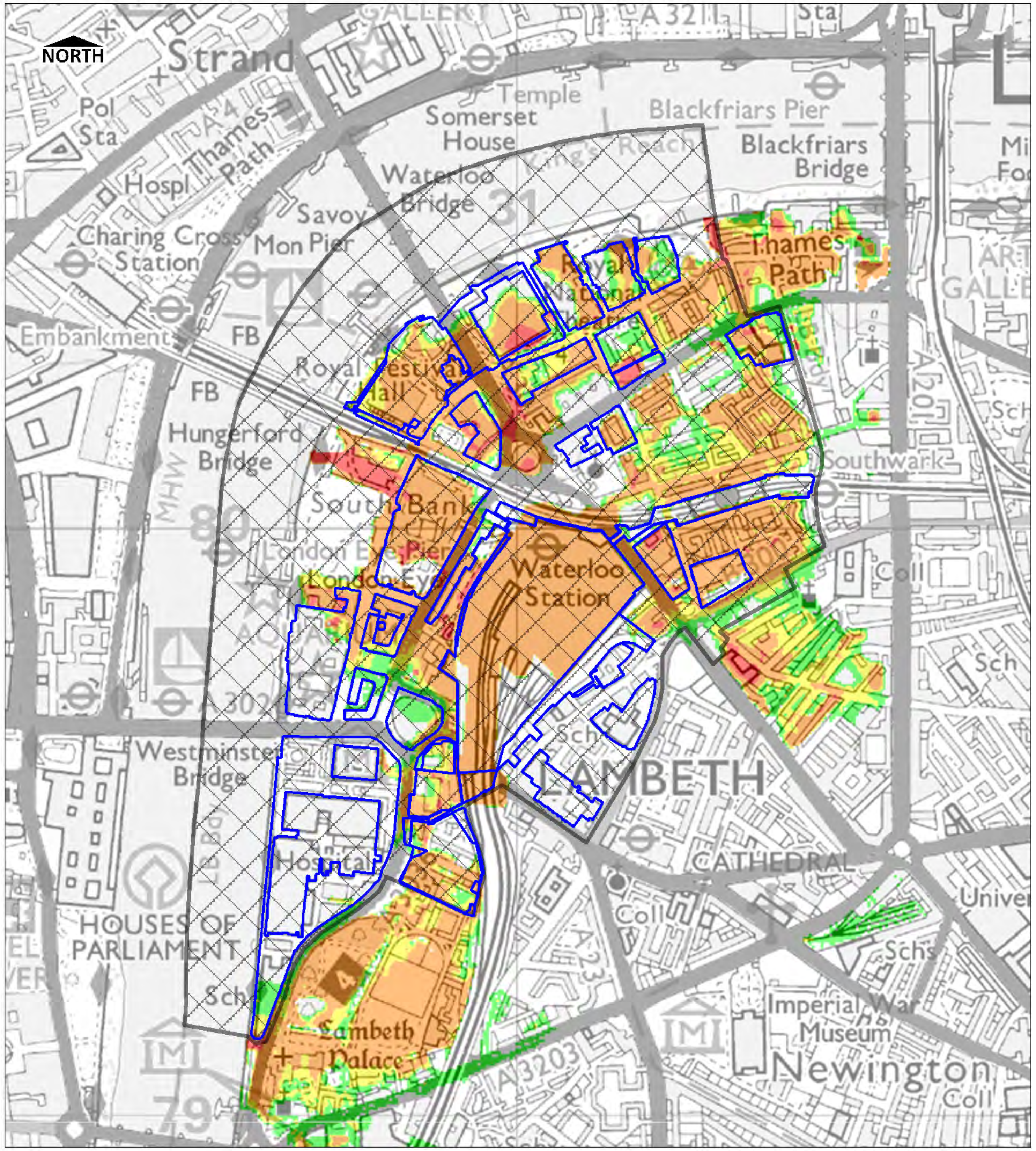
Scale at A3	Date	Drawn by	Approved by
1:40,000	Oct 2012	RM	TE

FIGURE 11





Depth Legend

- Waterloo Opportunity Area
- Potential Development Area

Maximum Flood Depth (m)

0.00 0.50 1.00 1.50 2.00

Hazard Legend

- Waterloo Opportunity Area
- Potential Development Area

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

Client: Lambeth

Scale at A3:	Date:	Drawn by:	Approved By:
1: 900	Oct 2012	RM	TE

Project: Lambeth SFRA

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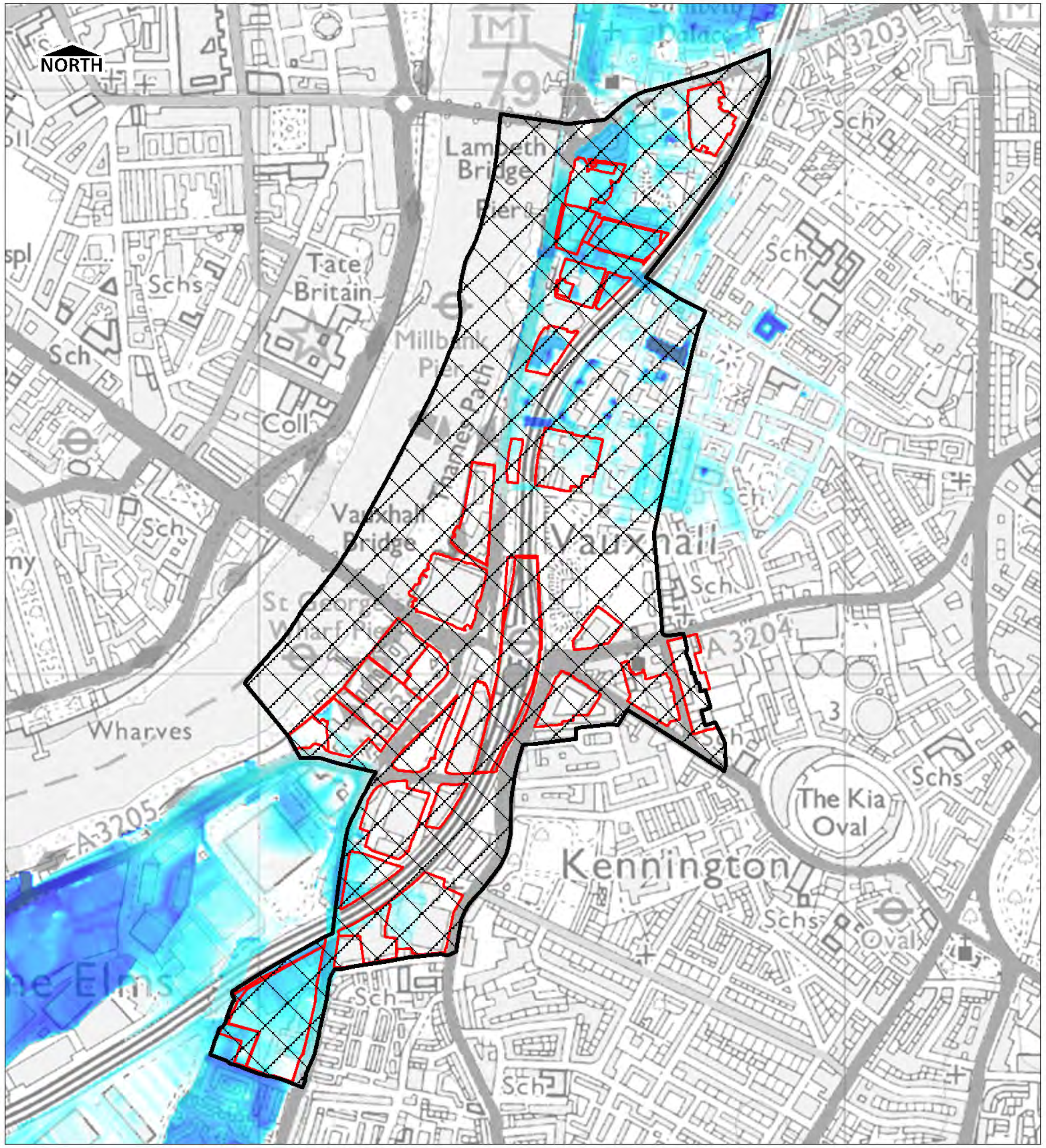
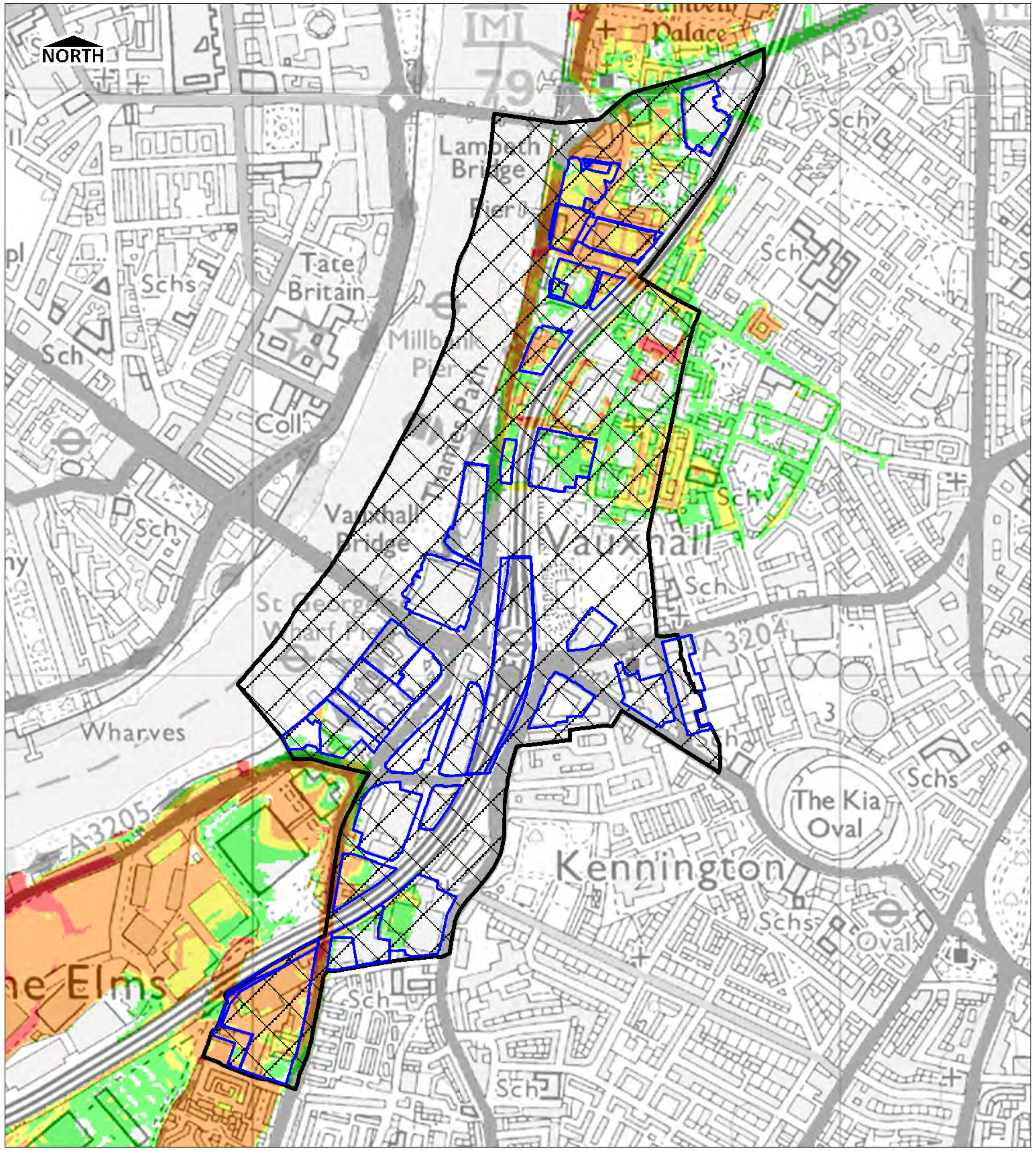
Temple Back
Bristol
BS1 6EZ
www.ursglobal.com

Figure 12: Waterloo Opportunity Area - Environment Agency Breach Analysis 1 in 200 Year Maximum Flood Depth and Flood Hazard





Depth Legend

- Vauxhall Opportunity Area
- Potential Development Area

Maximum Flood Depth (m)

0.00 | 0.50 | 1.00 | 1.50 | 2.00

Hazard Legend

- Vauxhall Opportunity Area
- Potential Development Area

Maximum Flood Hazard

- Low
- Moderate
- Significant
- Extreme

Client:

Lambeth

Project:
Lambeth SFRA

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Scale at A3:	Date:	Drawn by:	Approved By:
1: 900	Oct 2012	RM	TE

Figure 13: Vauxhall Opportunity Area - Environment Agency Breach Analysis 1 in 200 Year Maximum Flood Depth and Flood Hazard

APPENDIX B – DATA REGISTER

LONDON BOROUGH OF LAMBETH REQUESTS		
Data Set	**Data Provided**	**Confidence**
Site boundaries	August 2012	Very Good
Development Opportunity Areas	August 2012	Very Good
Historic flooding records	July 2010	Fair
Mapping Tiles	October 2012	Very Good
SWMP outputs	2011	Good
ENVIRONMENT AGENCY REQUESTS		
Data Set	**Data Provided**	**Confidence**
Flood Maps	October 2012	Good
Flood Warning Areas	2007	Good
NFCDD defence layers	August 2012	Good
LiDAR Data	July 2010	Good
River Wandle outputs	August 2012	Good
River Thames Flood Levels	July 2010	Good
Main Rivers	August 2012	Good
Historic flood map	July 2010	Good
Groundwater flooding	July 2010	Fair
AStGWF	October 2012	Fair
Breach modelling outputs	August 2012	Good
THAMES WATER REQUESTS		
Data Set	**Data Provided**	**Comments**
DG5 flooding incidents	October 2012	Good
Sewer Plans	October 2012	Good

APPENDIX C – RIVERSIDE ANALYSIS

The Riverside Analysis was completed for the original SFRA in 2008 and has not been updated for the current 2013 revision. However the original assessment below still provides an indication of residual risk, as it is unlikely that any significant changes in ground level have occurred since 2008.

Introduction

Four breach scenarios were previously modelled at what were deemed to be the four most high risk locations along the River Thames in the London Borough of Lambeth, as agreed with the Environment Agency. However, it was agreed that this study did not adequately assess the risk of flooding as a result of breaches in other areas along the river.

Therefore, an assessment of the topographical levels along the river (and the areas immediately inland) was conducted in order to categorise each area of riverfront in terms of potential flooding from breaches in the flood defences. This information can be used in conjunction with the breach modelling information to determine the appropriate level of assessment required for locations along the River Thames in the London Borough of Lambeth.

Overview

Many areas of the borough can be eliminated immediately from concern because they are located well above the 1 in 1000 year tidal level. The outline of this area is shown in Figure C1. Areas at risk from inundation are generally known as the 'flood cell'.

The Digital Terrain Map (DTM) for the borough, with a cell size of 0.5 metres by 0.5 metres, was derived during the previous breach modelling and is shown in Figure C2. This figure gives a very clear overview of the areas and categories of risk from a purely topographical point of view.

There are two notable low areas within the flood cell (the area at risk of inundation):

- Land to the east of Waterloo Station, extending to the edge of the borough to the east and towards the Imperial War Museum to the south; &
- Land to the east of the train lines between Vauxhall Bridge and Lambeth Bridge, to the north of Kennington Lane.

In order for breaches in the riverfront defences to cause widespread flooding, there needs to be pathways for the floodwaters. That is, low lying areas of land that provide the floodwaters with the storage volumes and potential to travel further and cause more damage and inundation. A breach at some locations may only cause a minimum amount of inundation if the areas of land adjacent to the river are relatively high (or none at all if the land is higher than the tide itself).

The aim of the this study, therefore, was to assess the levels along (and adjacent to) the riverfront, as well as the potential pathways and storage areas associated with each possible breach location, in order to associate an overall risk category to each area along the River Thames within the London Borough of Lambeth.

Topographic Matrix

In order to assess the levels behind the flood defences along the riverfront (where a breach would occur), and the levels directly adjacent to a breach, a simple matrix was constructed along the River Thames.

The outline of the river's edge was initially traced. Then, a series of parallel lines were buffered inwards at distances of 10, 25, 50, 100, 200, 300 and 400 metres. The line started at the western riverside edge of the borough, at the eastern end of Nine Elms Lane in Vauxhall. The line extended downstream to the far edge of the borough, 300 metres upstream of Blackfriars Bridge.

Figure C 1 shows a section of the river's edge between Lambeth Bridge and Westminster Bridge. The thick black line is the river's edge itself and the parallel lines are shown in red.

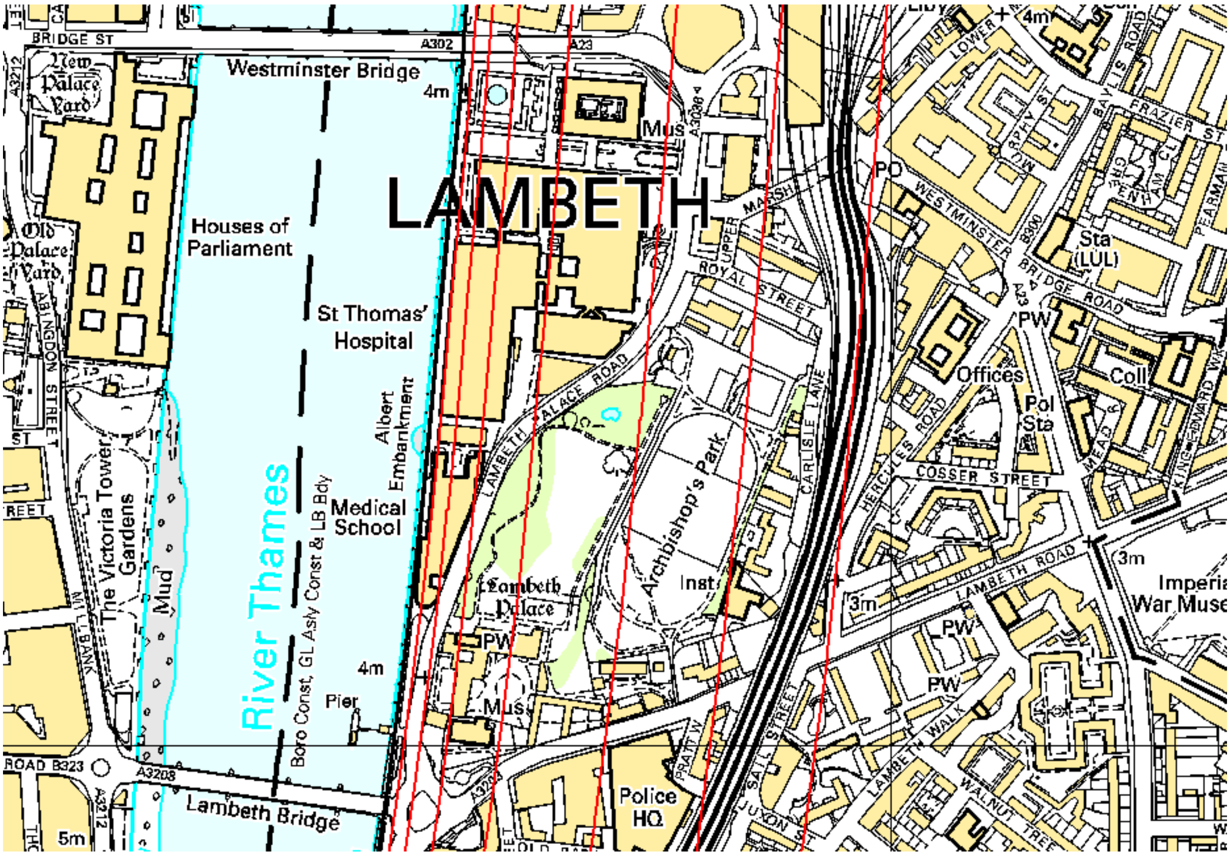


FIGURE C 1: EXAMPLE OF BUFFERED PARALLEL LINES ALONG RIVER'S EDGE

Each of the parallel lines was then divided up into 20 metre segments. Fortunately, as the line's wind to the left and right, the lengths of the lines are approximately of equal length (plus or minus around 5-10 metres). So there are an equal amount of points along the length of each line.

In total, seven sets of 161 points were defined along the 3220 metres of river frontage within the boundaries of the borough. The elevation (in metres above Ordnance Datum) at each of these points was then extracted from the Digital Elevation Model (DTM) data to create a basic matrix or grid for the strip of land running along the River Thames. The data is presented in this Appendix. Note that only the data for the 10, 25, 50 and 100 metre buffers is shown as the data from further inland was not used in the final process.

Data Analysis

The extracted data was initially inspected, point by point, in conjunction with the DTM data (see Figure A2) to correct any obvious errors or inconsistencies. This can occur when land excavations were in progress when the DTM data was recorded or if the DTM data is otherwise poor or incomplete.

Once all of the data was believed to be acceptable and consistent, all data where levels were above the peak 1 in 1000 year tide levels were identified. Note that the peak 1 in 1000 year tide levels vary slightly along the length of the study area (see the breach modelling methodology in Appendix F). For this stretch of the river, the levels for the 1 in 1000 year event range from approximately 5.26 metres AOD near Vauxhall

Bridge in the southwest to approximately 5.22 metres AOD downstream of Waterloo Bridge in the northeast. Although slight, this variation was taken into account.

All points that were higher than these peak levels were deemed to remain dry during a 1 in 1000 year tide event. All sections of the riverfront where the land is 'dry' at least 25-50 metres back from the river's edge were then categorised as Riverside Category 1 (RC-1).

The extent of each of these RC1 areas were also confirmed by a more detailed investigation of the DTM data using a colour palette that only displayed data above the local 1 in 1000 year peak level. An example is shown in Figure C 2, where the blue cells are those that are higher than 5.26 metres AOD.

For all other sections of the riverfront (that is, those that are at risk from flooding) a point by point inspection was done to determine a suitable breach height, should one occur, at that location. This was done using the same method used in breach modelling analyses, whereby a worst case scenario is assumed. The force of the breach is assumed to scour out the land behind the defences to the lowest level behind the breach, within a distance of 25-50 metres inland.

The tables at the back of this Appendix also list the assumed breach levels derived above. Notice that a very conservative approach has been used to assess these levels in terms of the amount of scouring that could potentially occur.

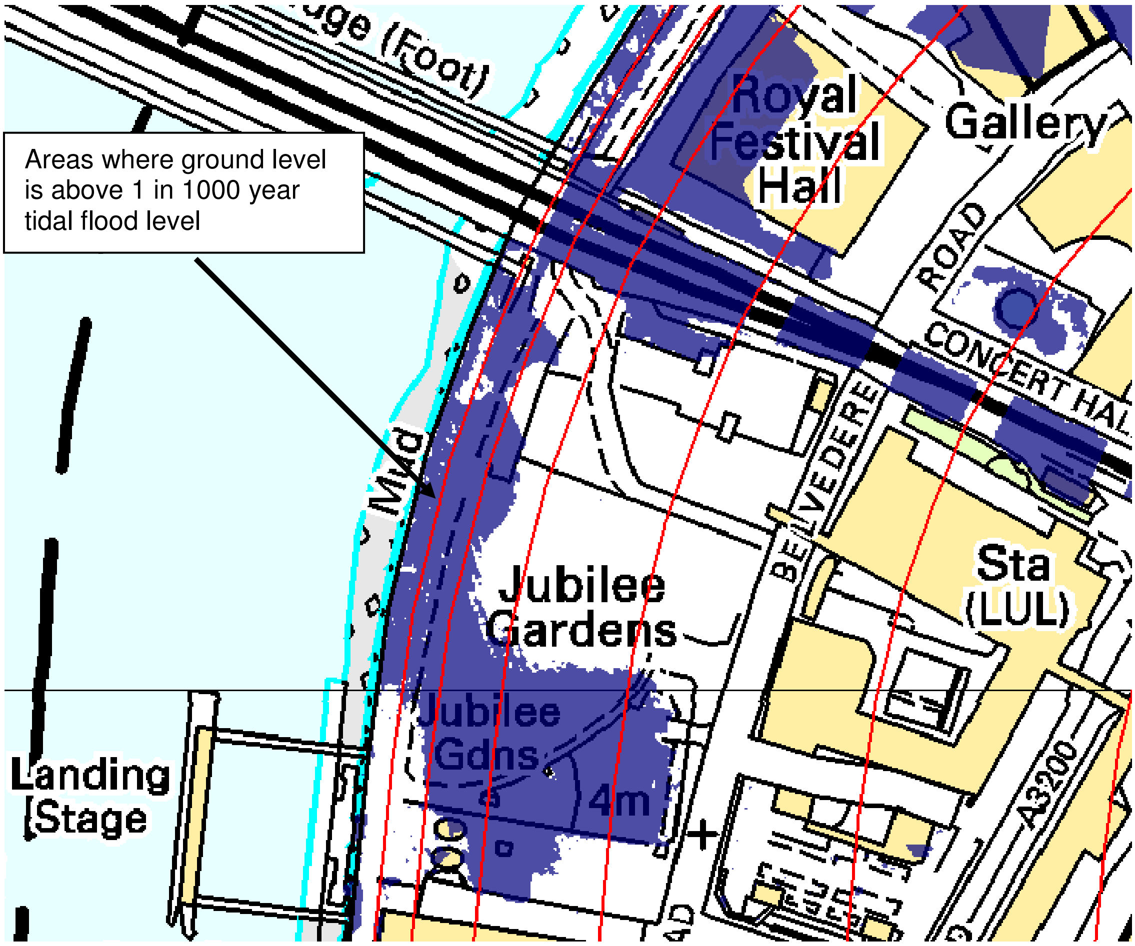


FIGURE H 2: EXAMPLE OF RAISED GROUND ALONG RIVER'S EDGE (HIGHLIGHTED IN BLUE)

Volume Calculations

To gain a general indication of the volumes of water that could travel through breaches of the various levels determined above a relationship was determined using the 1 in 1000 year extreme tidal curve (see Figure C 3), the Broad Crested Weir Equation and an assumed breach width of 20 metres for a range of breach levels.

The Broad Crested Weir Equation used is listed below:

$$\text{Flow } [m^3/s] = 1.55 \times \text{breach width } [20m] \times \text{depth } [m]^{1.5}$$

The depth in this equation is calculated by subtracting the breach level from the tide level at each time interval in the tide curve shown in Figure H 3. The volumes for each time interval while the tide curve is over the breach level are summed to give a total breach volume.

Such volumetric calculations were indicative only and do not match what would happen in a real life breach scenario, nor do they match what was observed during the previous breach modelling exercises for this area. This is because in real life there are obstructions and deviations and frictions that would significantly reduce the volumes that would flow through the 'weir' created by a breach scenario.

However, it once again provides an absolute worst case scenario 'ceiling' for breaches in the flood defences and can be used as a guide in determining the maximum volumes to expect from such breaches.

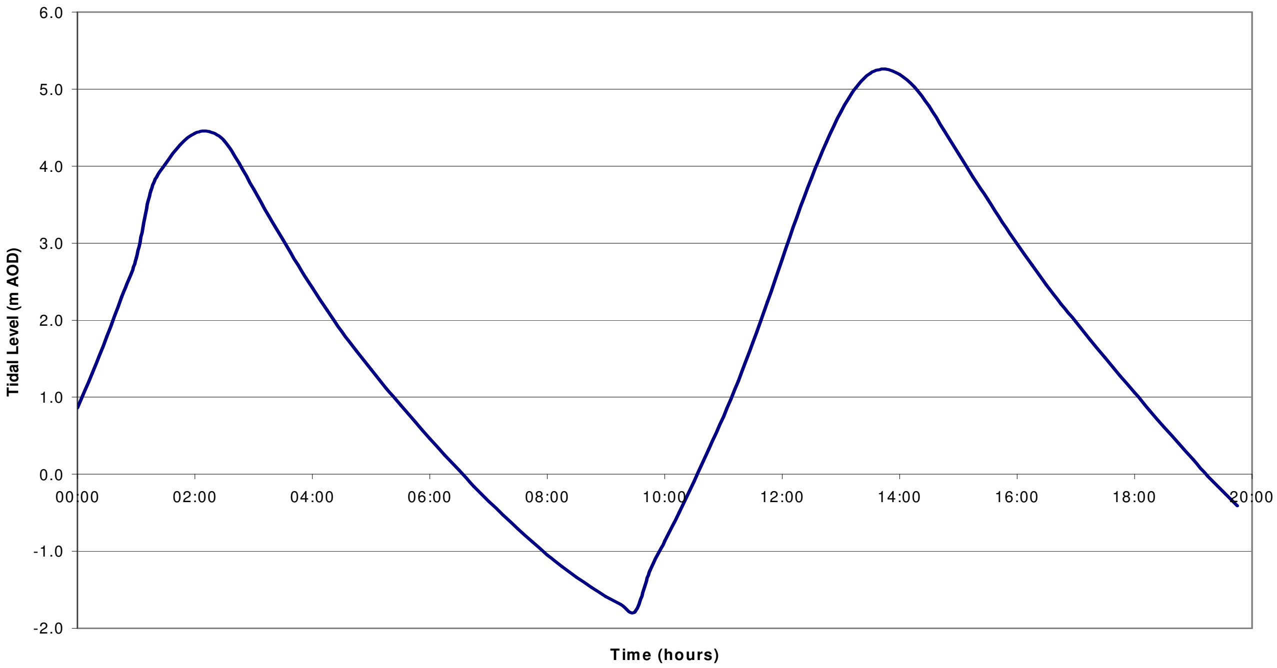


FIGURE C 3: 1 IN 1000 YEAR EXTREME TIDAL CURVE

Figure C 4 shows the relationship derived for breach level against total *maximum* volume that could pass through a breach of that level.

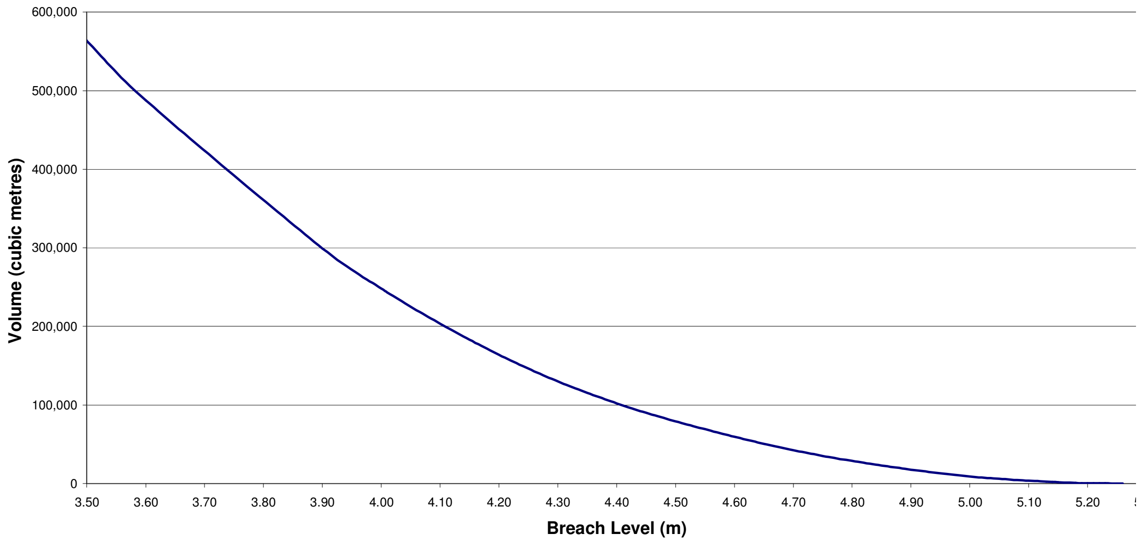


FIGURE C 4: MAXIMUM BREACH VOLUME FOR EACH ASSUMED BREACH LEVEL

Detailed Analysis

Once the assumed breach levels had been assigned for each 20 metre 'slice' of the river frontage, the sections could be further defined by risk categories.

These risk categories were defined principally according to their assumed breach level, according to the relationship in Table C 1 below. However, once again, a visual inspection of the DTM was also involved on a point by point basis. This required that possible flow paths and general topographical characteristics of the land behind the defences were also taken into account.

TABLE C 1: DEFINITION OF RISK CATEGORIES

Riverside Category	Assumed Breach Level [m AOD]	Potential Peak Depth of Flow through breach (1 in 1000 year event) [m]
RC-1	> 5.25	0
RC-2	4.8 – 5.25	0.5 – 0
RC-3	4.3 – 4.8	1.0 – 0.5
RC-4	< 4.3	>1.0

NOTE: Although 5.3 metres AOD has been used to define the 'No Risk' cutoff above, the actual local 1 in 1000 year levels (5.22 to 5.26 metres AOD) were used when greater detail was required

The river was then divided into eight distinct sections. These were generally defined by similar characteristics in the levels behind their defences and similar probable flood flow paths or significant infrastructure or other defining features.

The locations of these sections are shown in Figure H3.

The DTM topography data and the final assessed risk category for each of the eight separate river sections is shown in Figures H3 to H19 in this Appendix. Comparing the two figures for each section demonstrates the derivation of the categories. However, as previously mentioned, at times 'corrections' were made based on errors or inconsistencies in the DTM or by further investigation into the characteristics of the area via site photos, local knowledge or online aerial photos.

Conclusion

An assessment of the risks associated with breaching of the flood defences was made for each point along the Thames River frontage within the London Borough of Lambeth.

Each part of the river frontage was defined a riverside category according to the assumed level of any potential breach and the characteristics of the land behind the breach. The categories are not in any way based upon the probability of defence failure.

This information should be used, with case by case judgement, in conjunction with the previously completed detailed breach modelling study, in order to assess the risk to individual properties.

Riverside Figures List

Project:

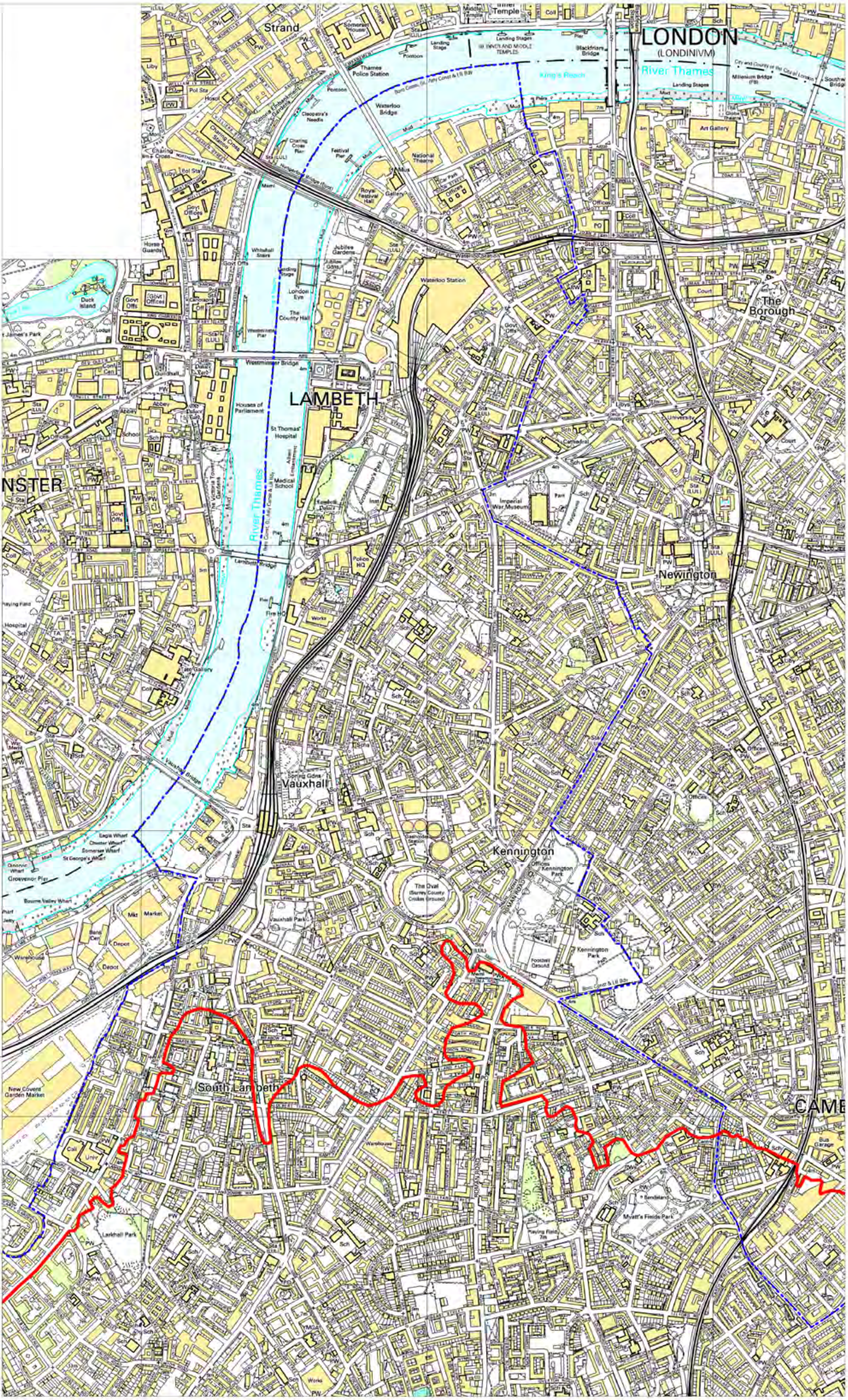
Lambeth SFRA

Title:

Maximum Possible Inundation Area

1 in 1000 Year Event

Outline of Maximum Possible Inundation



Drw:	NM
Date:	13/08/08

Scale: 1:12500 @ A3

FIGURE H1

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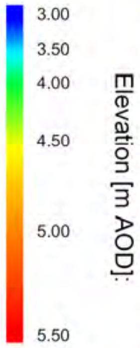
Project:

Lambeth SFRA

Title:

Digital Terrain Model



Drw:	NM
Date:	13/08/08

Scale: 1:12500 @ A3

FIGURE H2

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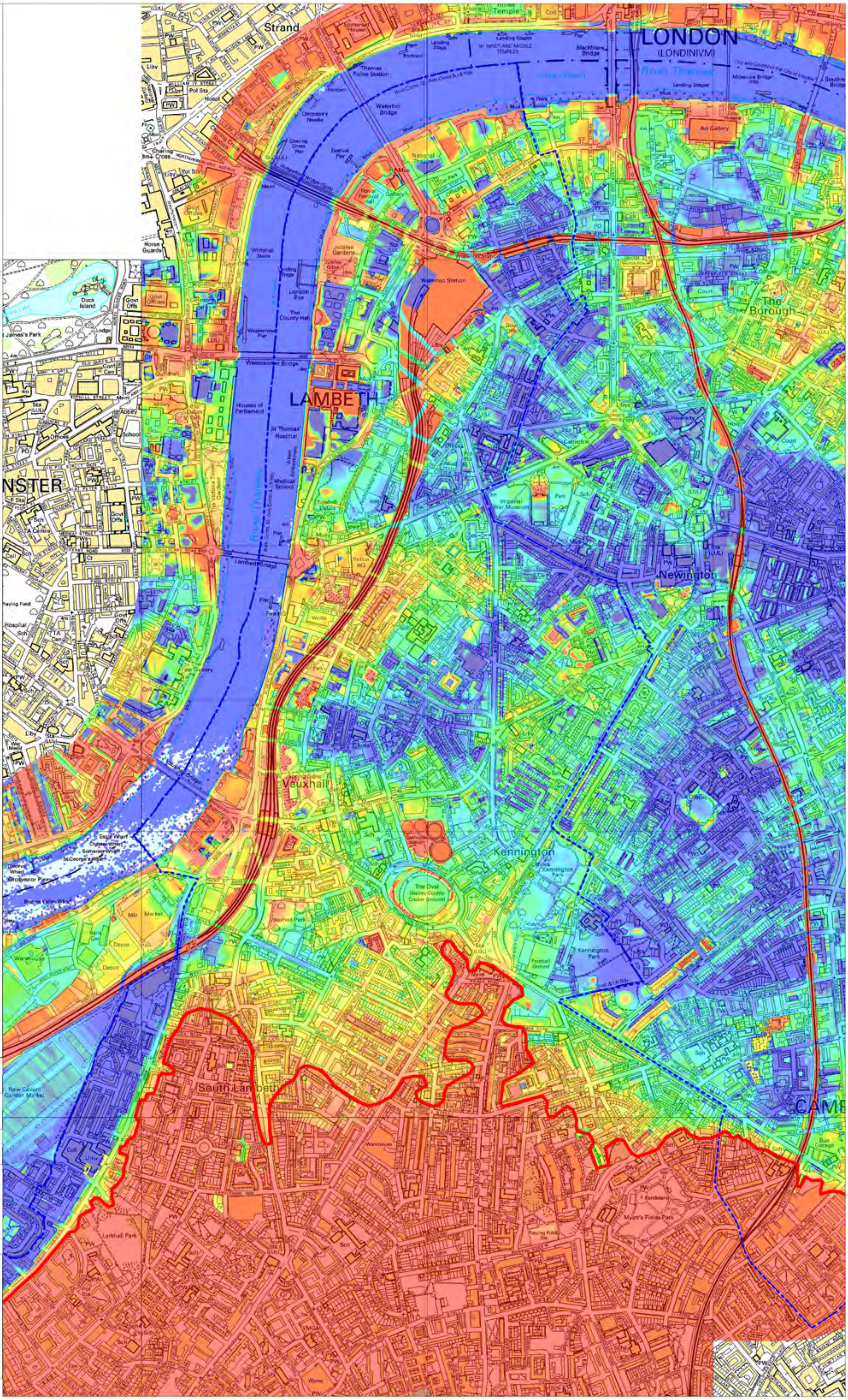

Project:

Lambeth SFRA

Title:

River Reaches Studied In Assessment

Drw:	NM
Date:	13/08/08

Scale: 1:7500 @ A3

FIGURE H3

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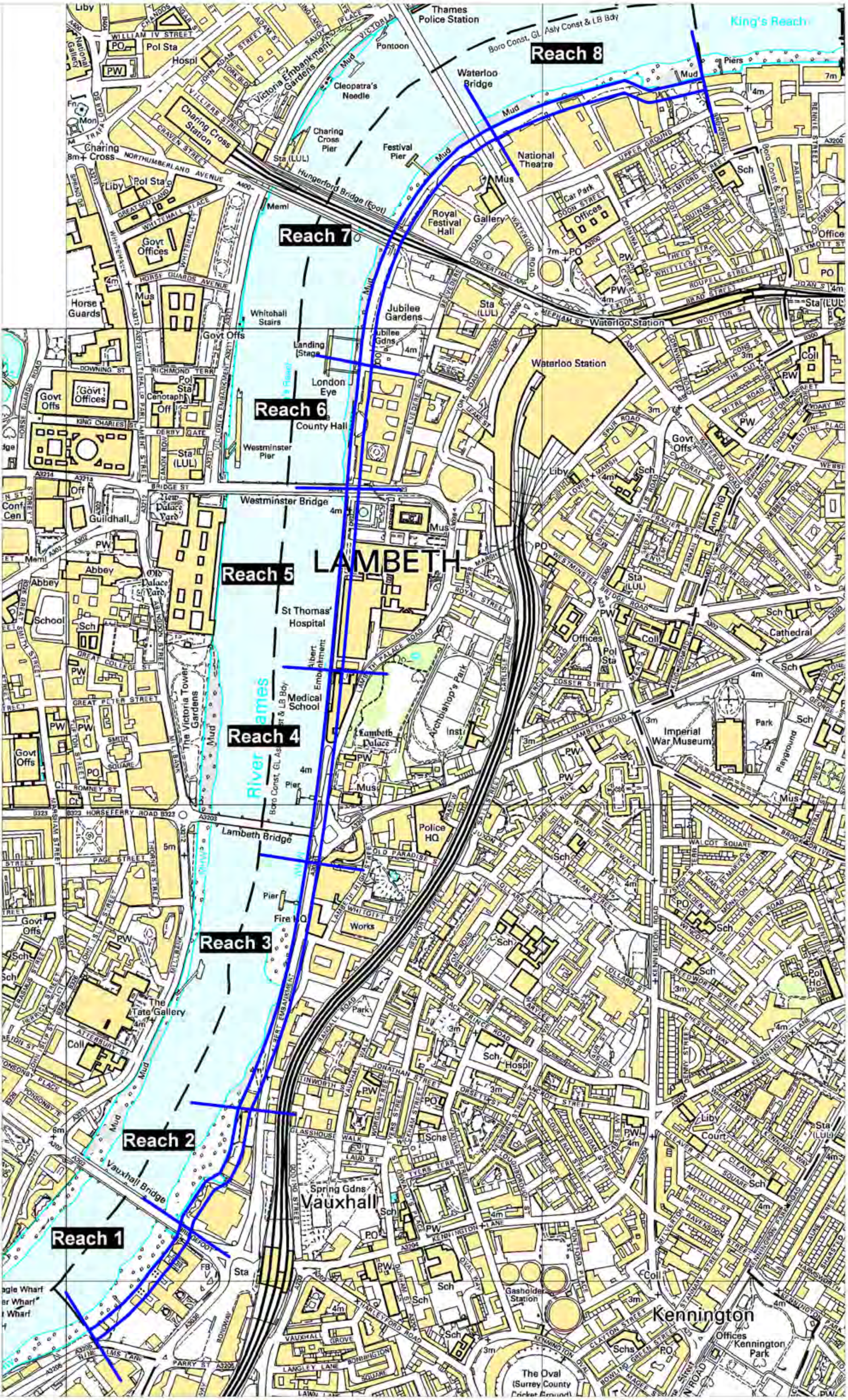

Project:
Lambeth SFRA

Title:
River Reach 1
Digital Terrain Model

Elevation [m AOD]:
3.00 3.50 4.00 4.50 5.00 5.50

FIGURE H4

Scale: 1:1500 @ A3

Drw NM | Date 13/08/08 | Rev 2

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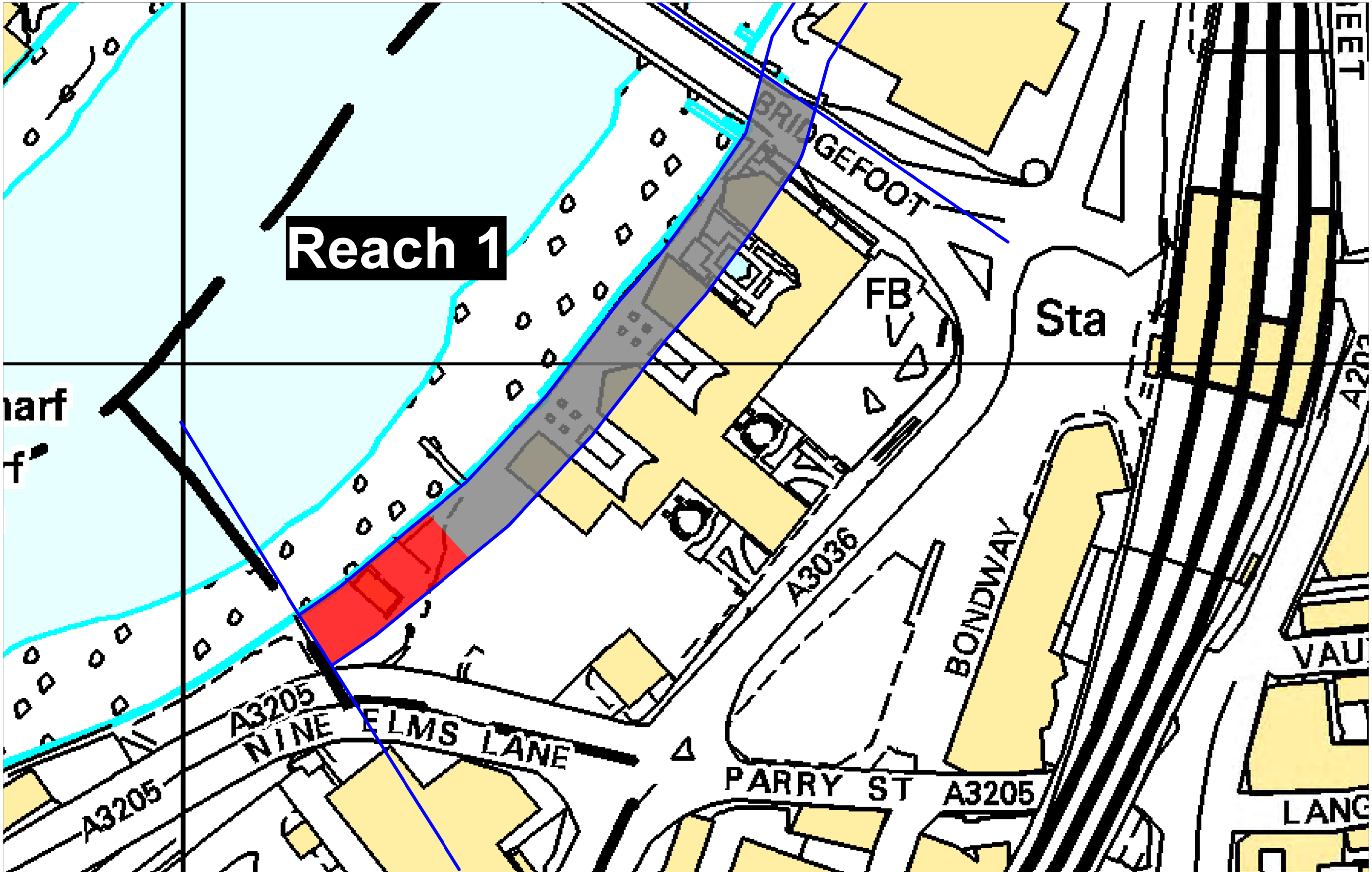

Project:
Lambeth SFRA

Title:
River Reach 1
Riverside Category

Category 4	Category 3
Category 2	Category 1 (High Ground)

FIGURE H5

Scale: 1:1500 @ A3

Drw NM | Date 13/08/08 | Rev 2

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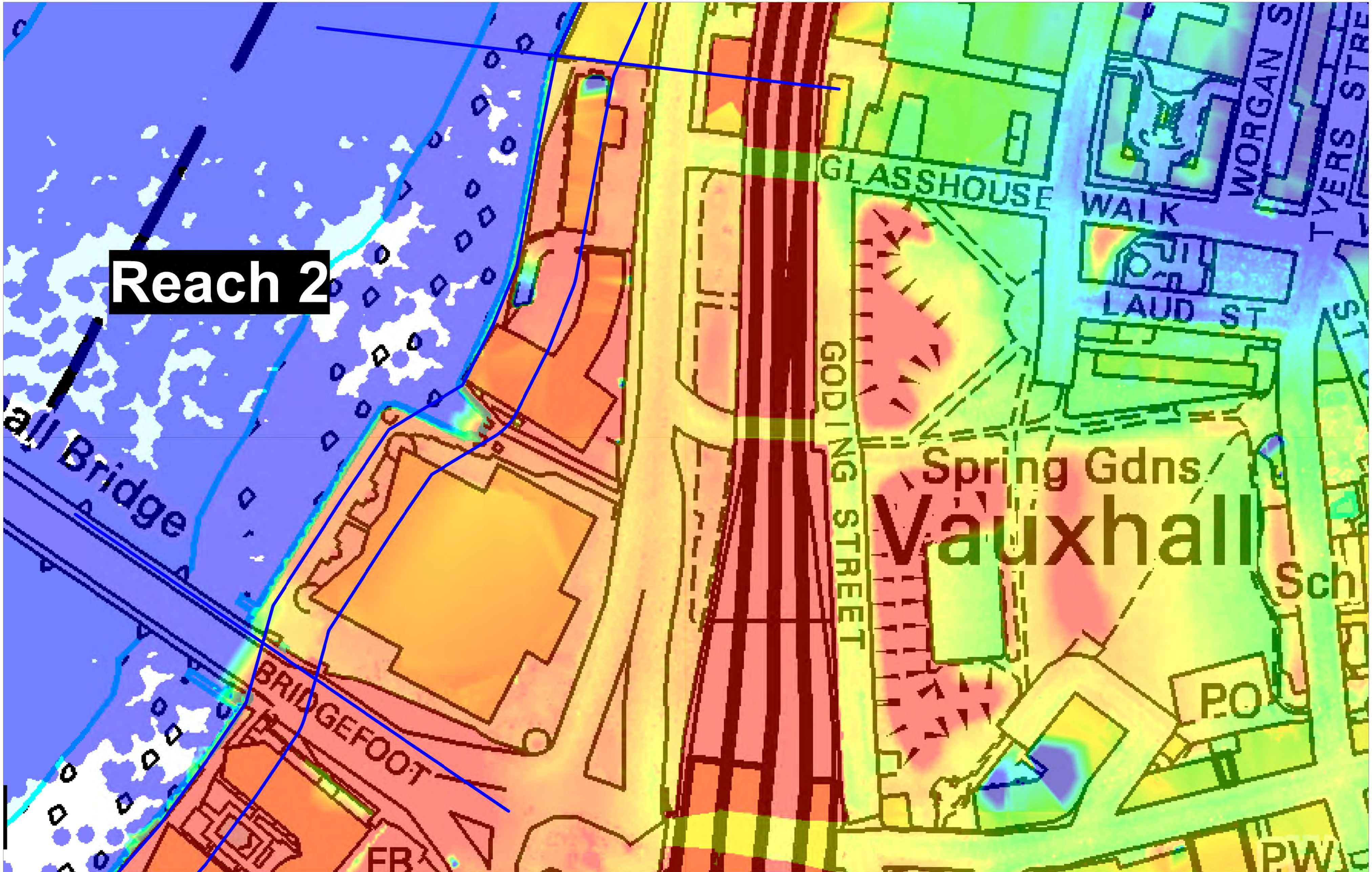

Project:	Title:	Elevation [m AOD]:	FIGURE H6
Lambeth SFRA	**River Reach 2** **Digital Terrain Model**	3.00 3.50 4.00 4.50 5.00 5.50	Scale: 1:1500 @ A3 Drw NM Date 13/08/08 Rev 2

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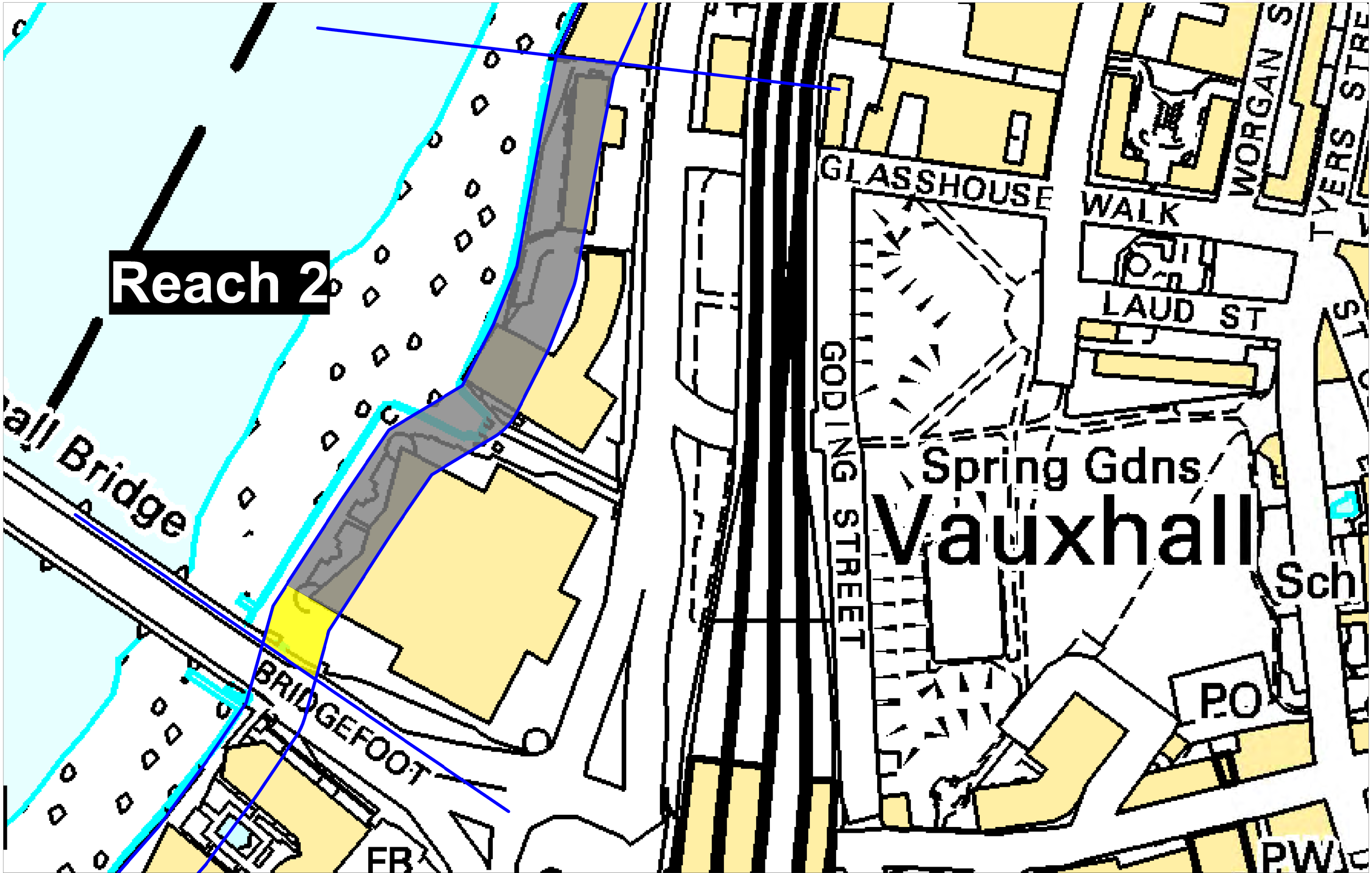

Project:
Lambeth SFRA

Title:
River Reach 2
Riverside Category

Category 4	Category 3
Category 2	Category 1 (High Ground)

FIGURE H7

Scale: 1:1500 @ A3

Drw NM | Date 13/08/08 | Rev 2

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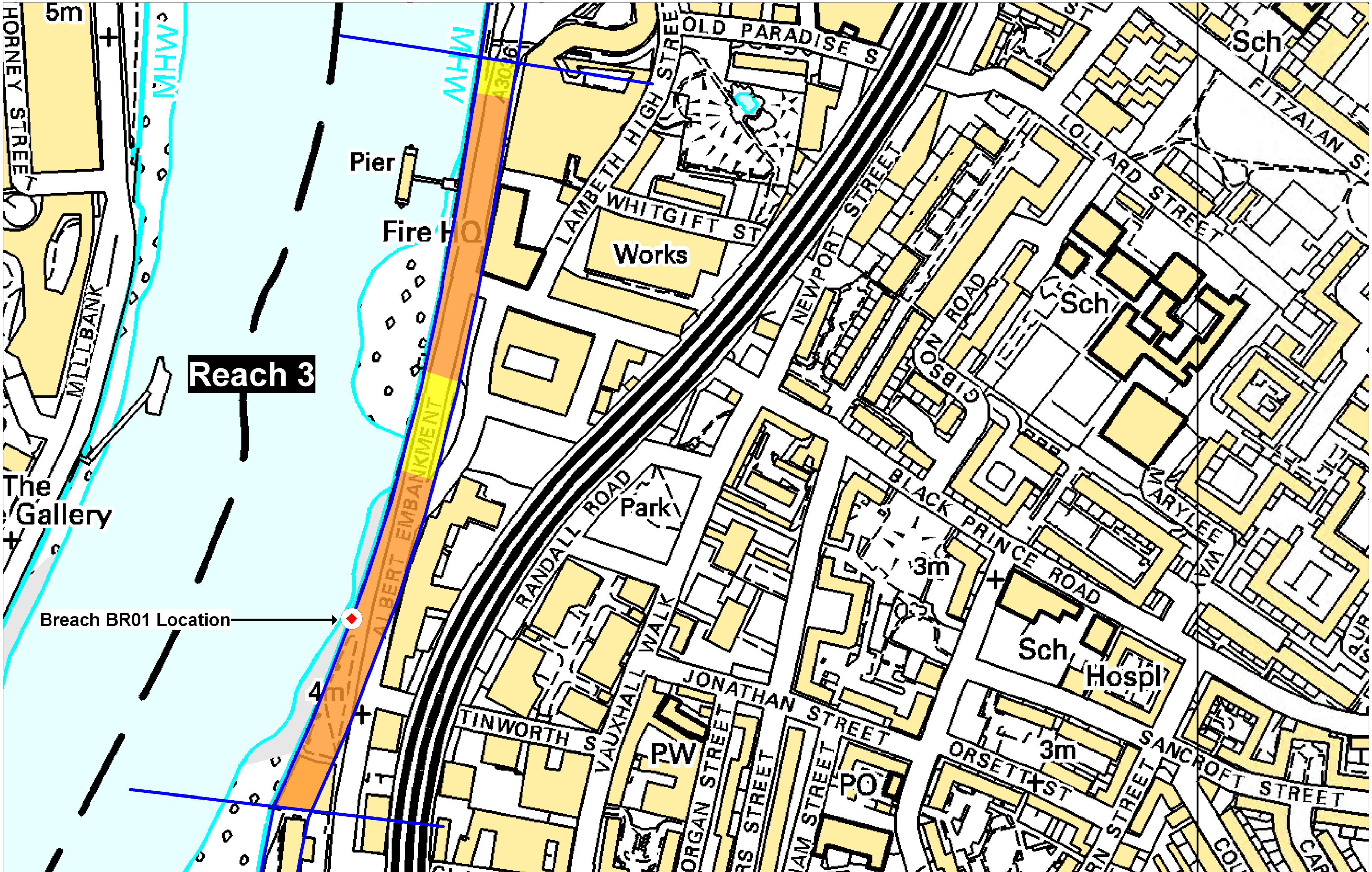

Project:
Lambeth SFRA

Title:
River Reach 3
Riverside Category

Category 4
Category 3
Category 2
Category 1 (High Ground)

FIGURE H9

Scale: 1:2500 @ A3

Drw	NM	Date	13/08/08	Rev	2

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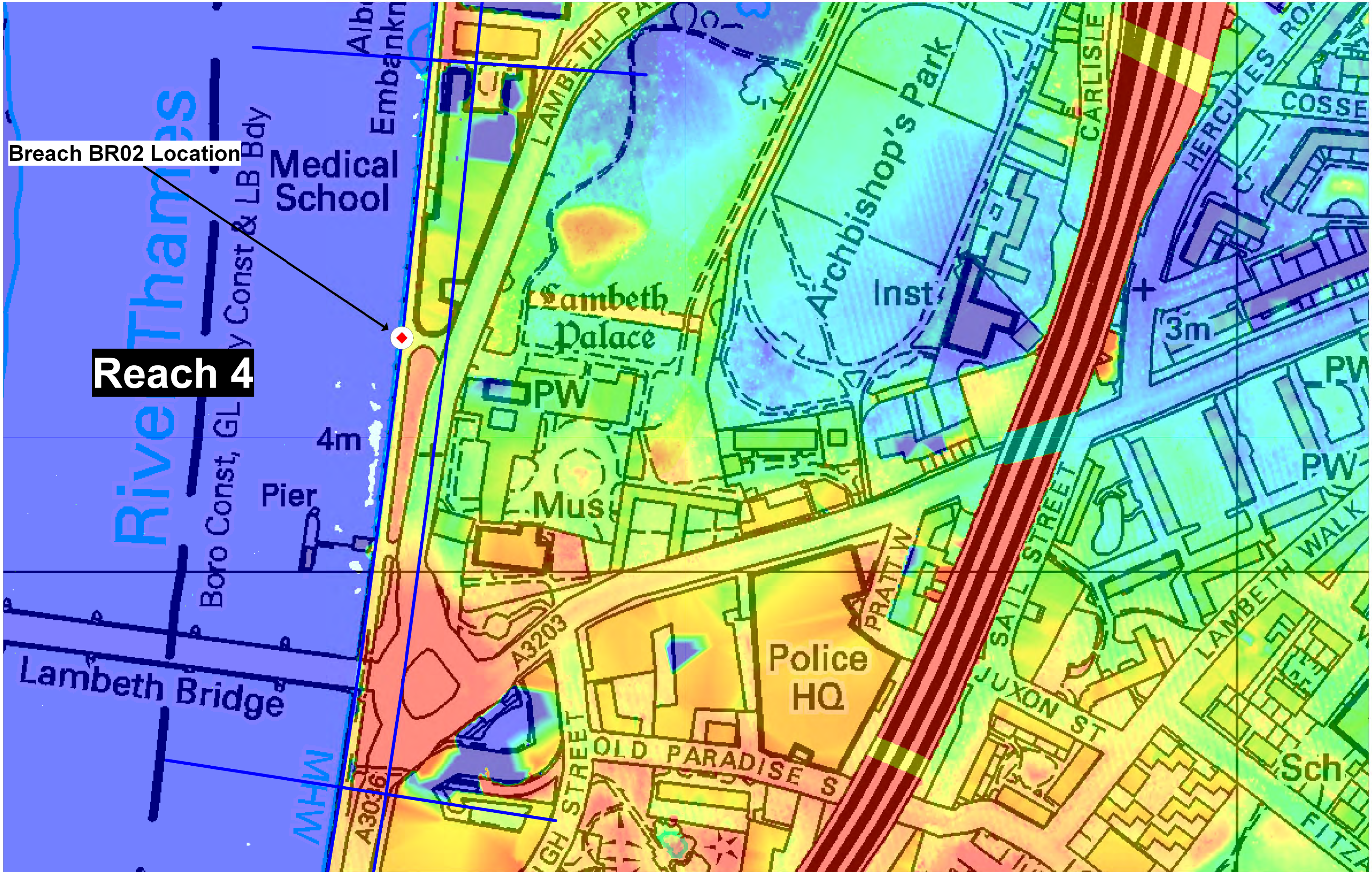

Project:
Lambeth SFRA

Title:
River Reach 4
Digital Terrain Model

Elevation [m AOD]:

3.00 3.50 4.00 4.50 5.00 5.50

FIGURE H10

Scale: 1:2000 @ A3

Drw NM | Date 13/08/08 | Rev 2

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