Spatial Quantification of Road Runoff Pollution in Greater London

Funded by GLA, TfL & EA

Undertaken in partnership with Middlesex University, ZSL, SERT.

Thames21
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1 EXECUTIVE SUMMARY

London's rivers suffer many forms of pollution. One of the most difficult to identify, quantify and prioritise solutions for is road runoff. Road runoff occurs when rainfall washes accumulated sediment and pollutants from the road surfaces into a river. This can carry over 300 different pollutants and its impacts can be both chronic (long term) and acute (short term), contributing to dissolved oxygen (DO) crashes and fish kills. Locating and quantifying road pollution hot spots is extremely difficult. To map and help prioritise key pollutant-contributing sections of roads, Thames21 has worked with Middlesex University to develop a new model, which looks at vehicle numbers and types to predict the roads which generate the most pollutants. Partners of the project include the Greater London Authority, Transport for London, Environment Agency, Middlesex University, Zoological Society of London and South East Rivers Trust.

The project examined the level of risk from 6 pollutants (zinc, cadmium, copper, total suspended solids, pyrene, benzo (a) pyrene), as a representative of the 300 pollutants on the strategic road network in London. The level of risk was calculated using TfL modelled traffic data for 2013 and 2025 to establish traffic volumes and calculating the total deposition on the road network for each pollutant. Years chosen for this study represent existing pollutant deposition and future predicted pollutant deposition masses. Incorporating rainfall data enables a total concentration (ug/L) for each pollutant and year per section of road mapped.

Thresholds were applied to each pollutant according to their potential to damage rivers health, created from a review of academic literature in combination with EU and UK water quality standards. To combine individual pollutant data for each road, the 'Number of pollutants on London's road network at high risk of causing damage to river health' map was created, which depicts the number of times the highest threshold for each pollutant was exceeded on each road. The map identifies the sections of roads contributing the most risk (shown in red; see Figure 5-1). A map highlighting the most polluting roads in London has also been produced with a view to help target interventions, such as implementing SuDS (see Figure 5-2). Additionally, heat maps for each pollutant were created to highlight areas at risk from specific pollutants (see Figures 13-1 to 13-4).

The work produced during this project has led to a comprehensive understanding of pollutant deposition on London's roads and the risk they propose to damaging river health. The maps and associated information created can be used to identify high risk areas of the road network which can be targeted to reduce the impact of the health on London's rivers through the implementation of SuDS: swales, filterstrips and raingardens. SuDS can improve water quality by absorbing the pollutants and intercepting the runoff.

There is a wealth of guidance available on the types of intervention controls including various SuDS options which can be both retrofitted and created in new developments (CIRIA, 2007; TfL, 2016; LES, 2018) to improve water quality. These include swales, retention ponds, filter strips and rain gardens. When choosing a particular SuDS feature (or treatment train) there are a number of factors one should consider including: space available, type of treatment required and cost (CIRIA, 2015).

Results from the road runoff project will also be disseminated to local councils to help aid future SuDS planning within individual boroughs and support local planning/traffic decision-making.

This project has identified the roads with the greatest impact on river health, with a view to enabling the relevant authorities to take action to resolve the pollution issues. However, there is currently a knowledge gap in how to identify the most appropriate types of SuDS for use at a particular site. The partnership from this project are currently investigating a Phase 2 project to overcome this knowledge gap through development of a SuDS decision support tool, and apply this through working with target local authorities to investigate how treatment systems identified can be used to treat pollution from London's roads.

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ACRONYMS

Acronym	Explanation
GIS	Geographical Information System
AADT	Annual Average Daily Traffic
UAL	Unit Area Loading
WFD	Water Framework Directive
SuD'S	Sustainable Drainage Systems
UWWTD	Urban Waste Water Treatment Directive
Major Roads	Roads investigated for Air Quality Considerations

2 INTRODUCTION

Many of London's rivers are polluted; for example, only one of London's 41 rivers is classed as 'good quality' under the EU Water Framework Directive (LES, 2018). Many London waterbodies are overloaded with pollution from leaking sewer infrastructure and urban diffuse pollution discharges such as road runoff. Road runoff is a significant threat to the quality of many receiving water bodies due to contamination by trace metals, hydrocarbons and other organic pollutants (Flanagan et al, 2019). Figure 2.1 shows rivers in London where road runoff has been identified as a reason why they have not achieved good status. Continued urban growth, traffic volumes and climate change are likely to extend and exacerbate the potential flood and pollution receiving water impacts (Ellis & Butler, 2014).

Whilst the long term (chronic) effects of pollutants in road runoff are not fully understood, the short term (acute) effects can be severe and contribute to fish kills in so-called 'first flush' events (see Figure 2.2). This happens when a long dry period is followed by intense rainfall events as seen following the 2018 drought in London. Organic material from tyre wear, break wear and oil leaks including hydrocarbons and other substances build up on impermeable road surfaces, with pollutant masses building up over time. When it rains this material can be flushed straight to the nearest river. Oxygen levels can drop to levels that endanger fish as bacteria break down the organic material entering the river, resulting in aquatic mortalities.

The mass of pollutants deposited on road surfaces vary in relation to factors such as driving styles, traffic volume and road layout patterns and therefore vary on a site-by-site basis, and various models have been developed to predict concentrations discharging from road surfaces when it rains. However, these typically require large spatial data sets from across a catchment (Ellis & Revitt, 2008). Further translating predicted total pollutant concentrations into a form for comparison with Water Framework Directive (WFD) standards: 'high' ,'good', 'moderate', 'poor', 'bad', cannot be derived from a mass balance calculation (an approach used to quantify pollutant inputs and outputs) (Novotny et al, 2005). However, adoption of a unit area loading (UAL) approach can identify source areas generating the highest concentrations of diffuse pollutant loads by quantifying the amount of pollutant accumulating in a specific location over a defined time (Ellis & Revitt, 2008). This approach has been applied, for example, to a 6310ha sub catchment of the River Lea to identify pollutant accumulation hotspots (Ellis & Revitt, 2008).

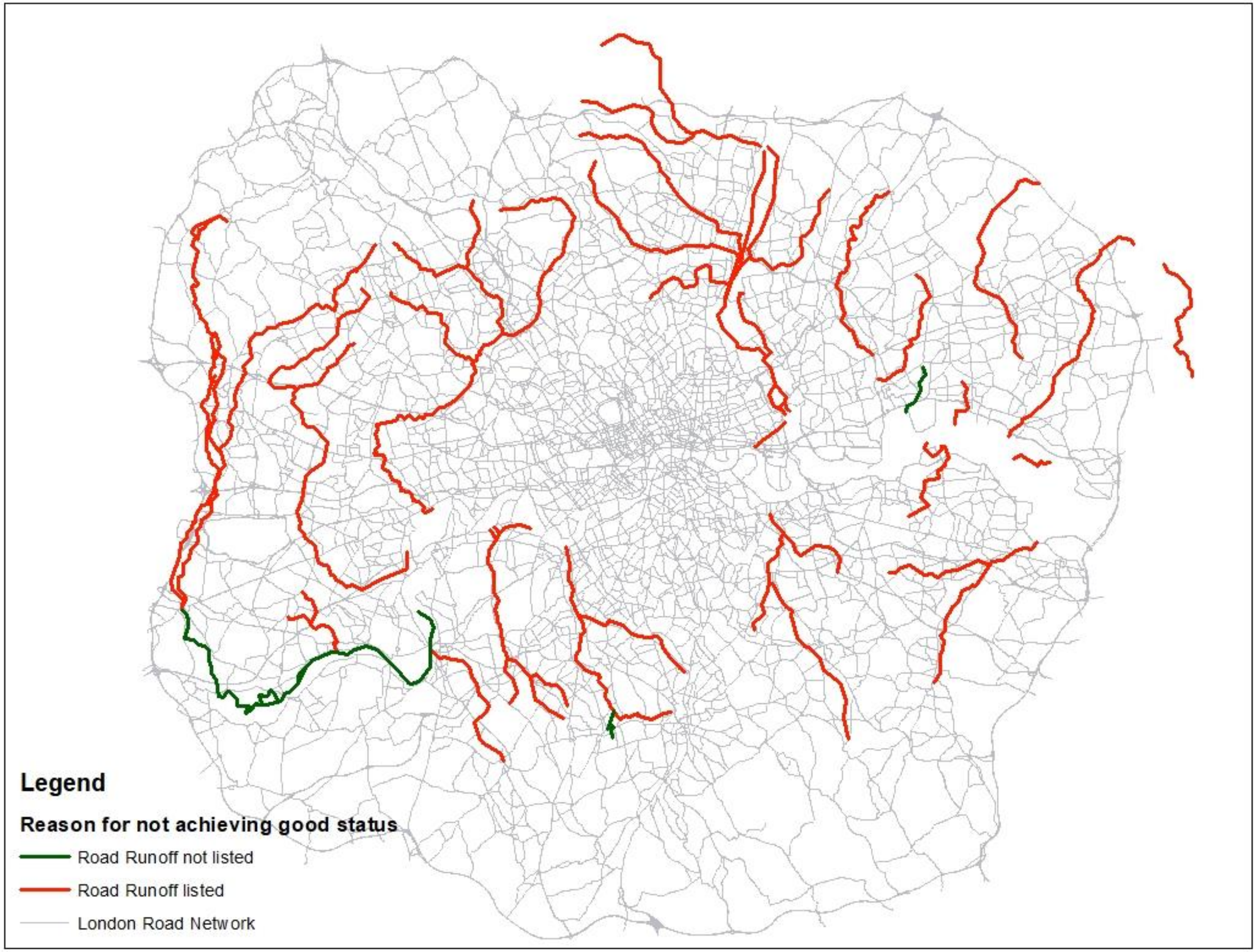

Figure 2-1 Rivers in London in which 'road runoff' is listed as a reason for not achieving good status. (Data Source: EA)

Figure 2-2 From clockwise: A fish kill on the River Lea, Olympic Park, Aug 2013 caused by road runoff, Water samples taken every 15mins during a 'first flush event' and a 'first flush' entering the Hogsmill River, South London.

To help tackle road runoff pollution in London, Thames21 and Middlesex University have developed and applied a methodology to identify which sections of London's roads are likely to contribute the most pollution to our rivers. This data is presented as a risk map to help identify and prioritise areas for the installation of intervention measures to reduce the amount of pollution entering rivers from roads.

Authorities and communities can use this information to develop mitigation measures to capture and treat the pollution through the installation of source control approaches such as sustainable urban drainage systems (SuDS); including swales, filter strips and raingardens. SuDS can improve water quality by absorbing the pollutants and intercepting the runoff.

This project is the first output of a wider collaborative project that brings together Thames21, Greater London Authority, Environment Agency, Transport for London, Zoological Society of London and South East Rivers Trust to take steps to tackle the complex issue of road run off pollution. The next phase will see project partners investigate treatment systems and work with a number of local authorities throughout London to develop catchment scale mitigation and treatment plans of London's worst roads.

3 METHODOLOGY

The following methodology developed by Middlesex University has been adopted to determine the spatial quantification of road runoff pollution across Greater London. The methodology quantifies the mass of selected pollutants deposited on road surfaces, which can potentially enter rivers through road stormwater runoff. The technical report accompanying this report provides further detailed information on assumptions and literature values used in the methodology. A brief overview of the data analysis is outlined below.

Pollutants

The pollutants modelled in this project include: zinc, cadmium, copper, benzo (a) pyrene, pyrene and total suspended solids. There are over 300 pollutants contained in road runoff, thus the pollutants chosen represent organic and inorganic pollutants which are widely reported within road runoff pollution and which reflect the greatest concern in terms of receiving water toxicity. Total suspended solids can be used as a proxy for a number of pollutants that naturally bind with particulate matter (such as street dusts) and thus enter a river.

Traffic

TfL Annual Average Daily Traffic (AADT) data was obtained for the major roads for the years 2013 and 2025 (TfL, 2019). The data provides modelled traffic data for the strategic road network, including 585km of the Transport for London Road Network. The most recently available traffic data is for 2013 (at the time of publication) and this is used to derive pollutant deposition rates associated with current patterns of traffic volumes and vehicle types within Greater London. Predicted traffic data for 2025 has also be released by TfL and this is used to inform predictions of road runoff quality associated with changes in traffic patterns over time, such as the potential reduction in traffic volumes, and vehicle types associated with the introduction of measures to improve air quality such as the Ultra Low Emission Zone (ULEZ). The types of vehicles included within AADT data during the road runoff project are shown in Table 3.1

Table 3.1 Types of vehicles investigated within road runoff project, including the type of fuel used with the pollutant deposition prediction methodology.

Type of Vehicle	Type of Fuel
Motorcycle	Petrol
Taxi	Diesel
Passenger Car	Petrol
Passenger Car	Diesel
Light Goods Vehicle	Petrol
Light Goods Vehicle	Diesel
Bus	Diesel
Coach	Diesel
Rigid Axle Heavy Goods Vehicle	Diesel
Articulated Heavy Goods Vehicle	Diesel
Passenger Car	Electric
Light Goods Vehicle	Electric

Road Widths

Road width is important for calculating surface area used when considering rainfall runoff. Road widths were studied in Thamesmead as a demonstration area to calculate the number of lanes different road types possessed. Thamesmead was used as an indication of number of lanes within an area, future work should examine other areas. The results are shown in Table 3.2 and extrapolated for Greater London.

Table 3.2 Number of lanes for different road natures in Thamesmead

Road Nature	Number of Lanes
Dual Carriageway	2
Slip Road	1
Single Carriageway	2
Roundabout	1
Traffic Island Link At Junction	1
Enclosed Traffic Area Link	1
Traffic Island Link	1

Sewer System

A significant contributing factor with regards to road runoff pollutants entering a receiving waterbody is whether the Borough is treated by a combined or separate sewer. If surface water is treated by a combined sewer; like the inner London Boroughs of Tower Hamlets and City of Westminster, water will be treated at a sewage treatment works, unless it is discharged by a combined sewer overflow (CSO) in an extreme event. Areas with a separate sewer system have two sewers, one to take foul water to a sewage treatment works, and the other to take rainwater. A GIS layer received from Thames Water highlights the areas covered by combined or separate sewers (see Figure 3.1) and this distinction between sewer types i.e. separate or combined, is integrated within the developed method, to only model separate sewers.

Calculations

Using data from the literature, the mass of each pollutant deposited on a road surface per vehicle type was identified for each of the following emission categories: tyre wear, engine emissions, brake wear, road surface wear and oil leakage. This emission data is then combined with site specific data relating to rainfall and surface area to produce a 'total monthly average concentration (in µg/L)' for each pollutant reflecting local traffic make-up and road characteristics. Values can hence be expressed either as a sum of all vehicle categories, or for individual vehicle types such as petrol cars or motorcycles.

Water Framework Directive

Adoption of the EU Water Framework Directive (EU WFD, 2000) introduced a comprehensive river basin management planning system to protect and improve the ecological health of our rivers, lakes, estuaries, coastal and groundwaters (EA, 2015). It set out to restore water bodies to good ecological status by 2021 – or at latest – 2027 (Defra, 2016). As part of its requirements, the WFD sets out a series of water quality standards (WQS) against which the health of all water bodies is assessed based on potential to damage river ecology. Acute (annual average) and chronic (maximum allowable concentration) WQS have been developed by the EA, for a range of metals and organic substances, with additional WQS identified for further substances of concern within the UK (see Table 3.3)

Table 3.3 Receiving water quality standards for selected road runoff pollutants

	Receiving water quality standards	Key traffic sources	Notes
Cadmium (Cd)	0.25 µg/l*	Brake linings	EU PSD(2013) Refers to dissolved concentrations
Copper (Cu)	1µg/l	Brake linings	UK TAG WFD (2015) Refers to bioavailable concentrations
Zinc (Zn)	10.9µg/l plus ambient background concentration**	Tyres, brake linings	UK TAG WFD (2015) Refers to bioavailable concentrations
Benzo (a) pyrene (BaP)	1.7×10^{-4} µg/l	Exhaust emissions; oil leakages; tyres;	EU PSD (2013). Refers to total concentrations
Total suspended solids (TSS)	35mg/l	Wear and tear of road surfaces and vehicles	

Notes: * standards vary with water hardness; water hardness within the River Lea and Thames falls within class 5 (≥ 200 mg $CaCO_3$ /l); ** annual average background for the River Thames is 3.3µg/l)

A full explanation of the method can be found in Appendix B. The developed model predicts total pollutant concentrations within road runoff based on traffic volume and type and must therefore be adjusted to enable comparison with the WQS identified in Table 3.3. To do so, a staged approach has been developed which varies in relation to the pollutant fraction to which the WQS refers to (i.e. the bioavailable fraction for Cu and Zn; dissolved fraction for Cd and the total concentration for TSS and BaP). The methodology is described in full in Appendix B, and is briefly summarised here as follows:

- Use of a minimum dilution ratio of 8:1 on discharge to receiving waters
- For Copper and Zinc – use of the literature data to predict the partitioning of metals between the dissolved and particulate phases within road runoff followed by use of the BIO-MET model (developed to support practitioners developing compliance with EU WFD WQS) to predict the fraction of the dissolved phase which is identified as bioavailable. This involves use of literature data on dissolved organic matter levels, calcium concentrations and pH with the River Thames catchment.
- For Cadmium – use of peer reviewed literature data to identify the partitioning of metals between the dissolved and particulate phase.
- For Benzo a Pyrene, Pyrene and Total Suspended Solids no further conversion required (dilution only) as total concentration can be used.
- Use of the pertinent WQS to calculate a risk characterisation ratio (RCR) involving division of the WQS by the predicted concentration. An RCR >1 indicates a risk to receiving waters with ranges of RCR use to develop a prioritised scale.

This methodology focuses on major roads and does not currently include sections of residential roads outside of TfL modelled data. However, as and when residential road data becomes available it can be inserted into the model and pollutant loads associated with this road type also calculated.

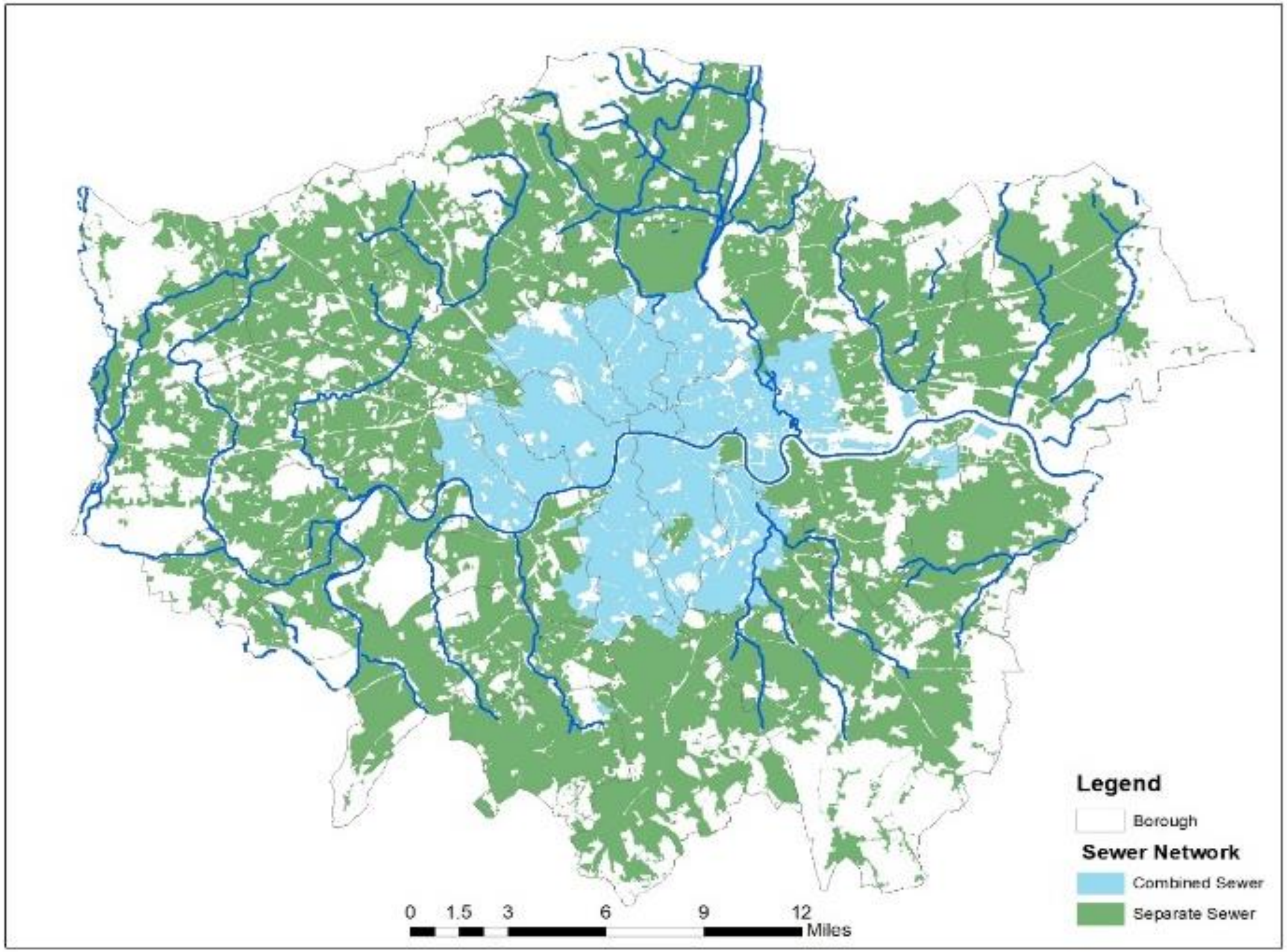

Figure 3-1 Greater London Catchment with type of sewer system shown.

4 LIMITATIONS

Whilst the methodology has been developed using peer-reviewed data sets, it has also involved the use of expert judgment in a number of areas which the user should be aware of. Full justification for assumptions made in relation to pollutant deposition data are given in the accompanying technical report. Assumptions have also been made in relation to the following aspects:

- Road width: no comprehensive database of road widths exist so calculations of road width based on generic values of road as given in Design Manual for Roads and Bridges data have been used
- Number of lanes per section of road modelled: this can vary even with a single road number. TfL does record number of lanes, however does not record road width and therefore data from the Thamesmead catchment has been used as indicative for the entire London catchment.
- Calculations on the mass of pollutant deposited and volume of runoff which mobilises it are dependent on road width / numbers of lanes and therefore an uncertainty in these factors will influence the results generated.

Limited information on the surface water drainage network (i.e. knowledge of where each section of road drains into the river) has led to use of the generic assumption that each section of road directly drains to the closest receiving water. As discussed in section 3 (Methodology), predicted concentrations cannot be directly compared with receiving water standards.

5 RESULTS

The following section presents two maps depicting the number of failures (exceedance of thresholds) of pollutants on each road in London (Figure 5.1) and the roads at highest risk of causing damage to river health (Figure 5.2). Appendix C includes an example of the modelled outputs for zinc from the project with comparisons between 2013 and 2025, similar maps are available for the other 5 pollutants. As discussed in Section 6, the data is available to use in GIS, each pollutant can be analysed individually or in combination.

Figure 5.1 shows the number of pollutant failures on each road, identifying sections of road in which road runoff pollution is detrimental to river health. It uses a matrix score to identify whether each pollutant fails the highest threshold identified per pollutant for receiving water quality. The total number of failures is 6 (i.e. the highest thresholds for all pollutants are exceeded) no section of road fails for all 6 pollutants, and all mapped roads fail the highest threshold value for at least two pollutants.

Figure 5.2 shows the roads at highest risk of causing damage to river health. This was calculated by identifying roads in which each pollutant failed the highest risk to river health thresholds. Once identified, the remaining roads were filtered to identify the top 25% of roads with the highest concentration for each pollutant. To assess the risk posed by these roads, a matrix score was applied in which roads in the top 25% for each pollutant received a score of 3. The results were used to identify roads in which a top score of 18 could be achieved. This was presented in ArcGIS using the natural breaks statistical technique [1] to categorise the data and produce Figure 5.2.

Reductions in pollutant concentrations on comparing 2013 to 2025 data, could indicate that the adoption of new targeted remediation strategies such as the ULEZ strategy – which may change traffic volume and potentially driving patterns - are reducing the amount of pollutants entering waterbodies. Figure 2.1 highlights the waterbodies in London where road runoff has been identified as a reason for not achieving good status. The purpose of the risk maps is to highlight locations that are likely to be the sources of the highest concentration of road-derived pollutants. Thus implementing appropriately designed SuDS at identified locations would have a positive effect on receiving water quality in rivers. However uncertainty remains around where runoff from roads enters the sewer system. Additional benefits of delivering SuDS in these locations potentially include: reductions in flood risk, improved air quality and greater biodiversity.

[1] Natural breaks classification are based on natural groupings inherent in the data. Class breaks are identified that best group similar values and that maximise the differences between classes.

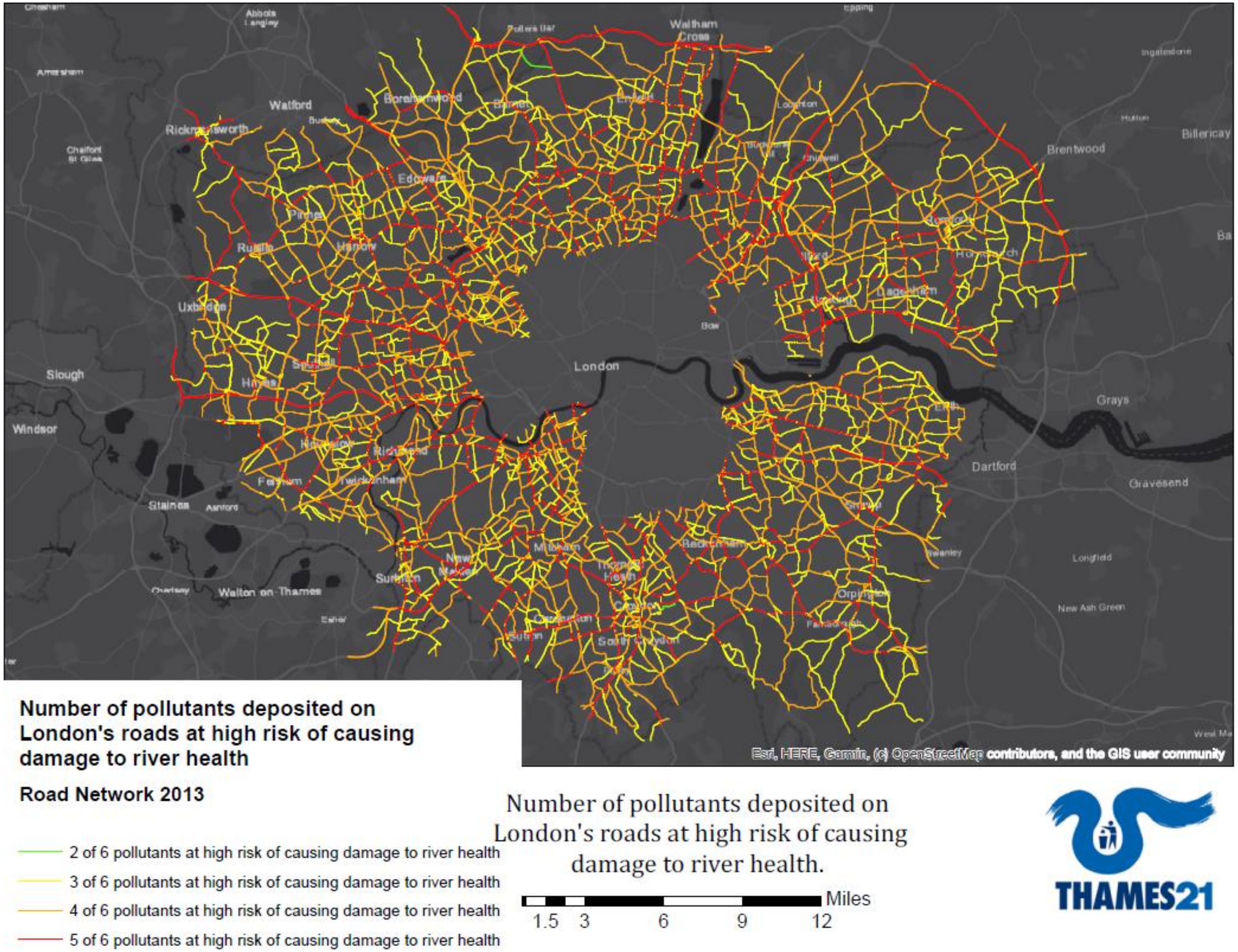

Figure 5-1 Number of pollutants deposited on London's roads at high risk of causing damage to river health in 2013.

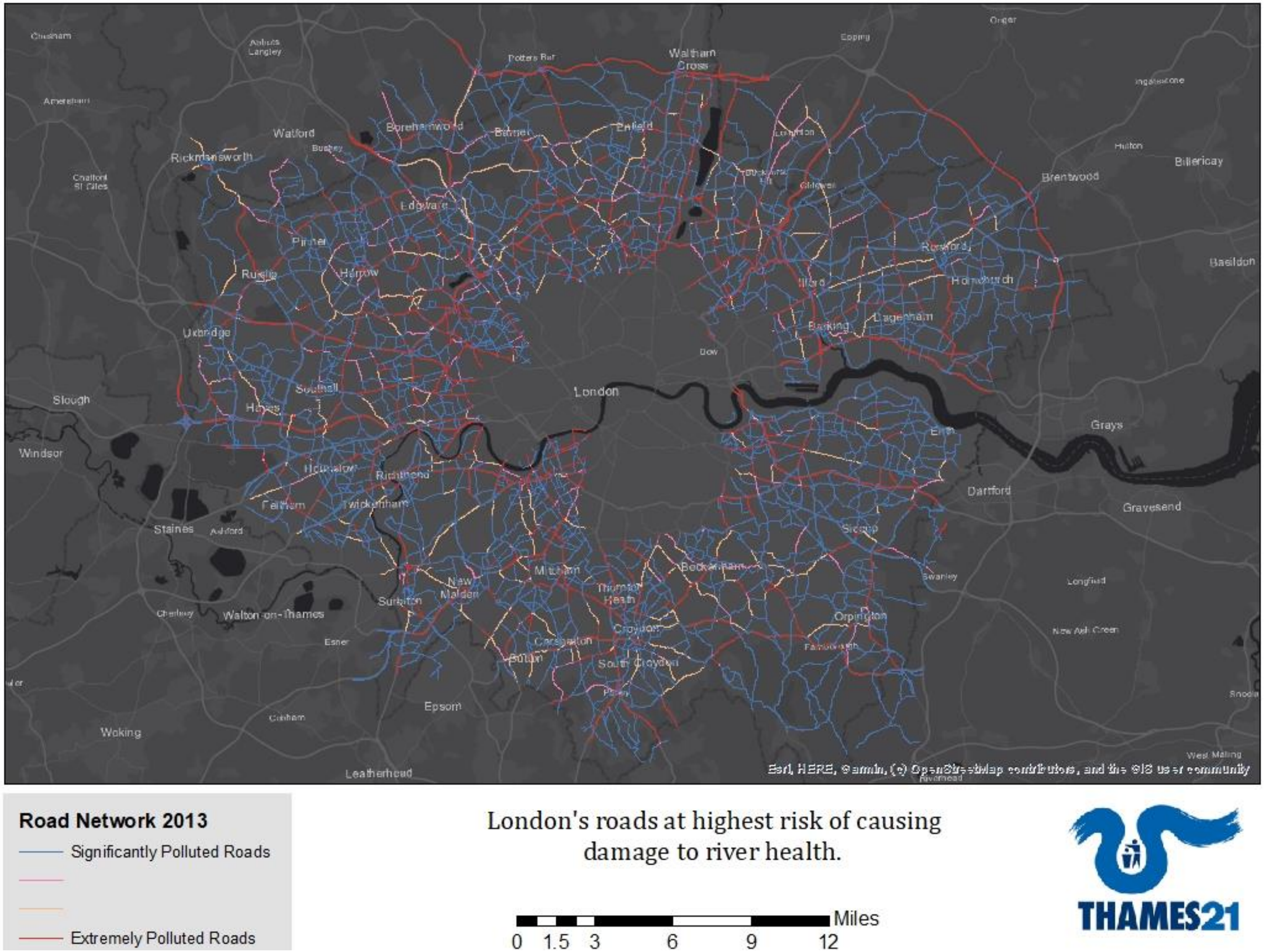

Figure 5-2 London's roads at highest risk of causing damage to river health.

6 DATA GUIDANCE

The following information provides brief guidance for using and manipulating the data outputs from this project.

The developed methodology is available in MS Excel spreadsheets. These contain inbuilt formulas such as 'AADT Taxi Zinc Brake' which calculate the brake-derived Zinc emissions per vehicle km. The formulas themselves do not require user inputs to run the model. However if values for the amount of Zinc in brake wear change as a result of further research or product substitution, the user can edit the cell and thus the formula will automatically update. This is the case for all included calculations: road width, monthly runoff, runoff coefficient and the amount deposited by engine, brake, tyre, surface and oil deposits.

The MS Excel spreadsheets can be opened within Arc GIS or viewed on the internal TfL and GLA online mapping platforms. Once opened, there are multiple categories for each vehicle on the roads, which can be viewed independently to understand how much pollutant concentration they are contributing to the road surface deposits. The data can be colour coded against thresholds according to frequency distribution curves of the data. The MS Excel spreadsheets can be manipulated using the software Python.

7 RECOMMENDATIONS

The spatially distributed data provided from this project can be used to target priority locations for the installation of mitigating interventions to reduce pollution such as sustainable drainage systems (SuDS). Such road runoff maps can identify areas in which SuDS will benefit receiving water quality by reducing the amount of pollutants entering rivers. In addition, the maps may help reinforce regulatory authority approaches to achieve statutory WFD requirements.

There is a wealth of guidance available on the types of intervention controls including various SuDS options which can be both retrofitted and created in new developments (CIRIA, 2007; TfL, 2016; LES, 2018) to improve water quality. These include swales, retention ponds, filter strips and rain gardens. When choosing a particular SuDS feature (or treatment train) there are a number of factors one should consider including: space available, type of treatment required and cost (CIRIA, 2015).

Results from the road runoff project will also be disseminated to local councils to help aid future SuDS planning within individual boroughs and support local planning/traffic decision-making.

This project has identified the roads with the greatest impact on river health, with a view to enabling the relevant authorities to take action to resolve the pollution issues. However, there is currently a knowledge gap in how to identify the most appropriate types of SuDS for use at a particular site. The partnership from this project are currently investigating a Phase 2 project to overcome this knowledge gap through development of a SuDS decision support tool, and apply this through working with target local authorities to investigate how treatment systems identified can be used to treat pollution from London's roads.

8 FUTURE

This project has spatially quantified the potential risk to receiving rivers associated with six major traffic-derived pollutants in Greater London Catchments. However, data collated from this project needs to be examined against monitored receiving water body quality and the sewer network volumes discharging into them. This will not only identify road pollution hotspots causing long-term instream problems but also help judge how mitigating performance measures match-up against instream pollutant thresholds.

Prioritisation of waterbodies most at risk from road runoff pollutants must be identified to help aid catchment interventions. Additional guidelines on the types of interventions, what scale to apply them and how local boroughs can mitigate road runoff will be developed within a further phase 2 of the current road runoff project.

9 REFERENCES

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10 APPENDICES

a. Justification of an excel spreadsheet approach for predicting road runoff pollutant concentrations. (2019) D. M. Revitt, J. B. Ellis, L. Lundy.
b. Thresholds (2019) L. Lundy – see below.
c. Example of Zinc Thresholds

11 Appendix A: Justification of an excel spreadsheet approach for predicting road runoff pollutant concentrations. (2019) – See accompanying document

12 Appendix B: Thresholds (2019)

Adoption of the EU Water Framework Directive (2000) introduced a comprehensive river basin management planning system to protect and improve the ecological health of our rivers, lakes, estuaries, coastal and groundwaters (EA, 2015). It set out to restore water bodies to good ecological status by 2015 – or at the latest – 2021 (Defra, 2016). As part its requirements, the WFD sets out a series of water quality standards (WQS) against which the health of all water bodies is assessed. Acute (annual average) and chronic (maximum allowable concentration) WQS have been developed for a range of metals and organic substances, with additional WQS identified for further substances of concern within the UK (see Table 12.1).

Table 12.1 Receiving water quality standards for selected road runoff pollutants

Pollutant	Receiving water quality standards	Key traffic sources	Notes
Cadmium (Cd)	0.25 µg/l*	Brake linings	EU Priority Substances Directive (PSD; 2013) Refers to dissolved concentrations
Copper (Cu)	1µg/l	Brake linings	UK Technical Advisory Group (TAG) WFD (2015) Refers to bioavailable concentrations
Zinc (Zn)	10.9µg/l plus ambient background concentration**	Tyres, brake linings	UK TAG WFD (2015) Refers to bioavailable concentrations
Benzo (a) pyrene (BaP)	1.7 x 10^{-4} µg/l	Exhaust emissions; oil leakages; tyres;	EU PSD (2013). Refers to total concentrations
Total suspended solids (TSS)	25mg/l	Wear and tear of road surfaces and vehicles	Value taken from the CIRIA SuDs Manual (2015)

Notes: * standards vary with water hardness; water hardness within the River Lea and Thames falls within class 5 (≥ 200 mg $CaCO_3$ /l); ** annual average background Zn concentration for the River Thames is 3.3µg/l)

The developed approach predicts total pollutant concentrations within road runoff based on traffic volume and type. This needs to be adjusted to enable comparison with the WQS identified in Table 12.1 which are relevant to receiving waters. To do this, a staged approach is adopted which varies in relation to the pollutant fraction to which the WQS refers (i.e. the bioavailable fraction for Cu and Zn ; dissolved fraction for the Cd WQS and the total concentration for TSS and BaP).

The pertinent receiving WQS has been used to 'back-calculate' the total concentration in road runoff entering a receiving water which would lead to its exceedance. To implement this approach, the following criteria have been used:

- The relationship between dissolved and bioavailable metal fractions can be predicted using a biotic ligand model (BLM) which predicts the bioavailable fraction based on site specific dissolved metal, calcium (Ca), dissolved organic carbon (DOC) and pH concentrations.
- The dilution ratio of receiving water to runoff volumes is assumed to be 8:1
- The partitioning of metals between the total and dissolved fractions can be predicted using data from the literature

The methodology is described in more detail below, including the identification of threshold values used to prioritise road sections in terms of the extent to which predicted pollutant runoff concentrations can lead to exceedance of identified WQS. To illustrate the approach, a worked example is provided below for Cu.

Pollutants for which the receiving water quality standard refers to the bioavailable fraction As the bioavailable fraction is analytically challenging to measure, the EU supports the use of biotic ligand modelling (BLM) to predict the fraction of the total metal which is likely to be bioavailable under local receiving water conditions. Data on pH, DOC and Ca concentrations for the River Thames catchment were sourced from the literature and, together with the pertinent bioavailable WQS, used in the BLM BIO-MET (2019) to work backwards to predict the dissolved metal concentration which would generate the identified bioavailable concentration.

Conversion of dissolved concentrations in the receiving water to equivalent dissolved concentrations in road runoff This stage of the prediction process converts the receiving water concentration to an equivalent road runoff concentration. This is achieved by applying a factor to address the dilution of runoff on entering a receiving water. Whilst the level of dilution offered by a receiving water will vary greatly in relation to, for example, rainfall, a dilution ratio of 8:1 is assumed as a minimum indicative value. Where WQS are quoted as total concentrations (e.g. TSS and B(a)P), these total concentrations were also multiplied by 8 to correct for dilution.

Conversion of dissolved concentrations to total concentrations Several studies in the peer-review literature have reported the distribution of selected metals between dissolved and total fractions. An evaluation of this data provide evidence of the following dissolved percentages for the selected metals: Cd (45% dissolved); Cu (40% dissolved); Zn (40% dissolved). These percentages were used as multiplication factors to calculate associated total concentrations

Development of runoff thresholds using risk characterisation ratios The risk characterisation ratio is calculated by dividing the predicted environmental concentration (PEC) by the predicted no-effect concentration (PNEC). Values equal to or greater than 1 present a potential risk. The approach outlined above, supports identification of a PNEC in road runoff i.e. the total concentration back-calculated from the receiving water WQS. Using an RCR of 1 can then be used to identify the total concentration of the selected pollutant in road runoff which would equal this concentration (i.e. the PNEC). The following ranges of RCR have been used to develop a prioritised scale which is indicative of risks to the receiving water:

- RCR ≥ 1.0 the runoff poses a risk to receiving waters
- RCR 0.75-1.0 the runoff may pose a risk to receiving waters
- RCR <0.75 the runoff is unlikely to pose a risk to receiving waters

Worked example for Cu The WQS for Cu is 1 µg/l in the bioavailable fraction. Using River Thames catchment data, the following values were selected for pH (7.9), DOC (4.4mg/l) and Ca (75.9mg/l) for use in the BIO-MET BLM. Under these ambient receiving water conditions, BIO-MET predicts a bioavailable fraction of 1 µg/l is associated with a dissolved Cu concentration of 11.2 µg/l. A dissolved concentration of 11.2 µg/l Cu in a receiving water would derive from a runoff concentration of 89.6 µg/l Cu (i.e. following an 8 fold dilution). A dissolved concentration of 89.6 µg/l of Cu in road runoff is equivalent to a total concentration of 179.2 µg/l (based on a 40% dissolved Cu composition). Using the RCR threshold approach described above, an RCR ≥ 1 (i.e. a concentration ≥ 179.2 µg/l) represents a high risk of the WQS in the receiving water being exceeded. The relationship between RCR ranges, total metal concentrations and the colours used to highlight sections of road in the GIS maps is given in Table 12.2.

Table 12.2 Relationship between RCR, total Cu concentration in road runoff and allocation of road colours in GIS maps

RCR	Total Cu concentration in runoff (µg/l)	Associated road colour on GIS map
≥1.0	≥179.2	
0.75-1.0	147.2-179.1	
<0.75	<147.1	

Table 12.3 presents the relationship between RCR ranges, concentrations of selected pollutants and the colours used to highlight sections of road in the GIS maps.

Table 12.3 Relationship between RCR, total pollutant concentrations in road runoff and allocation of road colours in GIS maps

RCR	Total Zn (µg/l)	Total Cd (µg/l)	Benzo (a) pyrene (µg/l)	TSS (mg/l)	Associated road colour on GIS map
≥1.0	≥770	≥4.4	≥0.0014	≥280	
0.75-1.0	590-769	3.3-4.3	0.00102-0.0013	210-279	
<0.75	<590	<3.3	<0.00102	<210	

13 Appendix C: Example of Zinc Thresholds

Zinc concentrations for the years 2013 and 2025 are presented in a risk map for Greater London (see Figures 13.1 and 13.2) and the Borough of Enfield used as a detailed example (see Figures 13.3 and 13.4). Sections of the TfL network contain no values for traffic data and are subsequently not represented within the results. As stated in the methodology only Boroughs using separate sewer infrastructure are considered within this project, thus the inner city roads of Greater London are left blank.

Figure 13.1 shows the modelled results for 2013 total zinc concentrations, which can be used to predict areas of greatest concern with regards to the deposition and accumulation of this pollutant. Maximum zinc concentrations predicted are 17033ug/L at a site located within the Borough of Barking and Dagenham. Specific sections of the road networks identified as high priority (i.e. predicted to exceed the pertinent WQS) are located on the M25, North Circular and M4, and are highlighted as areas of greatest potential risk to receiving waterbodies. Areas in which high volumes of traffic occur are associated with higher deposits of zinc derived primarily from tyre wear road but also engine emissions, oil leakage and surface wear. Figure 13.2 predicts that zinc maximum concentrations could increase to 18398ug/L by 2025 (as a function of predicted increases in road traffic volume), and risk areas highlighted in 2013 are also highlighted in 2025.

Using the Borough of Enfield as the detailed example (Figure 13.3) significant locational variation in pollutant concentrations do occur. Although volumes of traffic remain high, pollutants deposited on shorter roads can be elevated, presumably related to brake and tyre wear which contribute to high concentrations of pollutants. Figure 13.4 shows predicted concentrations of zinc in 2025 in Enfield with areas exceeding maximum thresholds becoming greater which might be due to a decrease in vehicle numbers associated with the ULEZ.

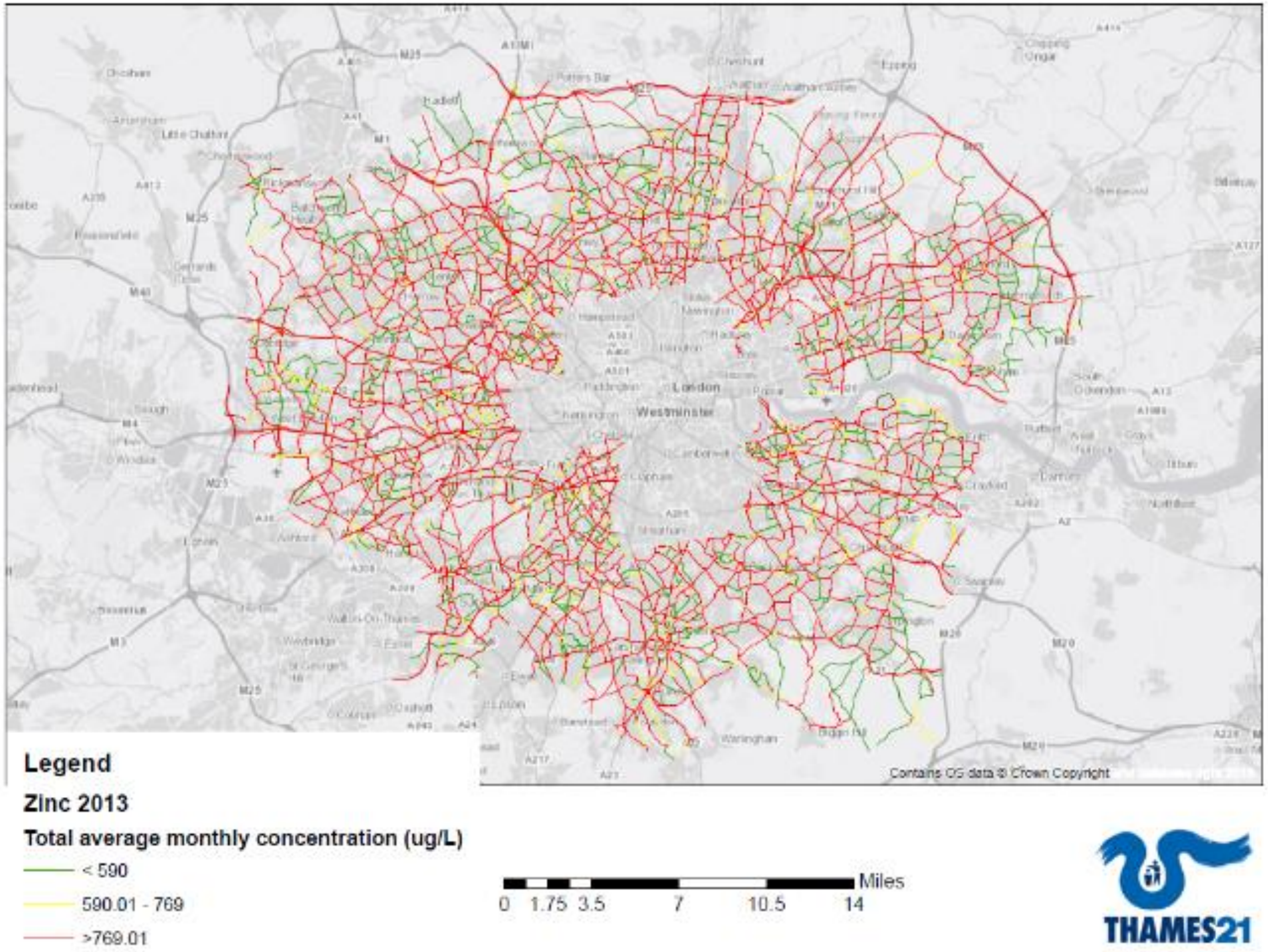

Figure 13-1 2013 Zinc concentrations in Greater London.

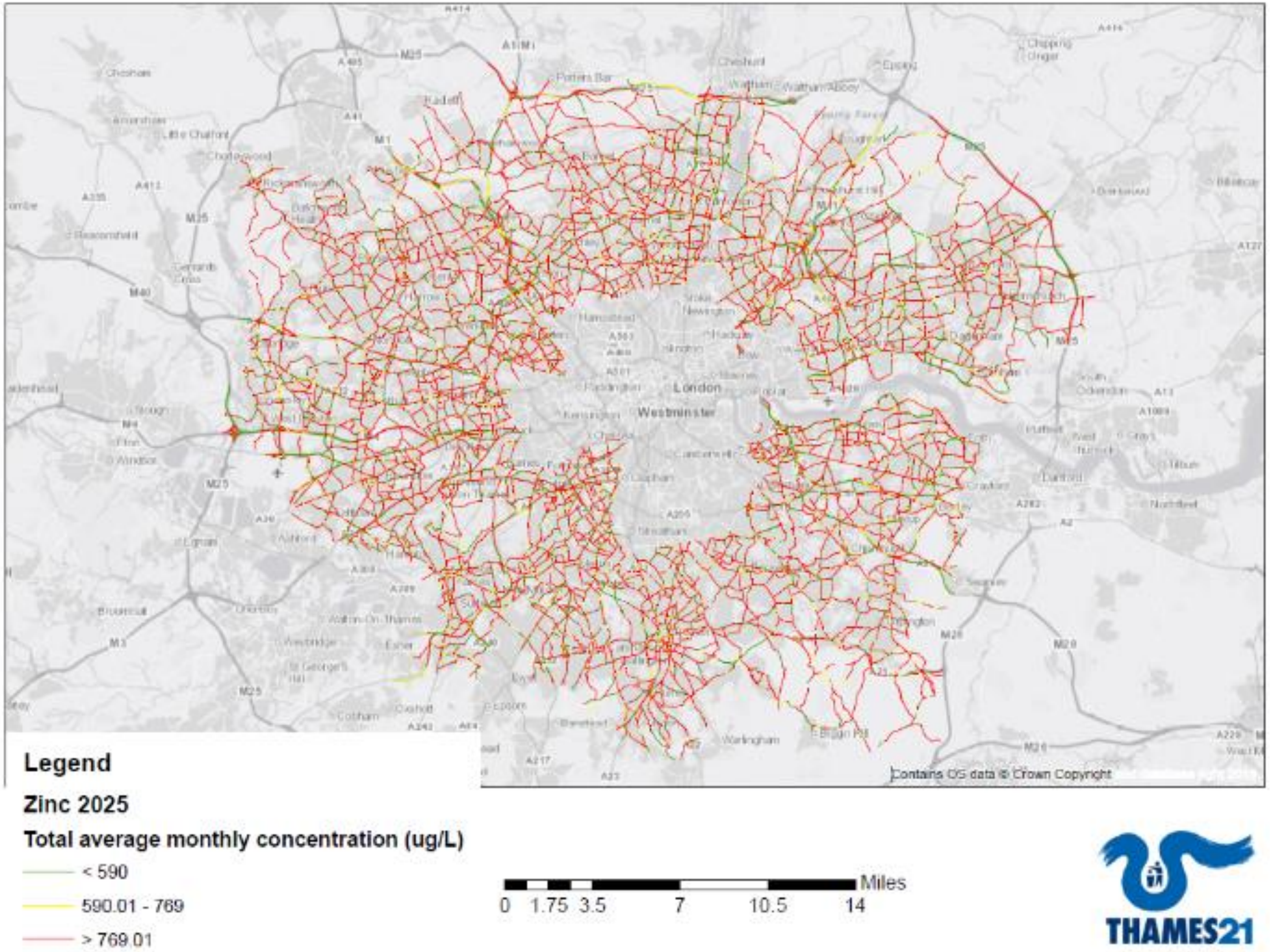

Figure 13-2 2025 Zinc concentrations in Greater London.

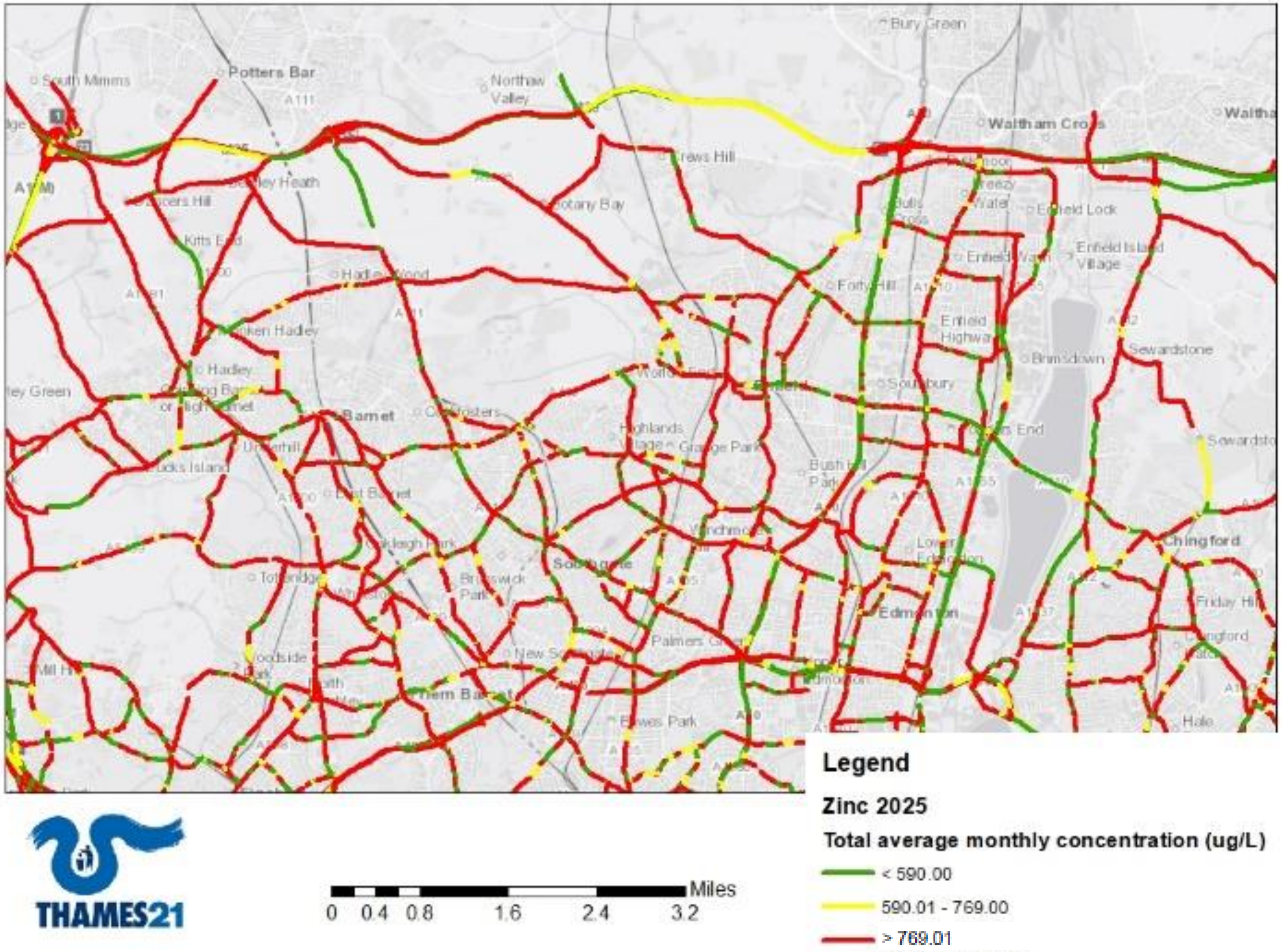

Figure 13-3 2013 Zinc concentrations in Enfield.

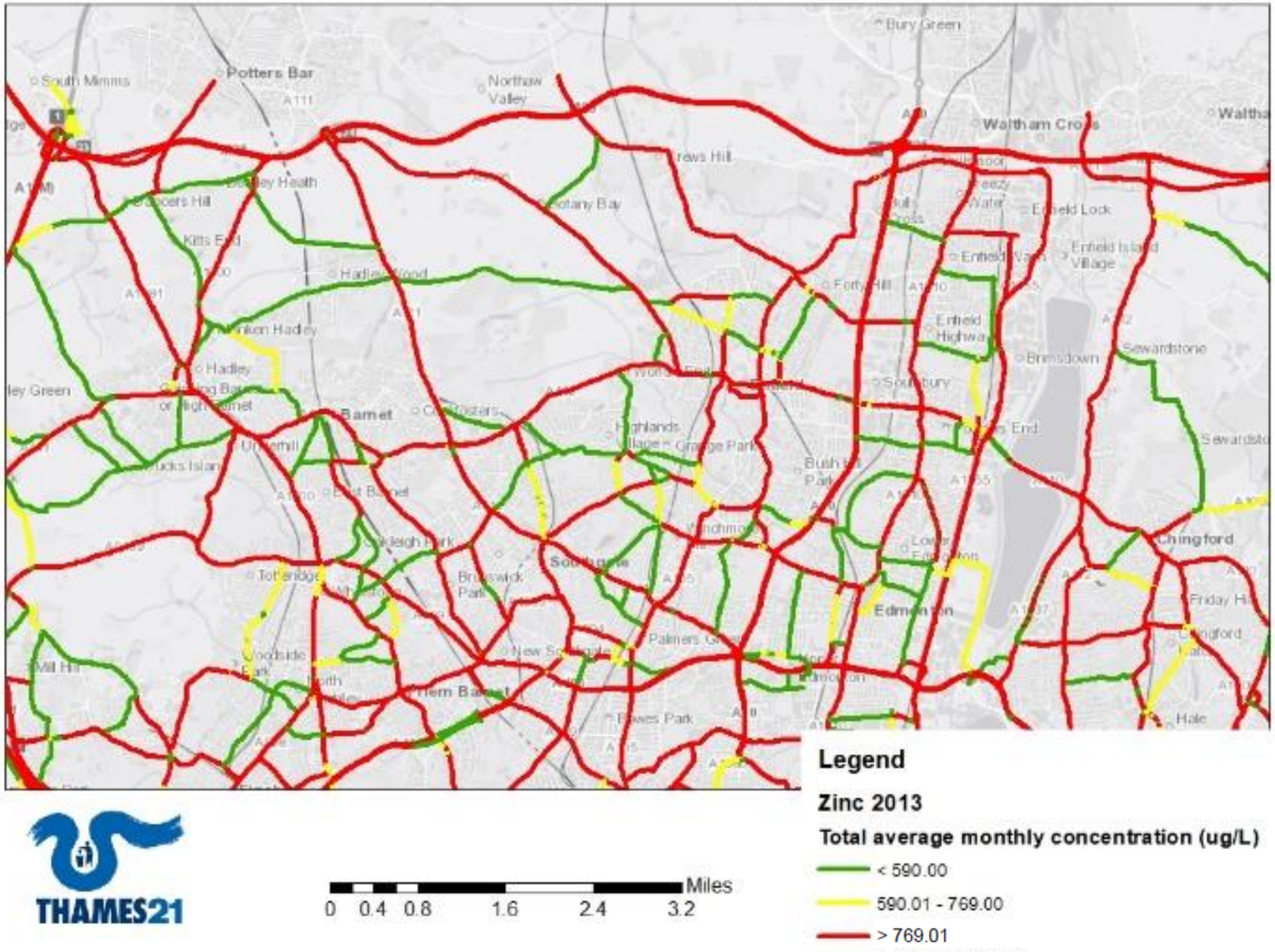

Figure 13-4 2025 Zinc concentrations in Enfield.