Cambridge
Environmental
Research
Consultants Ltd

Source Apportionment for London using ADMS-Urban

TOPIC REPORT

Prepared for

DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland

28th January 2004

C E R C

CONTENTS

REPORT INFORMATION

CERC Job Number:	FM489
Job Title:	Source Apportionment for London using ADMS-Urban
Prepared for:	DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland
Report Status:	Issued
Report Reference:	FM489/R3/04
Issue Date:	28/01/04
Author(s):	Jo Blair, Kate Johnson, David Carruthers
Reviewer(s):	

Issue	Date	Comments
1	14/03/03	1st DRAFT
2	26/01/04	2nd DRAFT
3	28/01/04	Final

Main File(s):	Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\London_SA(14feb03)1_TR-0359.doc
Figures 2.1 – 2.12	Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\NOx_emissions_maps.doc Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\PM10_emissions_maps.doc
Figures 4.1 – 4.7	Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\receptors_fig.doc
Figures 5.1 – 5.12	Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\NOx_conc_maps.doc Consult_FM489_DEFRA\Topic_reports\TBR4_LondonSA\PM10_conc_maps.doc

EXECUTIVE SUMMARY

The **UK 2005 annual mean NO_2** air quality standard (40µg/m^3) and the **EU 2010 annual mean NO_2** air quality standard (40µg/m^3) are likely to be breached across substantial areas of London in the target years (Blair et al., 2003). The **London 2010 annual mean PM_{10}** air quality standard (23µg/m^3) is likely to be exceeded on the busiest roads in central London, with the potential to exceed over the whole of London in a worst case meteorological year.

Source apportioned **emissions** maps broadly show trends and relative significance of individual sources. They cannot show directly which sources result in the breach of an air quality standard. The collection of emissions maps fails to demonstrate the relative significance of the different sources in detail, such as the impact of a nearby road.

In order to better understand the origin of pollutants contributing to predicted air quality, **NO_x and PM_{10} concentrations** due to various sources have been modelled for the years 1999, 2004/05 and 2010 over the Greater London area. The output is in the form of concentration contour maps and spot calculations at the location of air quality monitors. Although NO_2 concentration due to individual sources can not be modelled directly, its origin can be inferred from NO_x concentration.

The NO_x background can be a significant proportion of the total, particularly where the total concentration tends to be lower, e.g. at Teddington background is a third of the 1999 total concentration (60µg/m^3). For PM_{10} the background dominates the total concentrations at all locations in all years. Contributions from local sources have a very narrow margin before the 2010 air quality standards are breached.

The series of NO_x spot calculations and maps shows that traffic dominates, particularly at roadside sites, with cars generally making the most significant individual contribution in all years. For example, in 1999 the annual mean concentration at Marylebone Road is modelled as 392µg/m^3; 87% due to traffic with 26% due to cars alone. The concentrations are predicted to reduce in future years as does the proportion due to cars. Of the non-background PM_{10} sources traffic again dominates, with cars, LGVs and HGVs having approximately equal importance in 1999. The LGV contribution decreases less than car and HGV contributions, so it is more significant in 2010. At Marylebone Road cars contribute 11%, LGVs 9% and HGVs 13% in 1999 falling to cars 6%, LGVs 7% and HGVs 5% in 2010.

Taxi, bus and coach contributions to NO_x and PM_{10} and LGV contributions to NO_x are relatively less significant, but contribute most in the most sensitive areas.

The predicted NO_x and PM_{10} contribution from industrial sources and 'other' sources (mainly Heathrow) can be significant in the vicinity of the release. For both, better defined emissions would help to assess what improvement their reduction could make.

The results suggest the following improvements:

- Controls on NO_x emissions from cars and HGVs are most likely to result in the greatest improvements in NO_2 concentrations;
- Controls on NO_x and PM_{10} emissions from LGVs, taxis, buses and coaches may be helpful in targeting specific 'hot spots' on the busiest roads and central London;
- Controls on PM_{10} emissions from LGVs, cars and HGVs are most likely to result in the greatest improvements in PM_{10} concentrations;
- Controls on PM_{10} emissions from taxis, buses and coaches may be helpful in targeting specific 'hot spots' on the busiest roads located in central London.

1. Introduction

The 'source apportionment report' is the fourth in a series of topic reports prepared as part of CERC's contract to model air pollutants in urban areas in the UK. It records the process and results of modelling concentrations of NO_x and PM_{10} across London attributed to the various sources that emit the pollutants.

The other three topic reports are as follows:

- **Validation and sensitivity** study (Carruthers et al., 2003a);
- **Comparison** with the results of ERG and NETCEN pollution prediction methodologies (Carruthers et al., 2003b);
- **Map report** that presented maps of modelled NO_x, NO_2, PM_{10} and O_3 concentrations for London for 1999 and the AQS objective years of 2004 (PM_{10} only), 2005 (NO_x, NO_2, O_3 only) and 2010 (Blair et al., 2003). Maps of the modelled PM_{10} concentration for 2010 assuming the worst case meteorological conditions and maps of the annual mean NO_2/NO_x ratio for all relevant years were also included.

The map report presented concentrations without further measures, i.e. business as usual. It concluded that annual mean NO_2 UK and EU air quality standards are likely to be breached across substantial areas of London in the target years. If there is a standard meteorological year in 2010 the annual mean PM_{10} concentrations are unlikely to significantly exceed the London air quality standard (23μg/m^3) although they are more likely to exceed the EU standard (20μg/m^3) over a substantial area. However, in a worst case meteorological year the whole of London is predicted to exceed the London standard, mainly due to the majority of the total concentration being due to the background concentration, which is also worse in a worst case meteorological year.

The source apportionment work presented in this report builds on the work in the map report. It breaks down how much of the predicted concentrations of pollutants is derived from each source. The emissions of NO_x and PM_{10} from traffic, rail, shipping, domestic gas use, commercial gas use, industry and other sources (including airports) were modelled separately to produce results at receptor points and contour maps. The road traffic concentrations were further broken down into cars, LGVs, taxis, buses and coaches, rigid HGVs and articulated HGVs and other roads (including minor roads).

PM_{10} concentrations are presented as gravimetric values and all NO_x concentrations are presented as "NO_x as NO_2".

2. London Emissions Inventory

The Greater London Authority (GLA) supplied the London Atmospheric Emissions Inventory (LAEI), which covers emissions from all air pollutant sources for the Air Quality Strategy (AQS) pollutants. The LAEI is described and summarised in the map report (Blair et al., 2003).

Within the LAEI the emissions are broken down into rail, shipping, domestic gas use, commercial gas use, industry, other sources (including airports), cars, LGVs, taxis, buses and coaches, rigid HGVs, articulated HGVs and other roads (including minor roads). Table 2.1 summarises these data. Figures 2.1 to 2.12 show the breakdown of emissions in map form.

3. Model set-up

Source apportioned results predicted at receptor points were produced using the atmospheric dispersion model ADMS-Urban, version 1.7, described in the validation and sensitivity study (Carruthers et al., 2003a). The location of the receptor points is illustrated in Figure 3.1.

The modelling to produce source apportioned maps presented in this report used a specially tailored version of the atmospheric dispersion model ADMS-Urban, version 1.7SA. The source apportionment runs do not require calculations of atmospheric chemistry therefore they can use processed data which makes each run 5 to 10 times faster.

The methodology used for the base case scenario is provided in the map report (Blair et al., 2003). The following sections contain details of input data where they have not previously been described in the map report.

Figure 3.1 Location of Automatic Monitoring Network (AURN) Sites in Greater London

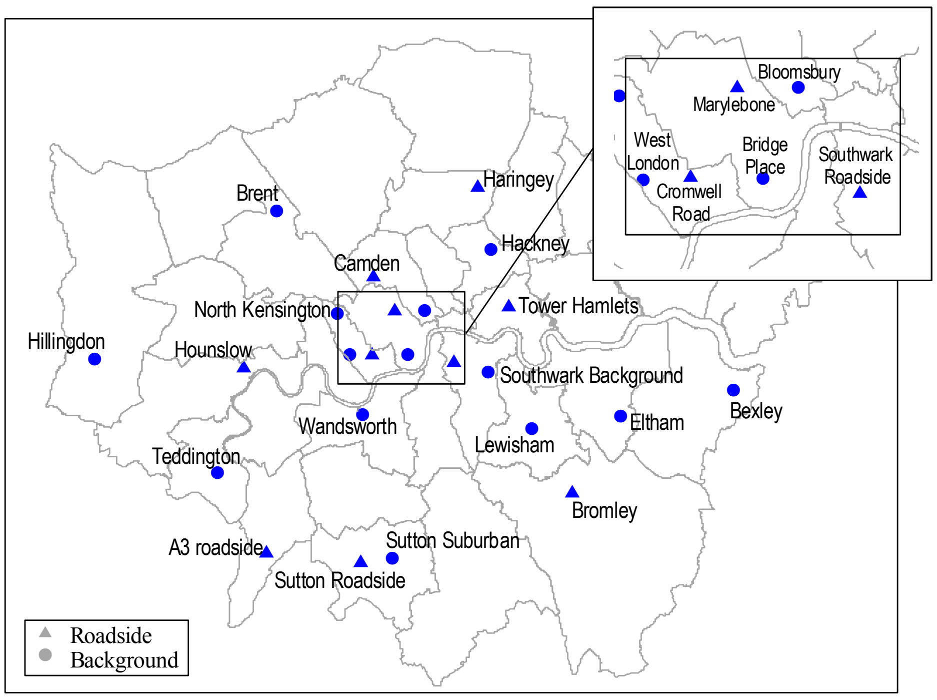

Table 2.1 Breakdown of emissions of NO_x and PM_{10} (T/a) by source and percentage of total emissions

	1999		2004/2005		2010	
	PM_{10}	NO_x	PM_{10}	NO_x	PM_{10}	NO_x
Total	4,058	97,141	2,997	74,777	2,140	63,557
Major roads	1,644 (41%)	34,266 (35%)	1,024 (34%)	22,089 (30%)	557 (26%)	15,827 (25%)
Other roads	1,303 (32%)	30,222 (31%)	899 (30%)	20,387 (27%)	474 (22%)	14,604 (23%)
Rail	99 (2%)	1,773 (2%)	99 (3%)	1,773 (2%)	99 (5%)	1,773 (3%)
Shipping	0	357 (0%)	0	357 (0%)	0	357 (1%)
Commercial gas	0	5,648 (6%)	0	5,734 (8%)	44 (2%)	6,520 (10%)
Domestic gas	0	10,010 (10%)	0	10,083 (13%)	78 (4%)	11,573 (18%)
Industrial	697 (17%)	7,139 (7%)	680 (23%)	7,047 (9%)	695 (32%)	6,679 (11%)
Other sources	315 (8%)	7,726 (8%)	295 (10%)	7,307 (10%)	193 (9%)	6,224 (10%)

3.1 Methodology

Total NO_x and PM_{10} concentration maps and receptor point values were presented in the map report for 1999, 2004/5 and 2010. The purpose of the work presented in this report is to break these maps down to their component parts, including the background contribution and the various sources:

- Source Breakdown: Traffic, rail, shipping, domestic gas use, commercial gas use, industry and other sources (including airports);
- Traffic Breakdown: Cars, LGVs, taxis, buses and coaches, rigid HGVs and articulated HGVs and other roads (including minor roads).

Sources with emissions in 1km×1km grid format (rail, shipping, domestic gas use, commercial gas use, industry, other sources and other roads) were modelled in this format with 75m high grid cells.

Large industrial sources were modelled explicitly with the remainder of industrial emissions modelled as a 1km×1km grid source with 75m high grid cells.

Major road sources (cars, LGVs, taxis, buses and coaches, rigid HGVs and articulated HGVs) were modelled explicitly within 3km of the output domain. The major road emissions outside this boundary were modelled as 1km×1km grid sources with 75m high grid cells.

Additional calculations have been made at the 24 AURN locations within London. The Bromley AURN site is believed to be unrepresentative due to poor siting of the monitor and has therefore been omitted from this study. These results were modelled to be comparable to the validation and sensitivity study (Carruthers et al., 2003a). Therefore only the hours when Heathrow and London Weather centre meteorological data were available (96% of hours) and when the receptor point data were available for the location in question were used.

3.2 Background Concentrations

The total concentration predictions presented in the map report include a proportion of concentration attributed to ‘background’, i.e. pollutants transported into the modelled area. When modelling total concentrations the background data is included in the ADMS-Urban run.

For source apportionment at receptor points a background value was defined. The appropriate hourly sequential background data were used for the same hours as the valid modelled receptor point results. Therefore the average background value varies between receptor points. The same process was carried out when modelling receptor points in the validation and sensitivity study (Carruthers et al., 2003a).

4. Source Apportioned Receptor Points

The source apportioned NO_x and PM_{10} concentrations for each modelled emission year at the 23 AURN receptor locations in London are given in Table 4.1 to 4.6. The value in the total column is the sum of the other columns. These are shown diagrammatically in Figures 4.1 to 4.6. The size of the pie chart indicates the total concentration.

For 1999 the total concentration is the equivalent of the total concentration at the receptor point presented in the validation and sensitivity study for the base case. There is up to 4% difference because the validation and sensitivity study used the December 2001 LAEI and this source apportionment study used the February 2002 LAEI. This does not affect the conclusions of the study.

4.1 Annual Mean NO_x

The total concentrations fall from 1999 to 2005 and again from 2005 to 2010. In all cases the greatest reduction in concentration occurs between 1999 and 2005.

In 1999 the traffic dominates the other sources, particularly at roadside sites. At roadside sites cars are the largest contributor of all of the sources. For the urban background sites the background contribution generally makes up a larger proportion of the total and the other road contribution (which includes minor roads) is often as significant as the car category. For rail, shipping, commercial and domestic gas, other sources and industry the contribution is always below 10%, with the notable exceptions of commercial gas at Bloomsbury and other sources (mainly airport related) at Hillingdon.

By 2005 other sources, shipping, industry, domestic and commercial gas have either not changed or only changed slightly. The other roads contribution has reduced as has the contribution by cars, however traffic is still dominant.

In 2010 the total, background and traffic has reduced further, although traffic is still dominant. The car contribution has reduced enough for it to be similar to the total HGV contribution. The domestic and commercial gas values have increased and are becoming relatively significant. The contribution of other at Hillingdon has reduced, although it is still a larger proportion at this site than any other.

4.2 Annual Mean PM_{10}

The total concentrations fall from 1999 to 2004 and again from 2004 to 2010. With the sole exception of Marylebone Road, the greatest reduction in concentration occurs between 1999 and 2004.

The background makes the dominant contribution to the total PM_{10} concentration at all sites and in all years. This is emphasised by the pie charts in Figure 4.7, which show the source apportioned PM_{10} and $PM_{2.5}$ concentrations at Marylebone Road and Bloomsbury AURN receptor locations. Here the background contribution is shown split into secondary and coarse components (the secondary component arbitrarily subdivided into UK and European contributions). The most significant difference between the source apportionment of PM_{10} and $PM_{2.5}$ is in the relative contribution of the ‘Other B/ground’ category, which represents resuspended material and wind-blown dust. The relative contribution to PM_{10} is more than twice the contribution to $PM_{2.5}$. More details about $PM_{2.5}$ will follow in a later topic report.

In 1999 the traffic dominates the other non-background sources, particularly at roadside sites. Contributions are fairly equal from cars, LGV and HGVs. Taxis are quite significant at some central sites, notably Marylebone Road. Rail, shipping and domestic gas contributions are trivial. Commercial gas, other sources and industry always contribute less than 2.5%.

By 2004 other sources, shipping, industry, domestic and commercial gas have either not changed or only changed slightly. The traffic and the background contributions have both decreased at every site. The majority of the reduction in the total concentration is due to the decrease in either the traffic or the background contribution.

By 2010 rail and shipping still make no contribution to the total concentration, but the contribution from domestic gas, commercial gas and industry at some sites has increased. The background and traffic contributions have decreased further at every site. Again either the decrease in background or the reduction in traffic contribution is mainly responsible for the reduction in the total concentration.

Table 4.1(a) Source Apportioned 1999 Annual Mean NO_x concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	230	18	1	0	4	2	1	5	13	120	1	4	17	27	16
	Camden	206	18	4	0	9	7	2	5	12	70	4	24	14	27	10
	Cromwell Road	270	18	2	0	10	7	2	7	12	104	21	28	23	28	8
	Haringey	111	18	1	0	8	5	2	5	11	27	1	9	6	11	5
	Hounslow	132	18	1	0	5	3	2	10	11	53	0	6	8	9	7
	Marylebone Road	392	19	2	0	9	9	3	5	12	102	35	50	36	79	29
	Southwark Roadside	186	18	1	0	8	7	2	4	10	46	3	25	15	32	14
	Sutton Roadside	76	18	1	0	5	3	1	4	12	18	0	3	3	4	2
	Tower Hamlets	195	19	1	0	9	8	4	4	12	55	3	13	20	36	11
Background Monitoring Sites	Bexley	77	18	1	0	7	4	3	3	13	12	0	3	3	5	5
	Bloomsbury	122	18	2	0	9	13	4	5	12	22	5	12	6	11	4
	Brent	77	18	2	0	6	3	2	5	11	18	0	3	3	4	2
	Bridge Place	110	19	2	0	10	8	4	5	12	19	3	9	5	9	3
	Eltham	86	19	1	0	8	4	4	3	11	17	1	4	4	6	4
	Hackney	113	19	2	0	10	6	4	4	12	25	1	9	6	11	5
	Hillingdon	206	20	1	0	2	1	2	21	15	92	1	6	9	18	19
	Lewisham	118	18	1	0	9	5	3	4	12	27	1	11	7	11	8
	North Kensington	101	18	4	0	9	6	2	7	13	22	1	4	5	7	3
	Southwark Urban Centre	101	18	1	0	10	8	4	5	11	17	2	9	4	8	3
	Sutton Suburban	68	18	1	0	6	3	1	4	12	13	0	3	3	4	2
	Teddington	60	18	1	0	4	2	1	8	12	8	0	1	1	2	1
	Wandsworth	130	19	1	0	8	5	2	7	11	31	2	12	8	17	7
	West London	92	18	2	0	9	6	2	8	12	17	1	5	4	6	3

Table 4.1(b) Source Apportioned 1999 Annual Mean NO_x concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	8	0	0	2	1	0	2	6	52	0	2	7	12	7
	Camden	9	2	0	4	3	1	2	6	34	2	12	7	13	5
	Cromwell Road	7	1	0	4	3	1	3	4	39	8	10	9	10	3
	Haringey	16	1	0	7	5	2	5	10	24	1	8	5	10	5
	Hounslow	14	1	0	4	2	2	8	8	40	0	5	6	7	5
	Marylebone Road	5	1	0	2	2	1	1	3	26	9	13	9	20	7
	Southwark Roadside	10	1	0	4	4	1	2	5	25	2	13	8	17	8
	Sutton Roadside	24	1	0	7	4	1	5	16	24	0	4	4	5	3
	Tower Hamlets	10	1	0	5	4	2	2	6	28	2	7	10	18	6
Background Monitoring Sites	Bexley	23	1	0	9	5	4	4	17	16	0	4	4	6	6
	Bloomsbury	15	2	0	7	11	3	4	10	18	4	10	5	9	3
	Brent	23	3	0	8	4	3	6	14	23	0	4	4	5	3
	Bridge Place	17	2	0	9	7	4	5	11	17	3	8	5	8	3
	Eltham	22	1	0	9	5	5	3	13	20	1	5	5	7	5
	Hackney	17	2	0	9	5	4	4	11	22	1	8	5	10	4
	Hillingdon	10	0	0	1	0	1	10	7	45	0	3	4	9	9
	Lewisham	15	1	0	8	4	3	3	10	23	1	9	6	9	7
	North Kensington	18	4	0	9	6	2	7	13	22	1	4	5	7	3
	Southwark Urban Centre	18	1	0	10	8	4	5	11	17	2	9	4	8	3
	Sutton Suburban	26	1	0	9	4	1	6	18	19	0	4	4	6	3
	Teddington	30	2	0	7	3	2	13	20	13	0	2	2	3	2
	Wandsworth	15	1	0	6	4	2	5	8	24	2	9	6	13	5
	West London	20	2	0	10	7	2	9	13	18	1	5	4	7	3

Table 4.2(a) Source Apportioned 2005 Annual Mean NO_x concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	141	13	1	0	4	2	1	5	9	53	1	4	12	24	12
	Camden	147	13	4	0	9	7	2	5	8	37	4	18	11	22	7
	Cromwell Road	195	13	2	0	10	7	4	6	8	56	21	21	17	23	6
	Haringey	82	13	1	0	8	5	2	4	8	14	1	7	5	9	3
	Hounslow	88	13	1	0	5	3	2	10	7	24	0	5	6	8	5
	Marylebone Road	294	13	2	0	10	10	3	5	8	57	38	38	26	63	20
	Southwark Roadside	136	13	1	0	8	7	3	4	6	24	3	19	11	27	10
	Sutton Roadside	56	13	1	0	6	3	1	4	8	9	0	3	3	4	2
	Tower Hamlets	143	14	1	0	9	8	4	4	8	29	3	10	15	30	8
Background Monitoring Sites	Bexley	58	13	1	0	7	4	3	2	9	6	0	2	2	5	4
	Bloomsbury	94	13	2	0	9	13	4	5	8	11	5	9	4	9	3
	Brent	57	13	2	0	6	3	2	5	7	9	0	3	3	4	1
	Bridge Place	85	14	2	0	10	8	4	5	8	10	3	7	4	8	3
	Eltham	64	14	1	0	8	4	4	3	7	9	1	3	3	5	3
	Hackney	85	14	2	0	10	7	4	4	8	13	1	7	4	9	3
	Hillingdon	134	15	1	0	2	1	2	21	10	40	1	5	6	15	15
	Lewisham	87	13	1	0	9	5	3	4	8	14	1	9	5	9	6
	North Kensington	77	13	4	0	9	7	2	6	8	11	1	3	3	6	2
	Southwark Urban Centre	78	13	1	0	10	8	4	4	7	9	2	7	3	7	2
	Sutton Suburban	50	13	1	0	6	3	1	4	8	7	0	2	2	3	2
	Teddington	46	13	1	0	4	2	1	8	8	4	0	1	1	2	1
	Wandsworth	96	13	1	0	8	5	3	7	7	16	2	9	6	13	5
	West London	71	13	2	0	9	6	3	7	8	9	1	3	3	5	2

Table 4.2(b) Source Apportioned 2005 Annual Mean NO_x concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	9	1	0	3	1	1	4	6	38	1	3	9	17	9
	Camden	9	3	0	6	5	1	3	5	25	3	12	7	15	5
	Cromwell Road	7	1	0	5	4	2	3	4	29	11	11	9	12	3
	Haringey	16	1	0	10	6	2	5	10	17	1	9	6	11	4
	Hounslow	15	1	0	6	3	2	11	8	27	0	6	7	9	6
	Marylebone Road	4	1	0	3	3	1	2	3	19	13	13	9	21	7
	Southwark Roadside	10	1	0	6	5	2	3	4	18	2	14	8	20	7
	Sutton Roadside	23	2	0	11	5	2	7	14	16	0	5	5	7	4
	Tower Hamlets	10	1	0	6	6	3	3	6	20	2	7	10	21	6
Background Monitoring Sites	Bexley	22	2	0	12	7	5	3	16	10	0	3	3	9	7
	Bloomsbury	14	2	0	10	14	4	5	9	12	5	10	4	10	3
	Brent	23	4	0	11	5	4	9	12	16	0	5	5	7	2
	Bridge Place	16	2	0	12	9	5	6	9	12	4	8	5	9	4
	Eltham	22	2	0	13	6	6	5	11	14	2	5	5	8	5
	Hackney	16	2	0	12	8	5	5	9	15	1	8	5	11	4
	Hillingdon	11	1	0	1	1	1	16	7	30	1	4	4	11	11
	Lewisham	15	1	0	10	6	3	5	9	16	1	10	6	10	7
	North Kensington	17	5	0	12	9	3	8	10	14	1	4	4	8	3
	Southwark Urban Centre	17	1	0	13	10	5	5	9	12	3	9	4	9	3
	Sutton Suburban	26	2	0	12	6	2	8	16	14	0	4	4	6	4
	Teddington	28	2	0	9	4	2	17	17	9	0	2	2	4	2
	Wandsworth	14	1	0	8	5	3	7	7	17	2	9	6	14	5
	West London	18	3	0	13	8	4	10	11	13	1	4	4	7	3

Table 4.3(a) Source Apportioned 2010 Annual Mean NO_x concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	107	12	1	0	5	2	1	4	6	36	1	3	8	18	9
	Camden	117	12	4	0	10	7	2	4	6	25	2	14	7	17	5
	Cromwell Road	148	12	2	0	12	8	2	6	5	38	13	17	12	17	4
	Haringey	69	12	1	0	10	5	2	4	5	10	1	5	3	7	2
	Hounslow	71	12	1	0	6	3	1	8	5	16	0	4	4	6	4
	Marylebone Road	223	12	2	0	11	11	3	4	6	38	27	31	17	47	15
	Southwark Roadside	109	12	1	0	10	8	2	3	5	17	2	15	7	20	7
	Sutton Roadside	47	12	1	0	6	3	1	3	6	6	0	2	2	3	1
	Tower Hamlets	115	13	1	0	11	9	4	3	6	20	2	8	10	23	6
Background Monitoring Sites	Bexley	50	12	1	0	8	4	3	2	6	4	0	2	1	3	3
	Bloomsbury	80	12	2	0	11	14	3	4	6	8	3	7	3	6	2
	Brent	49	12	2	0	7	3	2	4	5	6	0	2	2	3	1
	Bridge Place	72	13	2	0	12	9	3	4	6	7	2	6	2	6	2
	Eltham	55	13	1	0	9	5	4	2	5	6	0	2	2	4	2
	Hackney	73	12	2	0	12	7	4	3	6	9	1	5	3	7	2
	Hillingdon	104	14	1	0	3	1	2	18	7	28	0	4	4	11	11
	Lewisham	72	12	1	0	11	6	3	3	5	9	1	7	3	7	4
	North Kensington	66	12	4	0	11	7	2	5	6	7	1	3	2	4	2
	Southwark Urban Centre	67	13	1	0	11	9	3	4	5	6	1	5	2	5	2
	Sutton Suburban	43	12	1	0	7	3	1	3	5	4	0	1	1	2	1
	Teddington	40	12	1	0	5	3	1	7	6	3	0	1	1	1	1
	Wandsworth	78	13	1	0	9	5	2	6	5	11	1	7	4	10	4
	West London	61	12	2	0	11	6	2	6	6	6	1	3	2	4	1

Table 4.3(b) Source Apportioned 2010 Annual Mean NO_x concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	11	1	0	5	2	1	4	6	34	1	3	7	17	8
	Camden	10	3	0	9	6	2	3	5	21	2	12	6	15	4
	Cromwell Road	8	1	0	8	5	1	4	3	26	9	11	8	11	3
	Haringey	17	1	0	14	7	3	6	7	14	1	7	4	10	3
	Hounslow	17	1	0	8	4	1	11	7	23	0	6	6	8	6
	Marylebone Road	5	1	0	5	5	1	2	3	17	12	14	8	21	7
	Southwark Roadside	11	1	0	9	7	2	3	5	16	2	14	6	18	6
	Sutton Roadside	26	2	0	13	6	2	6	13	13	0	4	4	6	2
	Tower Hamlets	11	1	0	10	8	3	3	5	17	2	7	9	20	5
Background Monitoring Sites	Bexley	24	2	0	16	8	6	4	12	8	0	4	2	6	6
	Bloomsbury	15	3	0	14	18	4	5	8	10	4	9	4	8	3
	Brent	24	4	0	14	6	4	8	10	12	0	4	4	6	2
	Bridge Place	18	3	0	17	13	4	6	8	10	3	8	3	8	3
	Eltham	24	2	0	16	9	7	4	9	11	0	4	4	7	4
	Hackney	16	3	0	16	10	5	4	8	12	1	7	4	10	3
	Hillingdon	13	1	0	3	1	2	17	7	27	0	4	4	11	11
	Lewisham	17	1	0	15	8	4	4	7	13	1	10	4	10	6
	North Kensington	18	6	0	17	11	3	8	9	11	2	5	3	6	3
	Southwark Urban Centre	19	1	0	16	13	4	6	7	9	1	7	3	7	3
	Sutton Suburban	28	2	0	16	7	2	7	12	9	0	2	2	5	2
	Teddington	30	3	0	13	8	3	18	15	8	0	3	3	3	3
	Wandsworth	17	1	0	12	6	3	8	6	14	1	9	5	13	5
	West London	20	3	0	18	10	3	10	10	10	2	5	3	7	2

Table 4.4(a) Source Apportioned 1999 Annual Mean PM_{10} concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	30	24	0.03	0	0	0	0.18	0.19	0.56	2.12	0.13	0.13	1.71	1.15	0.48
	Camden	33	24	0.25	0	0	0	0.38	0.24	0.51	2.87	0.59	0.92	1.69	1.51	0.42
	Cromwell Road	38	23	0.10	0	0	0	0.40	0.28	0.51	4.34	3.13	1.25	2.76	1.57	0.34
	Haringey	28	24	0.08	0	0	0	0.32	0.60	0.49	1.03	0.21	0.35	0.73	0.59	0.19
	Hounslow	28	23	0.08	0	0	0	0.40	0.27	0.44	1.16	0.08	0.19	0.87	0.40	0.22
	Marylebone Road	49	23	0.13	0	0	0	0.39	0.25	0.53	5.50	5.47	2.91	4.59	4.92	1.36
	Southwark Roadside	32	23	0.07	0	0	0	0.47	0.23	0.50	1.92	0.47	0.98	1.84	1.87	0.62
	Sutton Roadside	26	24	0.03	0	0	0	0.19	0.18	0.54	0.60	0.07	0.11	0.40	0.23	0.09
	Tower Hamlets	33	23	0.07	0	0	0	0.55	0.23	0.51	2.22	0.49	0.48	2.31	1.95	0.43
Background Monitoring Sites	Bexley	26	24	0.04	0	0	0	0.39	0.15	0.55	0.37	0.06	0.09	0.31	0.27	0.19
	Bloomsbury	29	24	0.10	0	0	0	0.40	0.27	0.56	0.95	0.75	0.59	0.73	0.63	0.14
	Brent	26	24	0.08	0	0	0	0.34	0.19	0.47	0.58	0.05	0.12	0.38	0.22	0.07
	Bridge Place	28	23	0.09	0	0	0	0.46	0.25	0.50	0.72	0.48	0.44	0.58	0.49	0.13
	Eltham	26	24	0.05	0	0	0	0.45	0.17	0.47	0.57	0.09	0.13	0.45	0.30	0.15
	Hackney	28	23	0.09	0	0	0	0.42	0.23	0.51	0.90	0.22	0.34	0.67	0.60	0.17
	Hillingdon	28	24	0.05	0	0	0	0.24	0.39	0.54	1.38	0.08	0.14	0.92	0.64	0.48
	Lewisham	28	23	0.06	0	0	0	0.43	0.20	0.49	0.99	0.23	0.42	0.76	0.58	0.33
	North Kensington	27	24	0.23	0	0	0	0.39	0.26	0.53	0.71	0.14	0.16	0.51	0.34	0.13
	Southwark Urban Centre	27	23	0.08	0	0	0	0.39	0.24	0.49	0.67	0.29	0.36	0.51	0.46	0.12
	Sutton Suburban	25	23	0.03	0	0	0	0.20	0.18	0.51	0.44	0.05	0.09	0.29	0.18	0.08
	Teddington	25	23	0.03	0	0	0	0.18	0.24	0.50	0.23	0.02	0.05	0.15	0.09	0.04
	Wandsworth	29	23	0.07	0	0	0	0.32	0.24	0.48	1.37	0.26	0.50	0.92	0.98	0.30
	West London	26	23	0.11	0	0	0	0.34	0.27	0.51	0.62	0.12	0.18	0.43	0.34	0.11

Table 4.4(b) Source Apportioned 1999 Annual Mean PM_{10} concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	80	0.1	-	-	-	0.6	0.6	1.9	7.1	0.4	0.4	5.7	3.8	1.6
	Camden	73	0.8	-	-	-	1.2	0.7	1.5	8.7	1.8	2.8	5.1	4.6	1.3
	Cromwell Road	61	0.3	-	-	-	1.1	0.7	1.3	11.4	8.2	3.3	7.3	4.1	0.9
	Haringey	86	0.3	-	-	-	1.1	2.1	1.8	3.7	0.8	1.3	2.6	2.1	0.7
	Hounslow	82	0.3	-	-	-	1.4	1.0	1.6	4.1	0.3	0.7	3.1	1.4	0.8
	Marylebone Road	47	0.3	-	-	-	0.8	0.5	1.1	11.2	11.2	5.9	9.4	10.0	2.8
	Southwark Roadside	72	0.2	-	-	-	1.5	0.7	1.6	6.0	1.5	3.1	5.8	5.8	1.9
	Sutton Roadside	92	0.1	-	-	-	0.7	0.7	2.1	2.3	0.3	0.4	1.5	0.9	0.3
	Tower Hamlets	70	0.2	-	-	-	1.7	0.7	1.5	6.7	1.5	1.5	7.0	5.9	1.3
Background Monitoring Sites	Bexley	92	0.2	-	-	-	1.5	0.6	2.1	1.4	0.2	0.3	1.2	1.0	0.7
	Bloomsbury	83	0.3	-	-	-	1.4	0.9	1.9	3.3	2.6	2.0	2.5	2.2	0.5
	Brent	92	0.3	-	-	-	1.3	0.7	1.8	2.2	0.2	0.5	1.5	0.8	0.3
	Bridge Place	82	0.3	-	-	-	1.6	0.9	1.8	2.6	1.7	1.6	2.1	1.8	0.5
	Eltham	92	0.2	-	-	-	1.7	0.7	1.8	2.2	0.3	0.5	1.7	1.2	0.6
	Hackney	82	0.3	-	-	-	1.5	0.8	1.8	3.2	0.8	1.2	2.4	2.1	0.6
	Hillingdon	86	0.2	-	-	-	0.9	1.4	1.9	4.9	0.3	0.5	3.3	2.3	1.7
	Lewisham	82	0.2	-	-	-	1.5	0.7	1.8	3.5	0.8	1.5	2.7	2.1	1.2
	North Kensington	89	0.9	-	-	-	1.4	1.0	2.0	2.6	0.5	0.6	1.9	1.3	0.5
	Southwark Urban Centre	85	0.3	-	-	-	1.4	0.9	1.8	2.5	1.1	1.3	1.9	1.7	0.4
	Sutton Suburban	92	0.1	-	-	-	0.8	0.7	2.0	1.8	0.2	0.4	1.2	0.7	0.3
	Teddington	92	0.1	-	-	-	0.7	1.0	2.0	0.9	0.1	0.2	0.6	0.4	0.2
	Wandsworth	79	0.2	-	-	-	1.1	0.8	1.7	4.7	0.9	1.7	3.2	3.4	1.0
	West London	88	0.4	-	-	-	1.3	1.0	2.0	2.4	0.5	0.7	1.7	1.3	0.4

Table 4.5(a) Source Apportioned 2004 Annual Mean PM_{10} concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	27	22	0.03	0	0	0	0.21	0.18	0.39	1.45	0.10	0.05	1.39	0.67	0.35
	Camden	28	22	0.25	0	0	0	0.36	0.22	0.36	1.79	0.45	0.35	1.20	0.82	0.28
	Cromwell Road	32	22	0.10	0	0	0	0.37	0.26	0.35	2.70	2.42	0.41	1.96	0.85	0.23
	Haringey	25	22	0.08	0	0	0	0.35	0.59	0.34	0.64	0.16	0.13	0.52	0.32	0.13
	Hounslow	25	22	0.08	0	0	0	0.44	0.26	0.33	0.77	0.06	0.08	0.69	0.23	0.16
	Marylebone Road	38	22	0.13	0	0	0	0.38	0.23	0.36	3.28	4.38	0.80	3.06	2.56	0.87
	Southwark Roadside	28	22	0.07	0	0	0	0.41	0.21	0.34	1.25	0.36	0.38	1.33	1.03	0.42
	Sutton Roadside	24	22	0.03	0	0	0	0.21	0.17	0.37	0.39	0.05	0.05	0.29	0.13	0.07
	Tower Hamlets	28	22	0.07	0	0	0	0.53	0.21	0.35	1.41	0.37	0.18	1.65	1.07	0.29
Background Monitoring Sites	Bexley	24	22	0.04	0	0	0	0.42	0.14	0.38	0.24	0.04	0.04	0.23	0.15	0.13
	Bloomsbury	25	22	0.10	0	0	0	0.38	0.25	0.37	0.58	0.57	0.17	0.50	0.33	0.09
	Brent	24	22	0.08	0	0	0	0.53	0.18	0.33	0.37	0.04	0.05	0.28	0.13	0.05
	Bridge Place	25	22	0.09	0	0	0	0.45	0.23	0.34	0.46	0.37	0.14	0.41	0.27	0.09
	Eltham	24	22	0.05	0	0	0	0.47	0.16	0.33	0.37	0.07	0.05	0.33	0.17	0.10
	Hackney	25	22	0.09	0	0	0	0.41	0.21	0.35	0.56	0.17	0.12	0.47	0.33	0.12
	Hillingdon	26	22	0.05	0	0	0	0.26	0.39	0.37	0.99	0.06	0.06	0.81	0.37	0.37
	Lewisham	25	22	0.06	0	0	0	0.40	0.18	0.34	0.62	0.17	0.16	0.54	0.32	0.22
	North Kensington	25	22	0.23	0	0	0	0.37	0.24	0.38	0.45	0.10	0.06	0.38	0.19	0.09
	Southwark Urban Centre	24	22	0.08	0	0	0	0.38	0.22	0.34	0.42	0.22	0.13	0.36	0.25	0.08
	Sutton Suburban	23	22	0.03	0	0	0	0.22	0.16	0.35	0.28	0.04	0.04	0.21	0.10	0.05
	Teddington	23	22	0.03	0	0	0	0.20	0.24	0.34	0.15	0.02	0.02	0.11	0.05	0.03
	Wandsworth	25	22	0.07	0	0	0	0.33	0.22	0.33	0.83	0.20	0.19	0.64	0.52	0.20
	West London	24	22	0.11	0	0	0	0.33	0.25	0.35	0.39	0.09	0.06	0.31	0.18	0.07

Table 4.5(b) Source Apportioned 2004 Annual Mean PM_{10} concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	81	0.1	-	-	-	0.8	0.7	1.4	5.4	0.4	0.2	5.1	2.5	1.3
	Camden	79	0.9	-	-	-	1.3	0.8	1.3	6.4	1.6	1.3	4.3	2.9	1.0
	Cromwell Road	69	0.3	-	-	-	1.2	0.8	1.1	8.4	7.6	1.3	6.1	2.7	0.7
	Haringey	88	0.3	-	-	-	1.4	2.4	1.4	2.6	0.6	0.5	2.1	1.3	0.5
	Hounslow	88	0.3	-	-	-	1.8	1.0	1.3	3.1	0.2	0.3	2.8	0.9	0.6
	Marylebone Road	58	0.3	-	-	-	1.0	0.6	0.9	8.6	11.5	2.1	8.1	6.7	2.3
	Southwark Roadside	79	0.3	-	-	-	1.5	0.8	1.2	4.5	1.3	1.4	4.8	3.7	1.5
	Sutton Roadside	92	0.1	-	-	-	0.9	0.7	1.5	1.6	0.2	0.2	1.2	0.5	0.3
	Tower Hamlets	79	0.3	-	-	-	1.9	0.8	1.3	5.0	1.3	0.6	5.9	3.8	1.0
Background Monitoring Sites	Bexley	92	0.2	-	-	-	1.8	0.6	1.6	1.0	0.2	0.2	1.0	0.6	0.5
	Bloomsbury	88	0.4	-	-	-	1.5	1.0	1.5	2.3	2.3	0.7	2.0	1.3	0.4
	Brent	92	0.3	-	-	-	2.2	0.8	1.4	1.5	0.2	0.2	1.2	0.5	0.2
	Bridge Place	88	0.4	-	-	-	1.8	0.9	1.4	1.8	1.5	0.6	1.6	1.1	0.4
	Eltham	92	0.2	-	-	-	2.0	0.7	1.4	1.5	0.3	0.2	1.4	0.7	0.4
	Hackney	88	0.4	-	-	-	1.6	0.8	1.4	2.2	0.7	0.5	1.9	1.3	0.5
	Hillingdon	85	0.2	-	-	-	1.0	1.5	1.4	3.8	0.2	0.2	3.1	1.4	1.4
	Lewisham	88	0.2	-	-	-	1.6	0.7	1.4	2.5	0.7	0.6	2.2	1.3	0.9
	North Kensington	88	0.9	-	-	-	1.5	1.0	1.5	1.8	0.4	0.2	1.5	0.8	0.4
	Southwark Urban Centre	92	0.3	-	-	-	1.6	0.9	1.4	1.8	0.9	0.5	1.5	1.0	0.3
	Sutton Suburban	96	0.1	-	-	-	1.0	0.7	1.5	1.2	0.2	0.2	0.9	0.4	0.2
	Teddington	96	0.1	-	-	-	0.9	1.0	1.5	0.7	0.1	0.1	0.5	0.2	0.1
	Wandsworth	88	0.3	-	-	-	1.3	0.9	1.3	3.3	0.8	0.8	2.6	2.1	0.8
	West London	92	0.5	-	-	-	1.4	1.0	1.5	1.6	0.4	0.3	1.3	0.8	0.3

Table 4.6(a) Source Apportioned 2010 Annual Mean PM_{10} concentration ($\mu g/m^3$)

		TOTAL	Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	22	19	0.03	0	0.03	0.02	0.18	0.11	0.21	0.86	0.05	0.02	0.94	0.30	0.16
	Camden	23	19	0.25	0	0.07	0.05	0.38	0.15	0.19	1.01	0.22	0.11	0.78	0.37	0.12
	Cromwell Road	25	19	0.10	0	0.08	0.05	0.40	0.18	0.19	1.51	1.15	0.13	1.26	0.38	0.10
	Haringey	21	19	0.08	0	0.07	0.04	0.31	0.52	0.18	0.36	0.08	0.04	0.34	0.14	0.06
	Hounslow	21	19	0.08	0	0.04	0.02	0.40	0.17	0.17	0.46	0.03	0.02	0.47	0.10	0.07
	Marylebone Road	28	19	0.13	0	0.07	0.07	0.39	0.16	0.19	1.73	2.30	0.26	1.91	1.09	0.39
	Southwark Roadside	21	19	0.07	0	0.07	0.06	0.47	0.14	0.18	0.19	0.06	0.02	0.19	0.08	0.03
	Sutton Roadside	20	19	0.03	0	0.04	0.02	0.19	0.11	0.20	0.22	0.03	0.01	0.19	0.06	0.03
	Tower Hamlets	23	19	0.07	0	0.07	0.06	0.55	0.14	0.19	0.82	0.18	0.06	1.09	0.49	0.13
Background Monitoring Sites	Bexley	20	19	0.04	0	0.05	0.03	0.39	0.09	0.20	0.14	0.02	0.01	0.15	0.07	0.06
	Bloomsbury	21	19	0.10	0	0.07	0.10	0.40	0.17	0.20	0.32	0.27	0.05	0.32	0.14	0.04
	Brent	20	19	0.08	0	0.05	0.02	0.34	0.11	0.18	0.21	0.02	0.01	0.18	0.06	0.02
	Bridge Place	21	19	0.09	0	0.08	0.06	0.46	0.16	0.18	0.25	0.18	0.04	0.26	0.12	0.04
	Eltham	21	19	0.05	0	0.06	0.03	0.45	0.11	0.18	0.21	0.03	0.01	0.22	0.07	0.05
	Hackney	21	19	0.09	0	0.07	0.05	0.42	0.15	0.19	0.32	0.08	0.04	0.31	0.15	0.05
	Hillingdon	22	19	0.05	0	0.02	0.01	0.23	0.26	0.20	0.63	0.03	0.02	0.57	0.17	0.17
	Lewisham	21	19	0.06	0	0.07	0.04	0.42	0.12	0.18	0.35	0.08	0.05	0.35	0.14	0.10
	North Kensington	21	19	0.23	0	0.07	0.05	0.39	0.16	0.21	0.25	0.05	0.02	0.24	0.08	0.04
	Southwark Urban Centre	21	19	0.08	0	0.07	0.06	0.39	0.15	0.18	0.24	0.11	0.04	0.23	0.11	0.03
	Sutton Suburban	20	19	0.03	0	0.04	0.02	0.19	0.11	0.19	0.16	0.02	0.01	0.14	0.05	0.02
	Teddington	20	19	0.03	0	0.03	0.02	0.18	0.14	0.18	0.08	0.01	0.01	0.07	0.02	0.01
	Wandsworth	21	19	0.07	0	0.06	0.04	0.32	0.15	0.18	0.45	0.09	0.06	0.41	0.23	0.09
	West London	21	19	0.11	0	0.07	0.04	0.34	0.18	0.19	0.22	0.04	0.02	0.20	0.08	0.03

Table 4.6(b) Source Apportioned 2010 Annual Mean PM_{10} concentration (percentage)

		Background	Rail	Shipping	Domestic Gas	Commercial Gas	Industry	Other	Other Road	Car	Taxi	Bus & Coach	LGV	Rigid HGV	Articulated HGV
Roadside Monitoring Sites	A3	86	0.1	-	0.1	0.1	0.8	0.5	1.0	3.9	0.2	0.1	4.3	1.4	0.7
	Camden	83	1.1	-	0.3	0.2	1.7	0.7	0.8	4.4	1.0	0.5	3.4	1.6	0.5
	Cromwell Road	76	0.4	-	0.3	0.2	1.6	0.7	0.8	6.0	4.6	0.5	5.0	1.5	0.4
	Haringey	90	0.4	-	0.3	0.2	1.5	2.5	0.9	1.7	0.4	0.2	1.6	0.7	0.3
	Hounslow	90	0.4	-	0.2	0.1	1.9	0.8	0.8	2.2	0.1	0.1	2.2	0.5	0.3
	Marylebone Road	68	0.5	-	0.3	0.3	1.4	0.6	0.7	6.2	8.2	0.9	6.8	3.9	1.4
	Southwark Roadside	90	0.3	-	0.3	0.3	2.2	0.7	0.9	0.9	0.3	0.1	0.9	0.4	0.1
	Sutton Roadside	95	0.2	-	0.2	0.1	1.0	0.6	1.0	1.1	0.2	0.1	1.0	0.3	0.2
	Tower Hamlets	83	0.3	-	0.3	0.3	2.4	0.6	0.8	3.6	0.8	0.3	4.7	2.1	0.6
Background Monitoring Sites	Bexley	95	0.2	-	0.3	0.2	2.0	0.5	1.0	0.7	0.1	0.1	0.8	0.4	0.3
	Bloomsbury	90	0.5	-	0.3	0.5	1.9	0.8	1.0	1.5	1.3	0.2	1.5	0.7	0.2
	Brent	95	0.4	-	0.3	0.1	1.7	0.6	0.9	1.1	0.1	0.1	0.9	0.3	0.1
	Bridge Place	90	0.4	-	0.4	0.3	2.2	0.8	0.9	1.2	0.9	0.2	1.2	0.6	0.2
	Eltham	90	0.2	-	0.3	0.1	2.1	0.5	0.9	1.0	0.1	0.0	1.0	0.3	0.2
	Hackney	90	0.4	-	0.3	0.2	2.0	0.7	0.9	1.5	0.4	0.2	1.5	0.7	0.2
	Hillingdon	86	0.2	-	0.1	0.0	1.0	1.2	0.9	2.9	0.1	0.1	2.6	0.8	0.8
	Lewisham	90	0.3	-	0.3	0.2	2.0	0.6	0.9	1.7	0.4	0.2	1.7	0.7	0.5
	North Kensington	90	1.1	-	0.3	0.2	1.9	0.8	1.0	1.2	0.2	0.1	1.1	0.4	0.2
	Southwark Urban Centre	90	0.4	-	0.3	0.3	1.9	0.7	0.9	1.1	0.5	0.2	1.1	0.5	0.1
	Sutton Suburban	95	0.2	-	0.2	0.1	1.0	0.6	1.0	0.8	0.1	0.1	0.7	0.3	0.1
	Teddington	95	0.2	-	0.2	0.1	0.9	0.7	0.9	0.4	0.1	0.1	0.4	0.1	0.1
	Wandsworth	90	0.3	-	0.3	0.2	1.5	0.7	0.9	2.1	0.4	0.3	2.0	1.1	0.4
	West London	90	0.5	-	0.3	0.2	1.6	0.9	0.9	1.0	0.2	0.1	1.0	0.4	0.1

5. Source Apportioned Contour Maps

The source apportioned annual mean contour maps of NO_x and PM_{10} concentration modelled using ADMS-Urban over the Greater London area are presented in this section. The contour colour varies from greys, blues and greens through yellow to reds and purples indicating increasing pollutant concentration. For PM_{10} maps, which have associated air quality objectives, the yellow contour has been designated to indicate concentrations exceeding the London standard for 2010.

5.1 Annual Mean NO_x by Source

Figures 5.1, 5.2 and 5.3 show the annual mean NO_x concentration by source category for 1999, 2005 and 2010, respectively.

(a) Total NO_x

The 1999 annual mean total NO_x map shows how the concentration of NO_x varies across the modelled area. The highest contours are clearly associated with central London, the busiest roads and Heathrow airport. In the centre of London, approximately the area of the congestion charging zone, the concentration is above 100μg/m^3 everywhere. The maps modelled for 2005 and 2010 show that the areas of high concentration are predicted to reduce in area with time.

The total NO_x map is made up of the other seven maps on the page: traffic, rail, shipping, domestic gas, commercial gas, industrial and other sources, plus the background concentration.

(b) Traffic (Major and Minor Roads)

For all years the traffic is clearly the biggest contributor to the total NO_x. An area of higher concentration in the centre of London and along the busiest roads exceeds 60μg/m^3 in 1999. There is less area exceeding this threshold in 2005 and very little by 2010.

(c) and (d) Rail and Shipping

The concentration of NO_x due to rail and shipping does not exceed 5μg/m^3 for any year anywhere in London. These are clearly not major contributors.

(e) and (f) Domestic and Commercial Gas

The contribution by domestic and commercial gas use to the total annual mean NO_x is predicted to increase from 1999 to 2010. As the contribution by other sources is predicted to reduce, their proportional contribution is becoming increasingly significant in future years. In fact by 2010 commercial gas is predicted to be as polluting as traffic in some parts of central London.

(g) Industrial

The industrial emissions are the same for 1999 and 2005 and some emissions are removed from the 2010 emissions inventory. As such, the 1999 and 2005 maps are the same, showing generally low contributions, below 5μg/m^3 across most of London, with the local concentrations around some emission locations being relatively significant. Some reduction in concentration is seen along the north of the river by 2010.

(h) Other

The most significant feature in the 'other' category is Heathrow. It should be noted that the emissions data for Heathrow is relatively low resolution for the importance of the emission. Accordingly, in the vicinity of Heathrow the modelling has been carried out at a lower resolution than for other areas of high concentration, such as central London.

The footprint due to Heathrow can be seen very clearly on the source apportioned maps and also in the total NO_x maps. The concentration is seen to reduce in future years to below 80μg/m^3. It is still a significant contributor in that locality.

5.2 Annual Mean NO_x by Traffic

Figures 5.4, 5.5 and 5.6 show the annual mean NO_x concentration by traffic category for 1999, 2005 and 2010, respectively.

(a) and (b) Major Roads and Other Roads

The major roads and other roads are the two components in the traffic category on the sources map. Where major roads emissions were supplied explicitly, they were modelled explicitly. Other major roads that were not supplied explicitly and minor roads were combined into the other roads category. Major roads are clearly more significant than other roads across the majority of London in all three years. The detail in the maps also shows the busiest roads. Both sets of maps show a reduction in the concentration due to these categories in future years.

The major roads NO_x map is made up of the other six maps on the page: car, taxi, bus and coach, LGV, rigid HGV and articulated HGV.

(c) Cars

In 1999 cars are the major contribution to the major road category. On some of the busiest roads the concentration due to cars alone exceeds 100μg/m^3. The areas of high concentration reduce in future years. These areas tend to be along the busiest roads and not in central London. Concentrations due to cars do not exceed 80μg/m^3 by 2010.

(d) Taxi

In general the contribution due to taxis is low, below 5μg/m^3 over most of London. However, there are some areas of slightly elevated concentration in central London, where the worst total NO_x concentrations are located and there are most likely to be pollution problems. The contribution from taxis reduces in future years.

(e) Bus and Coach

As for taxis, the bus and coach contribution is below 5μg/m^3 over most of London. However, there are some areas of slightly elevated concentration in central London and along main roads. Again, this category is contributing most where concentrations of NO_x are highest. The contribution reduces in future years.

(f) LGVs

The LGV maps show some elevated concentration along the busier roads and in the centre. It is not as significant as the car, bus and coach or HGV contributions. It decreases in future years.

(g) and (h) Rigid and articulated HGVs

Rigid and articulated HGVs have been separated in the maps. The contribution from rigid HGVs tends to be concentrated towards central London, where it is almost as significant as the contribution from cars. Articulated HGV concentrations tend to be associated with the busy roads not in central London. For both categories the contribution reduces in future years.

5.3 Annual Mean PM_{10} by Source

Figures 5.7, 5.8 and 5.9 show the annual mean PM_{10} concentration by source category for 1999, 2004 and 2010, respectively.

(a) Total PM_{10}

The 1999 annual mean total PM_{10} map shows how the concentration of PM_{10} varies across the modelled area. As for NO_x, the highest contours are associated with central London, the busiest roads and Heathrow airport.

All of the mapped concentration is below the UK 2004 air quality standard (40µg/m^3), but above the London 2010 air quality standard (23µg/m^3). The maps modelled for 2005 and 2010 show that the areas of high concentration are predicted to reduce in size with time until the area that exceeds the London 2010 air quality standard is less than 1% in the target year of 2010.

Each total PM_{10} map is made up of the other seven maps on the page: traffic, rail, shipping, domestic gas, commercial gas, industrial and other sources, plus the background concentration. At 23µg/m^3, 22µg/m^3 and 19µg/m^3 for 1999, 2004 and 2010, respectively, the background concentration is by far the most significant proportion of the total for PM_{10}. As the background is close to the threshold of the 2010 air quality standard, very low contribution by local sources will cause it to be exceeded.

The following sections discuss the breakdown of the non-background sources.

(b) Traffic (Major and Minor Roads)

Traffic is biggest contributor of the non-background sources over most of London. Along the busiest roads some concentrations exceed 23µg/m^3 in 1999 due to traffic alone. By 2004 and 2010 there are no locations exceeding this threshold.

(c) to (f) Rail, Shipping, Domestic and Commercial Gas

The concentration of PM_{10} due to rail is generally below 0.1µg/m^3 except over some of the busiest routes in the West of London, which approach 0.5µg/m^3. This is the same for all years considered. The concentration due to shipping, commercial gas and domestic gas does not exceed 0.1µg/m^3 for any year anywhere in London.

As for NO_x these are clearly not major contributors.

(g) Industrial

The industrial emissions show distinct footprints. Assumptions from the emissions inventory for some processes in 2004 increase the footprints. These assumptions were not made for 2010. In summary, there are generally low contributions, below 0.5µg/m^3 across most of London, with the local concentrations around some emission locations approaching 5µg/m^3. There is some reduction in concentration by 2010 associated with the closure of some processes.

(h) Other

As for NO_x, the most significant feature in the ‘other’ category is the Heathrow footprint, which can be seen very clearly on the source apportioned maps and also detected in the total PM_{10} maps for 1999 and 2004. The areas of concentration approaching 5µg/m^3 decrease in future years.

5.4 Annual Mean PM_{10} by Traffic

Figures 5.10, 5.11 and 5.12 show the annual mean PM_{10} concentration by traffic category for 1999, 2004 and 2010, respectively.

(a) and (b) Major Roads and Other Roads

PM_{10} due to major roads are more significant than other roads across the majority of London in all three years. In some of the outer regions, major and other roads are of comparable concentrations. The detail in the maps also shows the busiest roads. Concentrations in both sets of maps decrease in future years.

(c) Cars

In 1999 cars are the major contribution to the major road category. However, nowhere do cars alone contribute more than 5µg/m^3. The areas of higher concentration reduce in future years.

(d) Taxi

In general the contribution due to taxis is low, below 0.5µg/m^3 over most of London. However, in central London, where the worst total PM_{10} concentrations are located the contribution approaches 5µg/m^3 in some locations. The area decreases in future years.

(e) Bus and Coach

As for taxis, bus and coach contribution is below 0.5µg/m^3 over most of London. However, there are some areas of up to 5µg/m^3 in central London and along main roads. Again, this category is contributing most where concentrations of PM_{10} are highest. The contribution reduces in future years.

(f) LGVs

Contribution to PM_{10} concentration by LGVs is almost as significant as that by cars in 1999. It also reduces in future years but not as much as the car contribution, until it is approximately equal in 2004 and them more significant in 2010.

(g) and (h) Rigid and articulated HGVs

The contribution from rigid HGVs tends to be concentrated towards central London, where it is almost as significant as the contribution from cars in 1999. As it reduces in future years it becomes proportionately less significant than the car contribution. Articulated HGV concentrations tend to be associated with busy roads not in central London. It also decreases in future years.

6. Conclusions

Apportionment of modelled concentrations to emission sources for receptor points and contour maps of London results in the following conclusions.

6.1 Annual Mean NO_x

The **UK 2005 annual mean NO_2** air quality standard (40µg/m^3) and the **EU 2010 annual mean NO_2** air quality standard (40µg/m^3) are likely to be breached across substantial areas of London in the target years (Blair et al., 2003).

NO_2 concentration is predicted from the dispersion of NO_x emissions and the effect of atmospheric chemistry on its components. As a result the modelling must be based on a complete set of emissions to fully represent the atmospheric conditions. Therefore it is not possible to model NO_2

concentrations using emissions from individual sources. However, source apportionment for NO_x is possible and can provide a valuable insight into which are the most significant sources of NO_x and therefore, by implication, NO_2. It will then be possible to target emission reductions in the most beneficial categories. The impact of NO_x emissions reductions on NO2 concentrations can be predicted when an emission reduction scenario has been defined.

The annual mean background NO_x has been calculated as $19\mu g/m^3$, $15\mu g/m^3$ and $13\mu g/m^3$ in 1999, 2005 and 2010, respectively. This can be a significant proportion of the total, as much as a third, particularly where the total concentration of NO_x tends to be lower, such as at locations more remote from busy roads.

Rail and shipping are not major contributors to the concentration due to non-background sources.

The modelling has indicated that the industrial and 'other' categories (mainly Heathrow emissions) can be significant in the area around the location. However, the industrial predictions were based on emissions data that had some potentially extreme assumptions and the 'other' predictions were based on emissions data with low resolution. It is likely that improved emissions data would reduce the predicted importance of these emission sources. This is advisable before further controls are considered for these sources, if only to help quantify what improvements might be expected if emission reductions are made.

The contribution due to domestic gas and commercial gas increases in future years. As the contribution from the other sources tends to decrease with time, the gas sources become increasingly significant.

Overall cars make the most significant traffic derived contribution in all years. Some of the busiest roads have concentrations of over $100\mu g/m^3$ due to cars alone. These are the locations where the NO_2 standard is most likely to be breached so reduction in emissions due to cars would be highly beneficial. However, there may not be any more potential to reduce emissions from cars further.

The highest concentrations due to rigid HGVs are concentrated towards central London and those due to articulated HGVs are concentrated on the busiest roads outside central London. In both cases they can be as much or more than the car concentrations. Again, these are the areas most likely to breach the NO_2 air quality standard and reduction in the NO_x emissions due to HGVs would be helpful to achieve the standard.

Although the contribution by the LGV, taxi, bus and coach categories is relatively less significant, the contribution is highest in the locations with higher total concentrations, thus they contribute most in the most sensitive areas

6.2 Annual Mean PM_{10}

Assuming a year of unexceptional meteorological data occurs in 2005, the **UK 2005 annual mean PM_{10}** air quality standard ($40\mu g/m^3$) should not be breached. Controls on particular PM_{10} emission sources are unlikely to be driven by this standard.

Assuming a year of standard meteorological data occurs in 2010, breaches of the **London 2010 annual mean PM_{10}** air quality standard ($23\mu g/m^3$) is predicted to be limited to the busiest roads in central London. The projected annual average background, i.e. pollutants transported into the modelled area, for this year is $19\mu g/m^3$, which leaves a margin of only $4\mu g/m^3$ for contributions from local sources before the standard is breached. There is an even smaller margin of $1\mu g/m^3$ between the background and the **EU 2010 annual mean PM_{10}** air quality standard ($20\mu g/m^3$).

If 2010 is a worst case meteorological year the background concentration could be as much as $23\mu g/m^3$. Thus there would be no margin for contribution by any local sources without breaching the London standard and the background alone will exceed the EU standard.

The London 2010 standard will drive any policy decisions on PM_{10} emission reduction. Although the emissions from the various non-background sources are generally not large, their control is imperative to avoid breaching the air quality standard.

Rail, shipping, domestic gas and commercial gas are not major contributors to the concentration due to non-background sources and controls focussed on these are unlikely to deliver the required improvements. However, it should be noted that the contribution from domestic and commercial gas increases in future years.

As for NO_x, industrial and 'other' categories can be significant in the area around the location. Again it is likely that improved emissions data would reduce the predicted importance of these emission sources.

Traffic is the largest contributor to the total annual mean PM_{10} concentration. Cars, LGVs and HGVs have approximately equal importance. These three categories have roughly the following order of significance in 1999:

$$\text{CARS} \geq \text{HGVs} \geq \text{LGVs},$$

but the LGV contribution decreases least rapidly and HGV most rapidly resulting in the following order of significance in 2010:

$$\text{LGVs} \approx \text{CARS} \geq \text{HGVs}.$$

Although the contribution by the taxi, bus and coach categories is relatively less significant, the contribution is highest in the locations with higher total concentrations, thus they contribute most in the most sensitive areas.

6.3 Summary of Conclusions

- Controls on NO_x emissions from cars and HGVs are most likely to result in the greatest improvements in NO_2 concentrations;
- Controls on NO_x and PM_{10} emissions from LGVs, taxis, buses and coaches may be helpful in targeting specific 'hot spots' on the busiest roads and central London;
- Controls on PM_{10} emissions from LGVs, cars and HGVs are most likely to result in the greatest improvements in PM_{10} concentrations;
- Controls on PM_{10} emissions from taxis, buses and coaches may be helpful in targeting specific 'hot spots' on the busiest roads located in central London;
- It may be necessary to reduce NO_x and PM_{10} emissions from industrial and 'other' sources, but improved emissions data would help to decide how much.

7. Acknowledgements

This report was prepared under contract Number EPG 1/3/176 for DEFRA, National Assembly for Wales, The Scottish Executive, and the Department of the Environment, Northern Ireland.

8. References

TOPIC REPORTS

Carruthers, D.J., Blair, J.W., Johnson, K.L. (2002a) Validation and Sensitivity Study of ADMS-Urban for London, Cambridge Environmental Research Consultants **TR-0191**

Carruthers, D.J., Blair, J.W., Johnson, K.L. (2002b) Comparison of ADMS-Urban, NETCEN and ERG Air Quality Predictions for London, Cambridge Environmental Research Consultants **TR-0232**

Blair, J.W., Johnson, K.L., Carruthers, D.J. (2003) Modelling Air Quality for London using ADMS-Urban, Cambridge Environmental Research Consultants **TR-0314**

AIR QUALITY OBJECTIVES

DETR, *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working Together for Clean Air,* January 2000

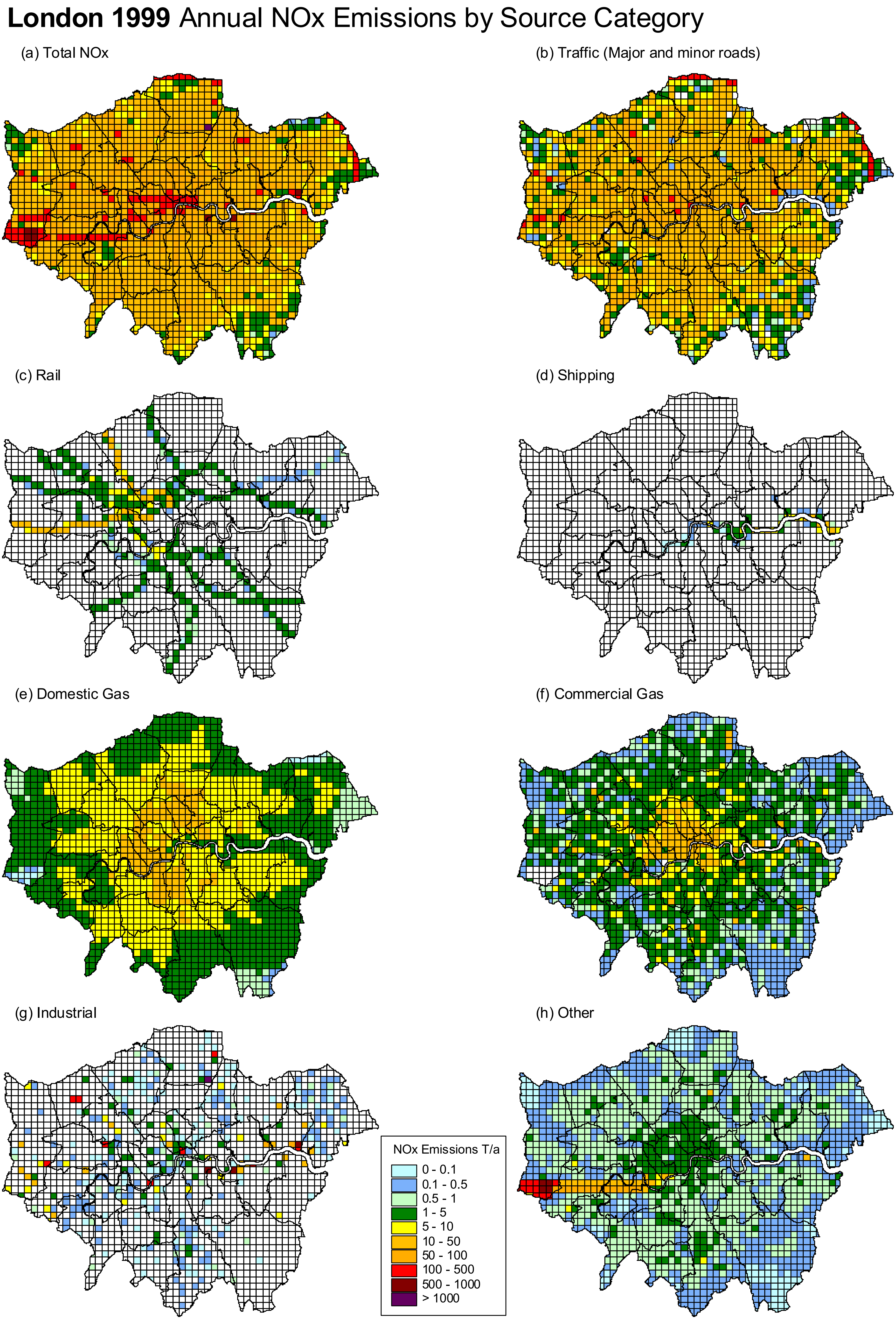
London 1999 Annual NOx Emissions by Source Category
(a) Total NOx
(b) Traffic (Major and minor roads)
(c) Rail
(d) Shipping
(e) Domestic Gas
(f) Commercial Gas
(g) Industrial
(h) Other
NOx Emissions T/a
0 - 0.1
0.1 - 0.5
0.5 - 1
1 - 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 1000
> 1000

FIGURE 2.1

London 2005 Annual NOx Emissions by Source Category

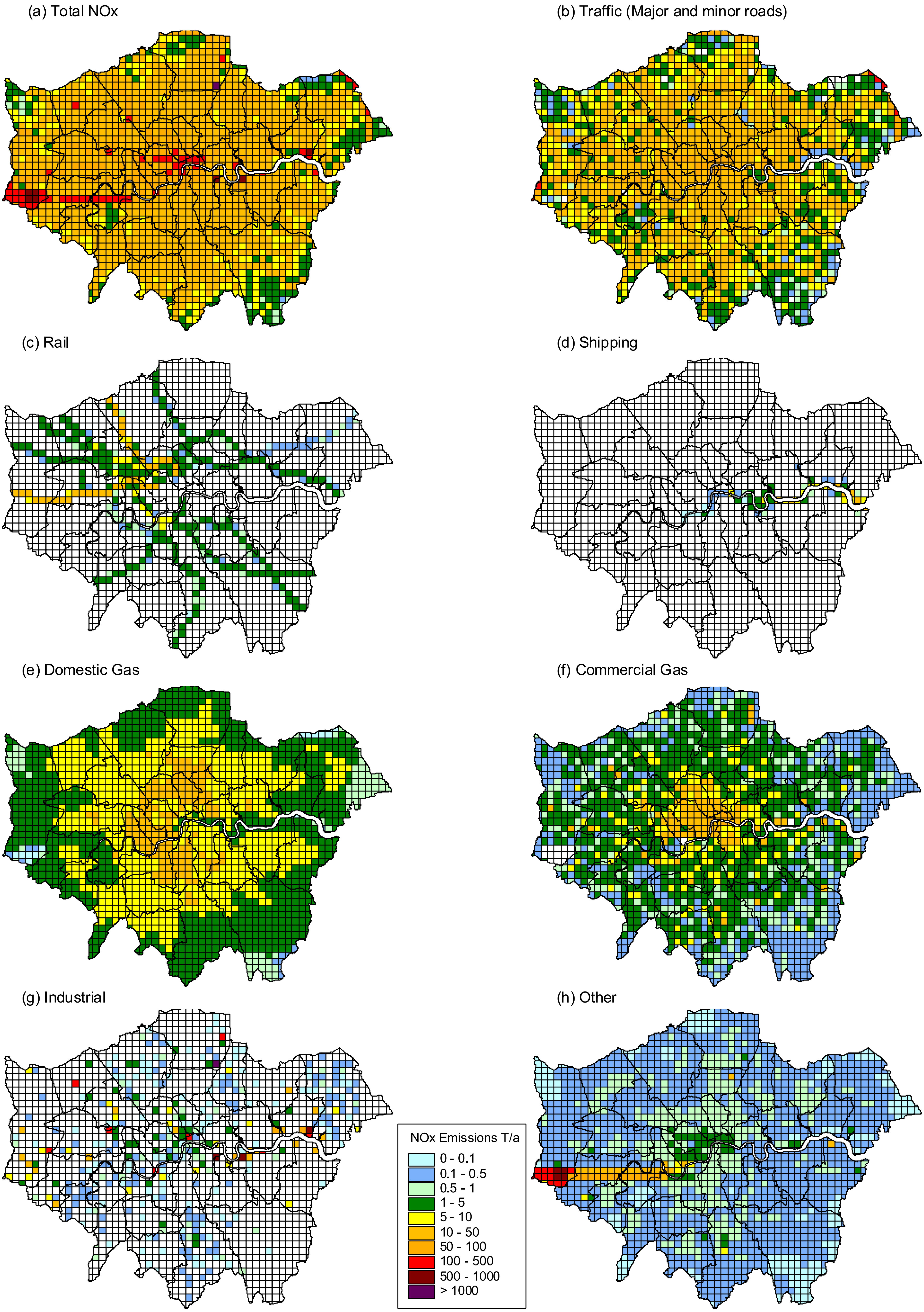

FIGURE 2.2

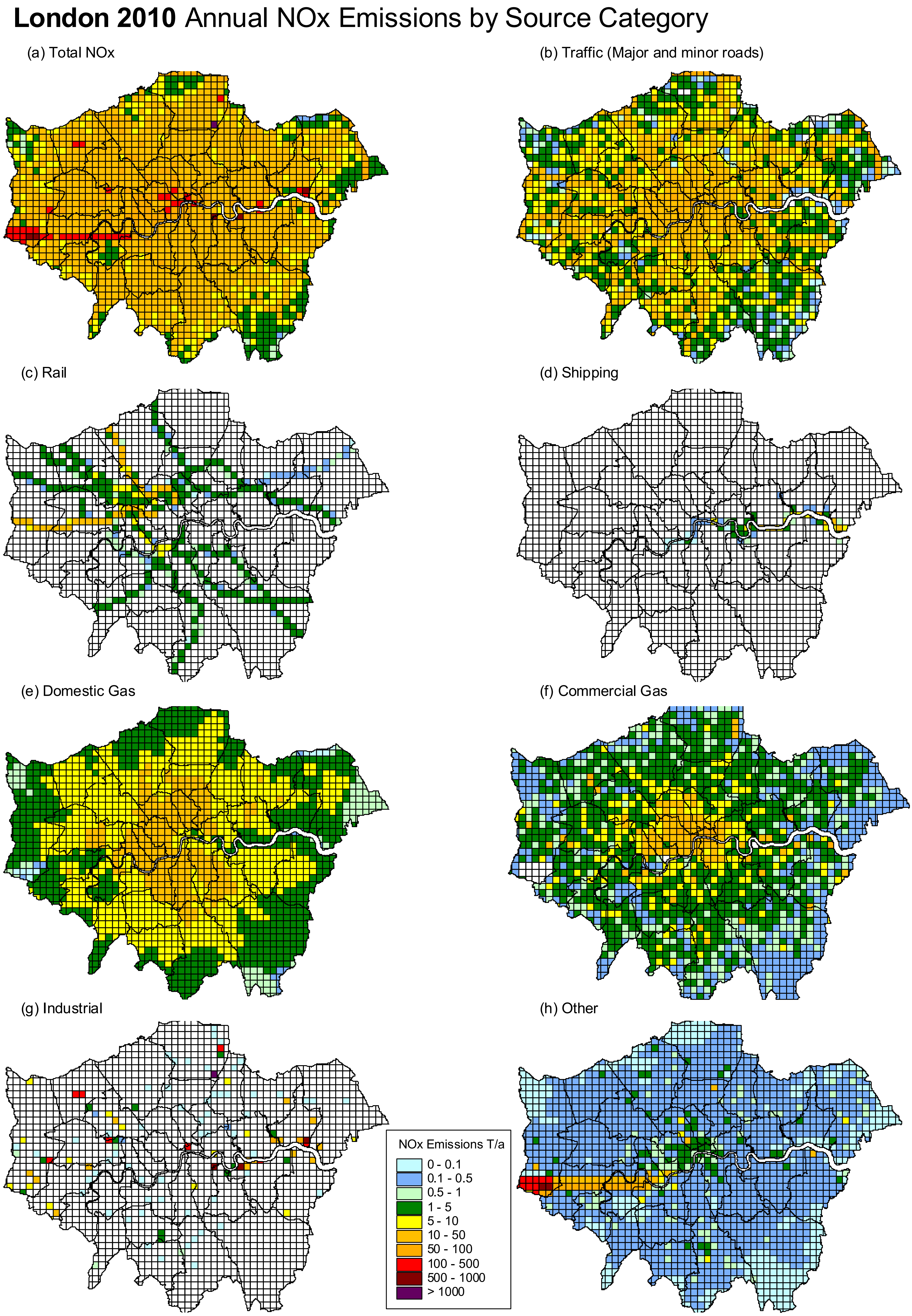
London 2010 Annual NOx Emissions by Source Category
(a) Total NOx
(b) Traffic (Major and minor roads)
(c) Rail
(d) Shipping
(e) Domestic Gas
(f) Commercial Gas
(g) Industrial
(h) Other
NOx Emissions T/a
0 - 0.1
0.1 - 0.5
0.5 - 1
1 - 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 1000
> 1000

FIGURE 2.3

London 1999 Annual NOx Emissions by Traffic Category

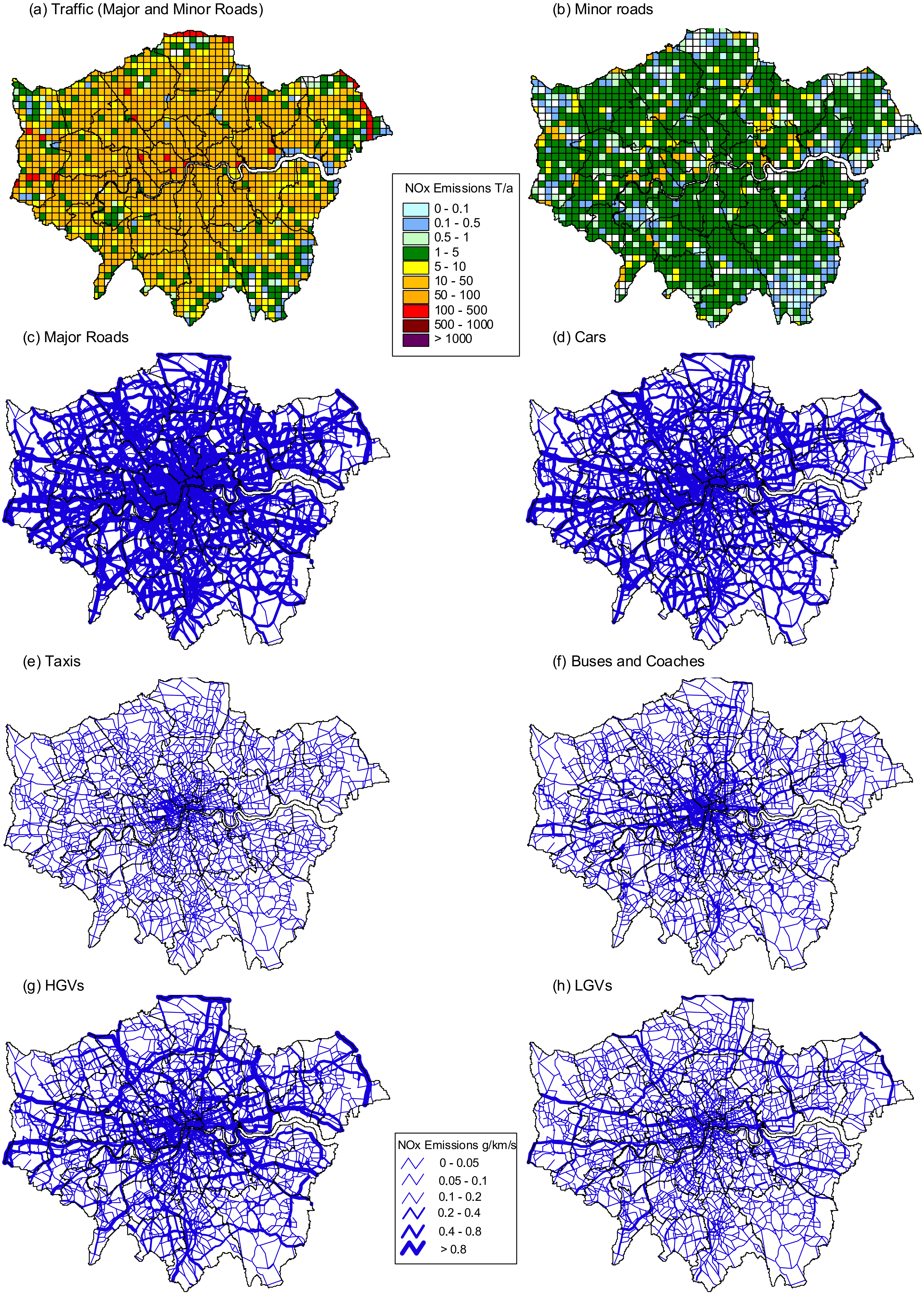

FIGURE 2.4

London 2005 Annual NOx Emissions by Traffic Category

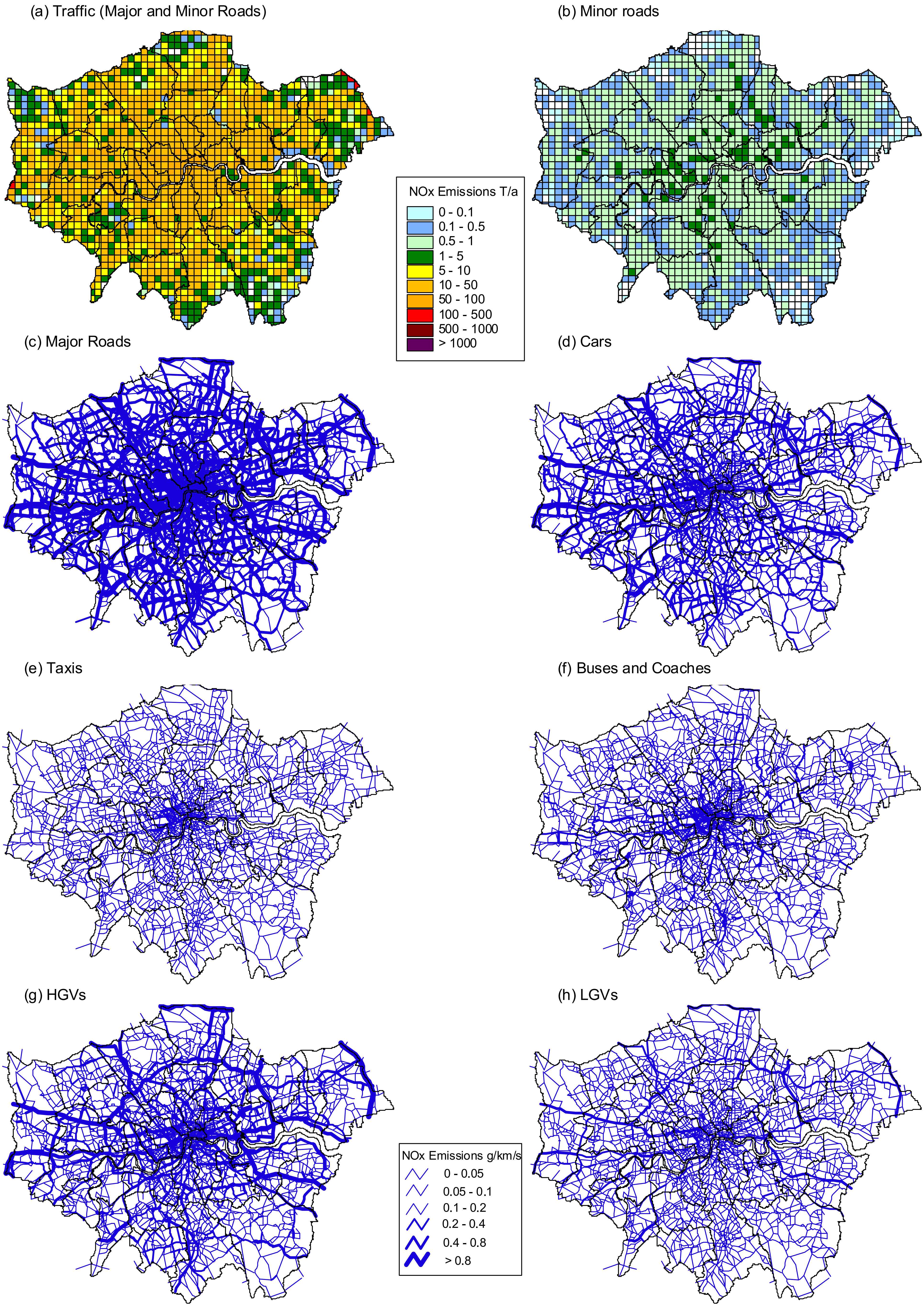

FIGURE 2.5

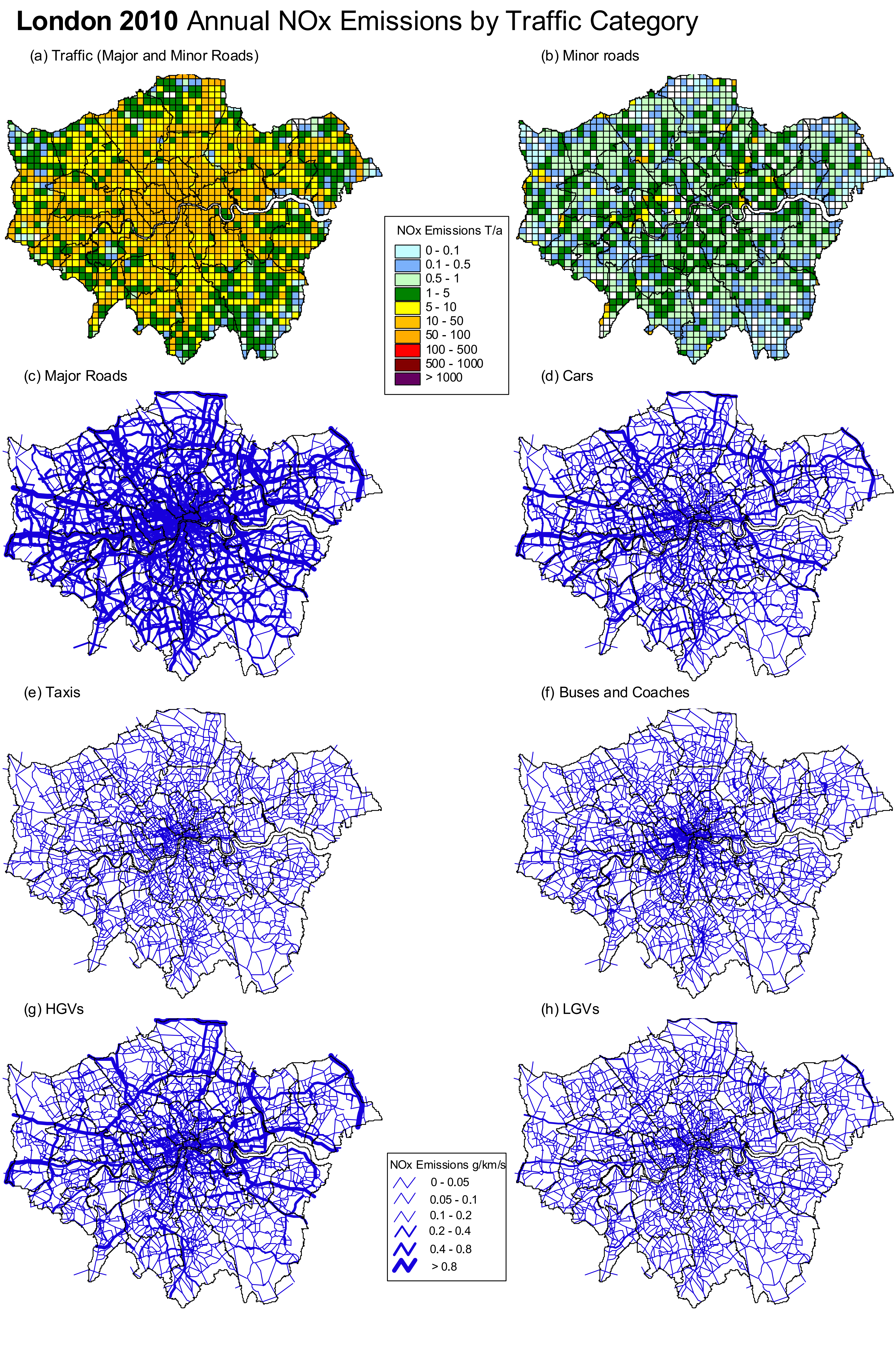
London 2010 Annual NOx Emissions by Traffic Category
(a) Traffic (Major and Minor Roads)
(b) Minor roads
NOx Emissions T/a
0 - 0.1
0.1 - 0.5
0.5 - 1
1 - 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 1000
> 1000
(c) Major Roads
(d) Cars
(e) Taxis
(f) Buses and Coaches
(g) HGVs
(h) LGVs
NOx Emissions g/km/s
0 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.4
0.4 - 0.8
> 0.8

FIGURE 2.6

London 1999 Annual PM10 Emissions by Source Category

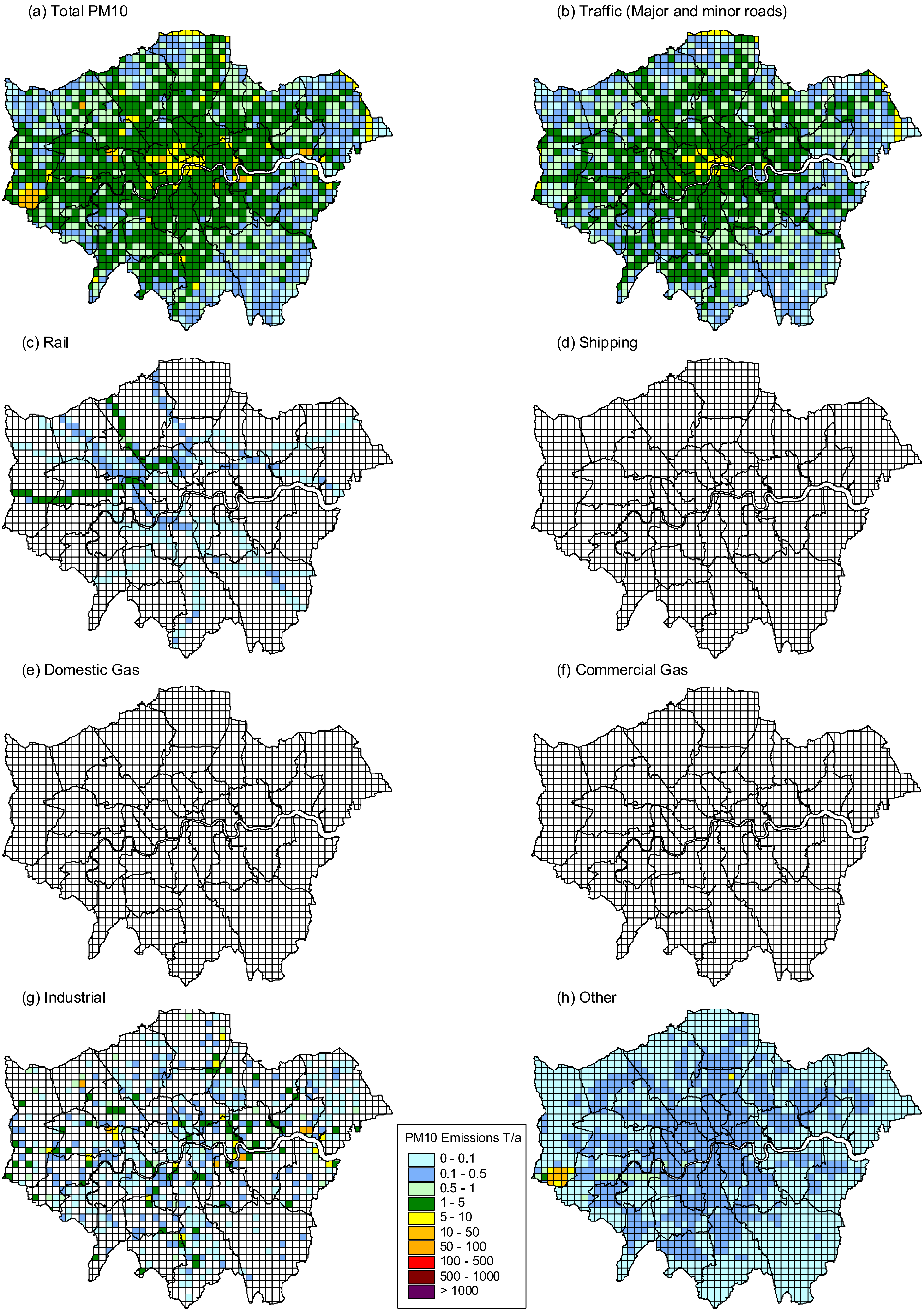

FIGURE 2.7

London 2004 Annual PM10 Emissions by Source Category

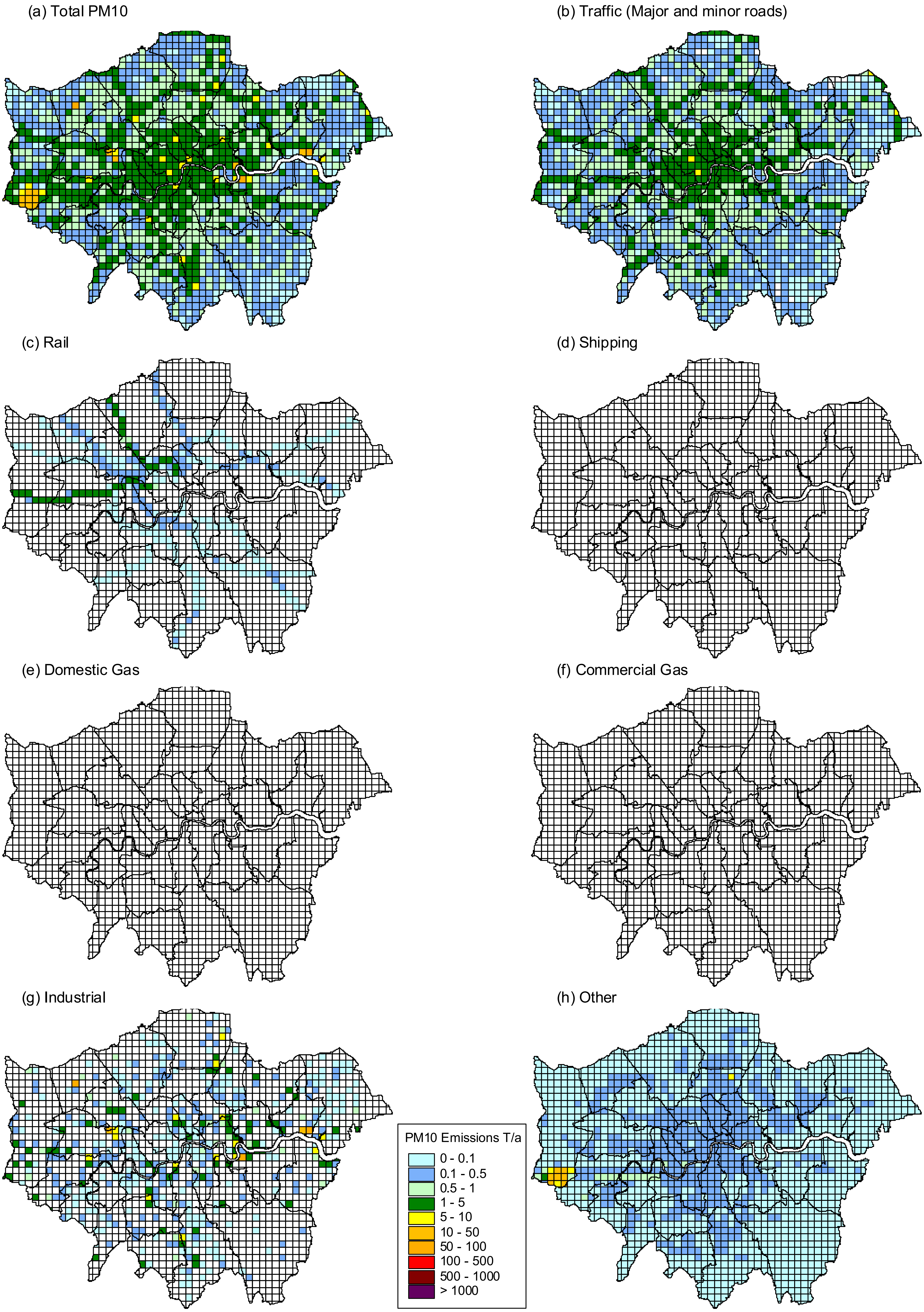

FIGURE 2.8

London 2010 Annual PM10 Emissions by Source Category

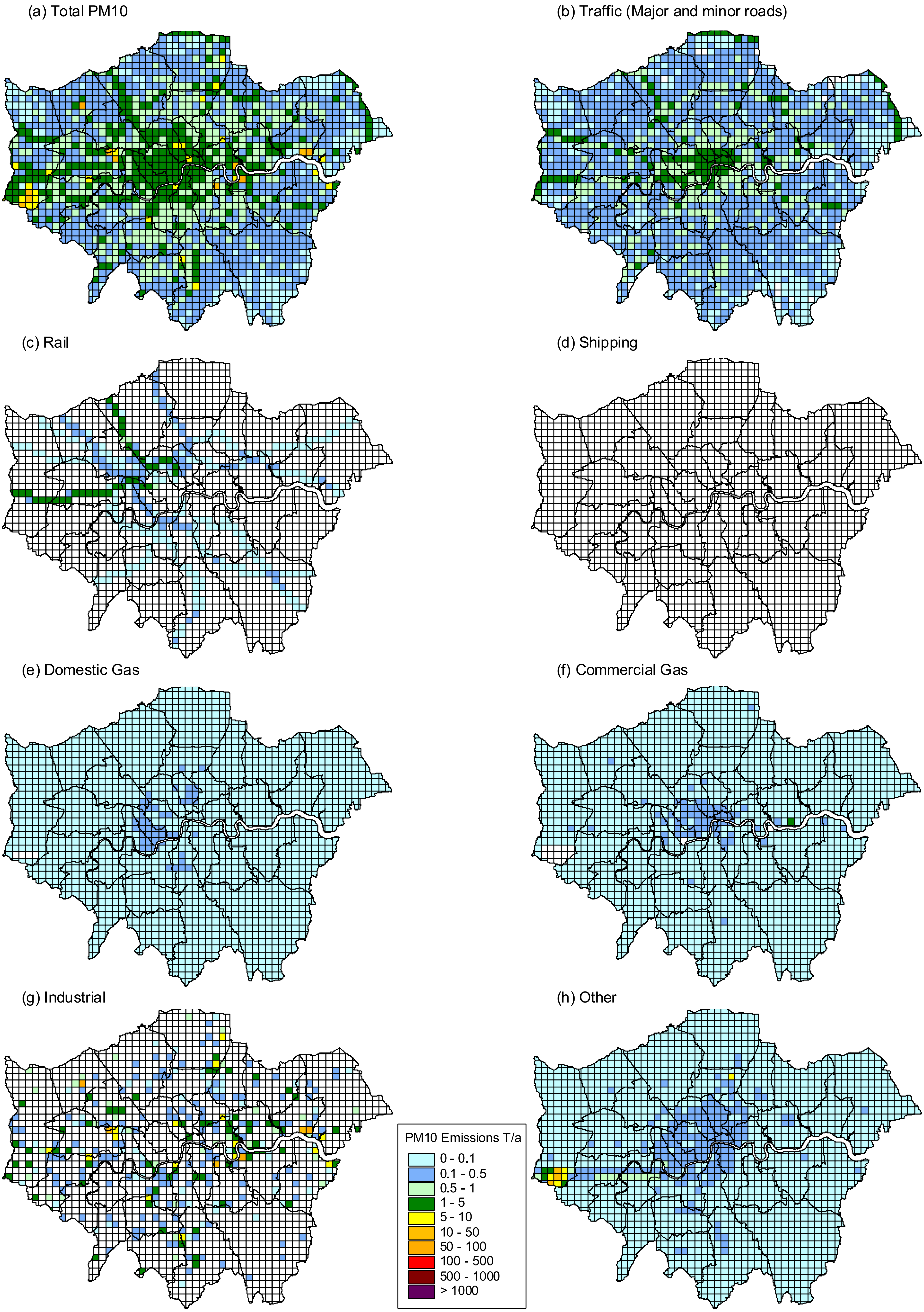

FIGURE 2.9

London 1999 Annual PM10 Emissions by Traffic Category

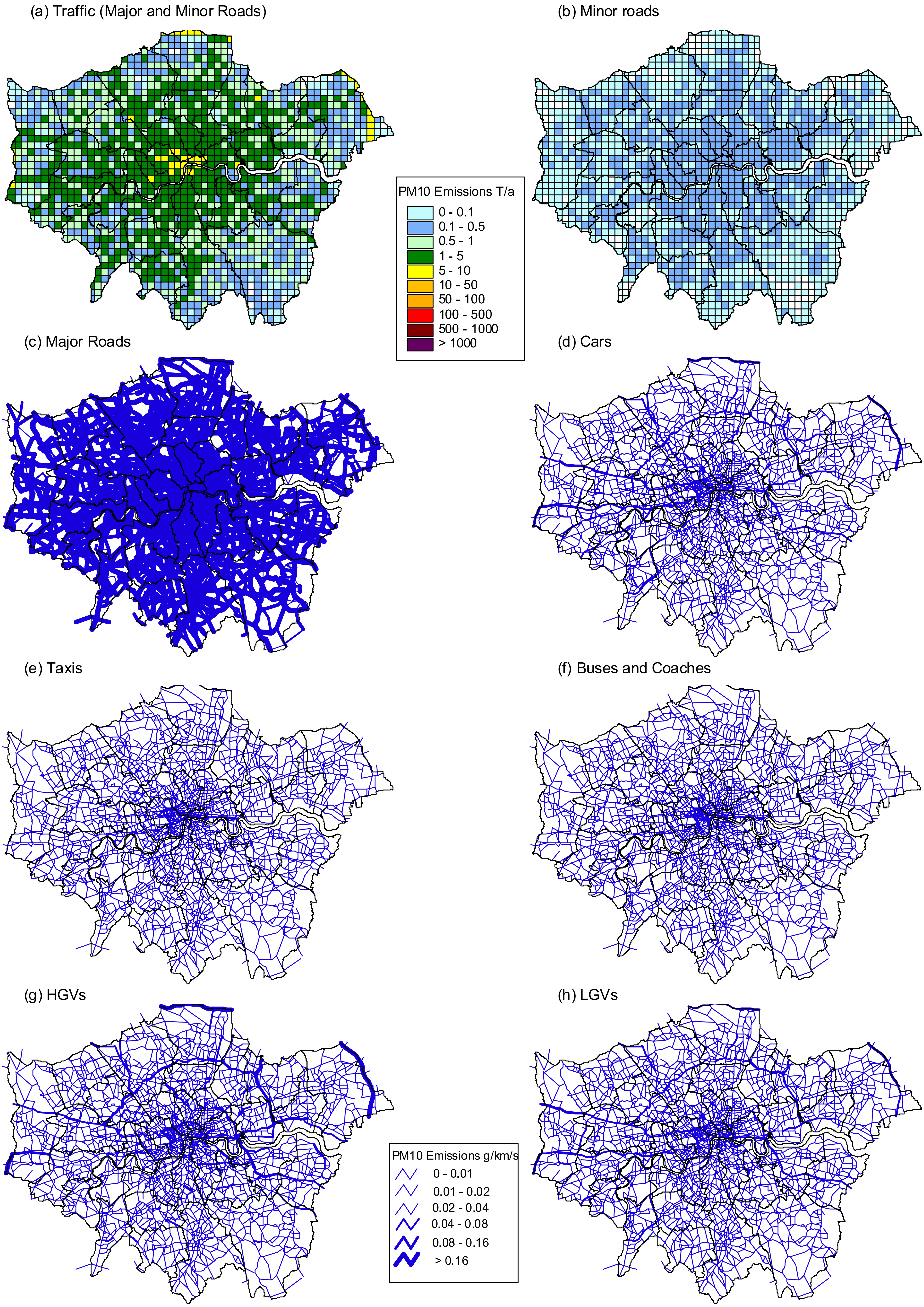

FIGURE 2.10

London 2004 Annual PM10 Emissions by Traffic Category

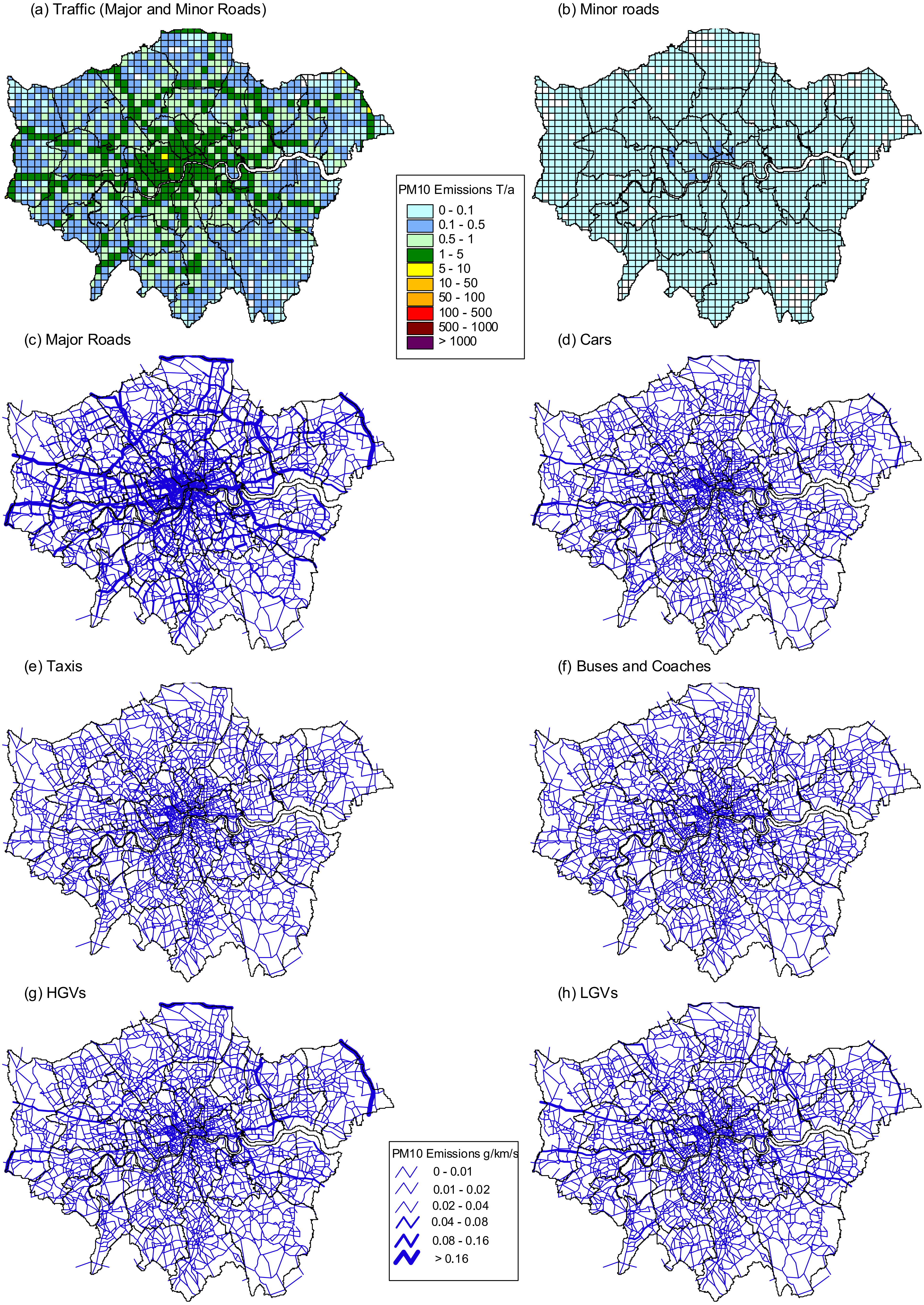

FIGURE 2.11

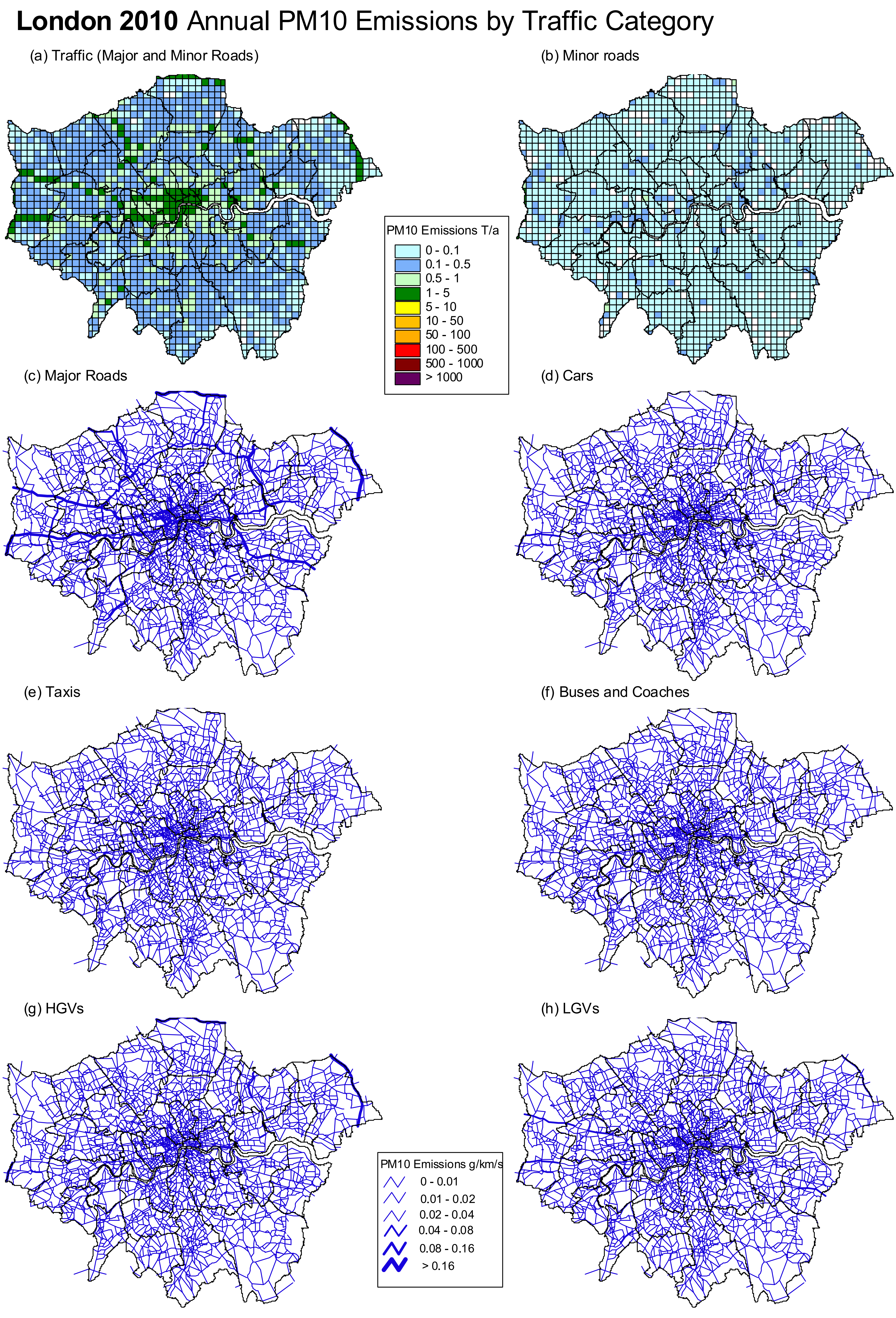
London 2010 Annual PM10 Emissions by Traffic Category
(a) Traffic (Major and Minor Roads)
(b) Minor roads
PM10 Emissions T/a
0 - 0.1
0.1 - 0.5
0.5 - 1
1 - 5
5 - 10
10 - 50
50 - 100
100 - 500
500 - 1000
> 1000
(c) Major Roads
(d) Cars
(e) Taxis
(f) Buses and Coaches
(g) HGVs
(h) LGVs
PM10 Emissions g/km/s
0 - 0.01
0.01 - 0.02
0.02 - 0.04
0.04 - 0.08
0.08 - 0.16
> 0.16

FIGURE 2.12

London 1999 Annual Mean NOx Receptor Point Concentrations

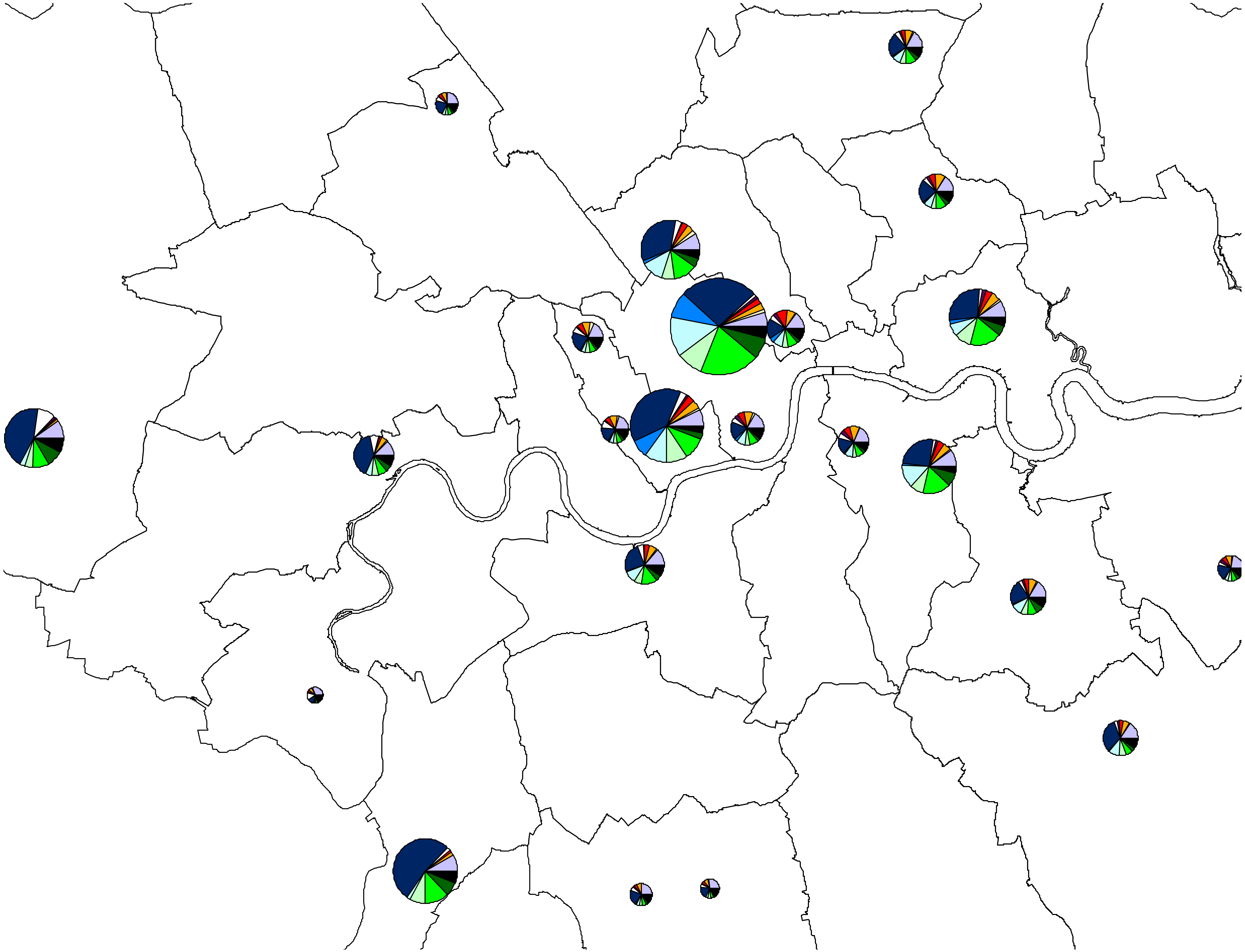

FIGURE 4.1

London 2005 Annual Mean NOx Receptor Point Concentrations

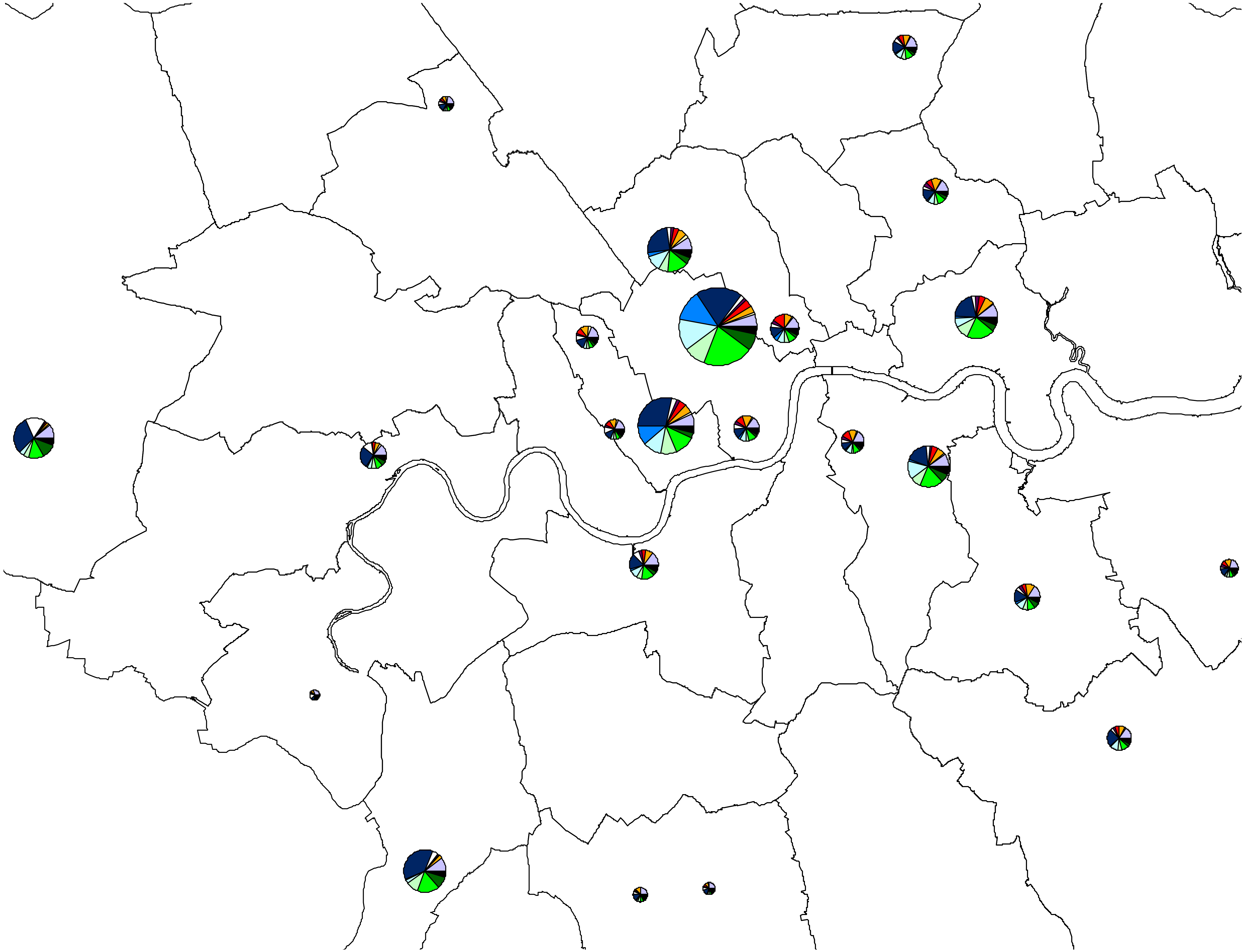

FIGURE 4.2

London 2010 Annual Mean NOx Receptor Point Concentrations

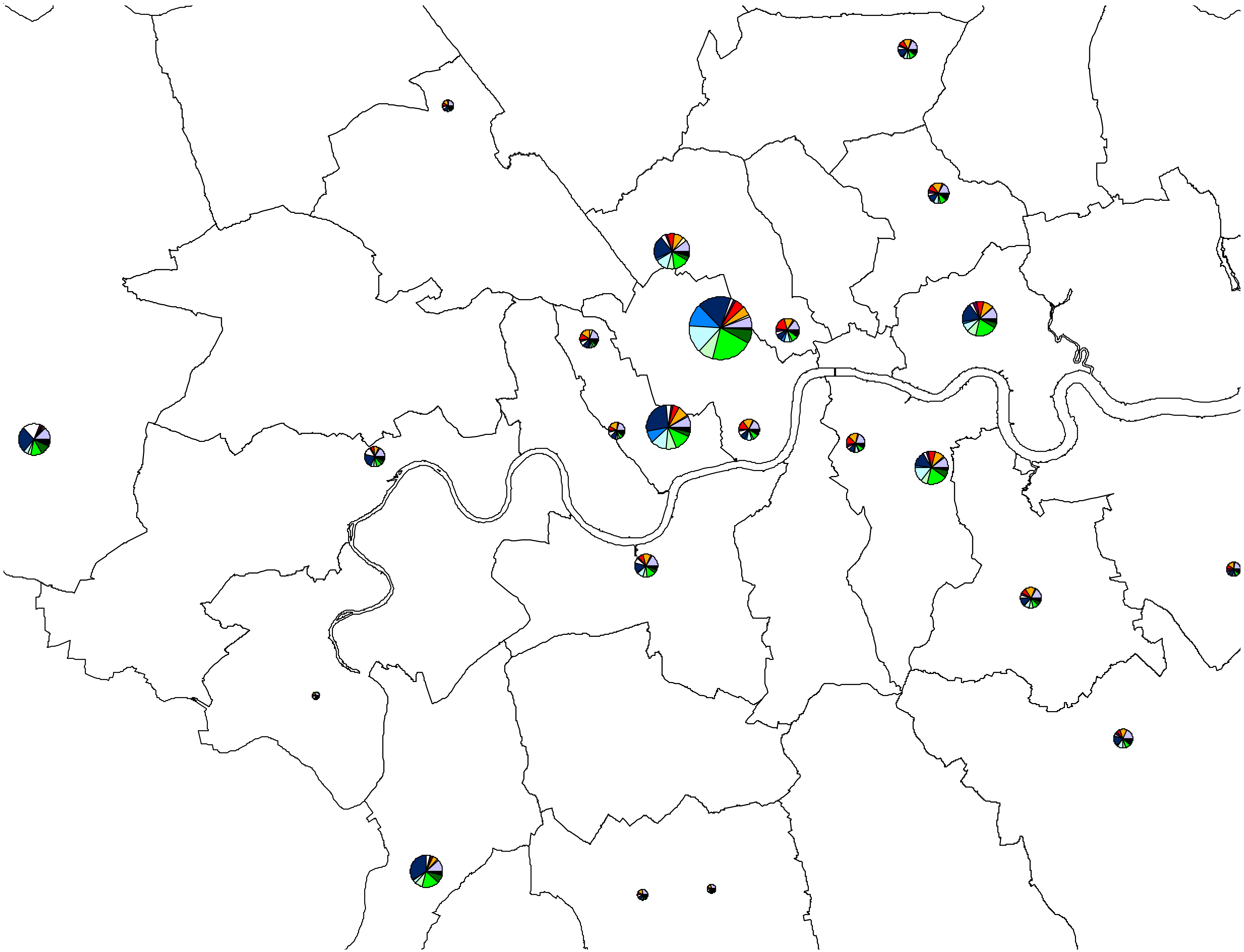

FIGURE 4.3

London 1999 Annual Mean PM10 Receptor Point Concentrations

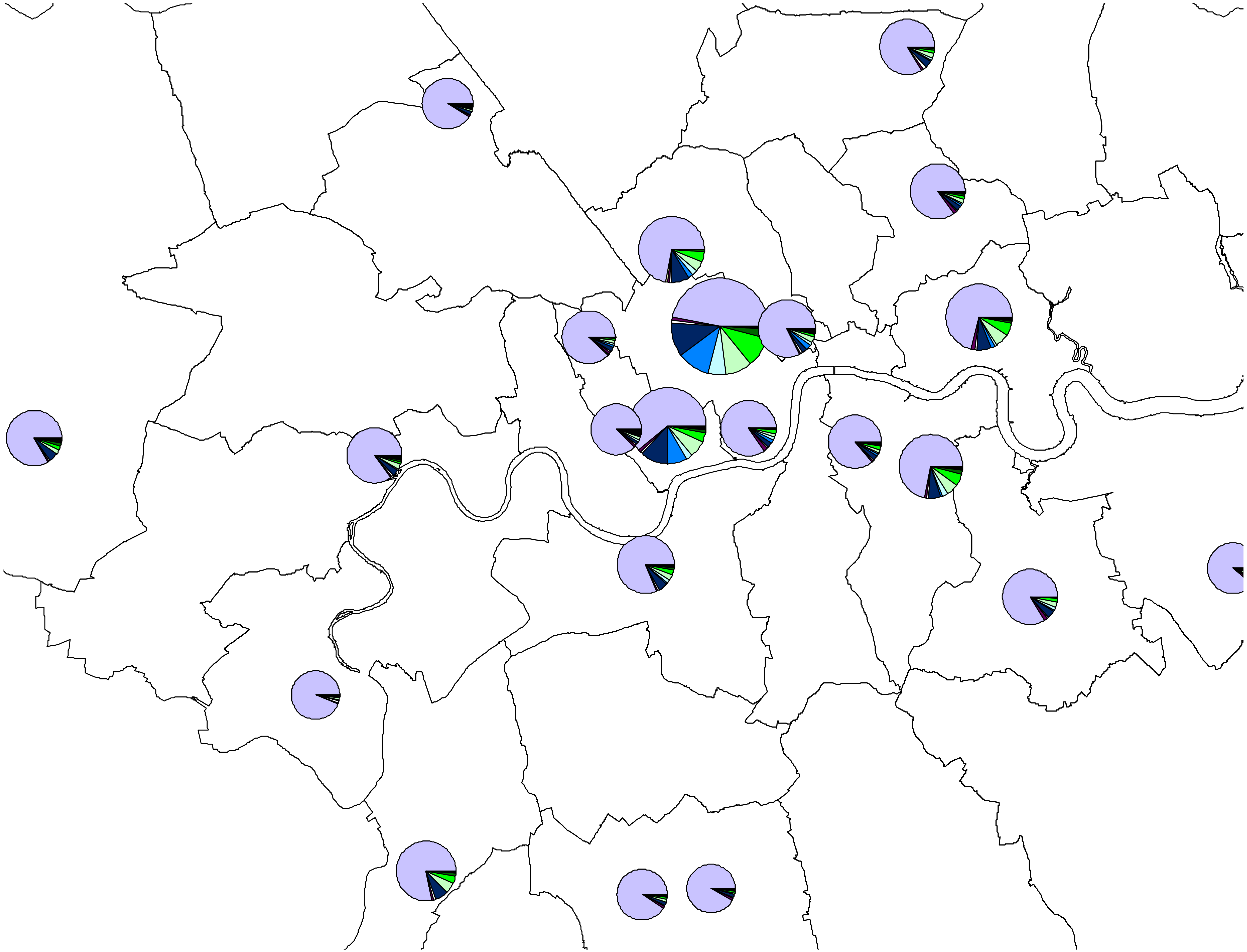

FIGURE 4.4

London 2004 Annual Mean PM10 Receptor Point Concentrations

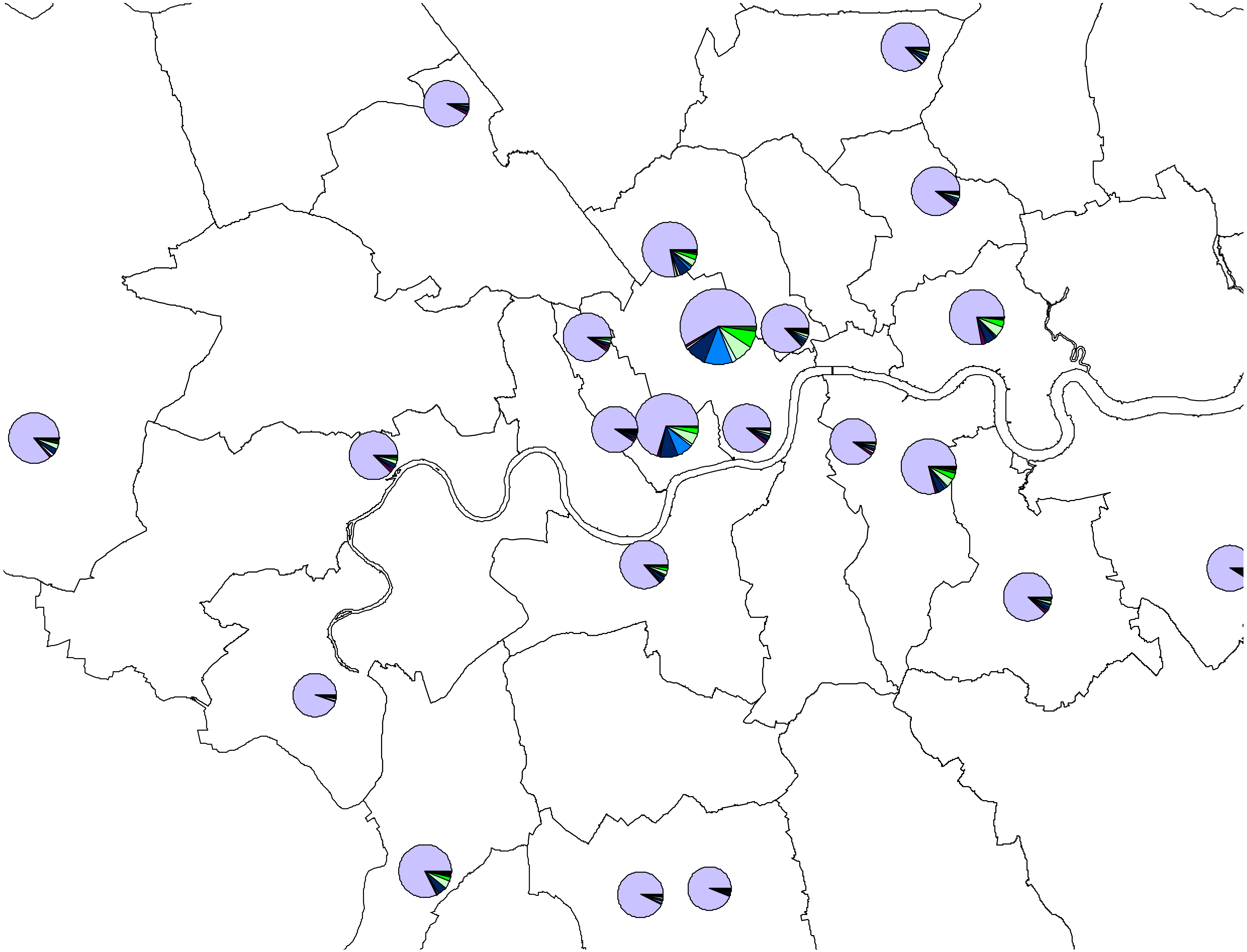

FIGURE 4.5

London 2010 Annual Mean PM10 Receptor Point Concentrations

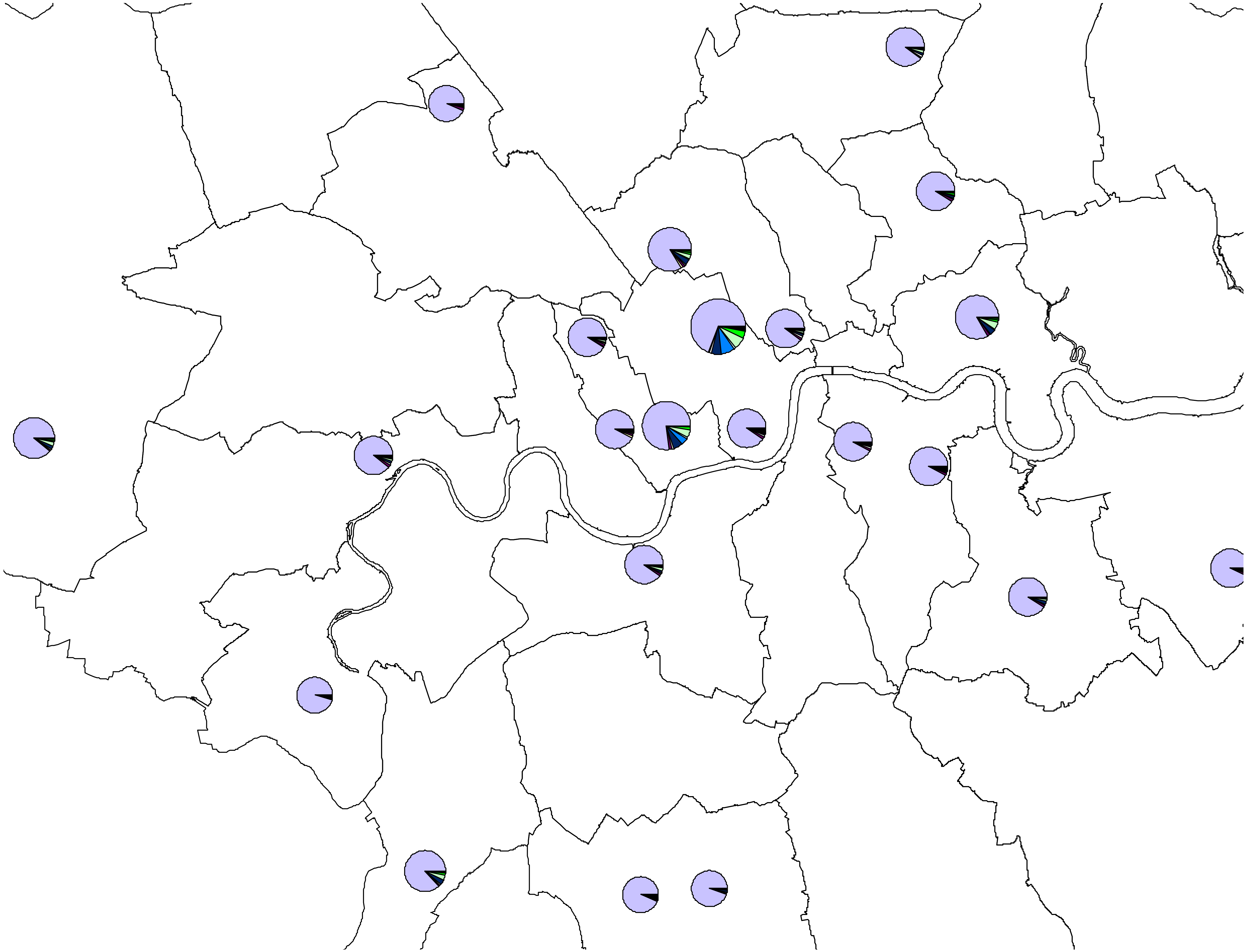

FIGURE 4.6

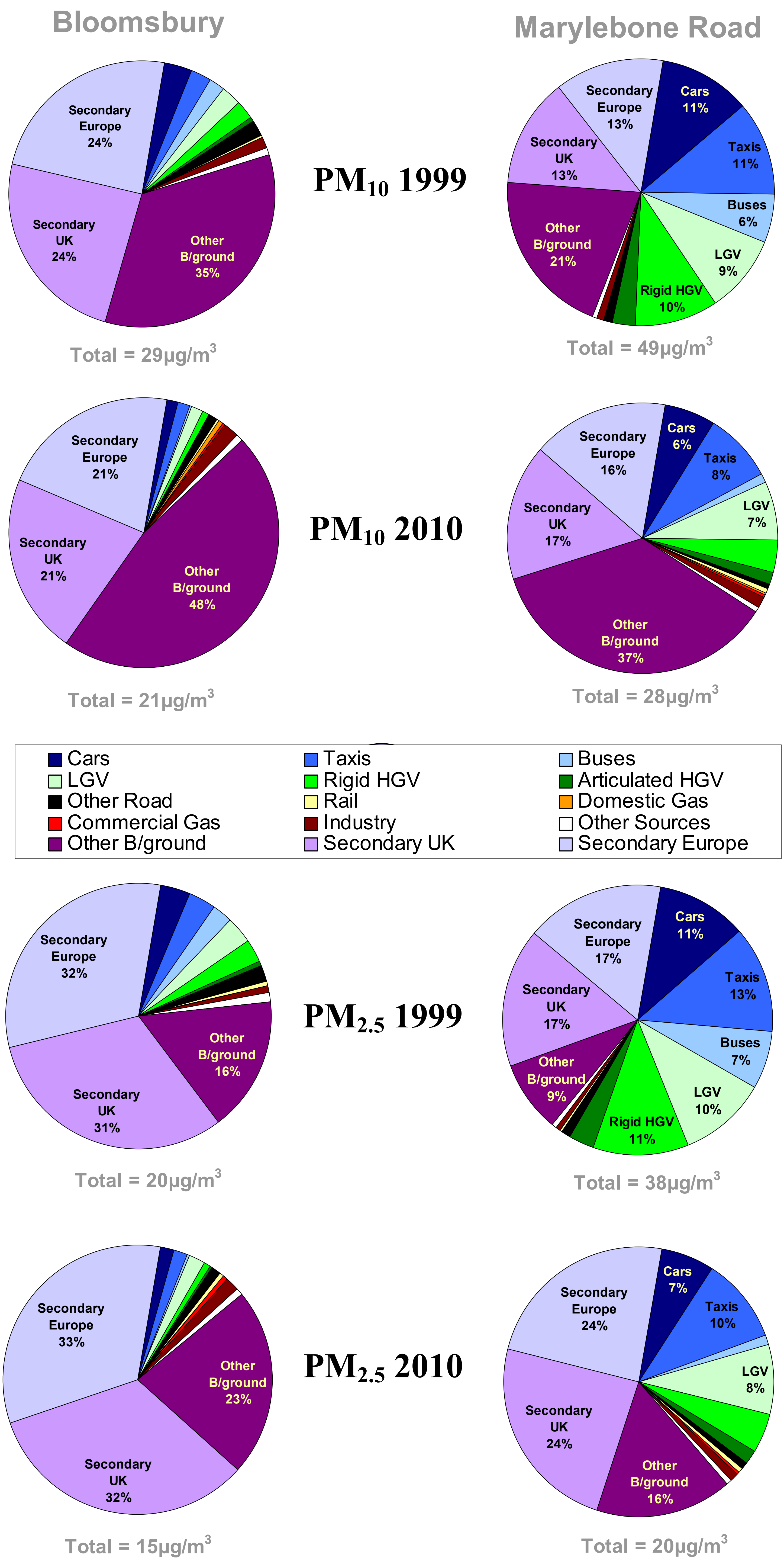
Bloomsbury
Marylebone Road
PM10 1999
Secondary Europe 24%
Secondary UK 24%
Other B/ground 35%
Total = 29µg/m3
Secondary Europe 13%
Cars 11%
Taxis 11%
Secondary UK 13%
Buses 6%
Other B/ground 21%
LGV 9%
Rigid HGV 10%
Total = 49µg/m3
PM10 2010
Secondary Europe 21%
Secondary UK 21%
Other B/ground 48%
Total = 21µg/m3
Secondary Europe 16%
Cars 6%
Taxis 8%
Secondary UK 17%
LGV 7%
Other B/ground 37%
Total = 28µg/m3
Cars
Taxis
Buses
LGV
Rigid HGV
Articulated HGV
Other Road
Rail
Domestic Gas
Commercial Gas
Industry
Other Sources
Other B/ground
Secondary UK
Secondary Europe
PM2.5 1999
Secondary Europe 32%
Other B/ground 16%
Secondary UK 31%
Total = 20µg/m3
Secondary Europe 17%
Cars 11%
Taxis 13%
Secondary UK 17%
Buses 7%
Other B/ground 9%
LGV 10%
Rigid HGV 11%
Total = 38µg/m3
PM2.5 2010
Secondary Europe 33%
Other B/ground 23%
Secondary UK 32%
Total = 15µg/m3
Cars 7%
Secondary Europe 24%
Taxis 10%
LGV 8%
Secondary UK 24%
Other B/ground 16%
Total = 20µg/m3

FIGURE 4.7

London 1999 Annual Mean NOx Concentrations by Source Category

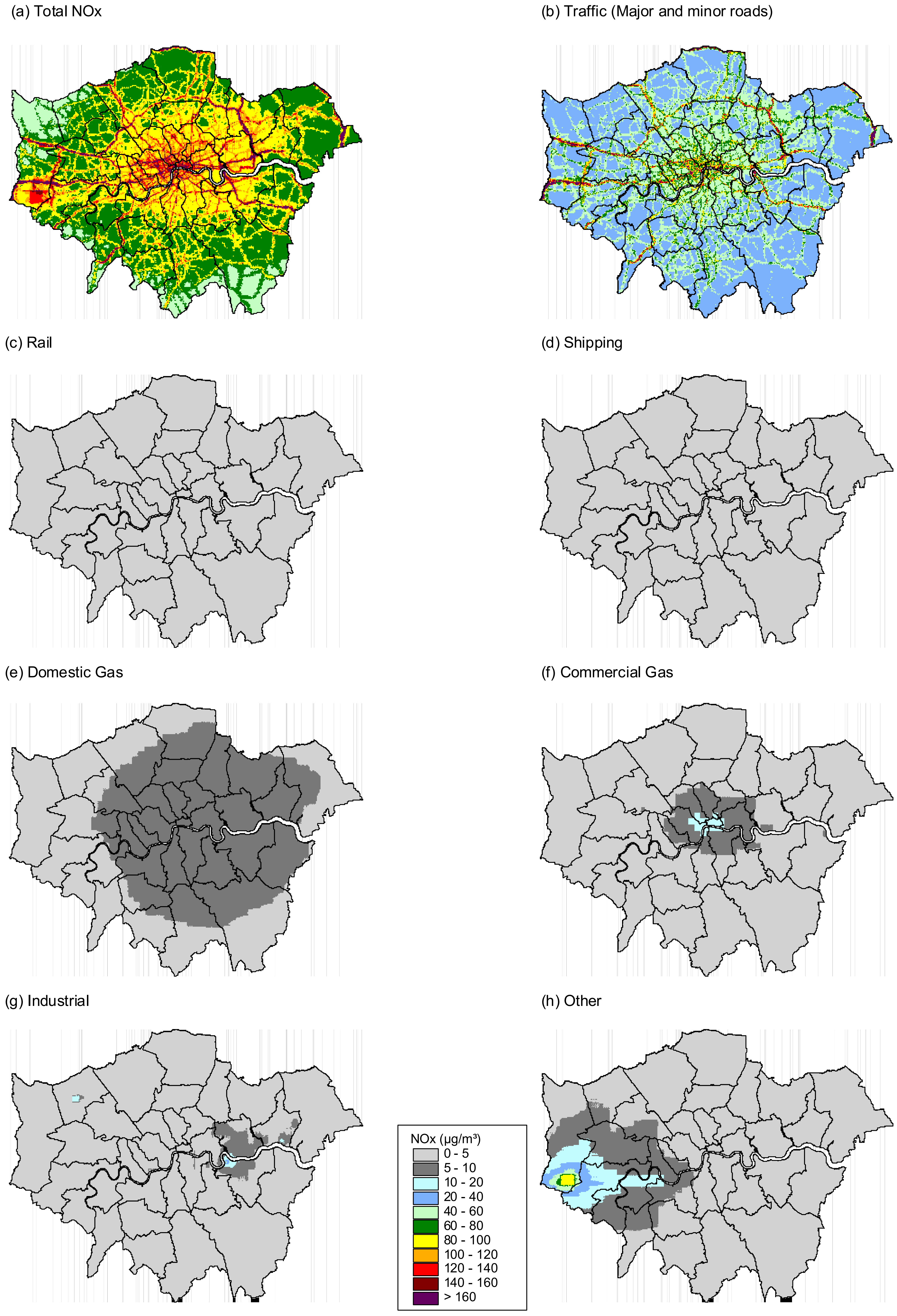

FIGURE 5.1

London 2005 Annual Mean NOx Concentrations by Source Category

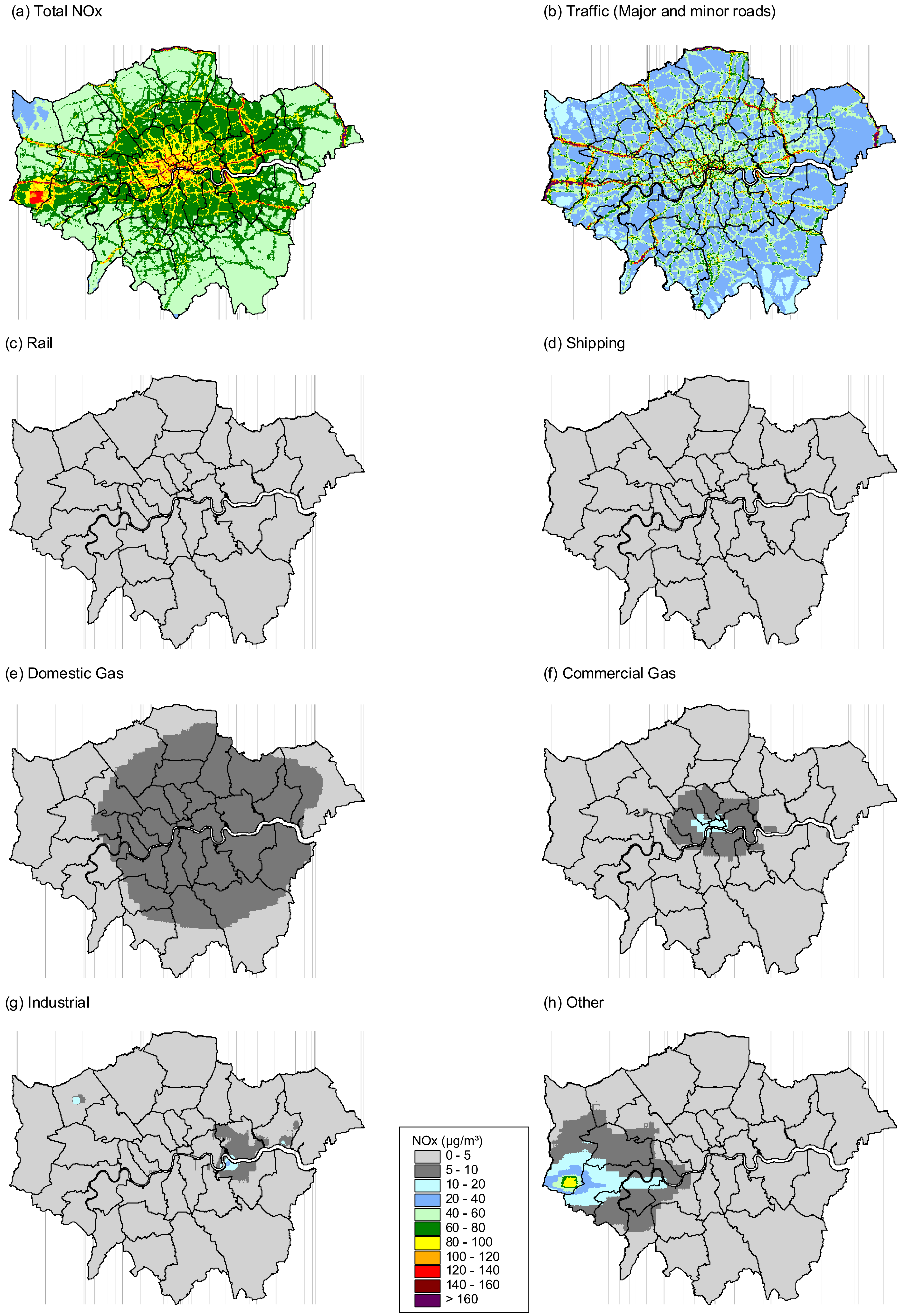

FIGURE 5.2

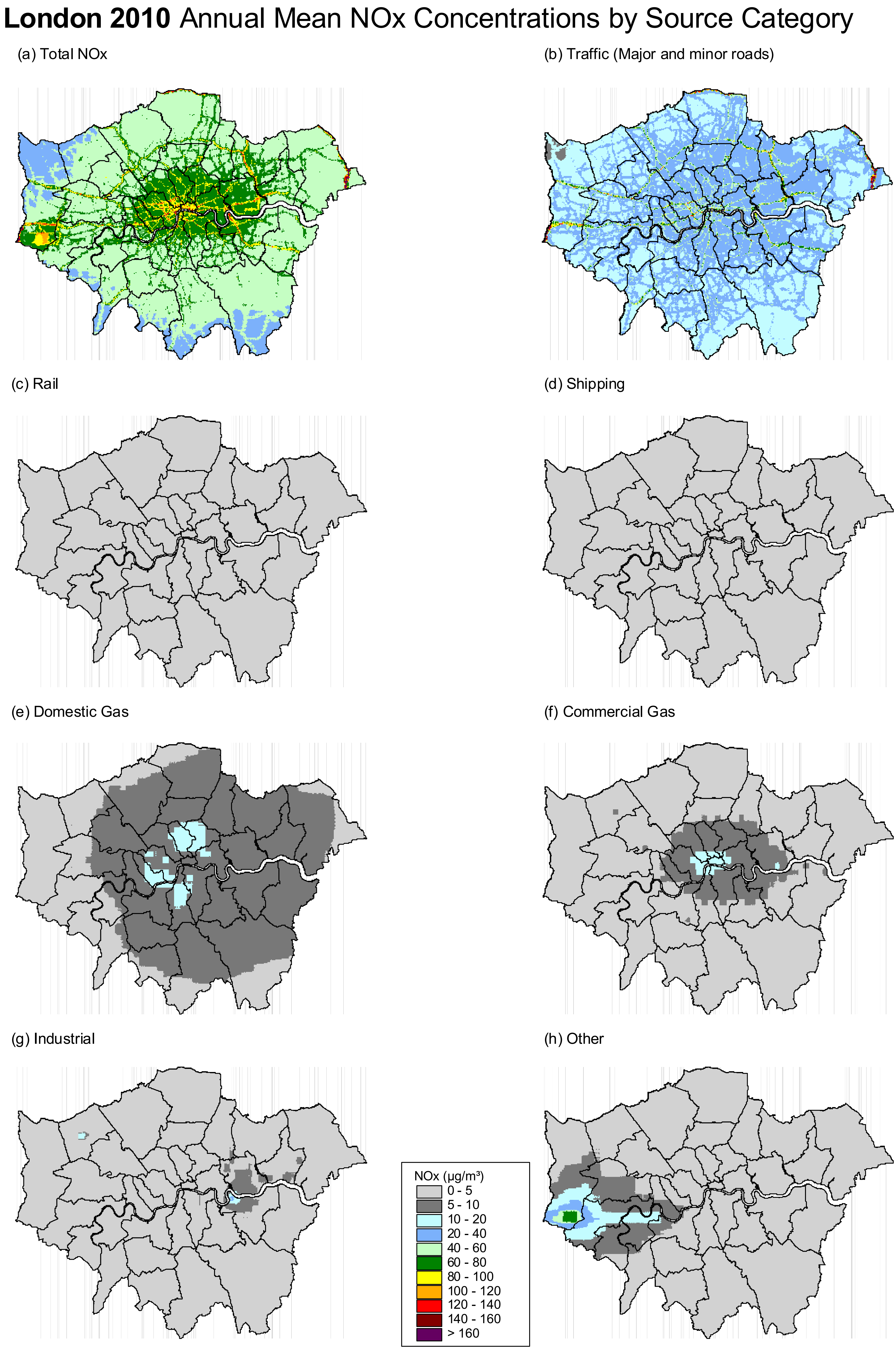
London 2010 Annual Mean NOx Concentrations by Source Category
(a) Total NOx
(b) Traffic (Major and minor roads)
(c) Rail
(d) Shipping
(e) Domestic Gas
(f) Commercial Gas
(g) Industrial
(h) Other
NOx (µg/m³)
0 - 5
5 - 10
10 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
> 160

FIGURE 5.3

London 1999 Annual Mean NOx Concentrations by Traffic Category

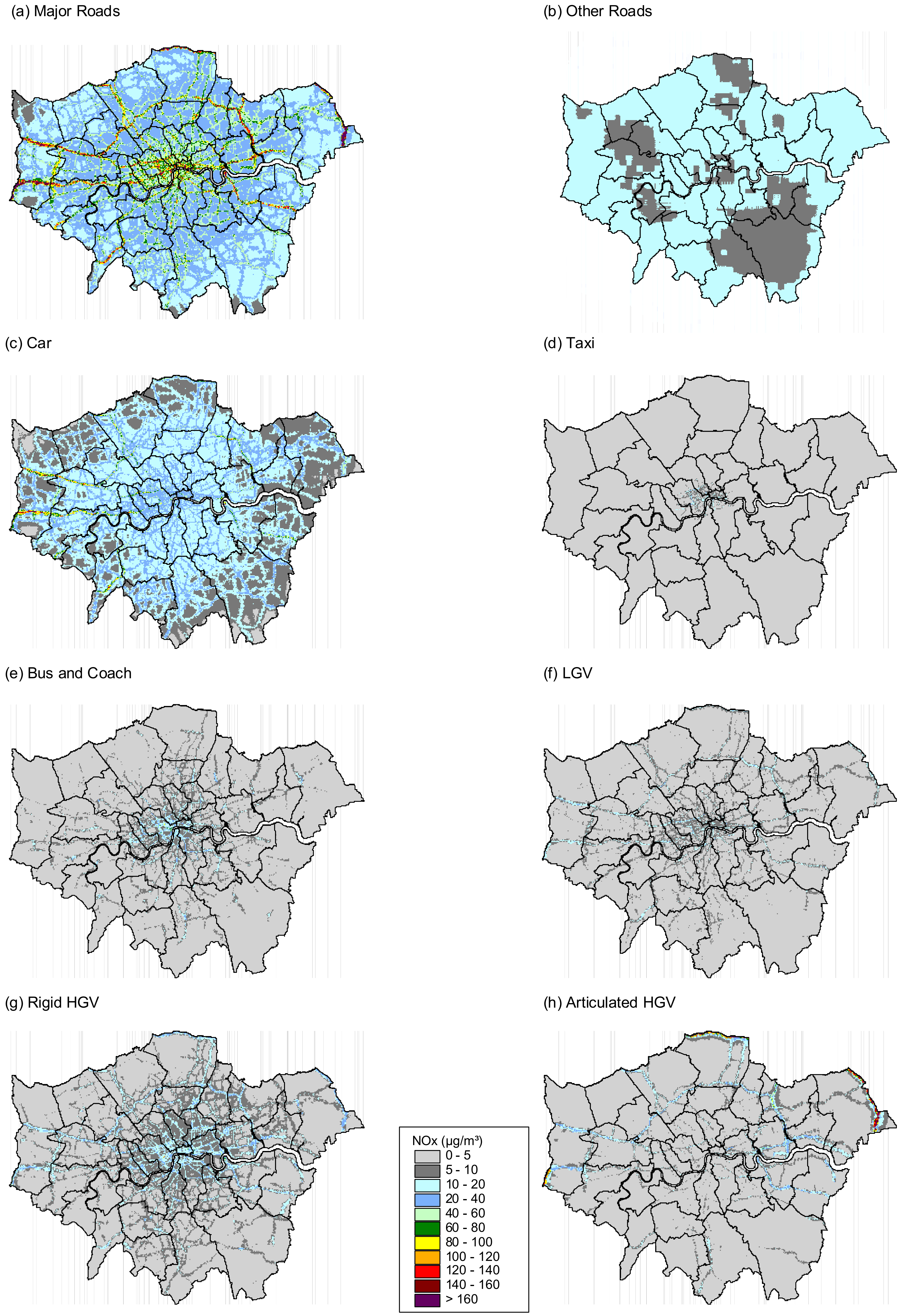

FIGURE 5.4

London 2005 Annual Mean NOx Concentrations by Traffic Category

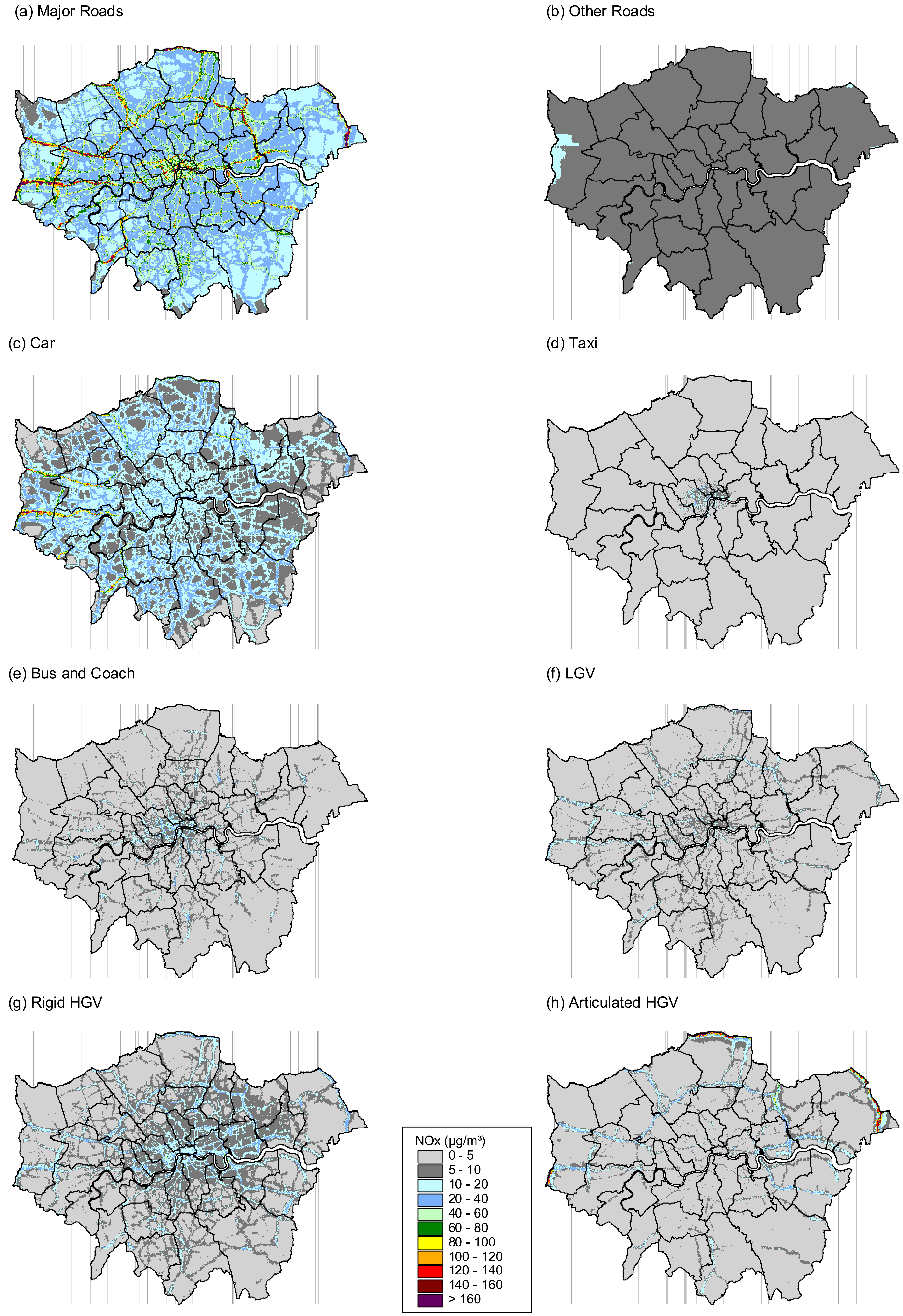

FIGURE 5.5

London 2010 Annual Mean NOx Concentrations by Traffic Category

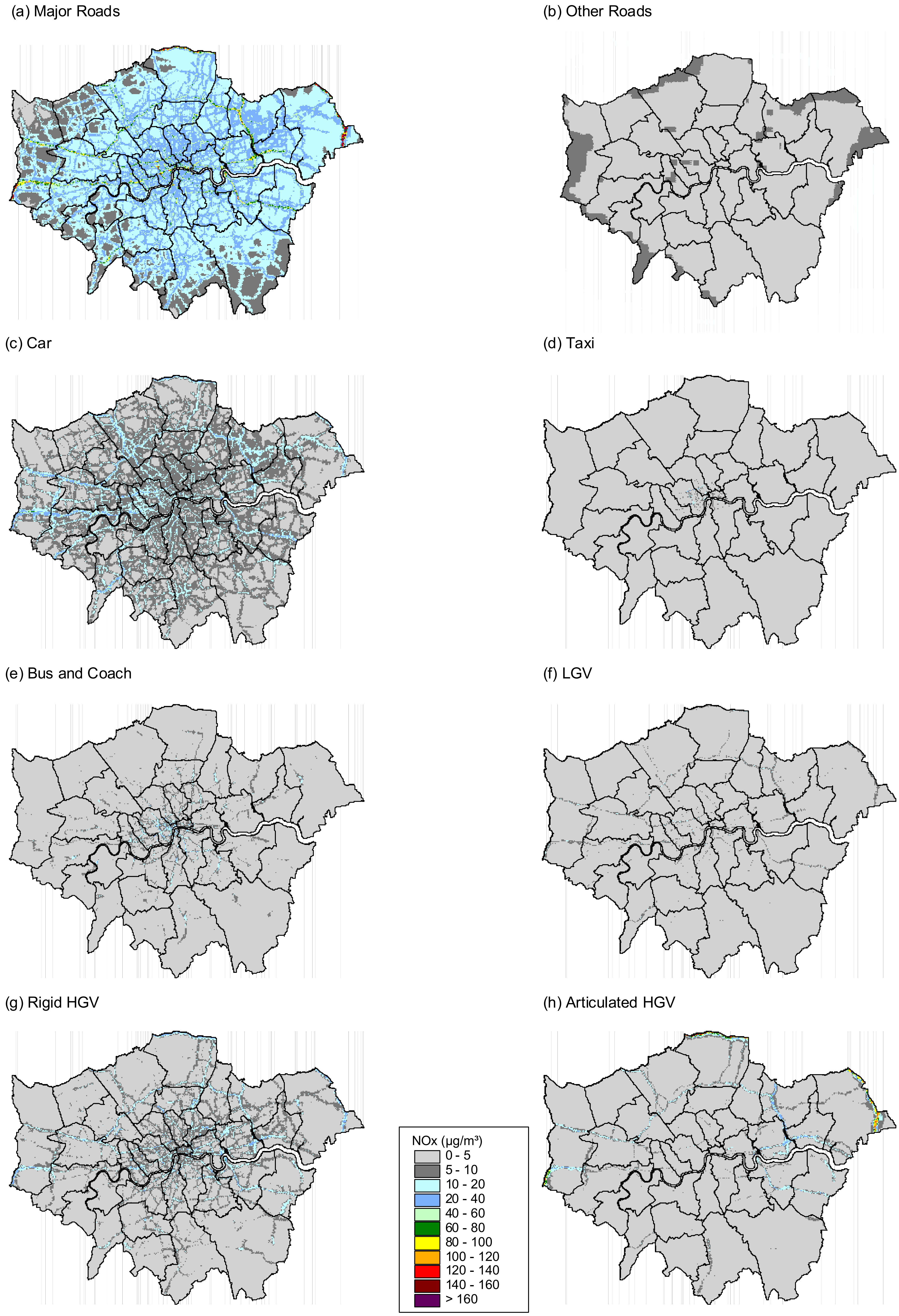

FIGURE 5.6

London 1999 Annual Mean PM10 Concentrations by Source Category

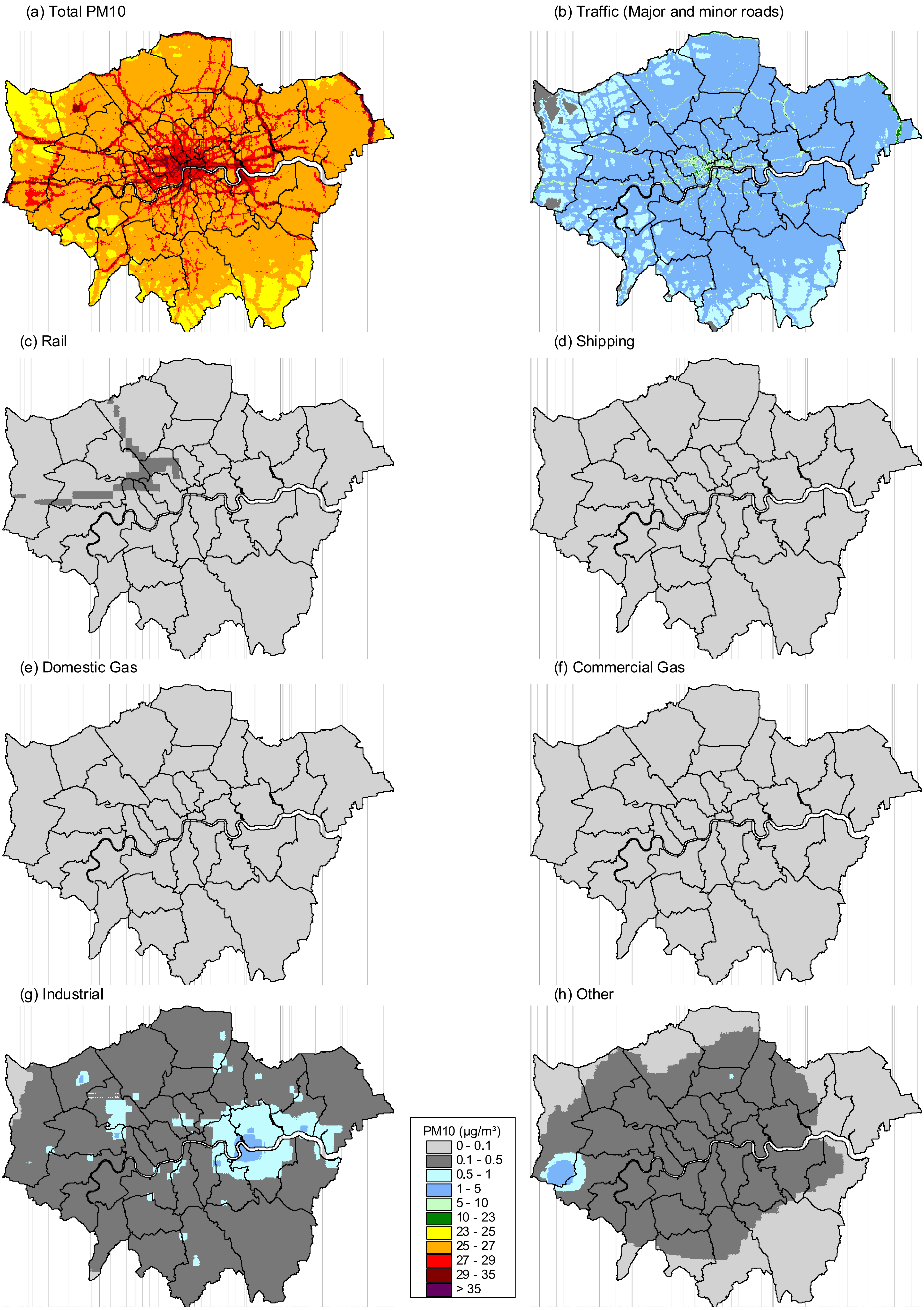

FIGURE 5.7

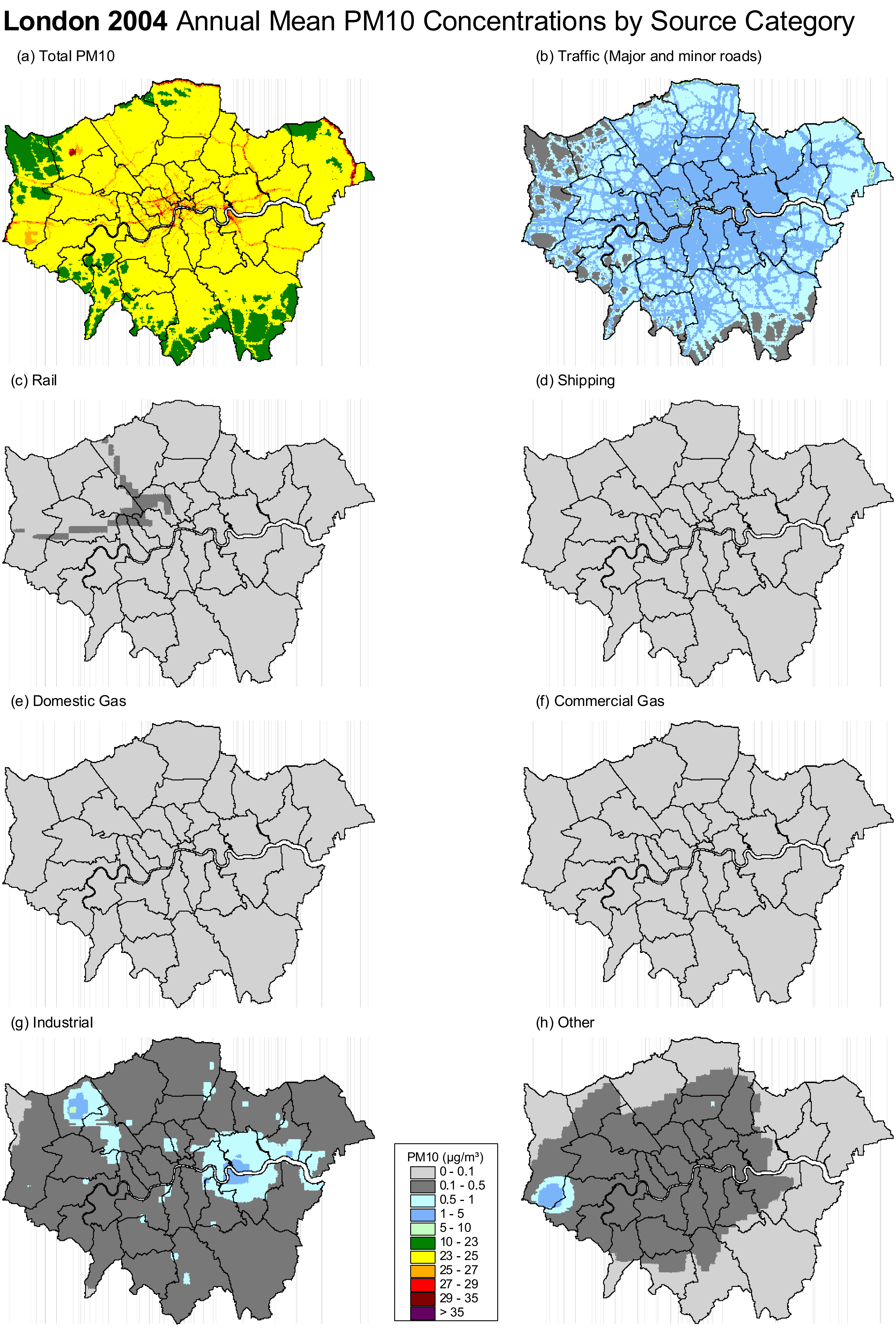
London 2004 Annual Mean PM10 Concentrations by Source Category
(a) Total PM10
(b) Traffic (Major and minor roads)
(c) Rail
(d) Shipping
(e) Domestic Gas
(f) Commercial Gas
(g) Industrial
(h) Other
PM10 (µg/m³)
0 - 0.1
0.1 - 0.5
0.5 - 1
1 - 5
5 - 10
10 - 23
23 - 25
25 - 27
27 - 29
29 - 35
> 35

FIGURE 5.8

London 2010 Annual Mean PM10 Concentrations by Source Category

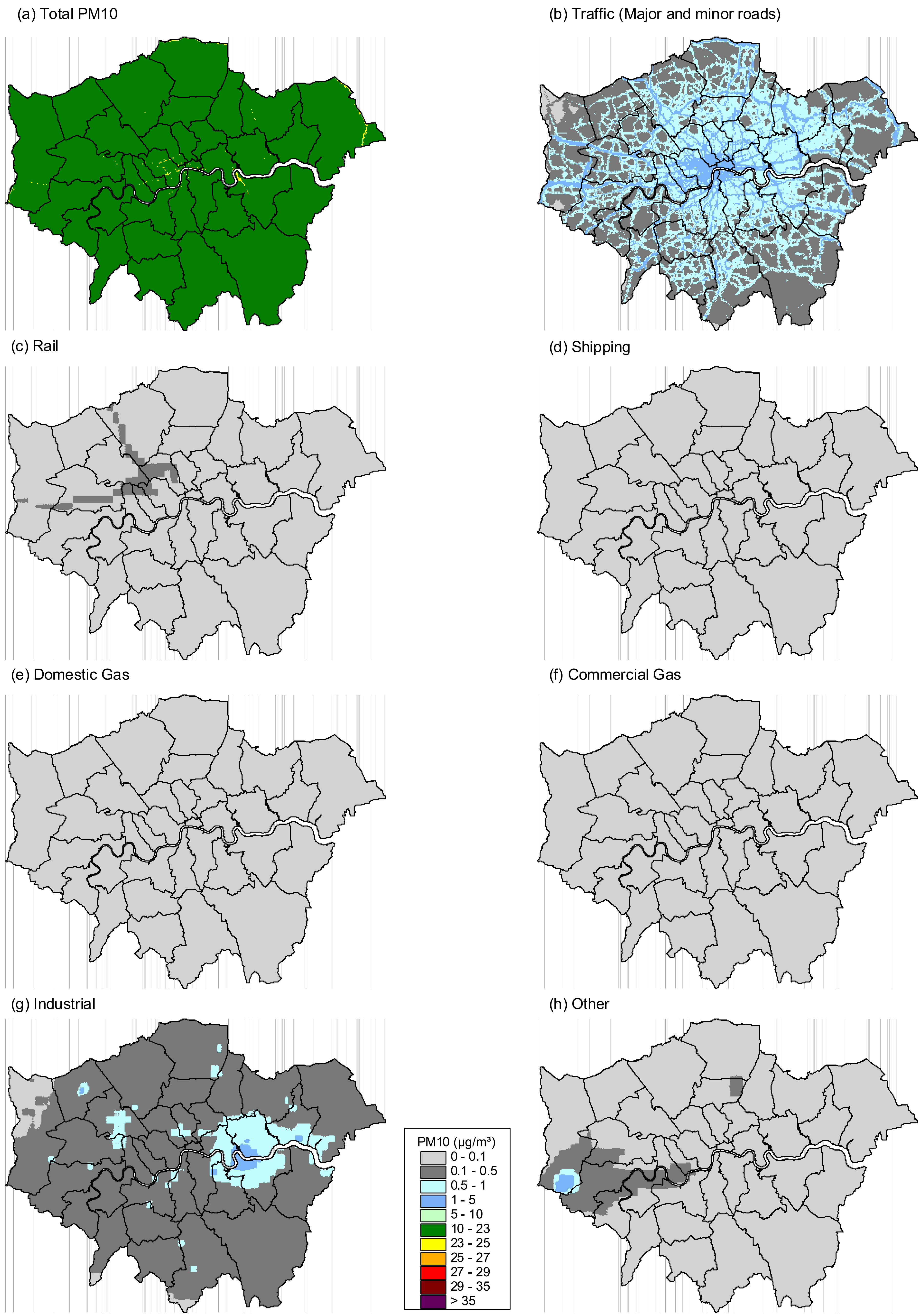

FIGURE 5.9

London 1999 Annual Mean PM10 Concentrations by Traffic Category

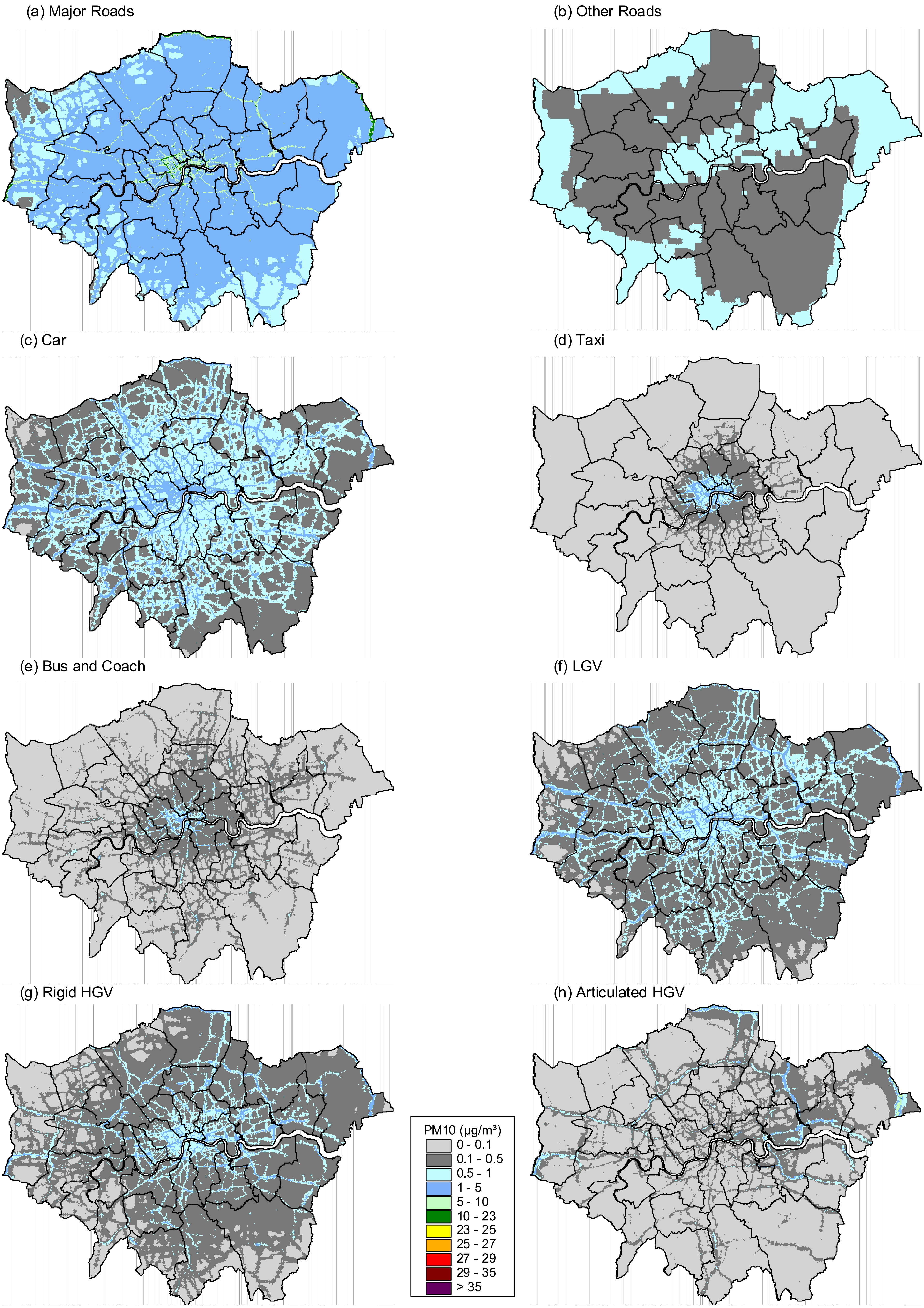

FIGURE 5.10

London 2004 Annual Mean PM10 Concentrations by Traffic Category

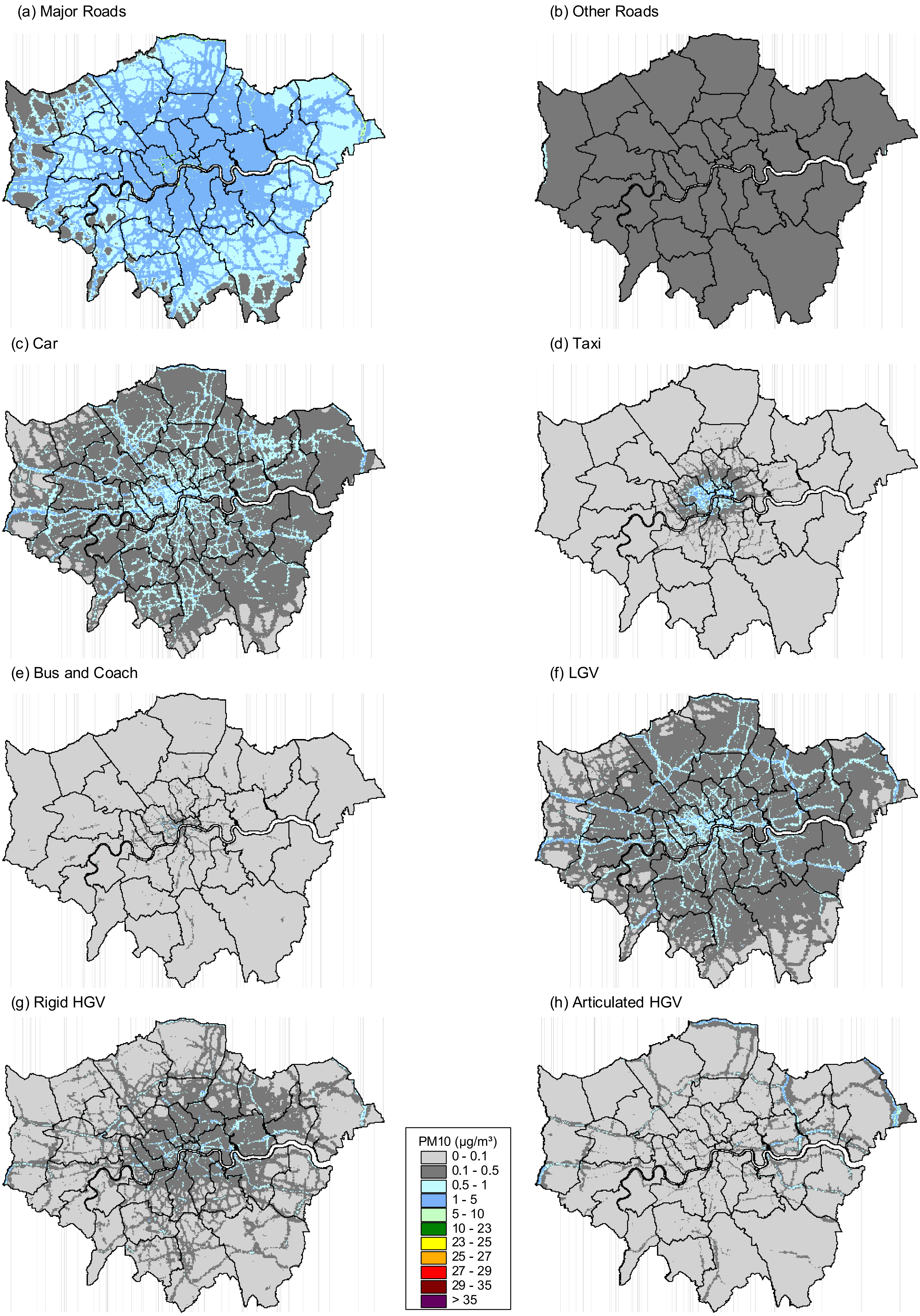

FIGURE 5.11

London 2010 Annual Mean PM10 Concentrations by Traffic Category

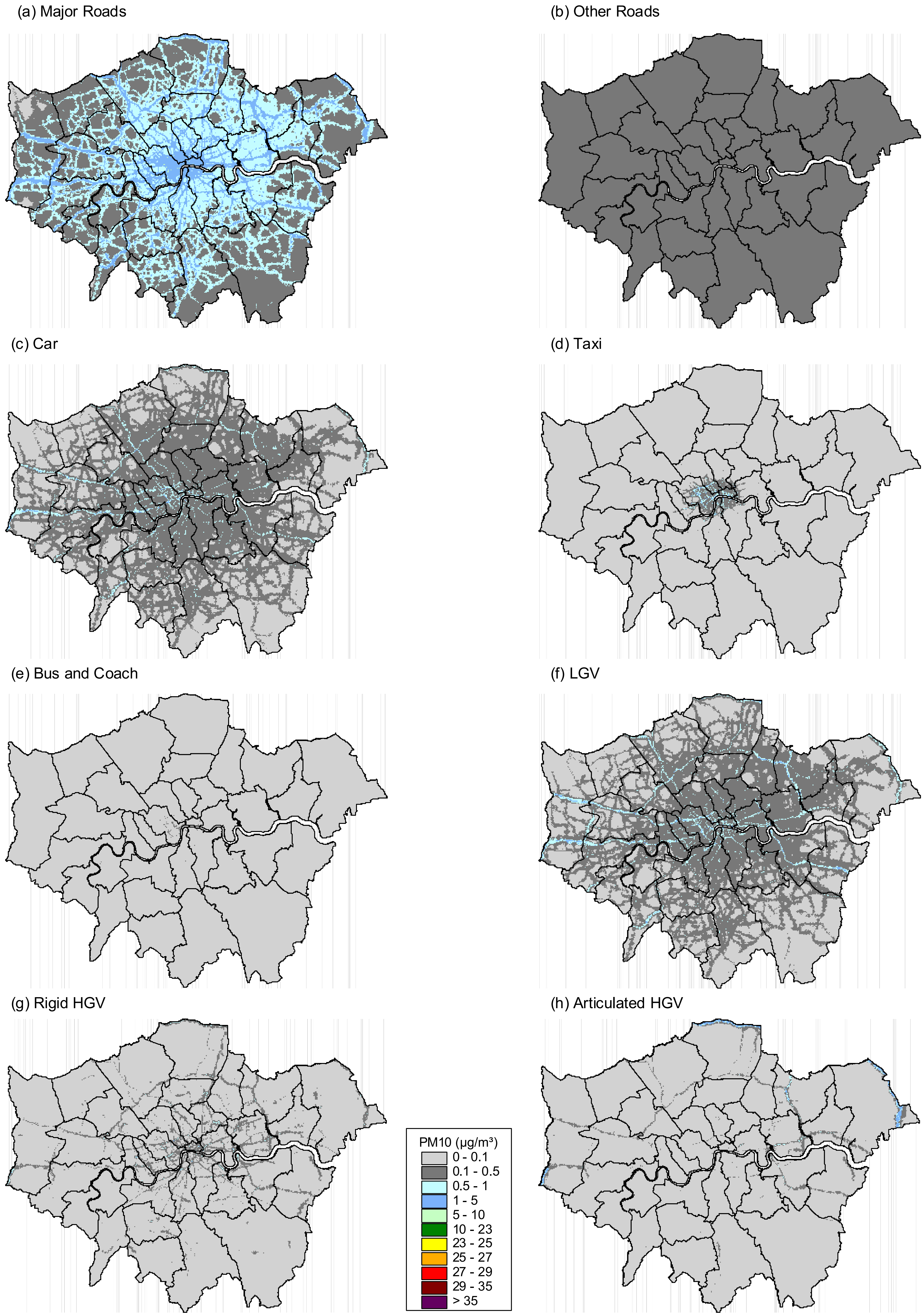

FIGURE 5.12