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Air Quality Modelling for the City of London Corporation: Model Verification & Air Quality Maps

Final Report

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Contents

1. Summary

The whole of the City of London has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO_2) and fine particles (PM_{10}) exceeding the UK air quality standards. Air quality modelling was previously carried out to determine the extent of any exceedences of the standards, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the City of London Corporation to carry out air quality modelling, taking into account the new LAEI and DfT emission factors. Modelling was required to determine the extent of any exceedences of the air quality standards in future years, to analyse the causes of these exceedences using source apportionment and to calculate the changes in pollutant concentrations resulting from various emission reduction scenarios.

This report contains the model verification and air quality maps for 2011 and 2015, for comparison against the air quality standards. Source apportionment and emission reduction scenarios are reported separately.

Air quality modelling was carried out using ADMS-Urban (version 2.3.3.1) air quality modelling software using emissions and traffic data from the London Atmospheric Emissions Inventory (LAEI) 2008.

Traffic emissions were calculated using the latest set of DfT emission factors, taking into account the lack of expected reduction in NO_x emissions from new diesel vehicles. PM_{10} and $PM_{2.5}$ emissions included contributions from exhaust, brake and tyre-wear, and road-wear and re-suspension, as applicable.

Model verification was carried out by comparing measured and modelled concentrations at the City's continuous monitoring sites for 2008. The modelling showed good agreement between measured and modelled concentrations with some over-prediction of 99.79th percentile of hourly average NO_2 concentrations at all monitoring sites, and under-prediction of PM_{10} concentrations at Sir John Cass School.

The air quality standard of 40 µg/m^3 for annual average NO_2 concentrations is predicted to be exceeded across the whole borough, for both 2011 and 2015. The air quality standard of 200 µg/m^3 for the 99.79th percentile of hourly average NO_2 concentrations is predicted to be exceeded around major roads for both 2011 and 2015; however, the model verification suggests that the areas of exceedence may be over-predicted.

There are no predicted exceedences of the air quality standard of 40 µg/m^3 for annual average PM_{10} concentrations for either 2011 or 2015. The air quality standard of no more than 35 exceedences of 50 µg/m^3 of 24-hour average PM_{10} concentrations is predicted to be exceeded along Upper Thames Street for 2011 and along Victoria Embankment, for both 2011 and 2015.

There are no predicted exceedences of the air quality standard of 25 µg/m^3 for annual average $PM_{2.5}$ concentrations for either 2011 or 2015.

Based on predicted concentrations for 2011, a 10% reduction in annual average $PM_{2.5}$ concentrations is required at urban background locations in the City of London by 2020, to meet the national exposure reduction target. A reduction of 6% - 7% is predicted between 2011 and 2015. Up to half of this predicted reduction represents projected reduction in $PM_{2.5}$ emissions from within London in the LAEI. The predicted $PM_{2.5}$ concentrations indicate that a further reduction of 3% - 4% is required at urban background locations, between 2015 and 2020 to meet the target.

2. Introduction

The whole of the City of London has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO_2) and fine particles (PM_{10}) exceeding UK air quality objectives. Air quality modelling was previously carried out to determine the extent of any exceedences of the objectives, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the City of London Corporation to carry out air quality modelling using ADMS-Urban, taking into account the new LAEI and DfT emission factors. Modelling was required to determine the extent of any exceedences of the air quality standards in future years, to analyse the causes of these exceedences using source apportionment and to calculate the changes in pollutant concentrations resulting from various emission reduction scenarios.

This report contains the model verification and air quality maps for 2011 and 2015, for comparison against the air quality objectives. Source apportionment and emission reduction scenarios are reported separately.

The air quality Limit Values and objectives, with which the calculated concentrations are compared, are presented in Section 3. The emissions data and model set-up are described in Sections 4 and 5. The results of the modelling are then presented: the model verification in Section 6; and the concentration maps in Section 7. A discussion of the results is presented in Section 8.

3. Air quality targets

The EU *ambient air quality directive* (2008/50/EC) sets binding limits for concentrations of air pollutants. The directive has been transposed into English legislation as the *Air Quality Standards Regulations 2010*[1], which also incorporates the provisions of the *4th air quality daughter directive* (2004/107/EC).

The Air Quality Standards Regulations 2010 include limit values and target values. Local authorities are required to work towards air quality objectives. In doing so, they assist the Government to meet the Limit Values. The Limit Values are presented in Table 3.1.

Table 3.1: Air quality limit values

	Value ($\mu g/m^3$)	**Description of standard**
NO_2	200	Hourly mean not to be exceeded more than 18 times a calendar year (modelled as 99.79th percentile)
	40	Annual average
PM_{10}	50	24-hour mean not to be exceeded more than 35 times a calendar year (modelled as 90.41st percentile)
	40	Annual average
$PM_{2.5}$	25	Annual average

Note that the limit value for $PM_{2.5}$ includes a margin of tolerance of 20% in June 2008, decreasing on the next 1st January and every 12 months thereafter by equal annual percentages to reach 0% by 1st January 2015. A target value of 25µg/m³ also exists for $PM_{2.5}$.

The regulations also include national exposure reduction targets for $PM_{2.5}$, as set out in Table 3.2. These are based on the average exposure indicator (AEI) which is calculated as the three-year average of all measured $PM_{2.5}$ concentrations at urban background locations, e.g. the AEI for 2010 must be based on measurements for the years 2009, 2010 and 2011.At the time of writing this report, local authorities are not required to assist the government to meet the Limit Value and reduction target for $PM_{2.5}$.

[1] http://www.legislation.gov.uk/uksi/2010/1001/contents/made

Table 3.2: Exposure reduction target for $PM_{2.5}$ relative to the AEI in 2010

Initial concentration (µg/m³)	Reduction target (%)	Year by which exposure reduction target should be met
Less than or equal to 8.5	0	2020
More than 8.5 but less than 13	10	
13 to less than 18	15	
18 to less than 22	20	
22 or more	All appropriate measures to reach 18 µg/m³	

The short-term objectives, i.e. those measured hourly or over 24 hours, are specified in terms of the number of times during a year that a concentration measured over a short period of time is permitted to exceed a specified value. For example, the concentration of NO_2 measured as the average value recorded over a one-hour period is permitted to exceed the concentration of 200 µg/m^3 up to 18 times per year. Any more exceedences than this during a one-year period would represent a breach of the objective.

It is convenient to model objectives of this form in terms of the equivalent percentile concentration value. A percentile is the concentration below which lie a specified percentage of concentration measurements. For example, consider the 98th percentile of one-hour concentrations over a year. Taking all of the 8760 one-hour concentration values that occur in a year, the 98th percentile value is the concentration below which 98% of those concentrations lie. Or, in other words, it is the concentration exceeded by 2% (100 – 98) of those hours, that is, 175 hours per year. Taking the NO_2 objective considered above, allowing 18 exceedences per year is equivalent to not exceeding for 8742 hours or for 99.79% of the year. This is therefore equivalent to the 99.79th percentile value. It is important to note that modelling exceedences of short term averages is generally not as accurate as modelling annual averages.

4. Emissions data

The modelling for this study has been based on emissions data taken from the London Atmospheric Emissions Inventory (LAEI 2008), released by the Greater London Authority (GLA) in 2010.

4.1. Traffic flow data

Traffic flows and speeds for all major roads in London were taken from the LAEI, where data are provided for the years 2008, 2011 and 2015. LAEI traffic projections for 2011 and 2015 were based on forecast traffic changes provided by TfL, consistent with the TfL Business Plan. The projections also include the impact of the recession and the introduction of Low Emissions Zone (LEZ) Phase 3 on traffic composition, as well as the impact of removing the Western Extension of the Congestion Charging zone (WEZ) on traffic flows and speeds.

For the model verification, all major roads within 1500 metres of the monitoring sites were modelled in detail, with all other roads in London modelled as part of a 1-kilometre resolution grid source. In order to generate pollution maps, all major roads inside and within a distance of 1500 metres of the City were modelled in detail. Figure 4.1 shows the major roads in the City.

Figure 4.1: Major roads in the City of London

4.2. Traffic emissions

Emission rates for each road were calculated using the LAEI traffic flows and speeds and the latest set of DfT emission factors[2] released in 2009. These include primary NO_2 emission factors for each vehicle type resulting in accurate road-by-road NO_x and NO_2 emission rates.

4.2.1. Diesel NO_x emissions

Recent evidence from NO_x and NO_2 monitoring data in urban areas has shown that diesel NO_x emissions are not decreasing at the expected rate, as discussed in a Defra Frequently Asked Question[3] in September 2010. In this modelling study, in line with Defra guidance, NO_x emissions from all EURO 2 to EURO 5 diesel vehicles have been set to be the same as the equivalent EURO 1 vehicles. Primary NO_2 emissions have been calculated by applying the primary NO_2 fraction for each vehicle type to the EURO 1-equivalent NO_x emissions. It is expected that emissions from EURO 6 vehicles will meet the expected emission reductions so these emission factors are unchanged. These changes have the effect of increasing NO_x and NO_2 road traffic emission rates for all years; PM_{10} and $PM_{2.5}$ emissions are unaffected.

4.2.2. Brake and tyre-wear

Brake and tyre-wear emissions data have been taken directly from the LAEI and added to the exhaust emissions for each road.

4.2.3. Road-wear and re-suspension

Concentrations of PM_{10} and $PM_{2.5}$ at roadside locations are affected by road-wear, and concentrations of PM_{10} are affected by re-suspension. These are not quantified in the LAEI but a recent study prepared for Defra[4] presented combined road-wear and re-suspension emission factors for light and heavy vehicles. These were used to calculate road-by-road road-wear and re-suspension emission rates and were added to the exhaust and brake and tyre-wear emission rates.

[2] http://www.dft.gov.uk/pgr/roads/environment/emissions/

[3] *Measured nitrogen oxides (NOx) and/or nitrogen dioxide (NO2) concentrations in my local authority area do not appear to be declining in line with national forecasts. Should I take this into account in my Review and Assessment work?* http://laqm2.defra.gov.uk/FAQs/General/Measured nitrogen oxides (NOx) and-or nitrogen dioxide (NO_2) concentrations do not appear to be declining in line with national forecasts.pdf

[4] *Road vehicle non-exhaust particulate matter: initial air quality model development and application, model uncertainty analysis and further model improvements*, prepared by TRL for DEFRA 2007 http://www.airquality.co.uk/archive/reports/cat15/0706061626_Report3__Modelling_Development.pdf

4.2.4. Daily traffic variation

The variation of traffic flow during the day has been taken into account by applying a set of diurnal profiles to the road emissions. These profiles were taken from the report *Air pollution and emissions trends in London*[5] used in the compilation of the LAEI, and are shown in Figure 4.2.

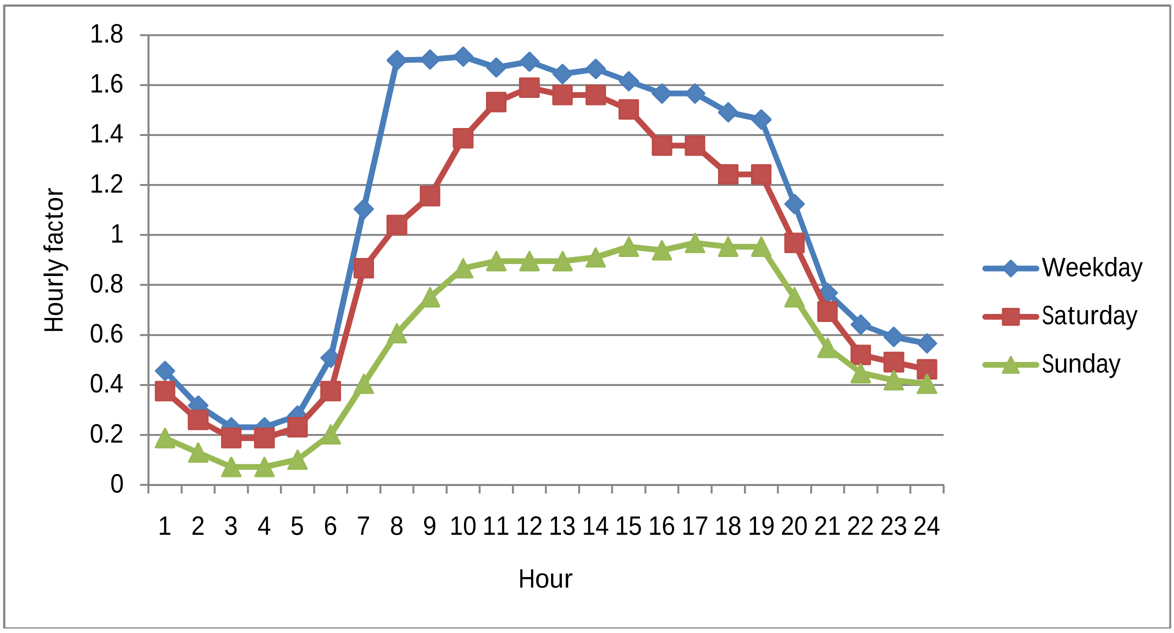

Figure 4.2: Diurnal profiles for Central London

4.3. Industrial sources

The South East London Combined Heat and Power Plant (SELCHP) is approximately 3 km to the south east of the City of London and, due to its proximity and high NO_x emission rate, has been included explicitly in the modelling.

4.4. Other emission

Emission rates for all other sources were taken from the LAEI and modelled as aggregated 1-kilometre resolution grid sources covering the whole of London.

[5] *Air pollution and emissions trends in London*, King's College London, Environmental Research Group and Leeds University, Institute for Transport studies
http://www.airquality.co.uk/reports/cat05/1004010934_MeasurementvsEmissionsTrends.pdf

5. Model set-up

Modelling was carried out using the ADMS-Urban[6] model (version 2.3.3.1). The model uses the detailed emissions data described in Section 4 together with a range of other input data to calculate the dispersion of pollutants. This section summarises the data and assumptions used in the modelling.

5.1. Surface roughness

A length scale parameter called the surface roughness length is used in the model to characterise the study area in terms of the effects it will have on wind speed and turbulence, which are key factors in the modelling. A value of 1 metre was used in the modelling.

The difference in land use at Heathrow compared to the study area was taken into account by entering a different surface roughness for the meteorological site. See Section 5.3 for further details.

5.2. Monin-Obukhov Length

In urban and suburban areas a significant amount of heat is emitted by buildings and traffic, which warms the air within and above a city. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the urban area the more heat is generated and the stronger the effect becomes.

In the ADMS-Urban model, the stability of the atmosphere is represented by the Monin-Obukhov parameter, which has the dimension of length. In very stable conditions it has a positive value of between 2 metres and 20 metres. In near neutral conditions its magnitude is very large, and it has either a positive or negative value depending on whether the surface is being heated or cooled by the air above it. In very convective conditions it is negative with a magnitude of typically less than 20 metres.

The effect of the urban heat island is that, in stable conditions, the Monin-Obukhov length will never fall below some minimum value; the larger the city, the larger the minimum value. A value of 75 metres was used in the modelling.

[6] http://www.cerc.co.uk/environmental-software/ADMS-Urban-model.html

5.3. Meteorological data

Meteorological data from Heathrow for the year 2008 were used in the modelling. A summary of the data is given in Table 5.1. Figure 5.1 shows a wind rose giving the frequency of occurrence of wind from different directions for a number of wind speed ranges.

The difference in land use at Heathrow compared to the study area was taken into account by entering a different surface roughness for the meteorological site. The surface roughness for Heathrow was set to 0.1 metre, compared to 1 metre for Central London.

Table 5.1: Summary of meteorological data

	Minimum	Maximum	Mean
Temperature (°C)	-3.7	29.1	11.3
Wind speed (m/s)	0	14.4	4.4
Cloud cover (oktas)	0	8	4.9

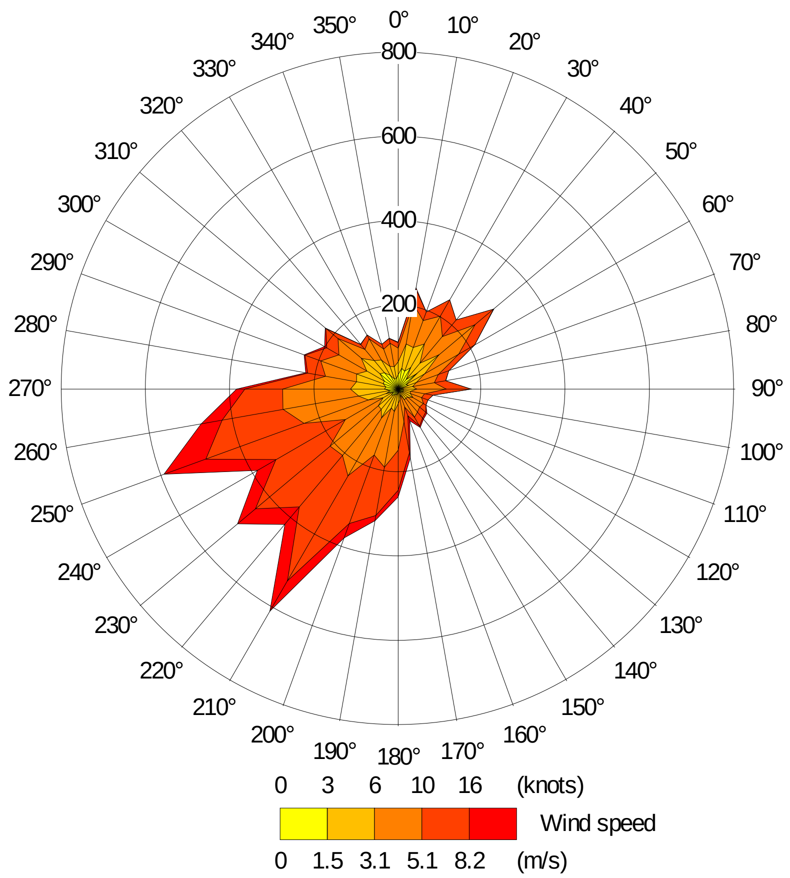

Figure 5.1: Wind rose for Heathrow, 2008

5.4. NO_x chemistry and background data

Nitrogen dioxide (NO_2) results from direct emissions from combustion sources together with chemical reactions in the atmosphere involving NO_2, nitric oxide (NO) and ozone (O_3). The combination of NO and NO_2 is referred to as nitrogen oxides (NO_x).

The chemical reactions taking place in the atmosphere were taken into account in the modelling using the Generic Reaction Set (GRS) of equations. These use hourly average background concentrations of NO_x, NO_2 and O_3, together with meteorological and modelled emissions data to calculate the NO_2 concentration at a given point.

All emissions of NO_x and NO_2 from within London are included in the modelling. Hourly background data for these pollutants and ozone were input to the model to represent the concentrations in the air being blown into London. These data were obtained from rural monitoring sites around the city as described in Section 5.4.1.

PM_{10} concentrations at any location can be thought of as being made up of a primary component (directly emitted), a secondary component (formed from primary particulates by subsequent reactions) and a coarse component (such as re-suspended dust). Only primary particulates are included in the emissions inventory, with secondary PM_{10} concentrations calculated by the model using SO_2 background and emissions data.

5.4.1. Background data for 2008

NO_x, NO_2 and O_3 concentrations from Rochester, Harwell, Lullington Heath and Wicken Fen were input to the model, the monitored concentration used for each hour depending upon the wind direction for that hour, as shown in Figure 5.2.

Two sources of PM_{10} and $PM_{2.5}$ background data were used for the 2008 validation modelling. For hours for which the wind direction was from the west, rural PM_{10} and $PM_{2.5}$ data from Harwell were used and for hours for which the wind direction was from the east, rural PM_{10} and $PM_{2.5}$ measurements from Rochester were used.

The PM_{10} and $PM_{2.5}$ background concentrations were calculated using data from Harwell and Rochester only, as these are the only rural sites which monitor hourly average PM_{10} and $PM_{2.5}$ in the south of England. A coarse component of 2µg/m^3 was added to the monitored PM_{10} concentrations.

Table 5.2 summarises the annual statistics of the resulting background concentrations used in the modelling for 2008.

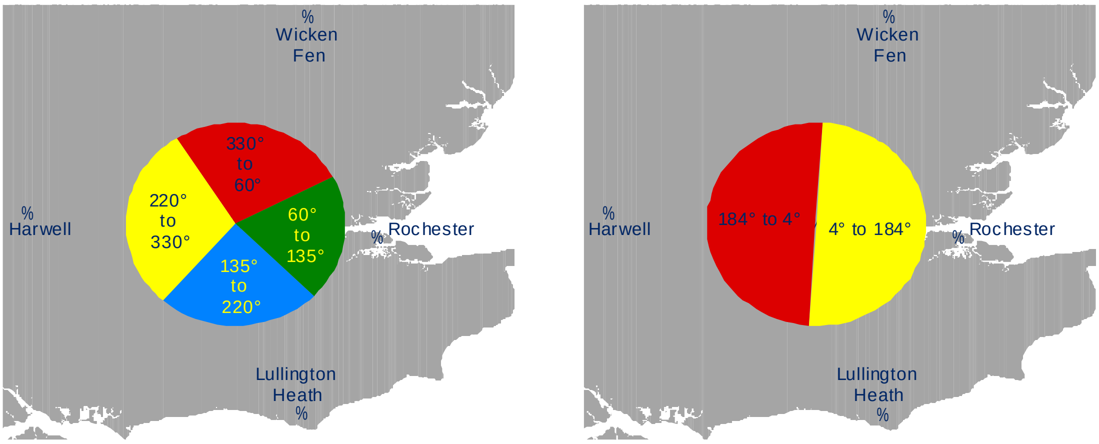

Figure 5.2 Wind direction segments used to calculate background concentrations for NO_x, NO_2 and O_3 (left) and PM_{10} and $PM_{2.5}$ (right)

Table 5.2: Background concentrations for 2008 (µg/m^3)

	NO_x	NO_2	O_3	PM_{10}	$PM_{2.5}$
Annual average	13.0	9.4	54.5	19.5	9.4
99.79th percentile of hourly average	147.9	60.3	127.1	-	-
90.41st percentile of 24-hour average	-	-	-	36.0	16.0

5.4.2. Background data for 2011 and 2015

Background concentrations of NO_x, NO_2 and O_3 for 2008 were used for 2011 and 2015. Defra guidance[3], discussed in Section 4.2.1, suggests that forecast reductions in background NO_x and NO_2 concentrations in future year projections are likely to be optimistic. In line with this guidance, background concentrations of NO_x, NO_2 and O_3 are assumed to remain constant between 2008 and 2015 in this modelling study.

Background concentrations of PM_{10} and $PM_{2.5}$ for 2011 and 2015 were obtained by projecting forward hourly measured data from 2008. Factors for the projection were calculated by comparing 2008 concentrations against 2011 and 2015 concentrations in the LAQM 2008 base year background maps[7], for the locations of the Harwell and Rochester stations.

Table 5.3 summarises the annual statistics of the resulting background PM_{10} and $PM_{2.5}$ concentrations used in the modelling for 2011 and 2015.

[7] http://laqm1.defra.gov.uk/review/tools/background-maps-info.php?year=2008

Table 5.3: PM_{10} and $PM_{2.5}$ background concentrations for 2011 and 2015 (µg/m^3)

	2011		**2015**	
	PM_{10}	**$PM_{2.5}$**	**PM_{10}**	**$PM_{2.5}$**
Annual average	18.7	8.9	18.2	8.5
90.41st percentile of 24-hour average	34.5	15.0	33.6	14.4

6. Model verification

The first stage of a modelling study is to model a current case in order to verify that the input data and model set-up are representative for the area. This was carried out by calculating hourly average concentrations of NO_x, NO_2 and PM_{10} at the sites of continuous monitors in the City and comparing the measured and modelled concentrations. Note that the meteorological data used in the modelling and the measured pollutant concentrations contain some missing values; the statistics compared in this exercise therefore only include hours for which both measured and modelled concentrations are available.

The City of London had six continuous monitors in operation in 2008; five measuring NO_x and NO_2 and three measuring PM_{10}. Figure 6.1 shows the locations of these monitoring sites.

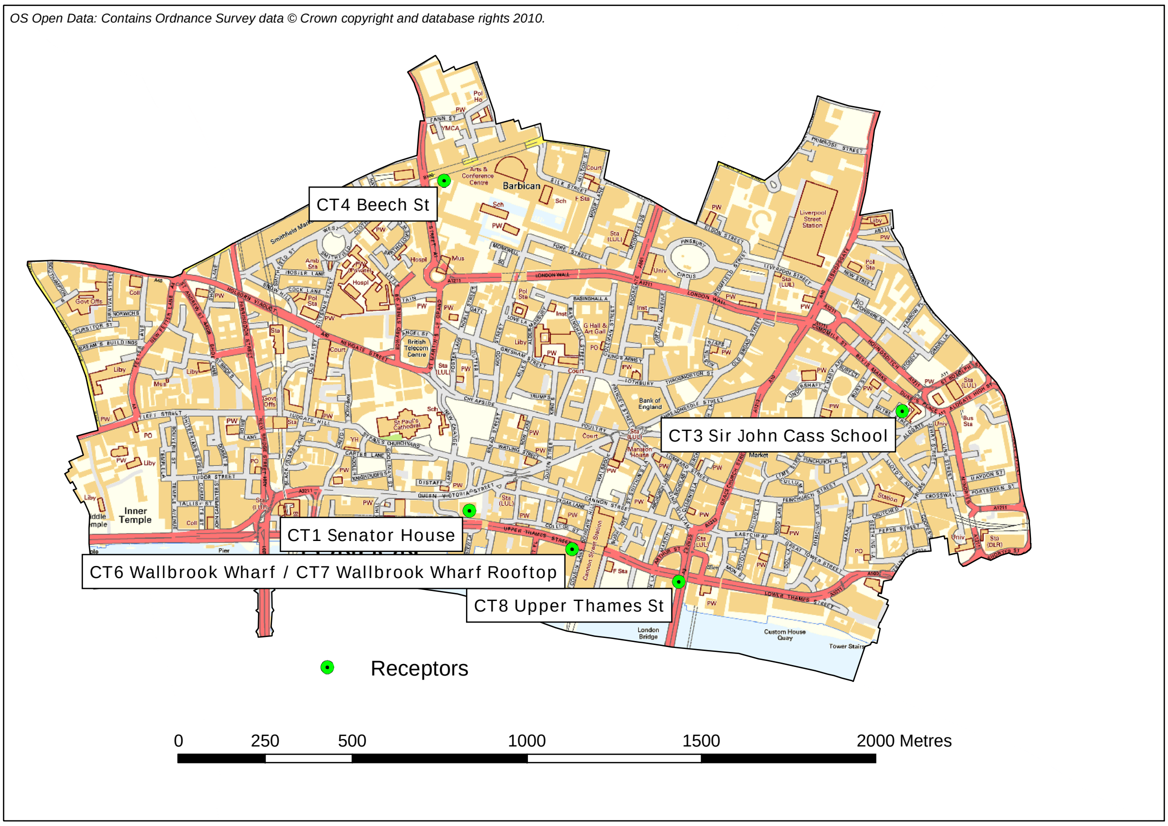

Figure 6.1: City of London continuous monitoring sites

Four monitoring stations, shown in Table 6.1, were chosen to verify the modelling. Model verification is carried out to check whether the input data and model set-up are representative of the modelled area.

Table 6.1: Details of monitoring sites used for verification

	Grid reference	Height (m)	Distance from road (m)	Street canyon height (m)
Senator House	532234 180894	24.5	40	-
Walbrook Wharf	532528 180784	2.8	4	20
Upper Thames Street	532834 180691	1.8	5	17
Sir John Cass School	533475 181179	1.8	30	-

Tables 6.2 to 6.4 show the measured and modelled concentrations of NO_x, NO_2 and PM_{10} for 2008 at the four sites, together with the modelled concentrations expressed as a percentage of the measured concentrations. A value of 100% would indicate perfect agreement between measured and modelled data, with values greater than 100% indicating that the model is over-predicting concentrations and values less than 100% showing model under-prediction.

Table 6.2: Measured and modelled concentrations of NO_x for 2008

Site	Annual average (µg/m³)			99.79^{th} percentile (µg/m³)		
	Measured	Modelled	%	Measured	Modelled	%
Senator House	78.6	78.2	100	435.5	547.8	126
Walbrook Wharf	427.1	351.9	82	1859.5	1463.3	79
Sir John Cass School	89.1	96.9	109	493.4	598.8	121

Table 6.3: Measured and modelled concentrations of NO_2 for 2008

Site	Annual average (µg/m³)			99.79^{th} percentile (µg/m³)		
	Measured	Modelled	%	Measured	Modelled	%
Senator House	48.3	44.3	92	126.4	164.8	130
Walbrook Wharf	127.4	124.1	97	310.1	372.6	120
Sir John Cass School	54.9	50.1	91	136.3	172.7	127

Table 6.4: Measured and modelled concentrations of PM_{10} for 2008

Site	Annual average (µg/m³)			90.41^{st} percentile (µg/m³)		
	Measured	Modelled	%	Measured	Modelled	%
Upper Thames Street	32.1	36.2	113	51.8	55.1	106
Sir John Cass School	31.2	22.6	72	51.8	38.4	74

The modelling shows generally good agreement between the measured and modelled concentrations indicating that the emissions data and model set-up are appropriate for the area. There is some over-prediction of the 99.79^{th} percentiles of hourly average NO_2 concentrations at all the monitoring sites. PM_{10} concentrations show good agreement at Upper Thames Street, which is a roadside site, but are under-predicted at Sir John Cass School, an urban background site. These two sites use different instrumentation to record PM_{10}.

7. Air Quality Maps

Ground level concentrations of NO_2, PM_{10} and $PM_{2.5}$, for 2011 and 2015, were calculated on a grid of receptor points across the whole borough, with a grid resolution of 50m. Extra receptor points were added close to the modelled roads, where concentration gradients are highest. Concentrations were predicted to allow comparison against the air quality standards presented in Section 3 and presented in the form of coloured contour maps.

7.1. NO_2 air quality maps

Figure 7.1 and Figure 7.2 show predicted annual average NO_2 concentrations across the City of London for 2011 and 2015 respectively. Predicted 99.79th percentile of hourly average NO_2 concentrations are shown in Figure 7.3 and Figure 7.4 for 2011 and 2015 respectively.

The air quality standard of 40 µg/m^3 for annual average NO_2 concentrations is predicted to be exceeded across the whole borough, for both 2011 and 2015.

The air quality standard of 200 µg/m^3 for the 99.79th percentile of hourly average NO_2 concentrations is predicted to be exceeded around major roads for both 2011 and 2015. However, note that this statistic is over-predicted at all the monitoring sites in the model verification. The area of exceedence is predicted to be smaller for 2015, than for 2011.

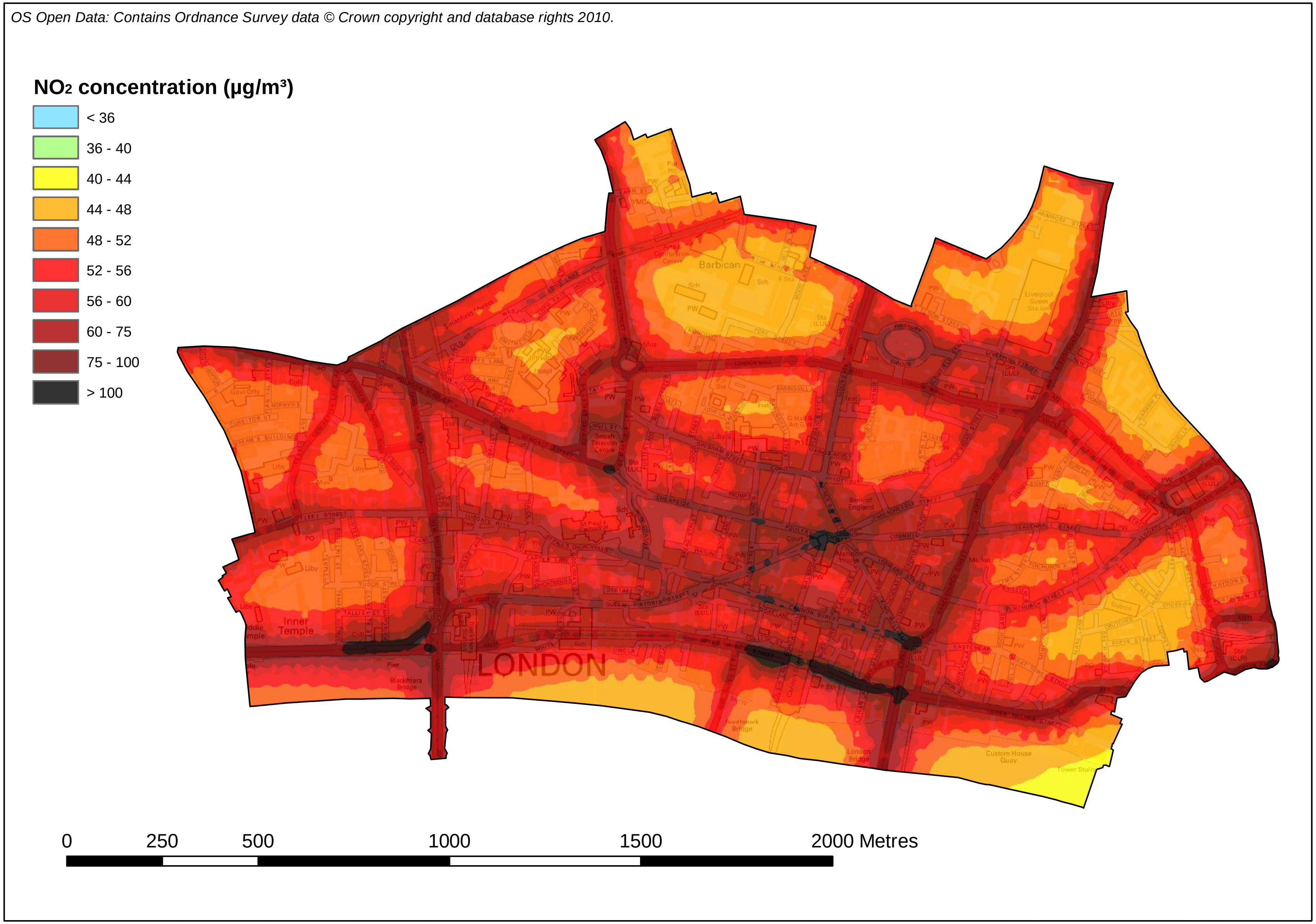

Figure 7.1: Predicted annual average NO_2 concentrations (µg/m^3), 2011

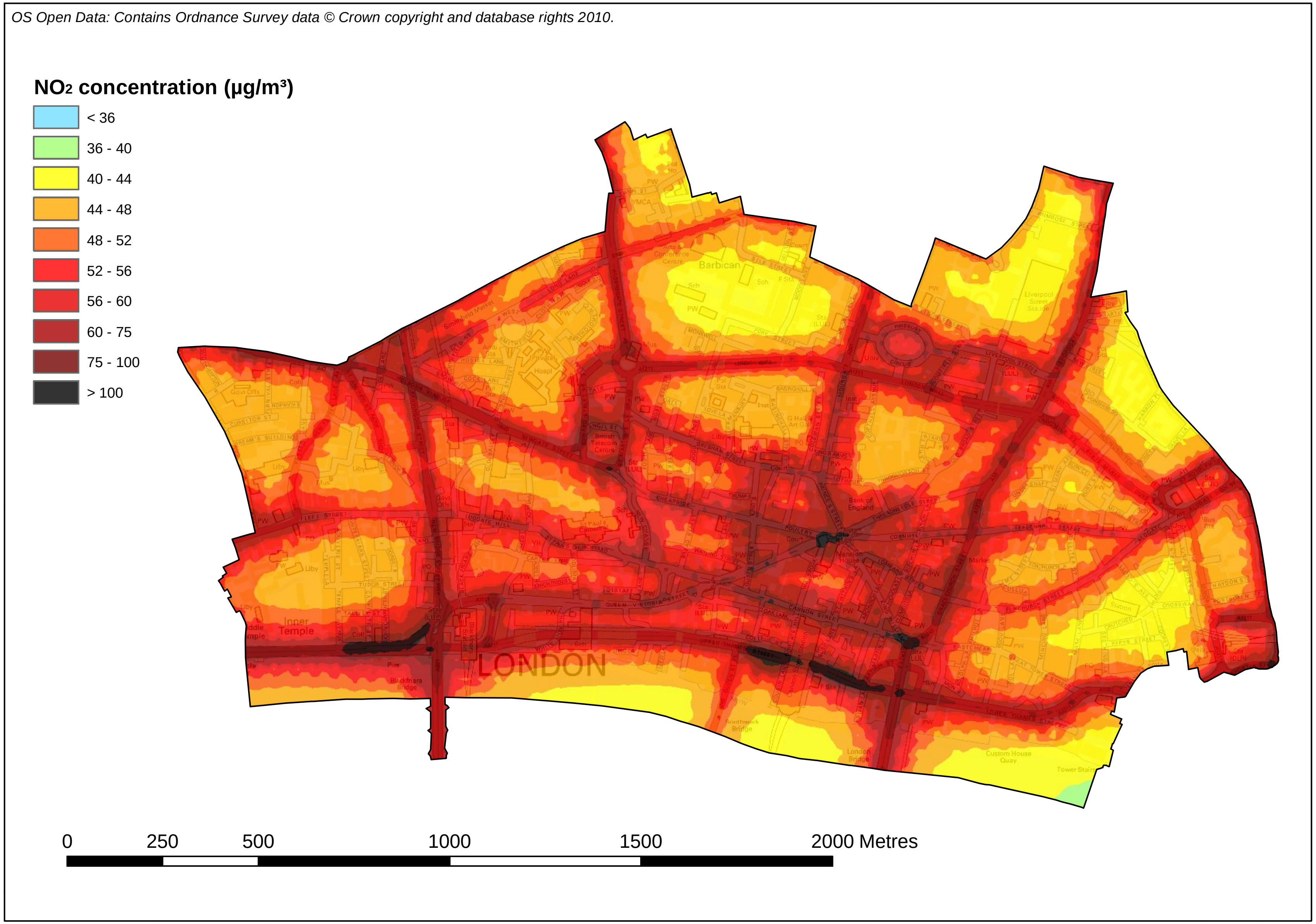

Figure 7.2: Predicted annual average NO_2 concentrations (µg/m^3), 2015

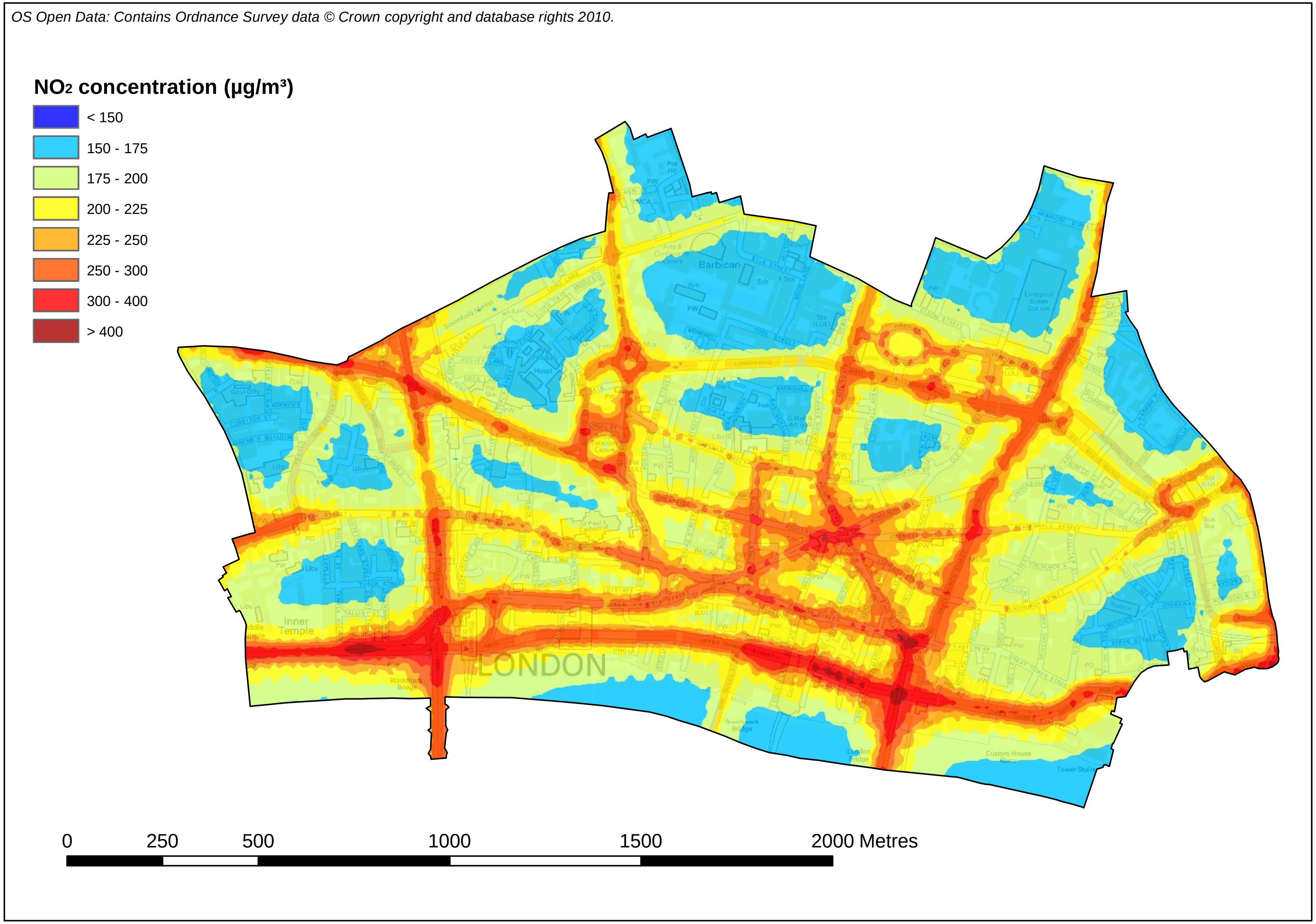

Figure 7.3: Predicted 99.79th percentile of hourly average NO_2 concentrations (µg/m³), 2011

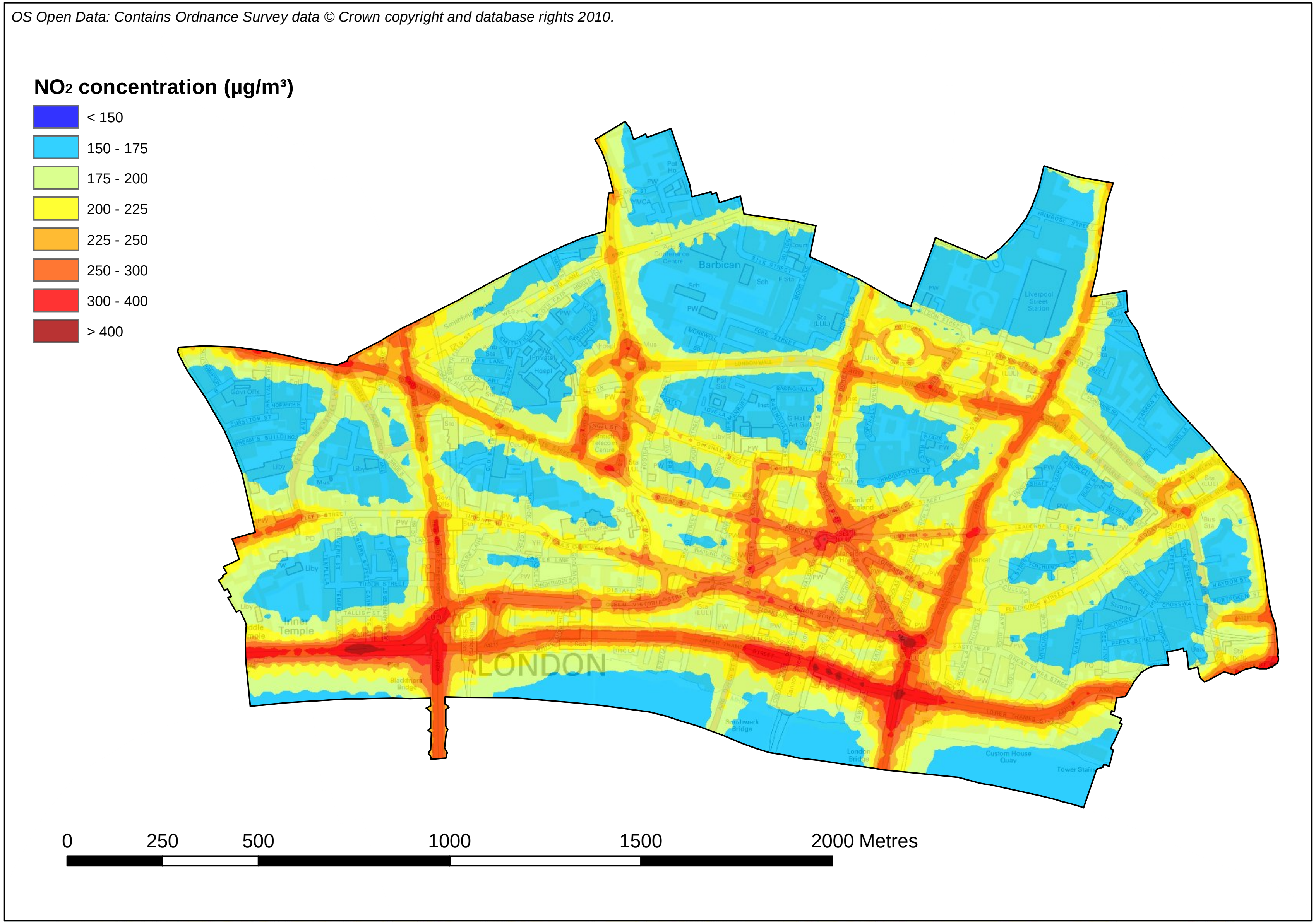

Figure 7.4: Predicted 99.79th percentile of hourly average NO_2 concentrations (µg/m³), 2015

7.2. PM_{10} air quality maps

Figure 7.5 and Figure 7.6 show predicted annual average PM_{10} concentrations across the City of London for 2011 and 2015 respectively. The number of predicted exceedences of 50 µg/m^3 for 24-hour average PM_{10} concentrations are shown in Figure 7.7 and Figure 7.8 for 2011 and 2015 respectively.

There are no predicted exceedences of the air quality standard of 40 µg/m^3 for annual average PM_{10} concentrations for either 2011 or 2015.

The air quality standard of no more than 35 exceedences of 50 µg/m^3 for 24-hour average PM_{10} concentrations is predicted to be exceeded along Upper Thames Street for 2011 and along Victoria Embankment for both 2011 and 2015.

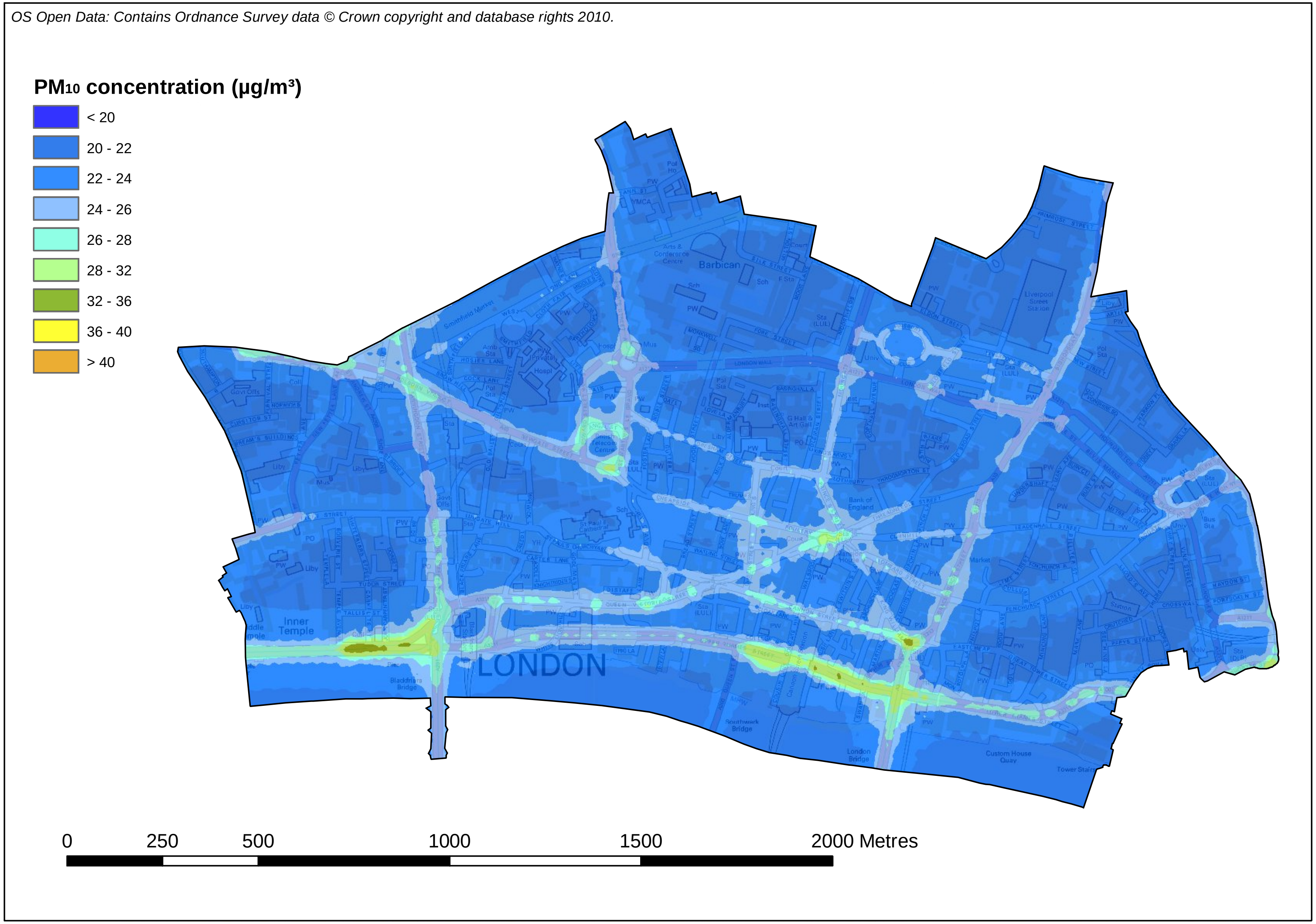

Figure 7.5: Predicted annual average PM_{10} concentrations ($\mu g/m^3$), 2011

Figure 7.6: Predicted annual average PM_{10} concentrations ($\mu g/m^3$), 2015

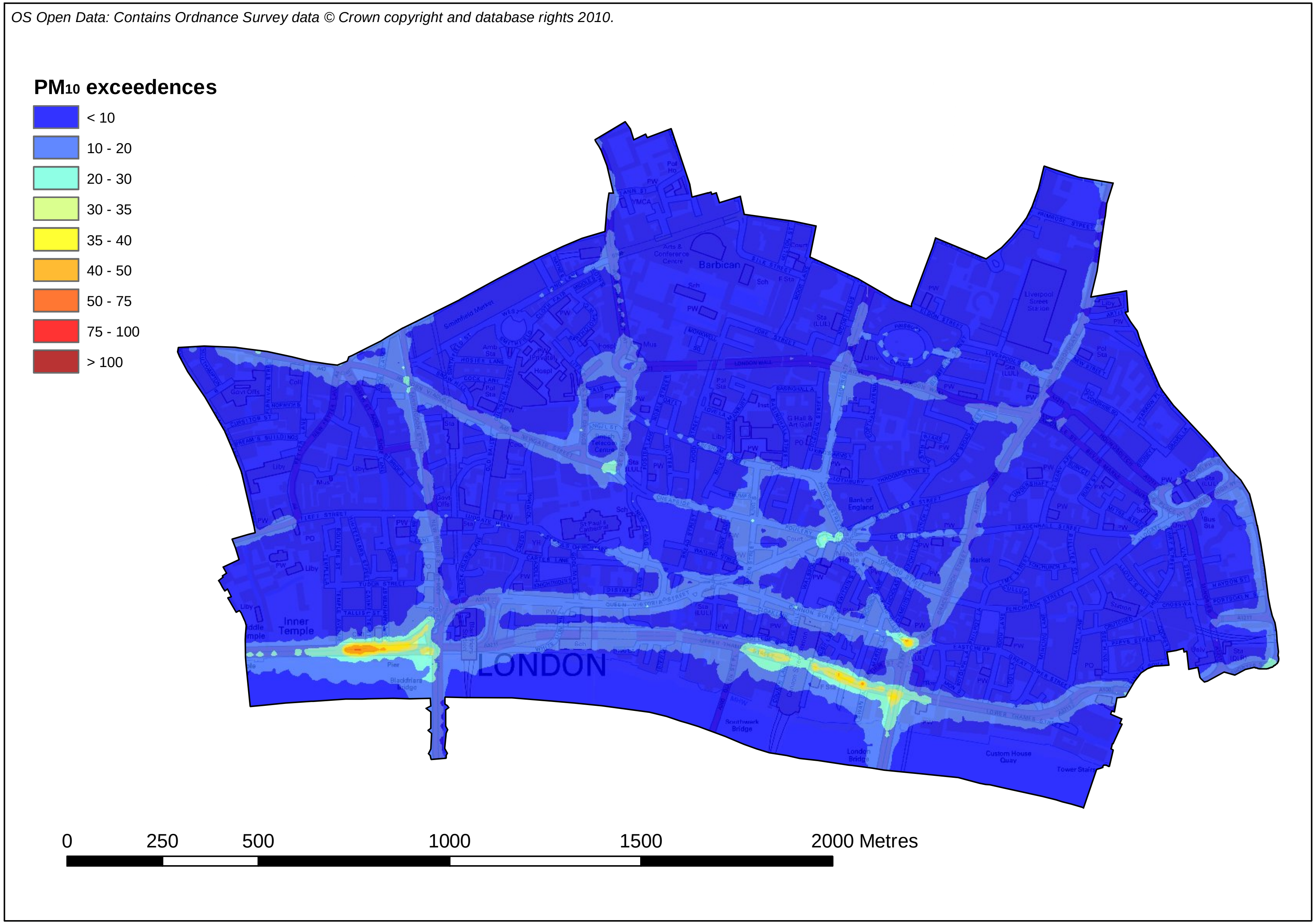

Figure 7.7: Predicted number of exceedences of 50 µg/m^3 for 24-hour average PM$_{10}$ concentrations, 2011

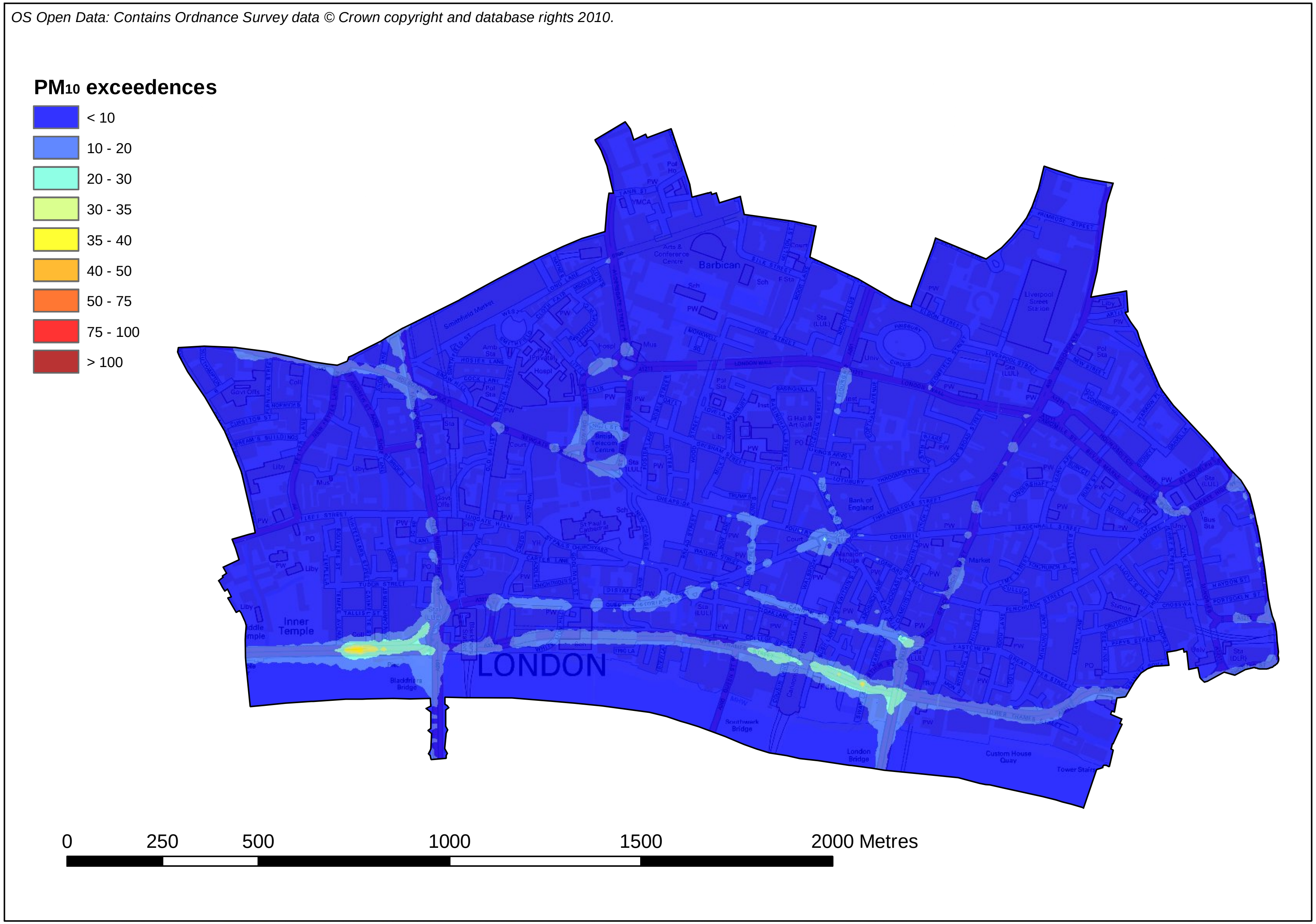

Figure 7.8: Predicted number of exceedences of 50 µg/m^3 for 24-hour average PM$_{10}$ concentrations, 2015

7.3. $PM_{2.5}$ air quality maps

Figure 7.9 and Figure 7.10 show predicted annual average $PM_{2.5}$ concentrations across the City of London for 2011 and 2015 respectively. The predicted change in annual average $PM_{2.5}$ concentrations between 2011 and 2015 is shown in Figure 7.11.

There are no predicted exceedences of the air quality standard of 25 $\mu g/m^3$ for annual average $PM_{2.5}$ concentrations for either 2011 or 2015.

Annual average $PM_{2.5}$ concentrations at urban background locations in the City of London are predicted to be between 10 $\mu g/m^3$ and 12 $\mu g/m^3$ for 2011 and between 10 $\mu g/m^3$ and 11 $\mu g/m^3$, across of most of the borough, for 2015.

Between 2011 and 2015, $PM_{2.5}$ concentrations at urban background locations are predicted to reduce by 6% - 7%.

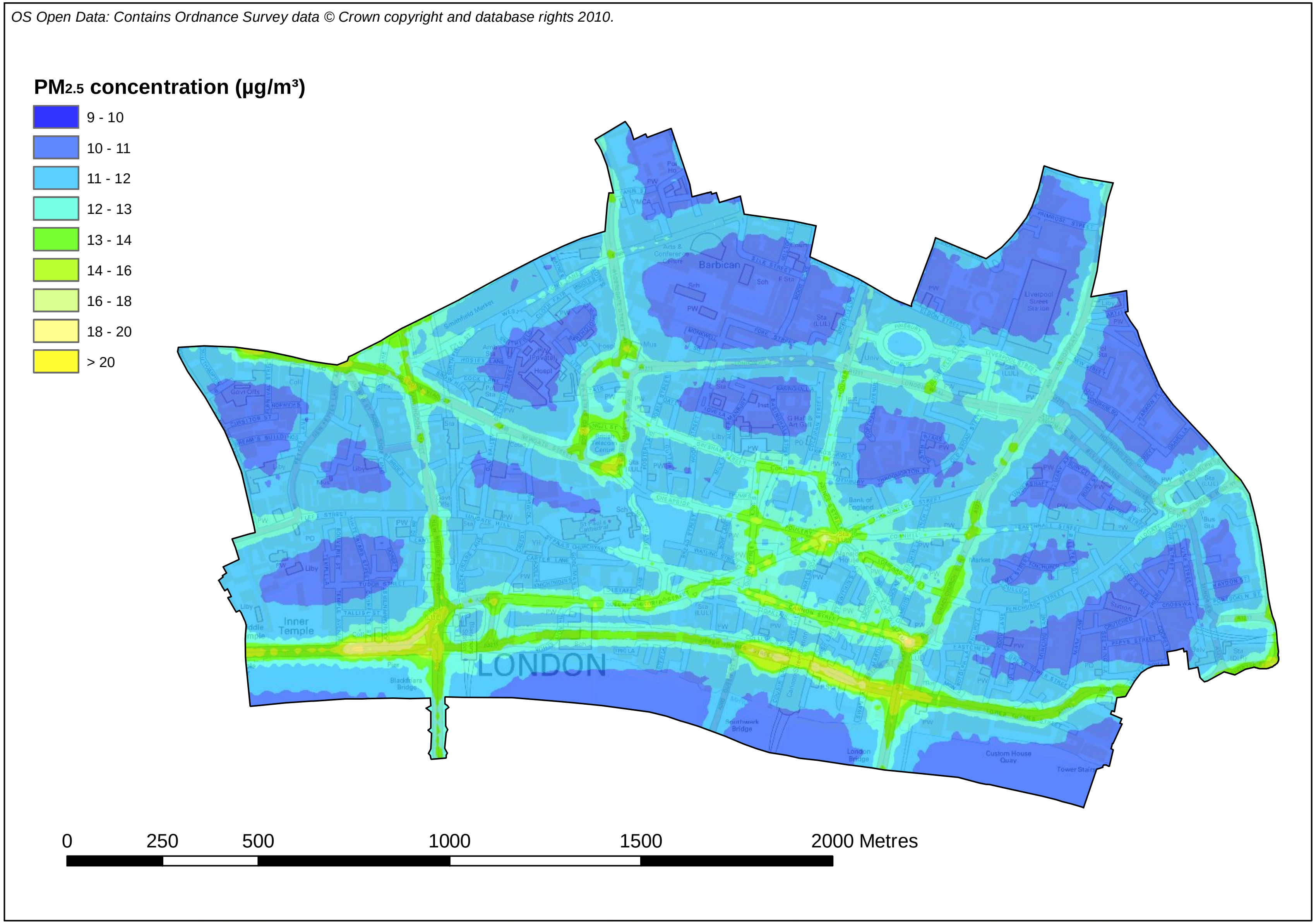

Figure 7.9: Predicted annual average $PM_{2.5}$ concentrations ($\mu g/m^3$), 2011

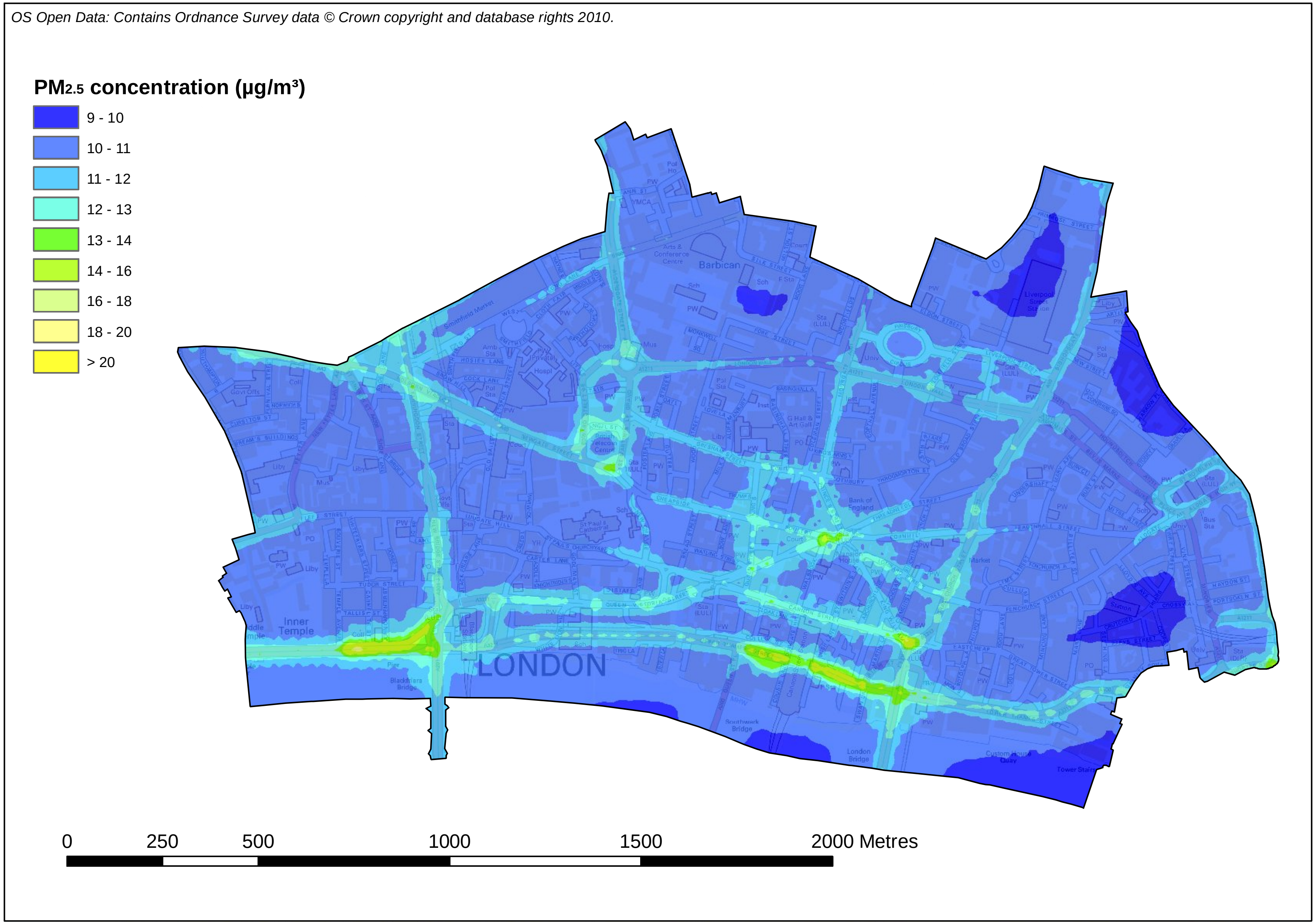

Figure 7.10: Predicted annual average $PM_{2.5}$ concentrations (µg/m^3), 2015

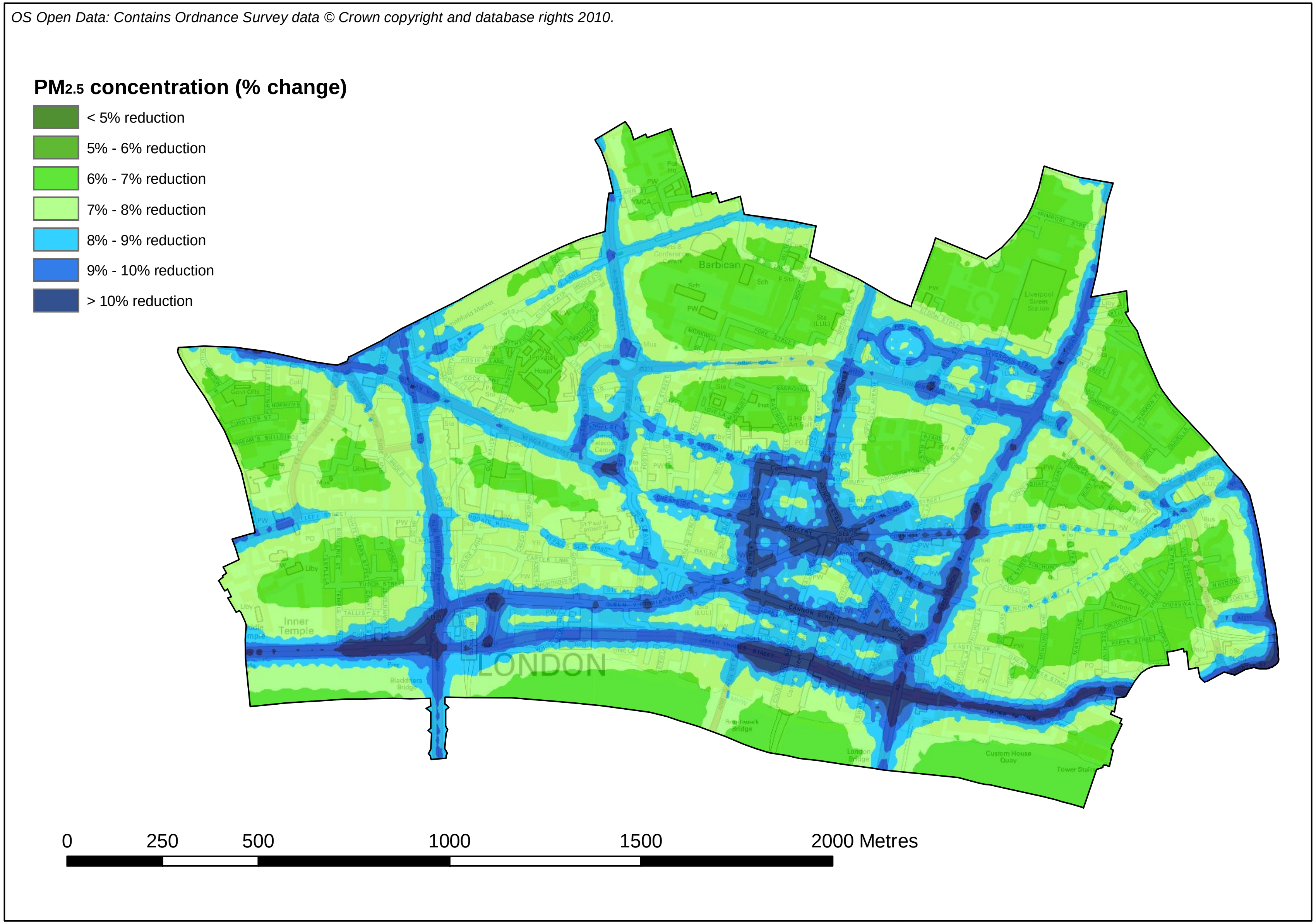

Figure 7.11: Percentage change in predicted annual average $PM_{2.5}$ concentrations between 2011 and 2015

8. Discussion

The whole of the City of London has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO_2) and fine particles (PM_{10}) exceeding the UK air quality standards. Air quality modelling was previously carried out to determine the extent of any exceedences of the objectives, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the City of London Corporation to carry out air quality modelling, using ADMS-Urban (version 2.3.3.1) air quality modelling software, with emissions and traffic data from the London Atmospheric Emissions Inventory (LAEI) 2008.

Traffic emissions were calculated using the latest set of DfT emission factors, taking into account the lack of expected reduction in NO_x emissions from new diesel vehicles. PM_{10} and $PM_{2.5}$ emissions included contributions from exhaust, brake and tyre-wear, and road-wear and re-suspension, as applicable.

Model verification was carried out by comparing measured and modelled concentrations at the City's continuous monitoring sites for 2008. The modelling showed good agreement between measured and modelled concentrations with some over-prediction of 99.79th percentile of hourly average NO_2 concentrations at all monitoring sites, and under-prediction of PM_{10} concentrations at Sir John Cass School.

Air quality maps were created for 2011 and 2015, for comparison against the air quality objectives and Limit Values.

The air quality objective of 40 µg/m^3 for annual average NO_2 concentrations is predicted to be exceeded across the whole borough, for both 2011 and 2015. The air quality objective of 200 µg/m^3 for the 99.79th percentile of hourly average NO_2 concentrations is predicted to be exceeded around major roads for both 2011 and 2015; however, the model verification suggests that the areas of exceedence may be over-predicted.

There are no predicted exceedences of the air quality objective of 40 µg/m^3 for annual average PM_{10} concentrations for either 2011 or 2015. The air quality objective of no more than 35 exceedences of 50 µg/m^3 for 24-hour average PM_{10} concentrations is predicted to be exceeded along Upper Thames Street for 2011, and along Victoria Embankment for both 2011 and 2015.

There are no predicted exceedences of the air quality objective of 25 µg/m^3 for annual average $PM_{2.5}$ concentrations for either 2011 or 2015.

Across the borough, annual average $PM_{2.5}$ concentrations at urban background locations are predicted to be between 10 µg/m^3 and 12 µg/m^3 for 2011. Therefore a 10% reduction in annual average $PM_{2.5}$ concentrations is required at these locations by 2020, to meet the national exposure reduction target.

At urban background locations in the City of London, annual average $PM_{2.5}$ concentrations are predicted to reduce by 6% - 7% between 2011 and 2015, equivalent to a reduction of approximately 0.6 $\mu g/m^3$ – 0.8 $\mu g/m^3$. Rural background $PM_{2.5}$ concentrations, representing pollutant concentrations from outside London, are projected to reduce by 0.4 $\mu g/m^3$ between 2011 and 2015. Therefore up to half the predicted reduction in $PM_{2.5}$ concentrations at urban background locations between these years is due to projected reduction in emissions within London, in the LAEI.

The predicted $PM_{2.5}$ concentrations indicate that a further reduction of 3% - 4% is required at urban background locations between 2015 and 2020, to meet the exposure reduction target.