Bristol Clean Air Plan

Air Quality Modelling Report (AQ3)

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JACOBS

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1	04/09/2018	Draft	Andrea Davidson	Piercarlo Smith and Clare Beattie	Becky Lloyd
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Acronyms and Abbreviations

ADMS	Atmospheric Dispersion Modelling System
ANPR	Automatic Number Plate Recognition
ATC	Automatic Traffic Counters
AQMA	Air Quality Management Area
BCC	Bristol City Council
CAZ	Clean Air Zone
COPERT	Computer Programme to calculate Emissions from Road Transport
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
GBATS	Greater Bristol Area Transport Model
HGV	Heavy Goods Vehicle
JAQU	Joint Air Quality Unit (Defra and the Department for Transport)
LDV	Light Duty Vehicle
LSOA	Lower Super Output Area
$\mu g/m^3$	micrograms per cubic metre
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
PCM	Pollution Climate Mapping
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 micrometres
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 micrometres
SGC	South Gloucestershire Council

1. Introduction

1.1 Background

Poor air quality is the largest known environmental risk to public health in the UK[1]. Investing in cleaner air and doing more to tackle air pollution are priorities for the EU and UK governments, as well as for Bristol City Council (BCC). BCC has monitored and endeavored to address air quality in Bristol since 2002. Despite this, Bristol has ongoing exceedances of the legal limits for Nitrogen Dioxide (NO_2) and these are predicted to continue until 2023 without intervention.

In 2017 the government published a UK Air Quality Plan for Nitrogen Dioxide[2] setting out how compliance with the EU Limit Value for annual mean NO_2 will be reached across the UK in the **shortest possible time**. Due to forecast air quality exceedances, BCC, along with 27 other Local Authorities, was directed by Minister Therese Coffey (Defra) and Minister Jesse Norman (DfT) in 2017 to produce a Clean Air Plan (CAP). The Plan must set out how BCC will achieve sufficient air quality improvements in the **shortest possible time**. In line with Government guidance BCC is considering implementation of a Clean Air Zone (CAZ), including both charging and non-charging measures, in order to achieve sufficient improvement in air quality and public health.

Jacobs has been commissioned by BCC to produce an Outline Business Case (OBC) for the delivery of the CAP; a package of measures which will bring about compliance with the Limit Value for annual mean NO_2 in the **shortest possible time** in Bristol. The OBC assesses the shortlist of options set out in the Strategic Outline Case[3], and proposes a preferred option including details of delivery. The OBC forms a bid to central government for funding to implement the CAP.

1.2 Purpose of Report

This report presents the validation process of the air quality modelling for the BCC CAZ Feasibility study and the results for the Baseline in order to establish the future baseline conditions for the assessment of identified measures. This version of the report presents the results of the baseline modelling for 2015, 2021 and 2031.

A detailed comparison between the local model presented in this report and the national PCM is provided through the Target Determination (TD1) which has been submitted to JAQU as a separate submission.

The option testing work (i.e. the results of the model for the identified measures) is presented within the Outline Business Case and will include the assessment of how soon the proposed measures will bring NO_2 concentration into compliance.

[1] Public Health England (2014) Estimating local mortality burdens associated with particular air pollution. https://www.gov.uk/government/publications/estimating-local-mortality-burdens-associated-with-particulate-air-pollution

[2] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

[3] Bristol Council Clean Air Plan: Strategic Outline Case, March 2018 (https://democracy.bristol.gov.uk/documents/s19804/Clean%20Air%20Plan%20-%20Cabinet%20Report%20and%20Appendices%20-%20Final%20with%20Early%20Measures%20Fund%20included%20-with%20legal.pdf)

2. Methodology

2.1 Overview

Air quality dispersion modelling has been undertaken using ADMS-Roads version 4.1 using vehicle emission factors from the EFT version 8.0.1a. A detailed model has been set up for Bristol, incorporating detail of on street canyons and gradients. The model has been verified and adjusted on the basis of 2015 measurements from 72 nitrogen dioxide monitoring locations situated across Bristol and South Gloucestershire.

The model has been run at receptors representing both locations relevant for the air quality objectives (façades of residential buildings, schools, hospitals etc.) and locations designed to be comparable with the Government's PCM model, which is used to report compliance with the Limit Values. These receptors have been presented separately as there are important differences, and the results included in this report are those comparable with the Government's PCM model.

The model uses a variety of input data. Importantly, the traffic data have been derived from the GBATS transport model, using local fleet composition as described in the T3 Local Plan Transport Modelling Methodology Report. Inputs and assumptions used are described in both the AQ1 Local Plan Air Quality Modelling Tracking Table and AQ2 Local Plan Air Quality Modelling Methodology Report, which also includes the full methodology.

All modelling undertaken follows relevant guidance issued by JAQU and has been subject to discussion with JAQU as the process has progressed.

3. Base Year Model Verification

3.1 Introduction

In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements.

Background concentrations of Nitrogen Dioxide (NO_2) for the verification sites have been derived and interpolated from the national maps, using the approach as described in AQ2 Local Plan Air Quality Modelling Methodology Report. The background concentrations have then been adjusted based on a comparison with local monitoring (described in detail in AQ2).

AADT flows, and the proportions of different types of vehicles in the fleet, for the all roads, including those adjacent to the monitoring sites, have been determined from the traffic model utilised for this feasibility study (and described in Report T3 Local Plan Transport Modelling Methodology Report). The specifics of the vehicle fleet have been derived from ANPR (Automatic Number Plate Recognition) data collected around Bristol and also described in Report T3 Local Plan Transport Modelling Methodology Report.

3.2 Nitrogen Dioxide

Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). It is also important to only verify that portion of the total concentration which is predicted by the dispersion model (i.e. the background component has been verified and adjusted separately). This is because the alternative (i.e. verifying against the total concentrations only) risks hiding poor performance in the dispersion model.

The model is unlikely to perform equally well at all locations, however verifying the model at a large number of sites is preferable to only using a small number of sites; which means making use of a combination of automatic monitors as well as diffusion tube monitors. While measurements made with diffusion tubes are generally of lower quality than those from automatic monitors, they are still considered to be more reliable than the results from a dispersion model; particularly one which is only verified for a small number of monitoring sites. The model has thus been run to predict the annual mean NOx concentrations during 2015 at 67 diffusion tube monitoring sites and 5 automatic monitoring sites. Concentrations have been modelled at the inlet height of the monitors, as presented in the BCC and SGC Air Quality Annual Status Reports (ASRs).

The model output of road-NOx has been compared with the 'measured' road-NOx, as set out in the JAQU Guidance. Measured road-NOx has been calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator (Version 6.1) available on the Defra LAQM Support website (Defra, 2018b). The results of this comparison indicate that the model consistently under-predicted road-NOx concentrations at the monitoring sites. This is a common experience when predicting NOx concentrations in urban environments using a dispersion model such as ADMS-Roads and emissions from Defra's EFT; which is the method recommended by JAQU and thus followed. The accepted approach to addressing this under-prediction, following both Defra and JAQU guidance, is to increase the model outputs in line with measurements.

Analysing the modelled results, it was found that the NOx emissions from all vehicles, on gradient and non-gradient roads, were being under-predicted. An adjustment factor of 2.2810 has therefore been applied to NOx emissions.

The EFT has been used to obtain both NOx and NO_2 emissions. Both uplifted NOx and NO_2 have been included within the air quality model to calculate location-specific primary NO_2[4] (f-NO_2) values for each receptor. These location specific values have then been used within the conversion of NOx to NO_2 (using the NOx to NO_2 calculator supplied by Defra). This is the approach recommended by JAQU.

[4] Emissions of NO_2 emitted directly to the atmosphere

The total NO_2 concentrations have then been determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentrations and f-NO_2 values within the NOx to NO_2 calculator.

Figures 1 compares final adjusted modelled total NO_2 at each of the monitoring sites to measured total NO_2.

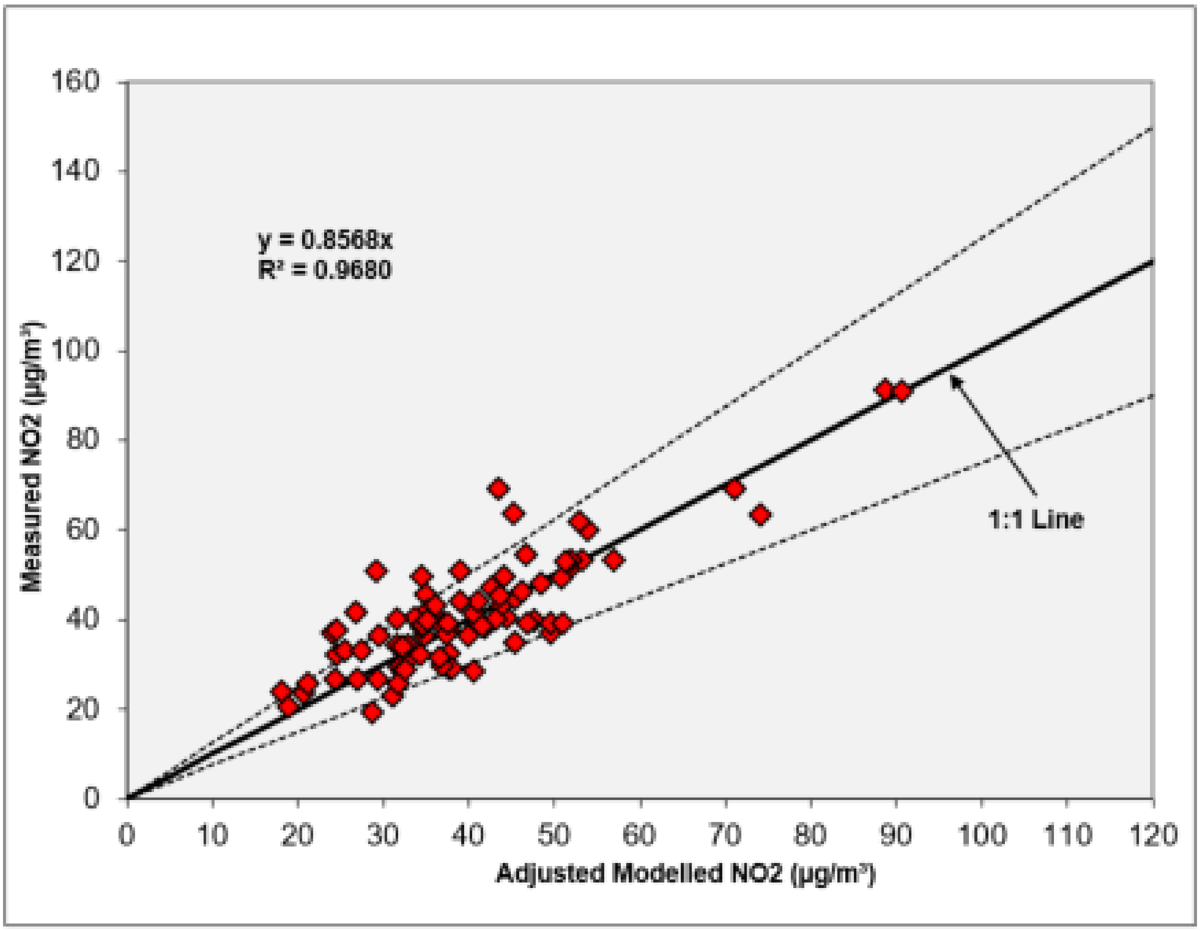

Figure 1: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

Table 1 shows the statistical parameters relating to the performance of the model, as well as 'ideal' values (Defra, 2018b). The values calculated for the model demonstrate that it is performing acceptably.

Table 1: Statistical Model Performance

Statistical Parameter	Model-Specific Value	'Ideal' Value
Correlation Coefficient [a]	0.8568	1
Root Mean Square Error (RMSE) [b]	7.56	0
Fractional Bias [c]	0.03	0

[a] Used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.

[b] Used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared (i.e. µg/m³). TG(16) (Defra, 2018b) outlines that, ideally, a RMSE value within 10% of the air quality objective (4 µg/m³) would be derived. If RMSE values are higher than 25% of the objective (10 µg/m³) it is recommended that the model is revisited.

[c] Used to identify if the model shows a systematic tendency to over or under predict. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.

3.3 PM_{10} and $PM_{2.5}$

Although Defra's Air Quality Plan sets out to tackle roadside NO_2 concentrations in the UK (Defra, 2017a), there are also Limit Values and Air Quality Objectives for particulate matter (PM), specifically PM_{10} and $PM_{2.5}$ which need some consideration as the UK has both a national and international obligation to regulate PM concentrations. The health effects and associated costs of PM are also interlinked with those of NO_2 and therefore require assessment.

In 2015, Bristol City Council monitored particulate matter (PM) at one monitoring site, the AURN site at St. Pauls (452). This site is set back from the main roads by more than 15 m, and adjacent roads are not being included in the model, and therefore it is judged that this is not a suitable site for verification.

It is also noted that the model significantly under-predicts local PM concentrations at this site, which provides further evidence that it is not a suitable site for verification. Therefore, in the absence of a suitable PM verification station, the derived NO_2 adjustment factor has been applied.

4. Baseline Forecasts

4.1 Background Concentrations

Estimated background concentrations in the study area have been determined for 2015 and the future year 2021 using Defra's background maps (Defra, 2018b), with the NO_2 values interpolated and adjusted based on a comparison with local measurements. The background concentrations are set out in Table 2 and have been derived as described in the Air Quality Modelling Methodology Report (AQ2). The background concentrations are all well below the objectives.

Table 2: Estimated Annual Mean Background Pollutant Concentrations in 2015 and 2021 (µg/m^3)

Year	NO_2	PM_{10}	$PM_{2.5}$
2015	9.0 – 28.4	11.4 – 17.6	7.5 – 11.1
2021	7.2 – 26.9	10.9 – 17.1	7.1 – 10.5
Objectives	**40**	**40**	**25 [a]**

The range of values interpolated for the different 1x1 km grid squares covering the study area.

a The $PM_{2.5}$ objective, which is to be met by 2020, is not in Regulations and there is no requirement for local authorities to meet it.

4.2 Baseline Dispersion Model Results: Nitrogen Dioxide

4.2.1 Baseline for Comparison with the PCM

Concentrations of nitrogen dioxide have also been modelled at relevant receptor locations adjacent to roads within the PCM model. The results, which cover the 2015, 2021 and 2031 years, are set out in Figure 2, Figure 3 and Figure 4 for locations modelled at 4 m from the kerb and 2 m in height (i.e. relevant for comparison with the PCM model). These model outputs have then been simplified to only report the maximum value for each census ID of the PCM model. These results are reported in spreadsheet TD1.

The predicted annual mean concentrations of nitrogen dioxide at PCM-equivalent receptors show exceedances of the annual mean Limit Value in 2015 at various location in Bristol as shown in Figure 2 below.

The predicted annual mean concentrations of nitrogen dioxide at PCM-equivalent receptors still show exceedances of the annual mean Limit Value in 2021 at various locations predominantly in central Bristol. In particular the following eight hotspots have been identified: Rupert Street; Upper Maudlin Street; Park Row; Park Street; Queen's Road; College Green; Newfoundland Way; Church Road.

The predicted annual mean concentrations of nitrogen dioxide at PCM-equivalent receptors show that all location will be compliant in 2031 with the only exception of Upper Maudlin Street. This is attributed to the combination of high traffic flows, street canyon effect, road gradient and elevated number of buses.

Results for each link road considered and the comparison against the PCM model are reported in spreadsheet TD1.

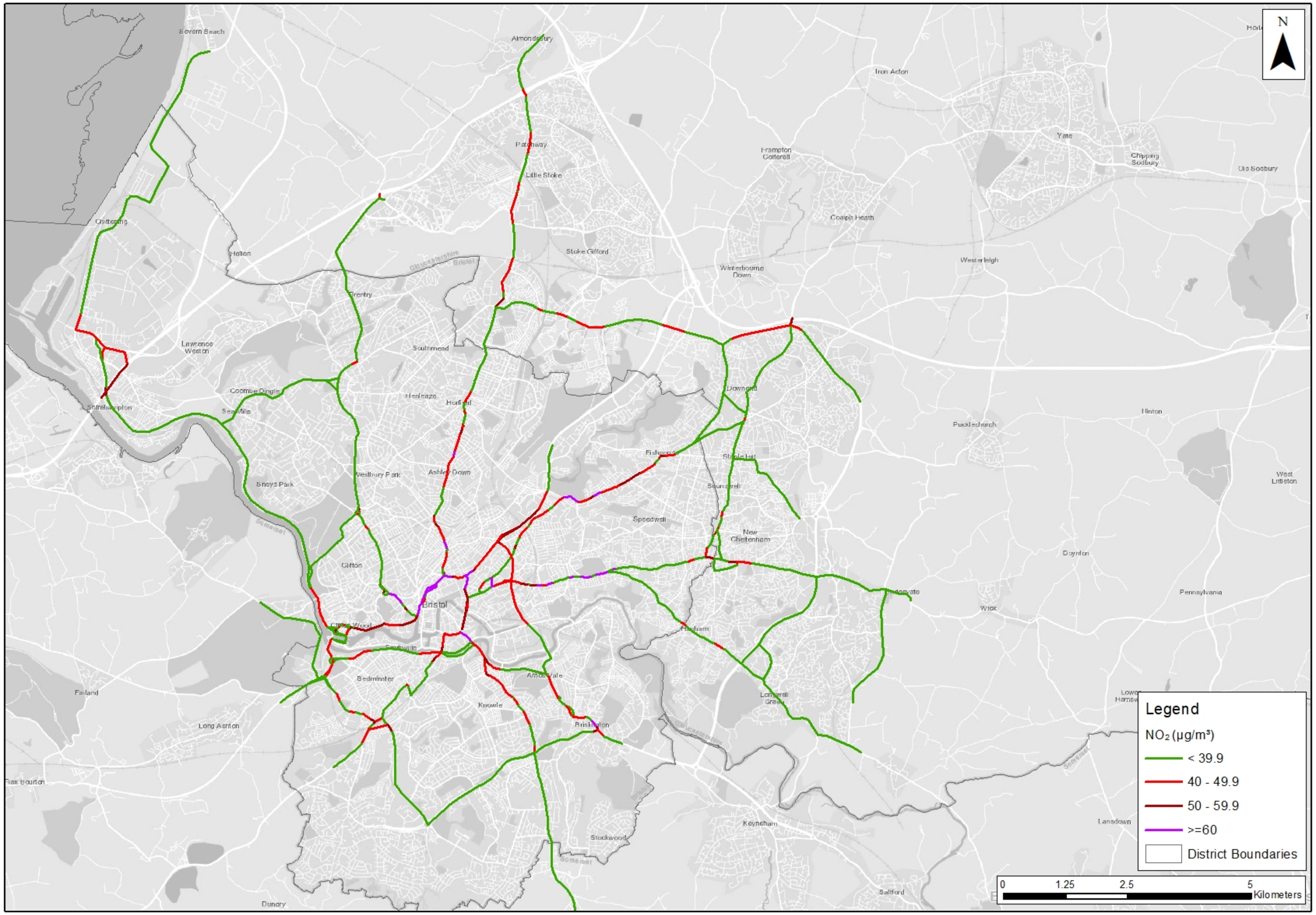

Figure 2: Predicted NO_2 concentrations in 2015 at PCM-equivalent receptor locations

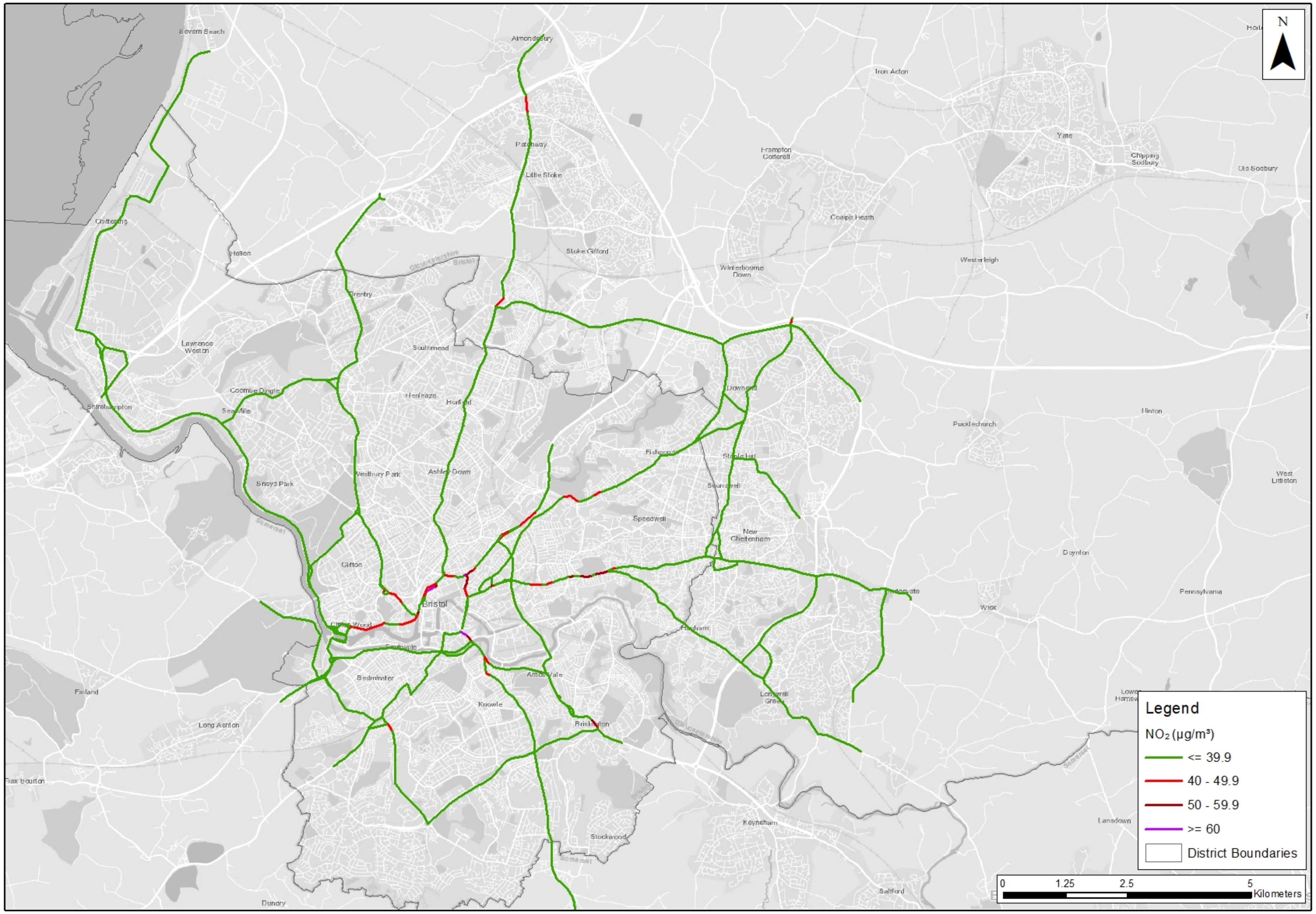

Figure 3: Predicted NO_2 concentrations in 2021 at PCM-equivalent receptor locations

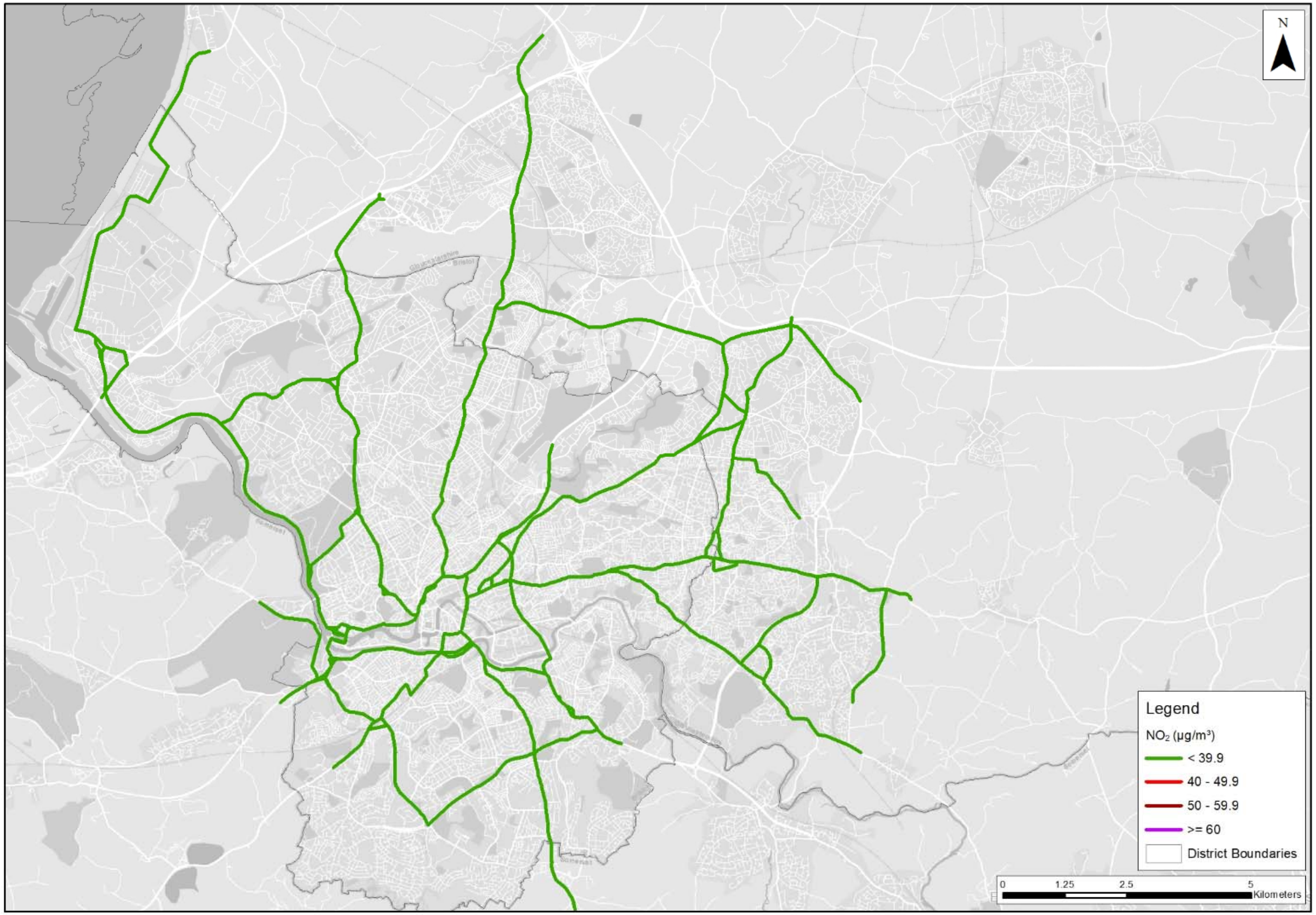

Figure 4: Predicted NO_2 concentrations in 2031 at PCM-equivalent receptor locations

4.3 Baseline Dispersion Model Results: PM_{10} and $PM_{2.5}$

4.3.1 Baseline for comparison with the PCM

Concentrations of PM_{10} and $PM_{2.5}$ have also been modelled at each of the relevant receptor locations adjacent to roads within the PCM model. The results, which cover both the 2015 and 2021 years for PM_{10} and $PM_{2.5}$, are set out in Figure 5, Figure 6 and Figure 7 for locations modelled at 4 m from the kerb and 2 m in height (i.e. relevant for comparison with the PCM model). These model outputs have then been simplified to only report the maximum value for each census ID of the PCM model.

The predicted annual mean concentrations of PM_{10} and $PM_{2.5}$ show no exceedances of the annual mean Limit Values in 2015. For PM_{10} there is also a Limit Value based on the 24-hour average. As described earlier, using a dispersion model to predict exceedances of the 24-hour mean objective can be inaccurate, but the outcomes of the model suggest there is a risk that the 24-hour Limit Value is exceeded in 2015.

The predicted annual mean concentrations of PM_{10} show no exceedances of the annual mean Limit Values in 2021. The predicted annual mean concentrations of PM_{10} still show a risk of exceedance of the 24-hour Limit Value in 2021 at a few locations, although it is noted that these findings are particularly uncertain.

As there are no exceedances of the annual mean objective for $PM_{2.5}$ in 2015, 2021 has not been presented.

Similarly, 2031 maps are not presented because there is not risk that the relevant PM_{10} and $PM_{2.5}$ limits will be exceeded.

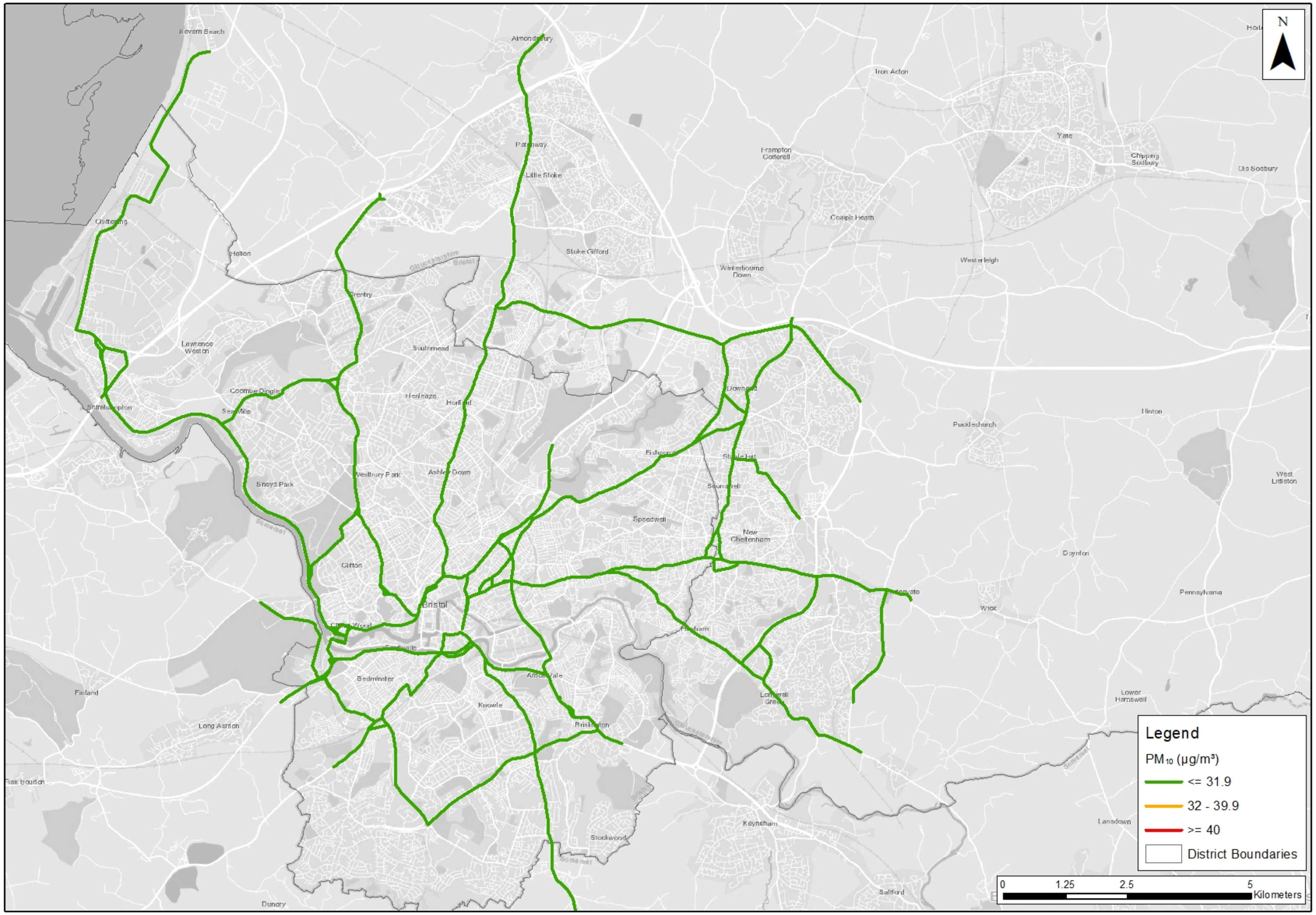

Figure 5: Predicted PM_{10} concentrations in 2015 at PCM-equivalent receptor locations

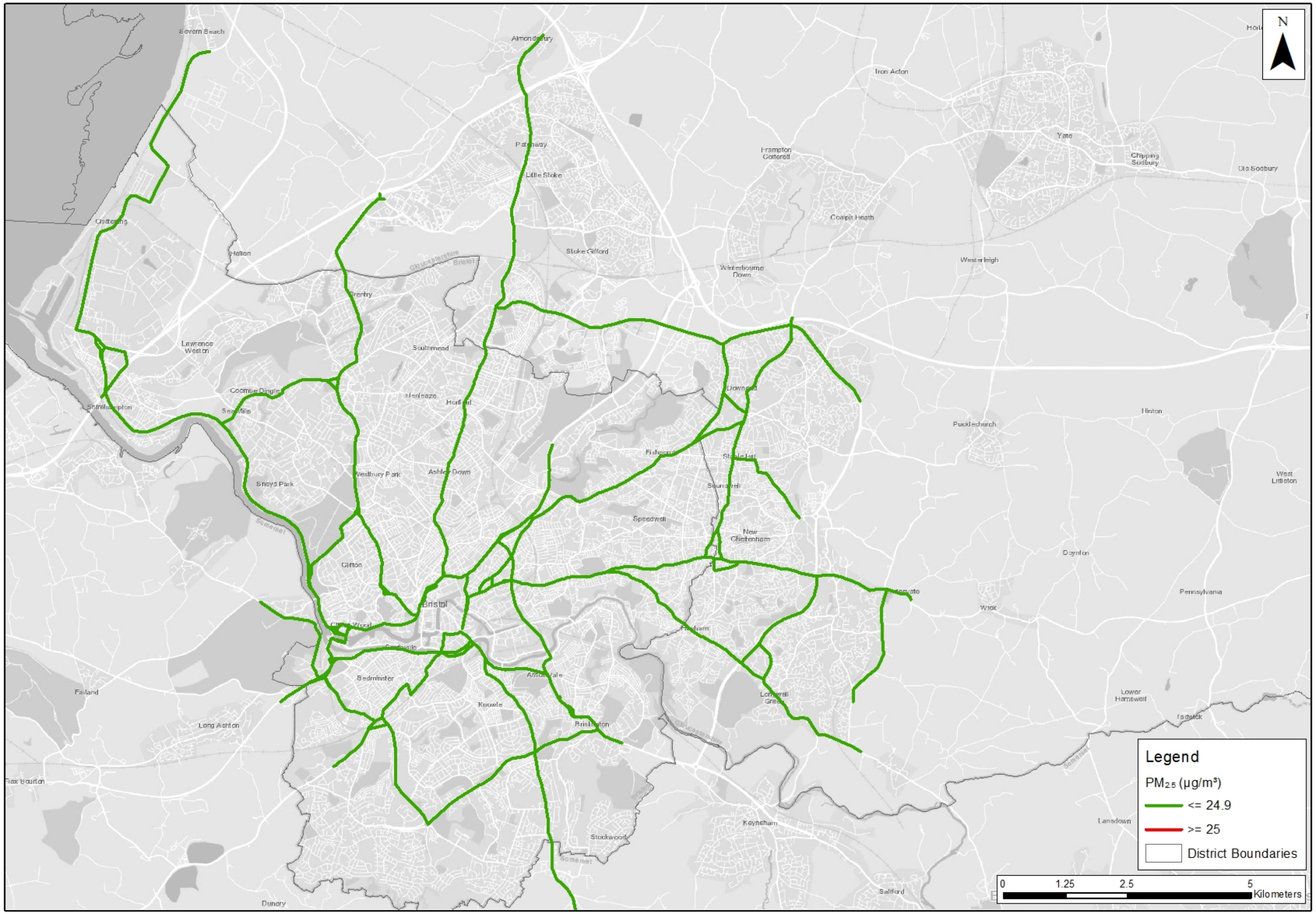

Figure 6: Predicted PM_{10} concentrations in 2021 at PCM-equivalent receptor locations

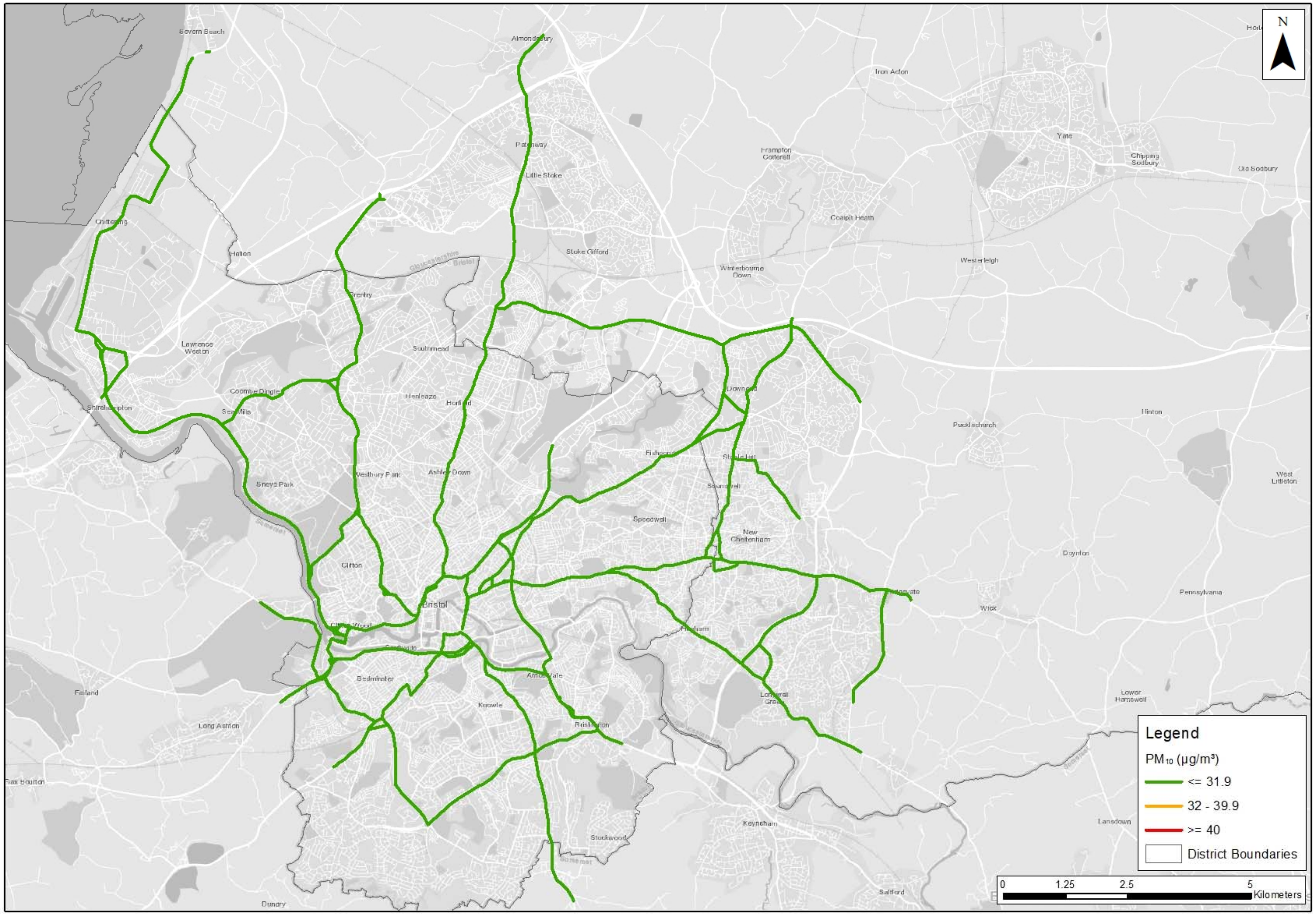

Figure 7: Predicted $PM_{2.5}$ concentrations in 2015 at PCM-equivalent receptor locations

5. References

Defra. (2017a). *Air quality plan for nitrogen dioxide (NO2) in the UK.* Retrieved from https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

Defra. (2018b). *Local Air Quality Management (LAQM) Support Website*. Retrieved from http://laqm.defra.gov.uk/

Defra. (2018b). *Review & Assessment: Technical Guidance LAQM.TG16 February 2018 Version.* Defra. Retrieved from https://laqm.defra.gov.uk/documents/LAQM-TG16-February-18-v1.pdf

Defra. (2018b). *Review & Assessment: Technical Guidance LAQM.TG16 February 2018 Version.* Defra. Retrieved from https://laqm.defra.gov.uk/documents/LAQM-TG16-February-18-v1.pdf