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# Detailed air quality modelling and source apportionment

Final report

*Prepared for*
Surrey Local Authorities

*23rd August 2019*

CERC

## Report Information

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|---|---|
| CERC Job Number: | FM1183 |
| Job Title: | Detailed air quality modelling and source apportionment |
| Prepared for: | Surrey Local Authorities |
| Report Status: | Final |
| Report Reference: | FM1183/R5/19 |
| Issue Date: | 23rd August 2019 |

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|---|---|
| Reviewer(s): | Sarah Strickland, Chetan Lad |

| Issue | Date | Comments |
|---|---|---|
| 1 | 20/02/19 | Draft, verification only |
| 2 | 26/02/19 | Draft, verification only, with minor amendments |
| 3 | 04/04/19 | Full draft report |
| 4 | 24/05/19 | Final report |
| 5 | 23/08/19 | Final report with additions to Section 9 |

| | |
|---|---|
| Main File(s): | FM1183_Surrey_CERC_R5_23August19.pdf |

# Contents

# Glossary

| | |
|---|---|
| AADTs | Annual Average Daily Traffic |
| AF | Attributable fraction |
| ATC | Automatic Traffic Count |
| AQAP | Air Quality Action Plan |
| AQMA | Air Quality Management Area; places designated by local authorities where statutory air quality objectives are not likely to be achieved |
| CRF | concentration response function |
| Defra | Department for Environment, Food and Rural Affairs |
| DfT | Department for Transport |
| DT | Diffusion tube |
| EFT | Emission Factors for Transport |
| LAQM | Local Air Quality Management; local authorities' process for reviewing and assessing air quality |
| LSOA | Lower Layer Super Output Area |
| NAEI | National Atmospheric Emissions Inventory |
| NO | nitric oxide |
| $NO_2$ | nitrogen dioxide |
| $NO_x$ | nitrogen oxides (nitrogen dioxide plus nitric oxide) |
| $O_3$ | ozone |
| ONS | Office for National Statistics |
| $PM_{10}$ | particulates of less than 10µm effective diameter |
| $PM_{2.5}$ | particulates of less than 2.5µm effective diameter |
| $SO_2$ | sulphur dioxide |
| TPM | Total Particulate Matter |
| VOC | Volatile Organic Compound |

# 1 Summary

CERC was commissioned to carry out county-wide air pollution dispersion modelling, source apportionment and local mortality burden calculations for the combined local authorities of Surrey.

The main source of air pollution across Surrey is road traffic emissions from major roads. Eight of the eleven local authorities have declared Air Quality Management Areas (AQMAs) for annual average $NO_2$ concentrations. Two of these AQMAs are also declared for $PM_{10}$ concentrations, in Runnymede (annual mean and 24-hour mean $PM_{10}$) and Surrey Heath (annual mean $PM_{10}$).

The main air quality modelling was carried out with ADMS-Urban (version 4.2) dispersion modelling software, using meteorological data from the Heathrow Airport meteorological station. Additional sensitivity analysis was carried out using meteorological data from the Gatwick Airport meteorological station.

Road traffic emissions input to the dispersion model were calculated from traffic flows provided from the Surrey Traffic Model, supplemented by Department for Transport (DfT) count data and local data from borough council detailed and further assessments. The Emission Factor Toolkit version 8.0.1, published by Defra, was used to calculate emissions from traffic flows. All other emissions data were taken from the NAEI.

Detailed model verification was carried out by comparing modelled concentrations against monitored data across Surrey for the year 2017, with iterative improvements to the model set-up to ensure acceptable agreement between modelled and monitored concentrations.

High resolution air quality maps for concentrations of nitrogen dioxide ($NO_2$) and particulate matter ($PM_{10}$ and $PM_{2.5}$) across Surrey were then generated to determine the extent to which the air quality objectives for these pollutants are exceeded. With exception of some locations close to major roads, the air quality objectives are met throughout the county. There are modelled exceedences of the annual mean $NO_2$ objective of 40 µg/m$^3$ along motorways and other busy roads. Exceedences of short-term $NO_2$ and $PM_{10}$ objectives are less extensive. The annual mean $PM_{2.5}$ objective of 25 µg/m$^3$ is met throughout the county.

Source apportionment was carried out to calculate relative contributions of each source group to pollutant emissions and concentrations. The following source groups were included: road sources, by vehicle type and non-exhaust component for PM; large industrial sources; other emissions sources; and background. Road transport is typically the largest contributor to $NO_x$ concentrations; diesel cars and LGVs are the largest contributors to the road transport $NO_x$ concentrations. Background concentrations, from outside Surrey, are the most significant contributors to concentrations of $PM_{10}$ and $PM_{2.5}$; sources inside Surrey contribute on an average 21% of total $PM_{10}$ concentrations and 24% of total $PM_{2.5}$ concentrations.

Local mortality burden calculations were carried out by coupling population data, by Lower Layer Super Output Areas (LSOA), with the modelled annual mean concentrations of $NO_2$ and $PM_{2.5}$. This includes deaths attributable to air pollution, the associated life-years lost and economic cost. This was done using the approach set out in Appendix A of the Public Health England guidance *Estimating local mortality burdens associated with particulate air pollution (April 2014)*; the approach used concentration response function (CRF) pairs for $NO_2$ and $PM_{2.5}$, these CRFs have been taken from the 2018 COMEAP report *Associations of long-term average concentrations of nitrogen dioxide with mortality*.

The combined health impacts of $NO_2$ and $PM_{2.5}$ for the whole of Surrey have been calculated to be in the range of 6,610 and 8,059 life-years lost, which equates to an economic cost of between £283 million and £345 million in 2017. Using the unadjusted value, the lowest life years lost were calculated to be 5,233, resulting from $NO_2$ concentrations. This equates to an economic cost of £224 million.

# 2 Introduction

The combined local authorities of Surrey commissioned CERC to carry out detailed air quality modelling, source apportionment and local mortality burden calculations across the county.

The modelling methodology and county-wide results, including air quality maps, are presented in this report.

Separate accompanying reports present the results for individual boroughs, including: air quality maps; source apportionment; and mortality burden by ward.

The air quality limit values and target values with which the calculated concentrations are compared are presented in Section 3. Section 4 summarises local air quality across the Surrey boroughs. The model setup and emissions data are described in Sections 5 and 6, respectively.

The results of the modelling are then presented: the model verification in Section 7; and the concentration maps for the year 2017 in Section 8. Mortality burden calculations are described in Section 9. Source apportionment is presented in Section 10. A discussion of the results is presented in Section 11.

Model verification was carried out using meteorological data from both Heathrow Airport and Gatwick Airport. The model set-up using Heathrow Airport was used for the main modelling and included in the main section of the report. Appendix A includes a comparison of the model verification using Heathrow Airport against the alternative set-up using Gatwick Airport data, with a summary of this alternative set-up using Gatwick Airport data in Appendix B.

Finally, a summary of the ADMS-Urban model is included as Appendix C.

# 3 Air quality standards and guidance

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. The $NO_2$, $PM_{10}$ and $PM_{2.5}$ Air Quality Objectives are presented in Table 3-1.

***Table 3-1: Air quality objectives***

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

The short-term standards considered 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$\mu g/m^3$ 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 98$^{th}$ percentile of one-hour concentrations over a year. Taking all of the 8760 one-hour concentration values that occur in a year, the 98$^{th}$ 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 99.79$^{th}$ percentile value.

Table 3-2 gives examples from the Defra TG(16) guidance of where the air quality objectives should apply.

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

*Table 3-2: Examples of where the air quality objectives should apply*

| **Averaging period** | **Objectives should apply at:** | **Objectives should generally not apply at:** |
|---|---|---|
| Annual average | All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, care homes etc | Building facades of offices or other places of work where members of the public do not have regular access.<br>Hotels, unless people live there as their permanent residence.<br>Gardens of residential properties<br>Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term. |
| 24-hour mean | All locations where the annual mean objective would apply, together with hotels.<br>Gardens of residential properties (where relevant for public exposure e.g. seating or play areas) | Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term. |
| Hourly average | All locations where the annual mean and 24-hour mean objectives apply and:<br>Kerbside sites (for example pavements of busy shopping streets).<br>Those parts of car parks, bus stations and railway stations etc. Which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or longer. | Kerbside sites where the public would not be expected to have regular access. |

# 4 Local air quality

The Local Air Quality Management (LAQM) process, as set out in Part IV of the Environment Act (1995), the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 and the relevant Policy and Technical Guidance documents places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where exceedences are considered likely, the local authority must then declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives.

Figure 4.1 shows the eleven local authorities in Surrey. The following subsections describe the AQMAs and monitoring data for each of the local authorities, in alphabetical order.

All monitoring data presented in this section were provided by individual boroughs, with diffusion tube concentrations presented as bias adjusted values. A 0.91 bias adjustment factor was applied to raw diffusion tube data of all boroughs except Spelthorne, for which a bias adjustment factor of 0.99 was used.

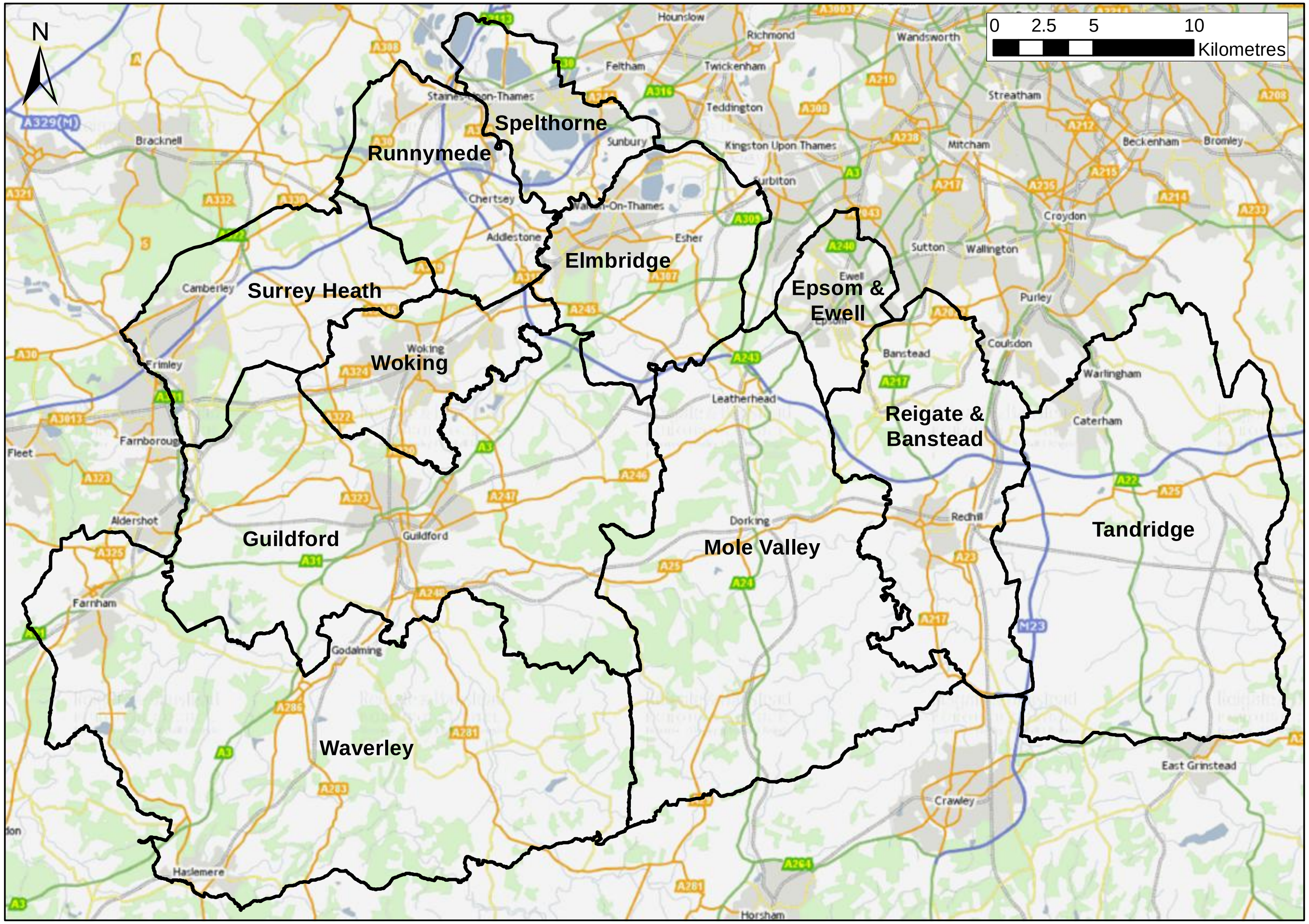


*Figure 4.1: Locations of Surrey local authorities*

## 4.1 Elmbridge Borough Council

Figure 4.2 presents the locations of monitoring sites and AQMAs in Elmbridge, comprising 40 diffusion tubes, two continuous monitors and seven AQMAs. The AQMAs are:

- Walton-on-Thames High Street;
- Weybridge High Street;
- Hampton Court;
- Cobham High Street;
- Hinchley Wood;
- Esher High Street; and
- Walton Road, Molesey.

All seven AQMAs were declared for annual mean $NO_2$ concentrations.

Table 4-1 presents the monitored annual average $NO_2$ concentrations for Elmbridge in 2017. The table includes annual average $NO_x$ concentrations for continuous monitors. Exceedences of the air quality objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**.

Two sites include triplicate diffusion tubes, collocated with continuous monitors: Hampton Court 2/3/4 are collocated with Hampton Court Parade; and Weybridge 10/11/12 are collocated with Weybridge High Street.

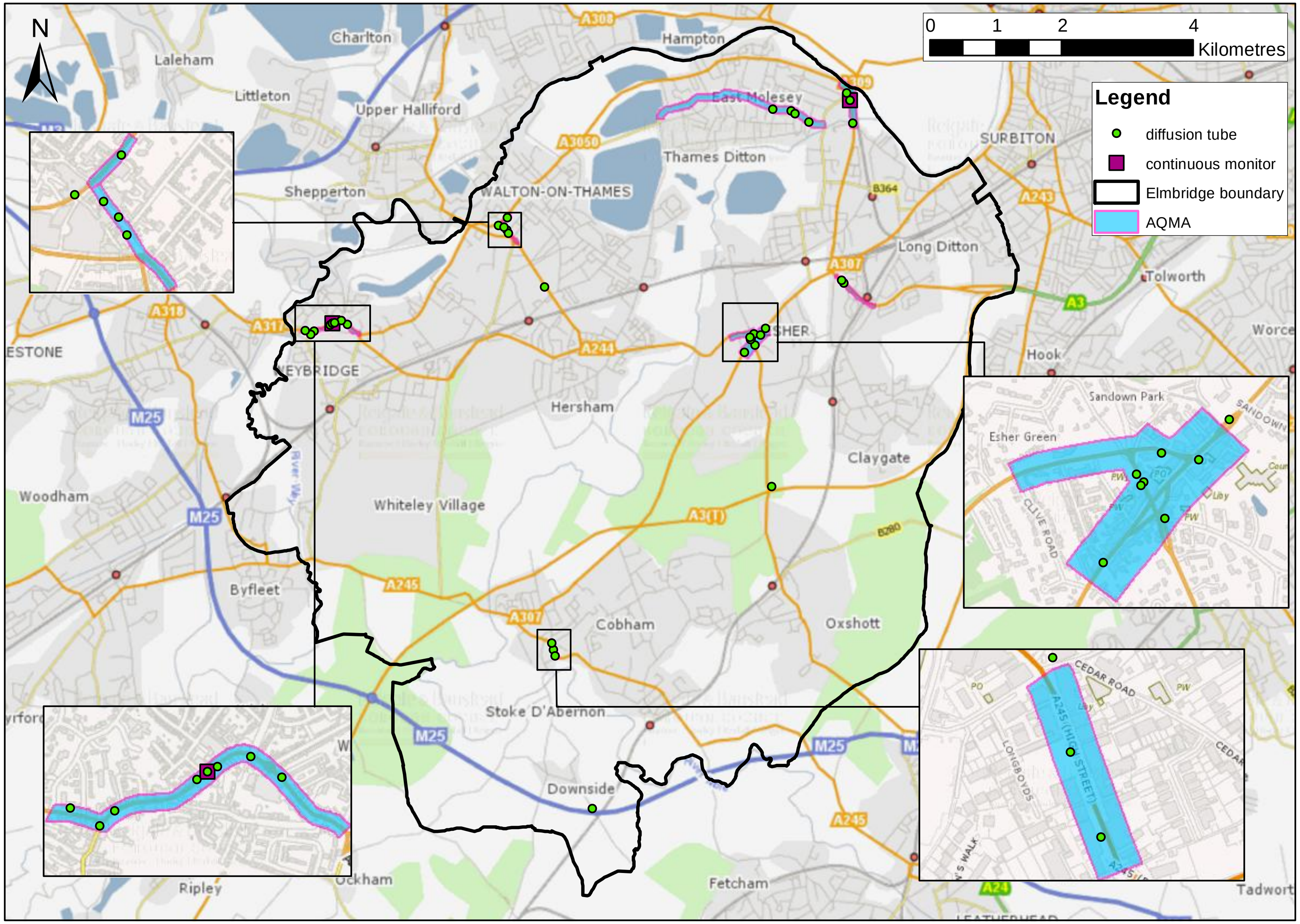


*Figure 4.2: Continuous monitoring stations, diffusion tubes and AQMA locations in Elmbridge*

***Table 4-1: Monitored annual average $NO_2$ concentrations at Elmbridge continuous monitoring stations and diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| Hampton Court Parade | Continuous | 515342, 168292 | 1.8 | 2 | **41** [$NO_x$ 108] |
| Weybridge High Street | Continuous | 507480, 164923 | 1.8 | 0.6 | 34 [$NO_x$ 78] |
| Cobham 1 | DT | 510833, 159998 | 2.4 | 0.6 | 30 |
| Cobham 6 | DT | 510814, 160098 | 2.4 | 6 | 25 |
| Cobham 7 | DT | 510866, 159908 | 2.4 | 3.1 | 33 |
| Downside 3 | DT | 511429, 157606 | 2.3 | 1.1 | 19 |
| Esher 1 | DT | 513841, 164693 | 2.6 | 1.5 | 38 |
| Esher 4 | DT | 514060, 164853 | 2.4 | 4.7 | 34 |
| Esher 5 | DT | 514148, 162467 | 2.4 | 1.4 | **43** |
| Esher 7 | DT | 513981, 164750 | 2.3 | 0.6 | **40** |
| Esher 8 | DT | 513834, 164685 | 2.4 | 3.2 | 39 |
| Esher 9 | DT | 513822, 164713 | 2.6 | 0.6 | 29 |
| Esher 10 | DT | 513886, 164767 | 2.4 | 2.1 | 29 |
| Esher 11 | DT | 513896, 164600 | 2.6 | 5.1 | 33 |
| Esher 13 | DT | 513737, 164488 | 2.4 | 0.9 | 32 |
| Hampton Court 1 | DT | 515384, 167947 | 2.2 | 0.9 | 36 |
| Hampton Court 2 | DT | 515342, 168292 | 1.7 | 1.9 | 35 |
| Hampton Court 3 | DT | | | | 35 |
| Hampton Court 4 | DT | | | | 35 |
| Hampton Court 5 | DT | 515292, 168406 | 2.5 | 0.4 | 26 |
| Hinchley Wood 1 | DT | 515247, 165535 | 2.4 | 4.5 | 36 |
| Hinchley Wood 2 | DT | 515217, 165577 | 1.9 | 9.8 | 31 |
| Molesey 1 | DT | 514449, 168132 | 2.5 | 1.1 | 29 |
| Molesey 8 | DT | 514716, 167960 | 2.5 | 2.6 | 32 |
| Molesey 9 | DT | 514508, 168088 | 2.4 | 2.6 | 33 |
| Molesey 10 | DT | 514170, 168156 | 2.4 | 4.9 | 28 |
| Walton 3 | DT | 510132, 166336 | 2.6 | 0.4 | 30 |
| Walton 5 | DT | 510704, 165473 | 2.3 | 0.9 | 28 |
| Walton 8 | DT | 510156, 166282 | 2.6 | 2.9 | 31 |
| Walton 9 | DT | 510086, 166382 | 2.5 | 2.6 | 30 |
| Walton 10 | DT | 510140, 166522 | 2.6 | 3.3 | 34 |
| Walton 11 | DT | 509999, 166402 | 2.4 | 2.3 | 31 |
| Weybridge 1 | DT | 507448, 164900 | 2.5 | 1 | 30 |
| Weybridge 4 | DT | 507704, 164906 | 2.4 | 2 | 31 |
| Weybridge 5 | DT | 507610, 164968 | 2.3 | 1.6 | 34 |
| Weybridge 6 | DT | 507510, 164937 | 2.3 | 0.5 | 28 |
| Weybridge 7 | DT | 507199, 164805 | 2.4 | 1.5 | **41** |
| Weybridge 8 | DT | 507153, 164760 | 2.4 | 4.6 | 36 |
| Weybridge 9 | DT | 507065, 164813 | 1.6 | 13.1 | 23 |
| Weybridge 10 | DT | 507480, 164923 | 1.8 | 0.6 | 32 |
| Weybridge 11 | DT | | | | 31 |
| Weybridge 12 | DT | | | | 32 |

## 4.2 Epsom and Ewell Borough Council

Figure 4.3 presents the locations of monitoring sites and the AQMA in Epsom and Ewell, comprising 20 diffusion tubes and one AQMA in High Street, Ewell. The AQMA was declared on the basis of annual mean $NO_2$concentrations.

Table 4-2 presents the monitored annual average $NO_2$ concentrations for Epsom and Ewell in 2017. Exceedences of the UK Air Quality Objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**.

***Table 4-2: Monitored annual average $NO_2$ concentrations at Epsom and Ewell diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| EE1 | DT | 520732, 160765 | 2.1 | 2.5 | 34 |
| EE3 | DT | 519293, 160026 | 2 | 2 | 17 |
| EE6 | DT | 520528, 165045 | 2.1 | 6.8 | 32 |
| EE7 | DT | 520919, 164643 | 2.3 | 6.8 | 36 |
| EE9 | DT | 519829, 163738 | 2.4 | 3.2 | 23 |
| EE10 | DT | 521998, 162633 | 2.1 | 1.3 | **45** |
| EE14 | DT | 520887, 161309 | 2 | 1.6 | 26 |
| EE16 | DT | 522026, 162624 | 1.7 | 1.1 | 31 |
| EE17 | DT | 522025, 162563 | 2.2 | 2 | 31 |
| EE22 | DT | 520968, 160864 | 2.3 | 0.5 | **40** |
| EE36 | DT | 521072, 160820 | 2.1 | 9.2 | 27 |
| EE38 | DT | 520722, 160866 | 1.8 | 2.8 | 25 |
| EE39 | DT | 520842, 160729 | 2.1 | 3.3 | 28 |
| EE42 | DT | 521008, 160901 | 2.1 | 7.7 | 29 |
| EE43 | DT | 521483, 161454 | 2.3 | 5.5 | 29 |
| EE45 | DT | 522208, 163100 | 2.1 | 8.3 | 23 |
| EE47 | DT | 520713, 162968 | 1.9 | 4.7 | 25 |
| EE48 | DT | 522016, 162504 | 2.1 | 1.7 | 29 |
| EE49 | DT | 520577, 160586 | 2.2 | 3.5 | 29 |
| EE50 | DT | 521974, 162676 | 2.1 | 0.9 | 37 |

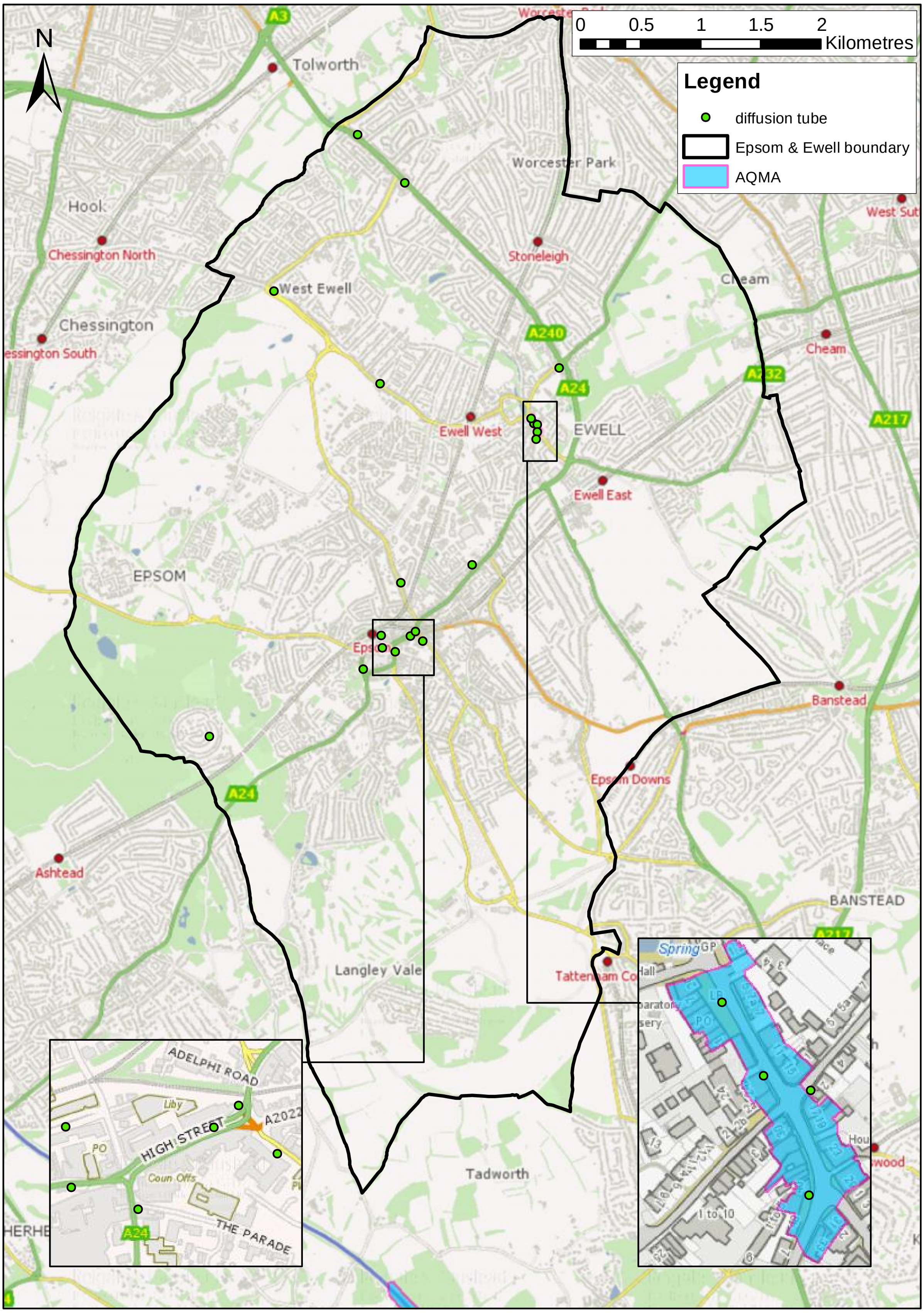


*Figure 4.3: Diffusion tube and AQMA locations, Epsom and Ewell*

## 4.3 Guildford Borough Council

Figure 4.4 presents the locations of monitoring sites in Guildford, comprising 26 diffusion tubes. Guildford Borough Council has not declared any AQMAs.

Table 4-3 presents the monitored annual average $NO_2$ concentrations for Guildford in 2017. Exceedences of the UK Air Quality Objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**.

***Table 4-3: Monitored annual average $NO_2$ concentrations at Guildford diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| GUL_ASH1 | DT | 489885, 150767 | 2.5 | 10 | 18 |
| GUL_ASH2 | DT | 488350, 150078 | 2.5 | N/A | 22 |
| GUL_C4 | DT | 495440, 147289 | 2.5 | 1.5 | **40** |
| GUL_C9 | DT | 495446, 147271 | 2.5 | 1 | **44** |
| GUL_C10 | DT | 495440, 147291 | 2.5 | 1 | 32 |
| GUL_FRH1 | DT | 499024, 149402 | 2.5 | N/A | 34 |
| GUL_GD1 | DT | 499272, 149524 | 2.5 | 5 | 29 |
| GUL_GD2 | DT | 499799, 149932 | 2.5 | 5 | 31 |
| GUL_GD3 | DT | 499658, 150732 | 2.5 | 5 | 17 |
| GUL_GD6 | DT | 500385, 148342 | 2.5 | 120 | 10 |
| GUL_GD9 | DT | 488276, 149859 | 2.5 | 5 | 17 |
| GUL_GD10 | DT | 488629, 150032 | 2.5 | 5 | 15 |
| GUL_GD11 | DT | 498133, 150648 | 2.5 | 8 | 24 |
| GUL_GD13 | DT | 499300, 149514 | 2.5 | 1 | 31 |
| GUL_GD14 | DT | 499800, 149912 | 2.5 | 5 | 32 |
| GUL_GD15 | DT | 499806, 150792 | 2.5 | 8 | 28 |
| GUL_RP1 | DT | 505242, 156820 | 2.5 | 5 | 28 |
| GUL_RP2 | DT | 505090, 156776 | 2.5 | 1 | 24 |
| GUL_send1 | DT | 502860, 155420 | 2.5 | 5 | 22 |
| GUL_send2 | DT | 502173, 155846 | 2.5 | 1 | 21 |
| GUL_SH1 | DT | 500045, 147603 | 2.5 | 1 | 36 |
| GUL_STN | DT | 498831, 151473 | 2.5 | 1 | 25 |
| GUL_T1 | DT | 488637, 148845 | 2.5 | N/A | 23 |
| GUL_WCL | DT | 504476, 151404 | 2.5 | 1 | 20 |
| GUL_WP1 | DT | 497971, 152575 | 2.5 | 1 | 25 |
| GUL_WS1 | DT | 507346, 158005 | 2.5 | NA | 14 |

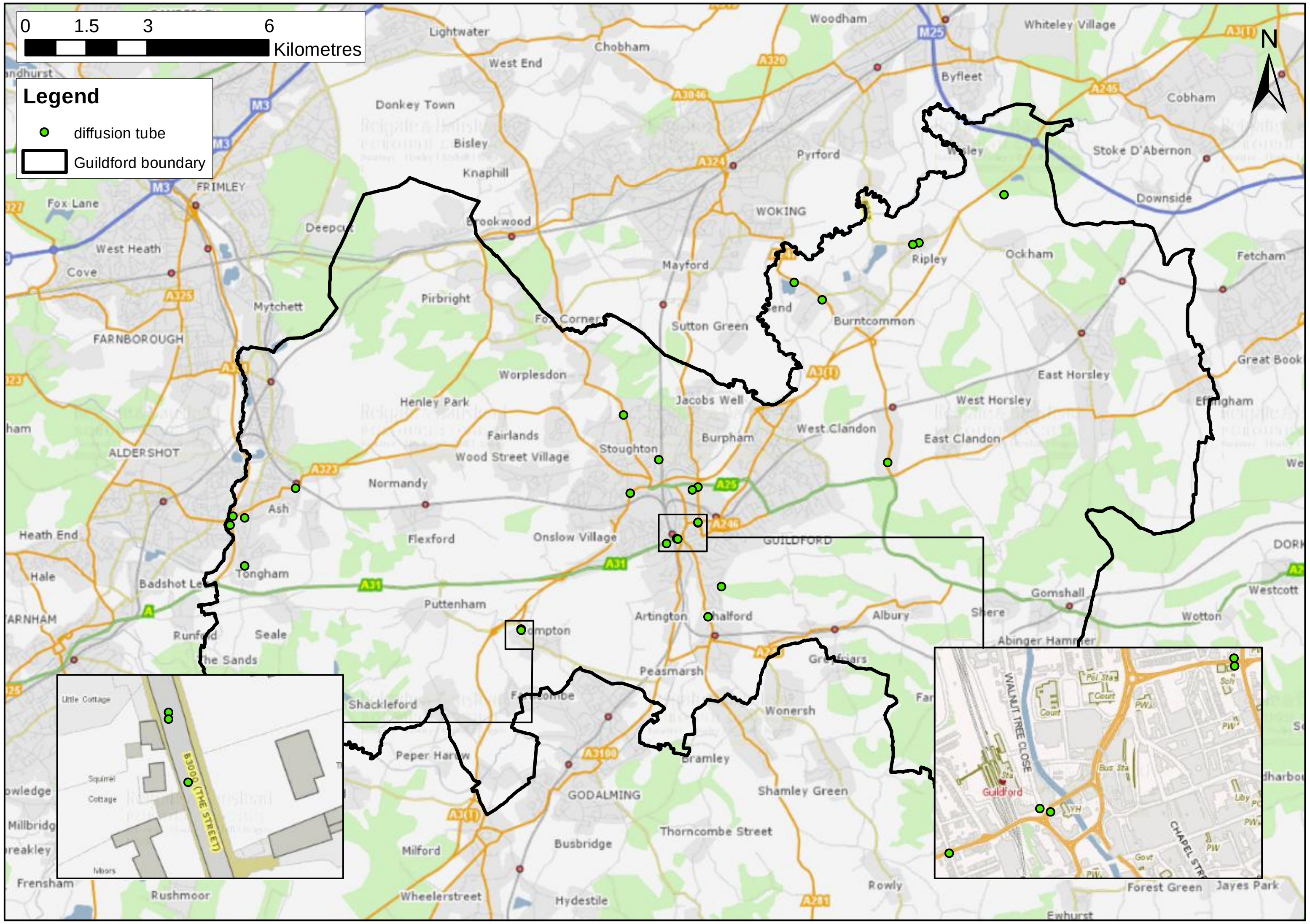


*Figure 4.4: Diffusion tubes locations, Guildford*

## 4.4 Mole Valley District Council

Figure 4.5 presents the locations of monitoring sites in Mole Valley, comprising 12 diffusion tubes. Mole Valley District Council has not declared any AQMAs.

Table 4-4 presents the monitored annual average $NO_2$ concentrations for Mole Valley in 2017. There were no monitored exceedences of the air quality objective of 40µg/m³ for annual average $NO_2$ concentrations in 2017.

***Table 4-4: Monitored annual average $NO_2$ concentrations at Mole Valley diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| MV1 | DT | 516388, 149369 | 2.5 | 2 | 24 |
| MV2 | DT | 516256, 148882 | 2.5 | 2 | 20 |
| MV3 | DT | 516867, 149800 | 2.5 | 27 | 17 |
| MV4 | DT | 514123, 155336 | 2.5 | 17 | 14 |
| MV6 | DT | 517214, 157204 | 2.5 | 28 | 30 |
| MV7 | DT | 520210, 150565 | 2.5 | 13 | 17 |
| MV8 | DT | 523419, 140580 | 2.5 | 36 | 18 |
| MV9 | DT | 526906, 142368 | 2.5 | 55 | 11 |
| MV10 | DT | 517712, 156744 | 2.5 | 2 | 33 |
| MV12 | DT | 517674, 156840 | 2.5 | 2 | 30 |
| MV13 | DT | 516125, 149357 | 2.5 | 1 | 33 |
| MV14 | DT | 517037, 149800 | 2.5 | 15 | 18 |

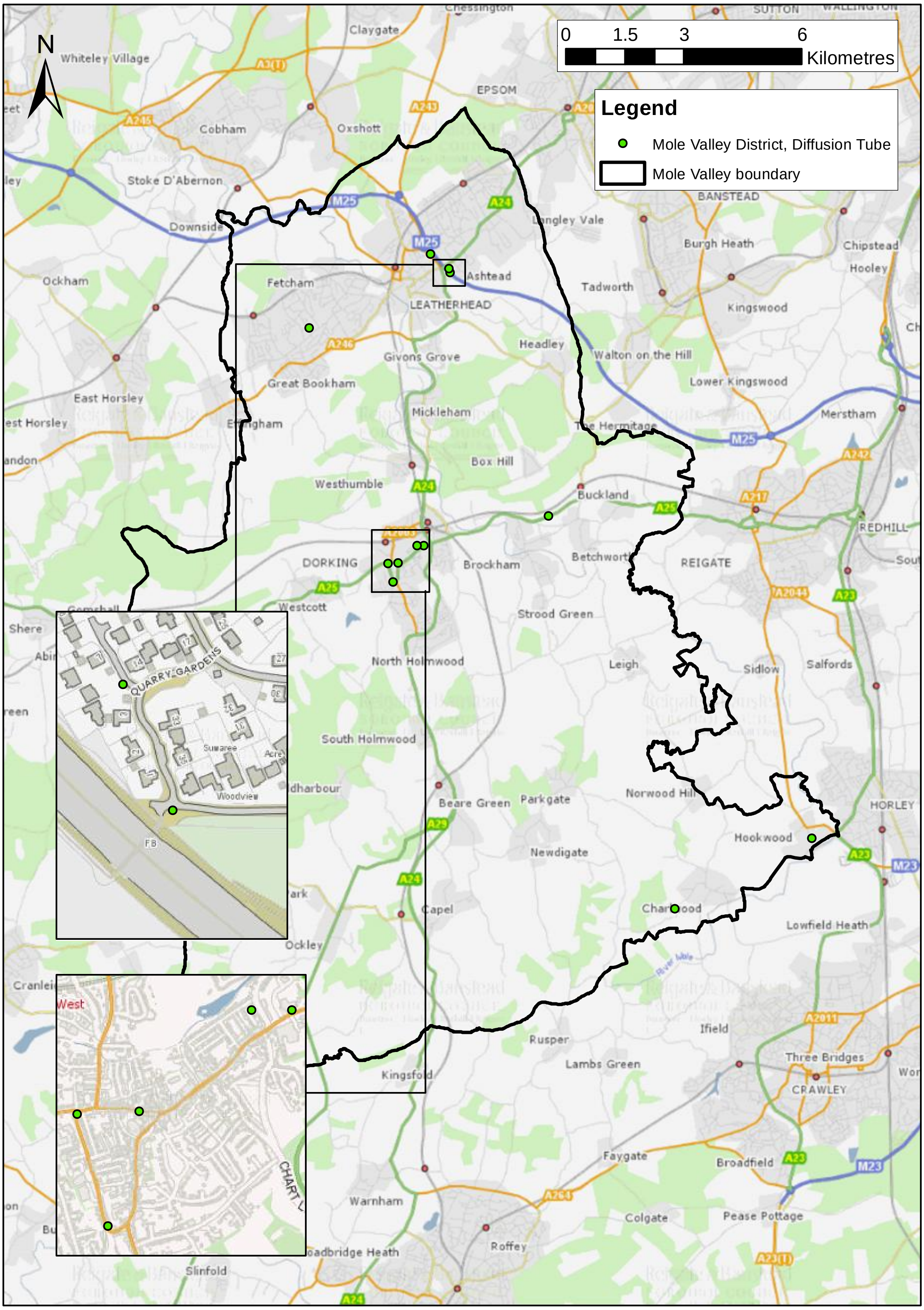


*Figure 4.5: Diffusion tubes, Mole Valley*

## 4.5 Reigate and Banstead Borough Council

Figure 4.6 presents the locations of monitoring sites in Reigate and Banstead, comprising 104 diffusion tubes, three continuous monitors and nine AQMAs. The AQMAs are:

- AQMA No. 1 (M25)
- AQMA No. 3 (Horley)
- AQMA No. 6 (Blackhorse Lane)
- AQMA No. 8 (Drift Bridge)
- AQMA No. 9 (Reigate High Street, West Street and Bell Street)
- AQMA No. 10 (Merstham)
- AQMA No. 11 (Reigate Hill)
- AQMA No. 12 (Redhill)
- AQMA No. 13 (Hooley)

All nine were declared on the basis of annual mean $NO_2$ concentrations.

Table 4-5 presents the monitored annual average $NO_2$ concentrations for Reigate and Banstead in 2017. The table includes annual average $NO_x$ concentrations for continuous monitors. Exceedences of the air quality objective of 40µg/m³ for annual average $NO_2$ concentrations are shown in **bold**.

Three sites include triplicate diffusion tubes collocated with continuous monitors:

- RB24, RB25 and RB26 are collocated with RG1;
- RB99, RB100 and RB101 are collocated with RG3.
- RB178, RB179 and RB180 are collocated with RG6; and

Note that RG3, and collocated RB99, RB100 and RB101 diffusion tubes fall outside of Surrey but are managed by Reigate and Banstead. One diffusion tube, RB102 is managed by Reigate and Banstead but falls within Tandridge District Council.

Table 4-6 presents the monitored annual average $PM_{10}$ concentrations at two continuous monitors in Reigate and Banstead in 2017. At the same location, $PM_{10}$ concentrations are measured using both Tapered Element Oscillating Microbalance (TEOM) and Filtered Dynamic Measurement System (FDMS) instruments, at RG1 and RG5 respectively.

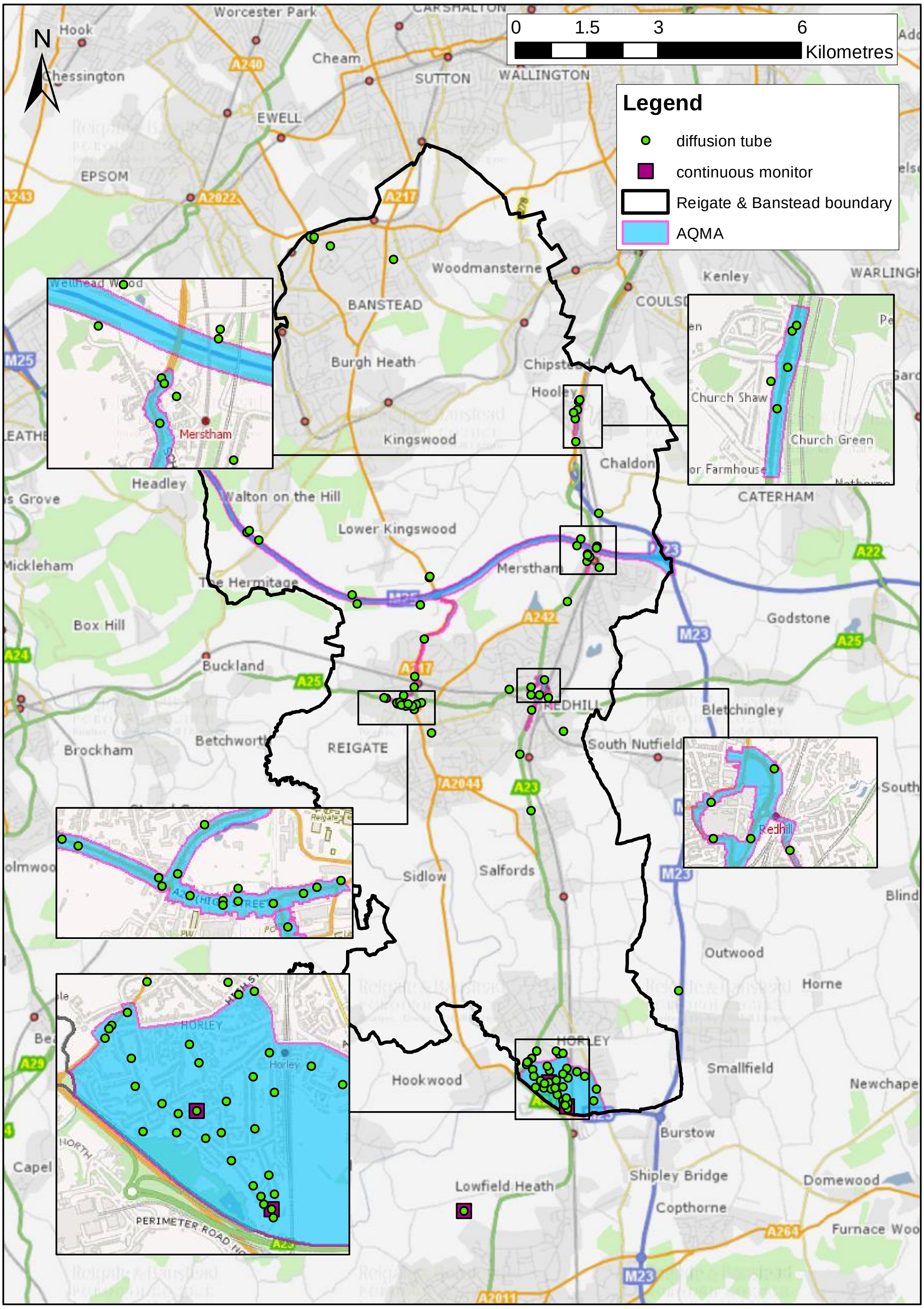


*Figure 4.6: Diffusion tubes, continuous monitoring sites and AQMAs,*
*Reigate and Banstead*

***Table 4-5: Monitored annual average $NO_2$ concentrations at Reigate and Banstead continuous monitoring stations and diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| RG1 | Continuous | 528208, 142337 | 3.5 | 19.1 | 20 [$NO_x$ 34] |
| RG6 | Continuous | 528591, 141830 | 1.5 | 0.7 | 27 [$NO_x$ 46] |
| RG3 | Continuous | 526421, 139639 | 2 | 12.6 | 14 [$NO_x$ 19] |
| RB1 | DT | 525246, 150251 | 3.1 | 5.1 | 32 |
| RB3 | DT | 524944, 159630 | 3 | 0.7 | 18 |
| RB8 | DT | 525246, 150287 | 3.7 | 39.2 | 18 |
| RB9 | DT | 525749, 149677 | 2.5 | 24.9 | 17 |
| RB11 | DT | 528104, 142226 | 3 | 1.4 | 23 |
| RB12 | DT | 528423, 142935 | 2.9 | 0.4 | 28 |
| RB13 | DT | 528368, 142996 | 2.9 | 30 | 20 |
| RB17 | DT | 528511, 149715 | 2.9 | 1.7 | 14 |
| RB18 | DT | 529262, 153156 | 3 | 1.3 | 23 |
| RB19 | DT | 529067, 153375 | 2.9 | 0.7 | 24 |
| RB20 | DT | 529025, 153419 | 2.9 | 2.6 | 33 |
| RB21 | DT | 523198, 160095 | 2.9 | 1.7 | 34 |
| RB22 | DT | 523279, 160101 | 2.9 | 1.1 | 20 |
| RB23 | DT | 523613, 159906 | 2.7 | 2.3 | 16 |
| RB24 | DT | 528208, 142337 | 3.5 | 19.1 | 21 |
| RB25 | DT | | | | 22 |
| RB26 | DT | | | | 21 |
| RB27 | DT | 521873, 153896 | 3 | 5.6 | 25 |
| RB29 | DT | 521921, 153937 | 3 | 11.7 | 25 |
| RB30 | DT | 522112, 153728 | 3 | 18.9 | 24 |
| RB31 | DT | 525506, 152366 | 3 | 19.5 | 16 |
| RB33 | DT | 524081, 152580 | 3 | 0 | 21 |
| RB34 | DT | 524177, 152393 | 3 | 45.6 | 24 |
| RB36 | DT | 528885, 153759 | 3 | 74.8 | 20 |
| RB37 | DT | 529217, 153605 | 3 | 12 | 24 |
| RB39 | DT | 529211, 153572 | 3 | 10.9 | 25 |
| RB40 | DT | 529252, 154290 | 3 | 15 | 20 |
| RB43 | DT | 528799, 153616 | 3 | 52.4 | 23 |
| RB44 | DT | 525534, 150308 | 3 | 14.6 | 31 |
| RB45 | DT | 525430, 150273 | 3 | 0.1 | 28 |
| RB46 | DT | 525344, 150245 | 3 | 0.4 | 36 |
| RB47 | DT | 525111, 150267 | 3 | 0.5 | 35 |
| RB49 | DT | 525698, 152943 | 3 | 3.5 | **42** |
| RB50 | DT | 525708, 152969 | 3 | 24 | 26 |
| RB51 | DT | 527873, 142606 | 3.5 | 15.1 | 21 |
| RB52 | DT | 527893, 142463 | 3.5 | 13.7 | 25 |
| RB53 | DT | 528030, 142374 | 3.5 | 4.3 | 25 |
| RB54 | DT | 528112, 142321 | 3.5 | 4.2 | 23 |
| RB55 | DT | 528254, 142196 | 3.5 | 1.1 | 23 |
| RB56 | DT | 528386, 142080 | 3.5 | 2.6 | 24 |
| RB57 | DT | 528499, 141953 | 3.5 | 2.6 | 26 |

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (μg/m³) |
|---|---|---|---|---|---|
| RB58 | DT | 528538, 141897 | 3.5 | 2.6 | 27 |
| RB59 | DT | 528602, 141789 | 3.5 | 2.2 | 28 |
| RB60 | DT | 528607, 141910 | 3.5 | 2.8 | 27 |
| RB61 | DT | 528578, 142006 | 3.5 | 1 | 23 |
| RB64 | DT | 528608, 142432 | 3.5 | 1.6 | 22 |
| RB65 | DT | 528581, 142635 | 3.5 | 16.8 | 22 |
| RB66 | DT | 528499, 142512 | 3.5 | 18.5 | 22 |
| RB68 | DT | 528505, 142246 | 3.5 | 18.5 | 24 |
| RB69 | DT | 528335, 142224 | 3.5 | 14 | 26 |
| RB70 | DT | 528360, 142384 | 3.5 | 17.8 | 24 |
| RB72 | DT | 528219, 142583 | 3.5 | 19.2 | 22 |
| RB73 | DT | 528172, 142679 | 3.5 | 17.8 | 22 |
| RB74 | DT | 529149, 141953 | 3.5 | 15.1 | 23 |
| RB75 | DT | 529210, 142195 | 3.5 | 12.4 | 24 |
| RB76 | DT | 528957, 142471 | 3.5 | 20.7 | 20 |
| RB77 | DT | 528797, 142567 | 3.5 | 13 | 21 |
| RB78 | DT | 528553, 141857 | 3.5 | 2.7 | 27 |
| RB81 | DT | 527595, 149235 | 3.5 | 5.5 | 31 |
| RB82 | DT | 528770, 155798 | 3.5 | 18.3 | 34 |
| RB95 | DT | 525382, 150639 | 2 | 5.9 | 25 |
| RB98 | DT | 527931, 142231 | 2 | 1 | 26 |
| RB99 | DT | | | | 14 |
| RB100 | DT | 526421, 139639 | 2 | 12.4 | 14 |
| RB101 | DT | | | | 14 |
| RB102 | DT | 530936, 144271 | 2 | 19.1 | 21 |
| RB104 | DT | 525204, 150252 | 2 | 4.9 | 35 |
| RB105 | DT | 525203, 150240 | 2 | 2.8 | 39 |
| RB106 | DT | 523254, 160055 | 2 | 2.1 | 29 |
| RB107 | DT | 525467, 150290 | 2 | 2.3 | 26 |
| RB109 | DT | 525385, 150178 | 2 | 3.6 | 32 |
| RB110 | DT | 529016, 153439 | 2 | 4.3 | 29 |
| RB111 | DT | 525032, 150293 | 2 | 4.3 | 30 |
| RB113 | DT | 524795, 150406 | 2 | 2.1 | 27 |
| RB115 | DT | 524750, 150425 | 2 | 0.6 | 30 |
| RB116 | DT | 525022, 150317 | 2 | 2.3 | 32 |
| RB117 | DT | 525075, 150327 | 2 | 2.9 | 35 |
| RB118 | DT | 525152, 150466 | 2 | 14.2 | 31 |
| RB120 | DT | 528195, 150421 | 2 | 2.2 | 33 |
| RB122 | DT | 528014, 150475 | 2 | 2.9 | 32 |
| RB123 | DT | 527838, 150475 | 2 | 0.5 | 36 |
| RB124 | DT | 529009, 153283 | 2 | 1.8 | 35 |
| RB125 | DT | 525590, 151655 | 2 | 2.7 | 35 |
| RB136 | DT | 528812, 156473 | 2 | 1 | **49** |
| RB137 | DT | 528833, 156648 | 2 | 6 | **42** |
| RB140 | DT | 528122, 150799 | 2 | 7.2 | 25 |
| RB141 | DT | 527372, 150595 | 2 | 2.7 | 24 |

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (μg/m³) |
|---|---|---|---|---|---|
| RB145 | DT | 527850, 150159 | 2 | 2.2 | 34 |
| RB146 | DT | 528760, 156277 | 2 | 3.2 | **41** |
| RB147 | DT | 528732, 156407 | 2 | 51 | 16 |
| RB148 | DT | 528855, 156674 | 2.5 | 2.1 | **63** |
| RB149 | DT | 527736, 142710 | 2.5 | 1.6 | **46** |
| RB150 | DT | 525397, 150867 | 2 | 3.4 | 38 |
| RB151 | DT | 528502, 142952 | 2.5 | 1.8 | 33 |
| RB152 | DT | 528599, 152439 | 2.5 | 1.6 | 33 |
| RB153 | DT | 527837, 148046 | 2.5 | 2.9 | 29 |
| RB167 | DT | 527829, 150643 | 3 | 3.1 | 25 |
| RB174 | DT | 527851, 142842 | 2 | 3 | 31 |
| RB175 | DT | 527952, 142999 | 2.5 | 2.8 | 31 |
| RB176 | DT | 527770, 142777 | 2 | 10.2 | 25 |
| RB177 | DT | 527757, 142759 | 2 | 8.6 | 25 |
| RB178 | DT | 528591, 141830 | 2.5 | N/A | 26 |
| RB179 | DT | | | | 25 |
| RB180 | DT | | | | 26 |

***Table 4-6: Monitored annual average $PM_{10}$ concentrations at Reigate and Banstead continuous monitoring stations, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (μg/m³) |
|---|---|---|---|---|---|
| RG1 | Continuous (TEOM) | 528208, 142337 | 3.5 | 19.1 | 16 |
| RG5 | Continuous (FDMS) | | | | 15 |

## 4.6 Runnymede Borough Council

Figure 4.7 presents the locations of monitoring sites throughout Runnymede, comprising 25 diffusion tubes and two AQMAs. The AQMAs are:

- M25 AQMA, declared for annual mean $NO_2$, annual mean $PM_{10}$ and 24-hour mean $PM_{10}$ concentrations. The AQMA combines 2 area: Area 1 extends 70m east and west of the centre line of the M25 between Junction 11 [and] Junction 13, plus an area where the M25 crosses over Vicarage Road/ High Street Egham; and Area 2 extends 55m east and west of the centre line of the M25 between Junction 11 [and] the southerly boundary of the borough.
- Addlestone AQMA, declared for annual mean $NO_2$concentrations.

Table 4-7 presents the monitored annual average $NO_2$ concentrations for Runnymede in 2017. Exceedences of the air quality objective of 40µg/m³ for annual average $NO_2$ concentrations are shown in **bold**.

***Table 4-7: Monitored annual average $NO_2$ concentrations at Runnymede diffusion tubes and continuous monitoring stations, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| RYMV | DT | 505797, 162303 | 2.3 | 2 | 32 |
| RY4 | DT | 505726, 164626 | 2 | 6 | 17 |
| RY14 | DT | 504993, 164602 | 2.3 | 2 | **48** |
| RY19 | DT | 505227, 162701 | 2 | 2 | 34 |
| RY21 | DT | 504260, 166943 | 2 | 1 | 34 |
| RY23 | DT | 504888, 166786 | 2.2 | 1 | **51** |
| RY25 | DT | 501749, 171325 | 2.3 | 13 | 30 |
| RY26 | DT | 501715, 171381 | 2.2 | 2 | **42** |
| RY33 | DT | 501679, 171677 | 2.1 | 15 | 31 |
| RY34 | DT | 499335, 170688 | 2.3 | 1 | 22 |
| RY39 | DT | 498829, 166213 | 1.8 | 10 | 23 |
| RY40 | DT | 502037, 165370 | 2.5 | 68 | 16 |
| RY43 | DT | 504996, 165339 | 2.3 | 2 | 37 |
| RY44 | DT | 504621, 164433 | 2.4 | 2 | 27 |
| RY45 | DT | 504844, 166647 | 2.3 | 2 | 37 |
| RY53 | DT | 504967, 164922 | 2.4 | 2 | 34 |
| RY54 | DT | 505032, 164552 | 2.3 | 2 | 30 |
| RY55 | DT | 505592, 164840 | 2.3 | 0.2 | 33 |
| RY59 | DT | 503012, 171332 | 2.3 | 1 | 32 |
| RY60 | DT | 504960, 164801 | 2.4 | 2 | 33 |
| RY61 | DT | 504906, 164558 | 2.4 | 2 | 31 |
| RY62 | DT | 505081, 164431 | 2.3 | 2 | 34 |
| RY64 | DT | 505253, 164400 | 2.3 | 1 | 26 |
| RY65 | DT | 505801, 165041 | 2.3 | 2 | 27 |
| RY66 | DT | 505705, 164951 | 2.3 | 2 | 25 |

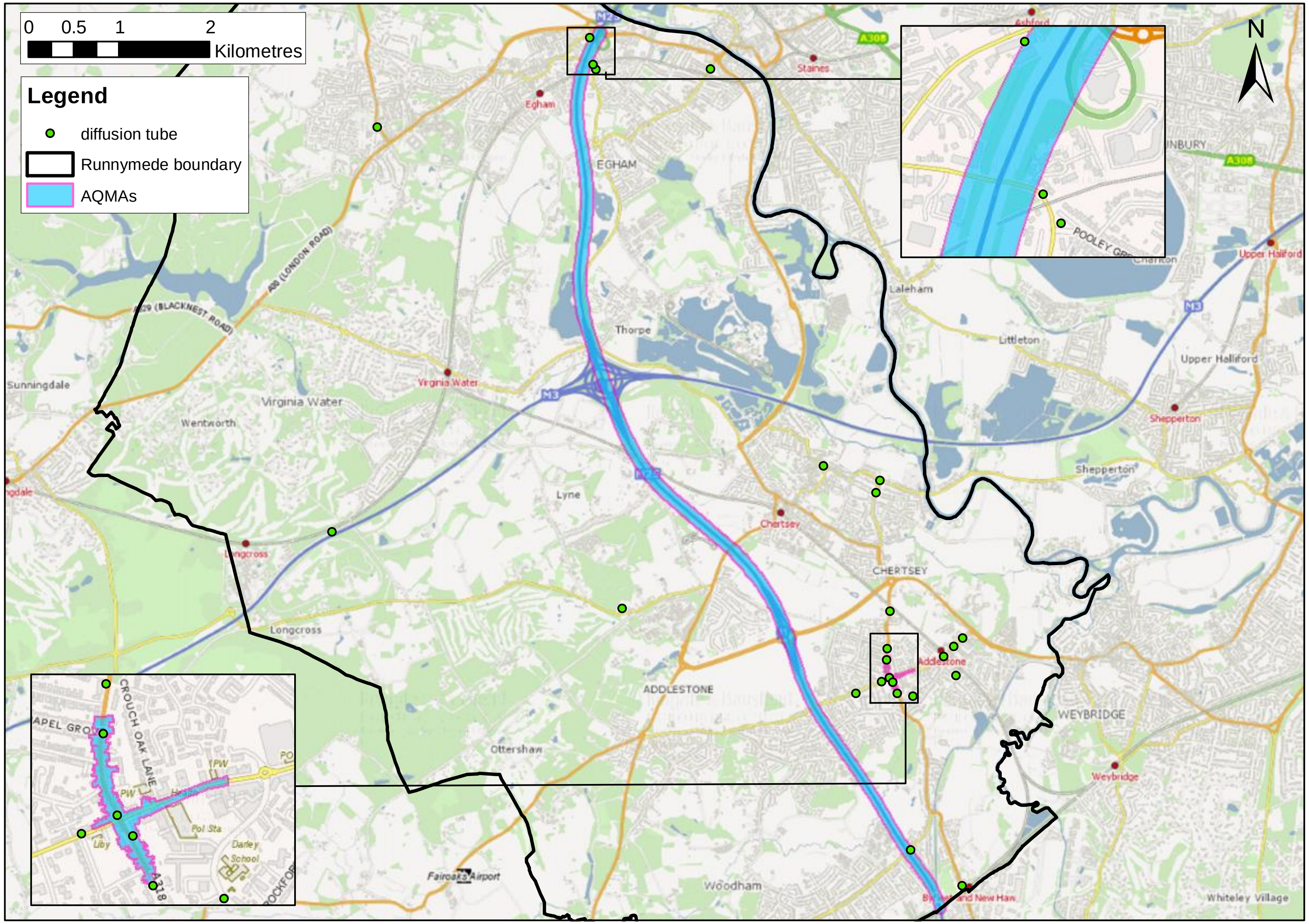


***Figure 4.7: Diffusion tubes, continuous monitoring stations and AQMA location, Runnymede***

## 4.7 Spelthorne Borough Council

Figure 4.8 presents the locations of monitoring sites in Spelthorne, comprising 44 diffusion tubes, three continuous monitors and one AQMA encompassing the entire borough of Spelthorne. The AQMA was declared for annual mean $NO_2$ concentrations.

Table 4-8 presents the monitored annual average $NO_2$ concentrations for Spelthorne in 2017. The table includes annual average $NO_x$ concentrations for continuous monitors. Exceedences of the UK Air Quality Objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**.

Table 4-9 presents the monitored annual average $PM_{10}$ and $PM_{2.5}$ concentrations at three continuous monitors in Spelthorne in 2017.

Three sites include triplicate diffusion tubes collocated with continuous monitors:

- SP16/17/18 are collocated with BAA_Oaks; and
- SP43/44/45 are collocated with SUN_01.

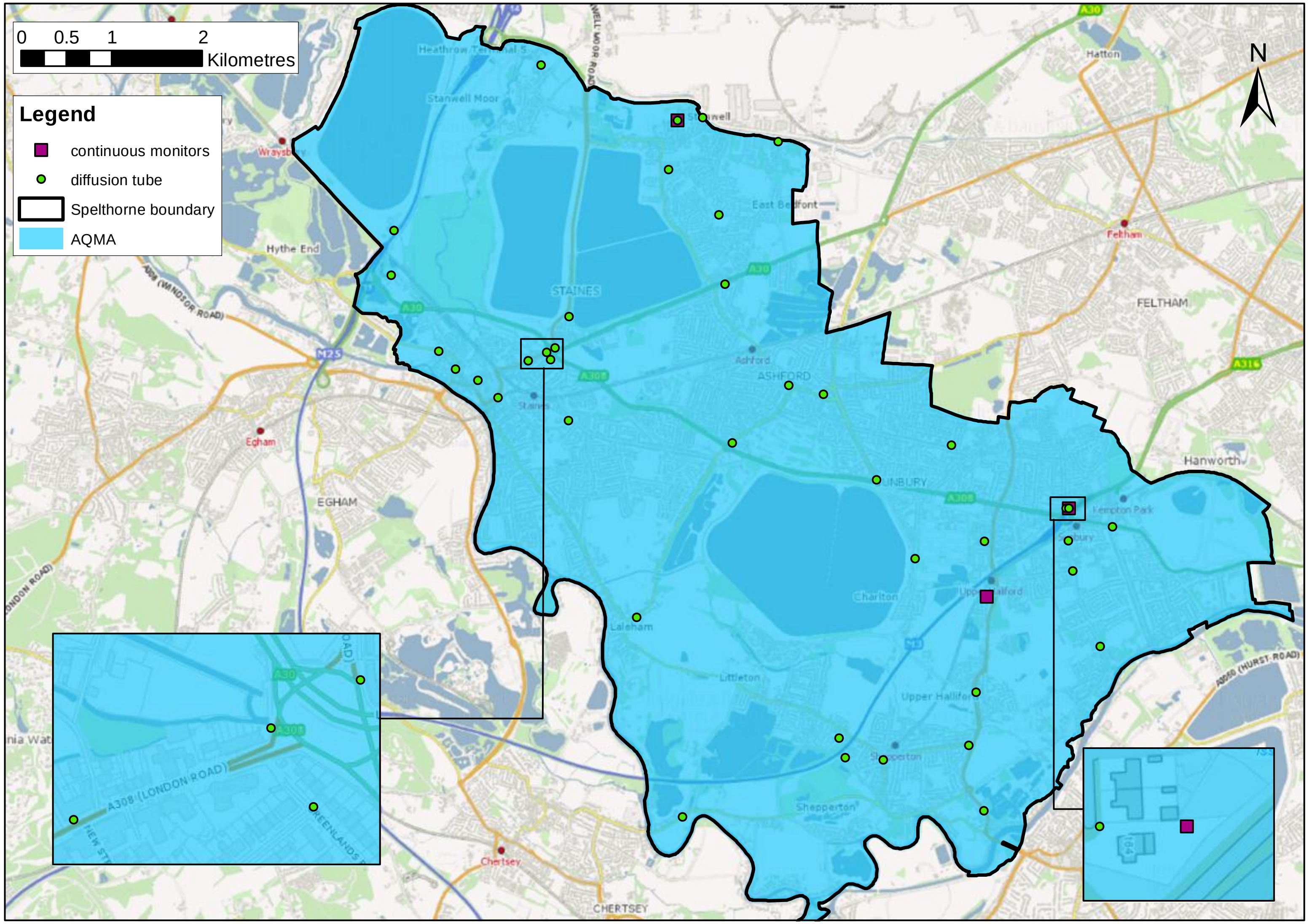


*Figure 4.8: Diffusion tubes, continuous monitoring stations and AQMA, Spelthorne*

***Table 4-8: Monitored annual average $NO_2$ and $NO_x$ concentrations at Spelthorne continuous monitoring stations and diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| BAA_Oaks | Continuous | 505735, 174489 | 3.5 | 1 | 26 [$NO_x$ 47] |
| SCC_ECO | Continuous | 509155, 169228 | 2.16 | 5.5 | 24 [$NO_x$ 44] |
| SUN_01 | Continuous | 510063, 170200 | 2.06 | 19 | 33 [$NO_x$ 59] |
| SP1 | DT | 503529, 171619 | 2.5 | N/A | 28 |
| SP3 | DT | 503098, 171935 | 2.5 | 0.5 | 31 |
| SP4 | DT | 510054, 169843 | 2.5 | 2 | 27 |
| SP5 | DT | 506967, 171563 | 2.3 | 1.5 | 37 |
| SP6 | DT | 508763, 170900 | 2.5 | 0.5 | 24 |
| SP10 | DT | 509124, 166861 | 2.4 | 1.5 | 35 |
| SP11 | DT | 509034, 168169 | 2.2 | 1.8 | 35 |
| SP12 | DT | 504538, 172318 | 2.5 | 1 | 31 |
| SP14 | DT | 504228, 175098 | 2.8 | N/A | 25 |
| SP16 | DT | 505735, 174489 | 1.7 | N/A | 26 |
| SP17 | DT | | | | 26 |
| SP18 | DT | | | | 27 |
| SP19 | DT | 506851, 174252 | 2.5 | 1.5 | 32 |
| SP20 | DT | 504334, 171845 | 1.7 | 1 | 32 |
| SP21 | DT | 509131, 169840 | 2.5 | N/A | 26 |
| SP23 | DT | 507525, 167662 | 2.7 | 1 | 23 |
| SP24 | DT | 502577, 172777 | 2.8 | N/A | 27 |
| SP26 | DT | 505635, 173948 | 2.7 | N/A | 28 |
| SP27 | DT | 503286, 171743 | 2.8 | 2 | 31 |
| SP28 | DT | 504291, 171926 | 2.4 | 1.5 | 35 |
| SP29 | DT | 504383, 171975 | 2.4 | 1 | **44** |
| SP31 | DT | 506265, 172682 | 2.4 | 2 | 36 |
| SP32 | DT | 507347, 171462 | 2.2 | 1 | 29 |
| SP33 | DT | 506339, 170927 | 2.3 | 3 | 34 |
| SP34 | DT | 507936, 170518 | 2.2 | 2 | 38 |
| SP35 | DT | 510028, 170200 | 2.5 | 10 | 37 |
| SP36 | DT | 510104, 169508 | 2.5 | 2.2 | **40** |
| SP38 | DT | 505289, 168996 | 2.1 | 2 | 24 |
| SP39 | DT | 504532, 171172 | 2.4 | N/A | 25 |
| SP41 | DT | 510407, 168677 | 2.2 | 0.5 | 30 |
| SP43 | DT | 510063, 170200 | 2 | 29 | 33 |
| SP44 | DT | | | | 33 |
| SP45 | DT | | | | 33 |
| SP46 | DT | 503754, 171428 | 2.5 | 1 | 31 |
| SP47 | DT | 506193, 173447 | 2.5 | 1.5 | 25 |
| SP48 | DT | 506012, 174518 | 2.5 | 1 | 30 |
| SP49 | DT | 502605, 173274 | 2.15 | 7.5 | 29 |
| SP50 | DT | 508364, 169648 | 2.6 | 1.8 | 33 |
| SP51 | DT | 504087, 171832 | 2.1 | 3.3 | 37 |
| SP52 | DT | 510542, 169996 | 2.1 | 2.1 | 32 |
| SP53 | DT | 505792, 166789 | 2.44 | 1.6 | 29 |
| SP55 | DT | 508954, 167584 | 2.3 | 1 | 33 |
| SP56 | DT | 507587, 167445 | 2 | 1.6 | 21 |
| SP57 | DT | 508008, 167422 | 2.5 | 1.7 | 33 |

***Table 4-9: Monitored annual average $PM_{10}$ and $PM_{2.5}$ concentrations at Spelthorne continuous monitoring stations, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | $PM_{10}$ Concentration (µg/m³) | $PM_{2.5}$ Concentration (µg/m³) |
|---|---|---|---|---|---|---|
| BAA_Oaks | Continuous | 505735, 174489 | 3.5 | 1 | 14 | 9 |
| SCC_ECO | Continuous | 509155, 169228 | 2.16 | 5.5 | 21 | 15 |
| SUN_01 | Continuous | 510063, 170200 | 2.06 | 19 | 13 | 8 |

## 4.8 Surrey Heath Borough Council

Figure 4.9 presents the locations of monitoring sites in Surrey Heath, comprising 36 diffusion tubes, one continuous monitor and one AQMA, extending along the M3 bounded by Frimley Road, Camberley and Ravenswood Roundabout, Camberley. The AQMA was for $NO_2$ annual mean and $PM_{10}$ 24-hour mean concentrations.

Table 4-10 presents the monitored annual average $NO_2$ concentrations for Surrey Heath in 2017. The table includes annual average $NO_x$ concentrations for continuous monitors. Exceedences of the UK Air Quality Objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**. $PM_{10}$ is also monitored at the continuous monitor CM1, in accordance with monitoring the 24-hour mean for $PM_{10}$ within the AQMA.

Table 4-11 presents the monitored annual average for $PM_{10}$ concentrations at the continuous monitor in Surrey Heath in 2017. SH15/22/25, are triplicate diffusion tubes collocated with the continuous monitor CM1.

***Table 4-10: Monitored annual average $NO_2$ concentrations at Surrey Heath continuous monitoring station and diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| CM1 | Continuous | 488649, 159805 | 1.5 | 17 | 36 [$NO_x$ 66] |
| SH1 | DT | 491010, 163344 | 2.5 | 1 | 14 |
| SH2 | DT | 491063, 163333 | 1.75 | 2.5 | 19 |
| SH3 | DT | 492810, 164408 | 1.75 | N/A | 13 |
| SH4 | DT | 494764, 159623 | 1.75 | N/A | 21 |
| SH5 | DT | 489463, 160583 | 1.75 | 17 | 19 |
| SH6 | DT | 494973, 159612 | 1.75 | 2.3 | 19 |
| SH7 | DT | 496221, 164430 | 1.75 | 10 | 28 |
| SH8 | DT | 496169, 164464 | 1.75 | 62 | 16 |
| SH9 | DT | 489617, 161874 | 1.75 | 4.8 | 16 |
| SH10 | DT | 485860, 160109 | 1.75 | 3 | 21 |
| SH11 | DT | 486933, 159006 | 1.75 | 6 | 21 |
| SH12 | DT | 487490, 160788 | 1.75 | 2 | 22 |
| SH13 | DT | 488740, 159579 | 1.75 | 1 | 20 |
| SH14 | DT | 488619, 159658 | 1.75 | 1 | 21 |
| SH15 | DT | 488649, 159805 | 1.75 | 17 | 24 |
| SH22 | DT | | | | 25 |
| SH25 | DT | | | | 23 |
| SH16 | DT | 486834, 158336 | 1.75 | 35 | 24 |
| SH17 | DT | 495487, 158960 | 1.75 | 2 | 15 |
| SH20 | DT | 490353, 157214 | 1.75 | 2 | 17 |
| SH21 | DT | 495134, 161087 | 1.75 | N/A | 14 |
| SH23 | DT | 490781, 160269 | 1.75 | 1 | 17 |
| SH24 | DT | 497344, 161734 | 1.75 | 2 | 22 |
| SH26 | DT | 487762, 161392 | 1.75 | N/A | 21 |
| SH27 | DT | 495546, 158848 | 1.75 | 3 | 23 |

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (μg/m³) |
|---|---|---|---|---|---|
| SH28 | DT | 495325, 159055 | 1.75 | 5 | 19 |
| SH29 | DT | 494222, 163476 | 1.75 | 0 | 14 |
| SH30 | DT | 487181, 158432 | 1.75 | 20 | 24 |
| SH31 | DT | 487024, 158415 | 1.75 | 20 | 19 |
| SH32 | DT | 486982, 158389 | 1.75 | 20 | 21 |
| SH33 | DT | 486848, 158311 | 1.75 | 20 | 25 |
| SH34 | DT | 487934, 159132 | 1.75 | 50 | 19 |
| SH35 | DT | 489189, 160209 | 1.75 | 5 | 19 |
| SH36 | DT | 489347, 160392 | 1.75 | 15 | 20 |
| SH37 | DT | 489081, 160271 | 1.75 | 5 | 21 |
| SH38 | DT | 491706, 163145 | 1.75 | 15 | 24 |

***Table 4-11: Monitored annual average $PM_{10}$ concentration at Surrey Heath continuous monitoring station, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | $PM_{10}$ Concentration (μg/m³) |
|---|---|---|---|---|---|
| CM1 | Continuous | 488649, 159805 | 1.5 | 1.7 | 17 |

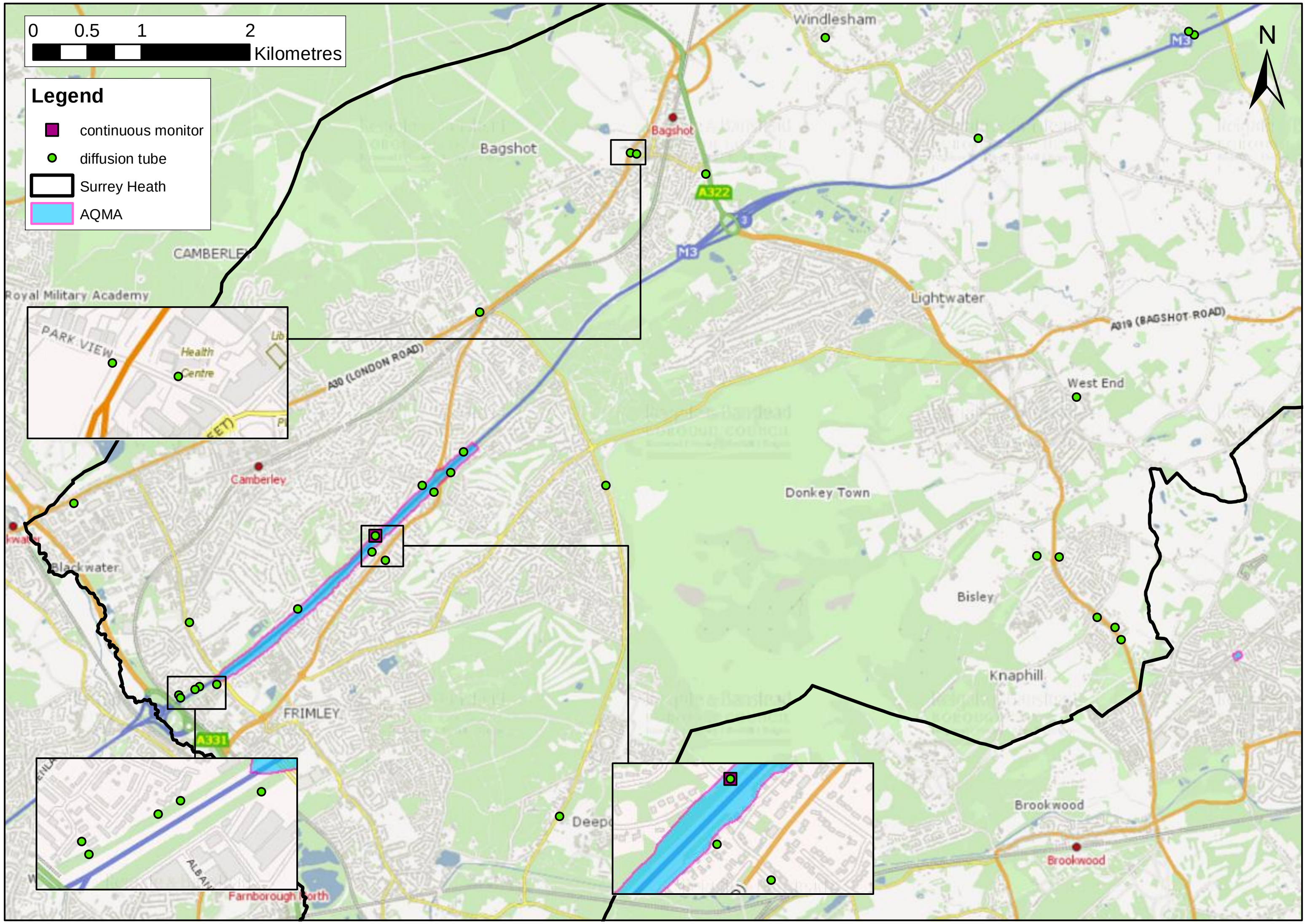


*Figure 4.9: Diffusion tubes, continuous monitoring station and AQMA across Surrey Heath*

## 4.9 Tandridge District Council

Figure 4.10 presents the locations of monitoring sites throughout Tandridge, comprising 28 diffusion tubes. Tandridge District Council has not declared any AQMAs.

Table 4-12 presents the monitored annual average $NO_2$ concentrations in Tandridge in 2017. Exceedences of the air quality objective of 40µg/m³ for annual average $NO_2$ concentrations are shown in **bold**. Note, there is one diffusion tube in Tandridge managed by Reigate and Banstead Borough Council. Details for this diffusion tube, RB102, are provided in Table 4-5

***Table 4-12: Monitored annual average $NO_2$ concentrations at Tandridge diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| TANWI_001 | DT | 534825, 151633 | 2.5 | N/A | 23 |
| TANWI_002 | DT | 534949, 151684 | 2.5 | N/A | 31 |
| TANWI_003 | DT | 535012, 151821 | 2.5 | N/A | **42** |
| TANWI_004 | DT | 535002, 151856 | 2.5 | N/A | 26 |
| TANWI_005 | DT | 534993, 152052 | 2.5 | N/A | **41** |
| TANWI_006 | DT | 535020, 152269 | 2.5 | N/A | 25 |
| TD5 | DT | 535071, 152659 | 2.5 | 2.2 | 29 |
| TD7 | DT | 535167, 152200 | 2.5 | 152 | 19 |
| TD8 | DT | 534883, 152316 | 2.5 | 132 | 19 |
| TD9 | DT | 539111, 153656 | 2.5 | 1.5 | 17 |
| TD14 | DT | 534364, 157506 | 2.5 | 0.5 | 27 |
| TD19 | DT | 531134, 143585 | 2.5 | 130 | 21 |
| TD23 | DT | 535840, 158430 | 2.5 | 1.5 | 23 |
| TD25 | DT | 533839, 158847 | 2.5 | 1.7 | 19 |
| TD26 | DT | 531105, 142939 | 2.5 | 133 | 23 |
| TD27 | DT | 530719, 150539 | 2.5 | 1.3 | 29 |
| TD28 | DT | 539881, 152746 | 2.5 | 1.5 | 28 |
| TD30 | DT | 540258, 153783 | 2.5 | 1.5 | 22 |
| TD31 | DT | 535186, 159127 | 2.5 | 0.5 | 20 |
| TD32 | DT | 539684, 152744 | 2.5 | 1.5 | 22 |
| TD33 | DT | 532790, 155873 | 2.5 | 1 | 25 |
| TD34 | DT | 539464, 152936 | 2.5 | 0.4 | 20 |
| TD35 | DT | 531952, 150789 | 2.5 | 2.5 | 27 |
| TD36 | DT | 534050, 155838 | 2.5 | 1 | 25 |
| TD37 | DT | 530385, 150477 | 2.5 | 1 | 19 |
| TD38 | DT | 531840, 150826 | 2.5 | 1 | 25 |
| TD39 | DT | 536909, 139713 | 2.5 | 0.5 | 26 |
| TD40 | DT | 530592, 150508 | 2.5 | 1.5 | 33 |

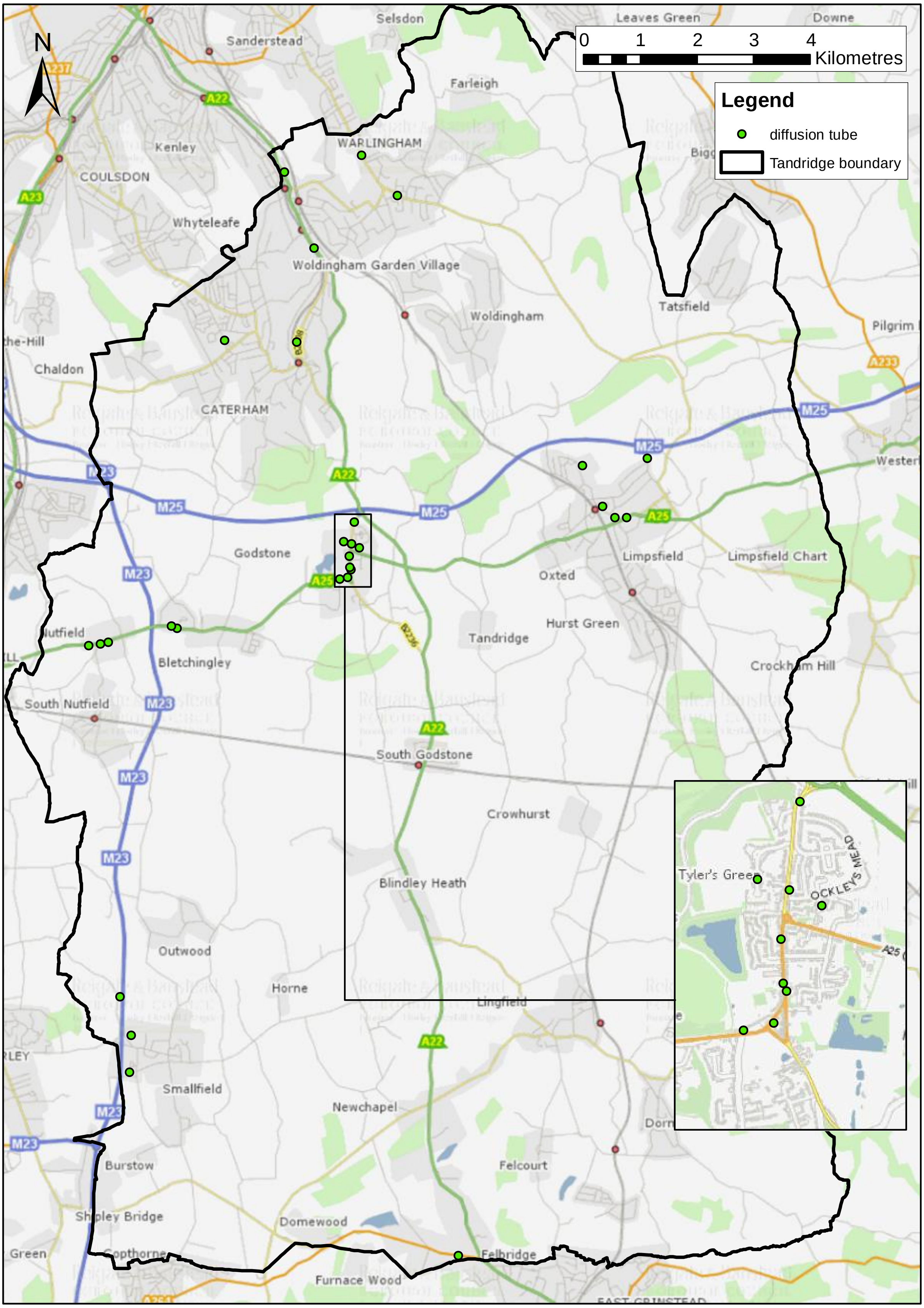


*Figure 4.10: Diffusion tube locations, Tandridge*

## 4.10 Waverley Borough Council

Figure 4.11 presents the locations of the two active AQMAs in Waverley. The AQMAs are:

- AQMA No. 1 Farnham
- AQMA No. 2 Godalming

Both AQMAs were declared for annual mean $NO_2$ concentrations.

Monitoring data for Waverley were not provided.

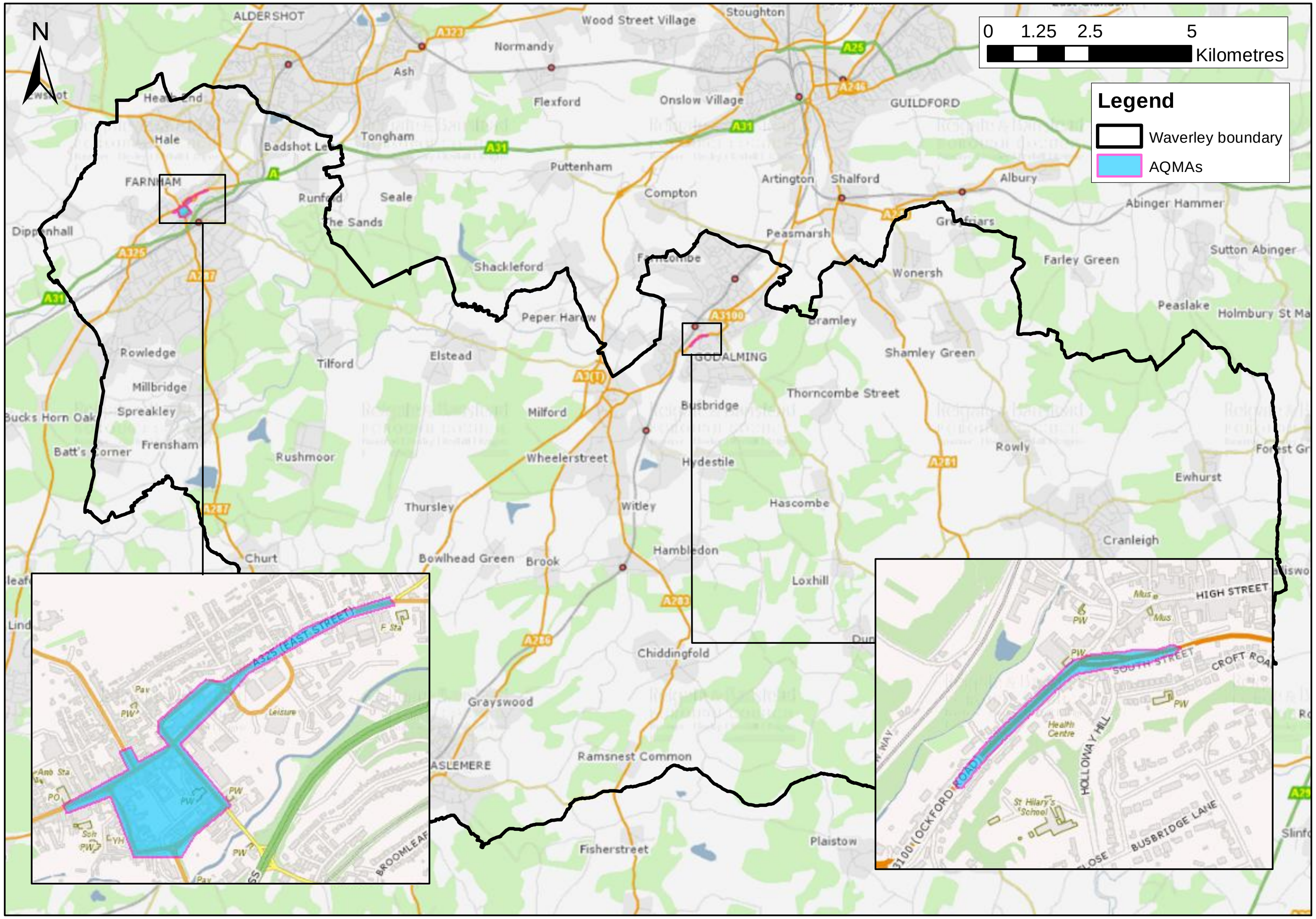


*Figure 4.11: AQMA locations: Waverley*

## 4.11 Woking Borough Council

Figure 4.12 presents the locations of monitoring sites throughout Woking, comprising 32 diffusion tubes and two AQMAs. The AQMAs are:

- Anchor Hill
- A small section of Guildford Road

Both AQMA were declared for annual mean $NO_2$ concentrations.

Table 4-13 presents the monitored annual average $NO_2$ concentrations for Woking in 2017. Exceedences of the UK Air Quality Objective of 40µg/m³ for annual average $NO_2$ concentrations are highlighted in **bold**.

***Table 4-13: Monitored annual average $NO_2$ concentrations at Woking diffusion tubes, 2017***

| Site ID | Monitor type | Location | Height (m) | Distance to kerb (m) | Concentration (µg/m³) |
|---|---|---|---|---|---|
| WOK_AH1 | DT | 496618, 158700 | 2.5 | 1 | 35 |
| WOK_AH2 | DT | 496615, 158695 | 2.5 | 5 | 32 |
| WOK_AH3 | DT | 496646, 158750 | 2.5 | 5 | 23 |
| WOK_AH4 | DT | 496679, 158767 | 2.5 | 2 | 27 |
| WOK_AH5 | DT | 496594, 158698 | 2.5 | 5 | 26 |
| WOK_AH6 | DT | 496585, 158688 | 2.5 | 2 | 29 |
| WOK_BD | DT | 498025, 158949 | 2.5 | 2 | 15 |
| WOK_BR | DT | 495822, 157793 | 2.5 | 1 | 25 |
| WOK_BR1 | DT | 495850, 157187 | 2.5 | 1.5 | 23 |
| WOK_BW | DT | 495875, 157972 | 2.5 | 1 | 22 |
| WOK_CH | DT | 500417, 158102 | 2.5 | 1.5 | 37 |
| WOK_CH2 | DT | 500368, 158072 | 2.5 | 1 | **42** |
| WOK_CH3 | DT | 500332, 158012 | 2.5 | 1.5 | **42** |
| WOK_CH4 | DT | 500332, 157983 | 2.5 | 1 | 38 |
| WOK_CR | DT | 506401, 160505 | 2.5 | 1 | 21 |
| WOK_CW | DT | 496215, 157991 | 2.5 | 2 | 22 |
| WOK_GR | DT | 499950, 158540 | 2.5 | 1 | 26 |
| WOK_LD | DT | 503243, 159658 | 2.5 | 1 | 17 |
| WOK_LGR | DT | 496601, 158668 | 2.5 | 3 | 24 |
| WOK_LT1 | DT | 500453, 158100 | 2.5 | 1 | 35 |
| WOK_LTK | DT | 500442, 158121 | 2.5 | 1 | 25 |
| WOK_M25 | DT | 505611, 161179 | 2.5 | 0 | **43** |
| WOK_MR | DT | 501613, 159646 | 2.5 | 2 | 32 |
| WOK_MR2 | DT | 501613, 159646 | 2.5 | 2 | 28 |
| WOK_OR | DT | 501665, 159161 | 2.5 | 3 | 25 |
| WOK_PR | DT | 504925, 161063 | 2.5 | 1 | 23 |
| WOK_RC | DT | 500946, 157110 | 2.5 | 1 | 18 |
| WOK_TC | DT | 506731, 161230 | 2.5 | 4 | 26 |
| WOK_TW | DT | 498435, 159451 | 2.5 | 1.5 | 14 |
| WOK_VW | DT | 500515, 159020 | 2.5 | 1 | 32 |
| WOK_YR | DT | 500450, 158278 | 2.5 | 1 | 25 |
| WOK_YR1 | DT | 500451, 158256 | 2.5 | 1 | 25 |

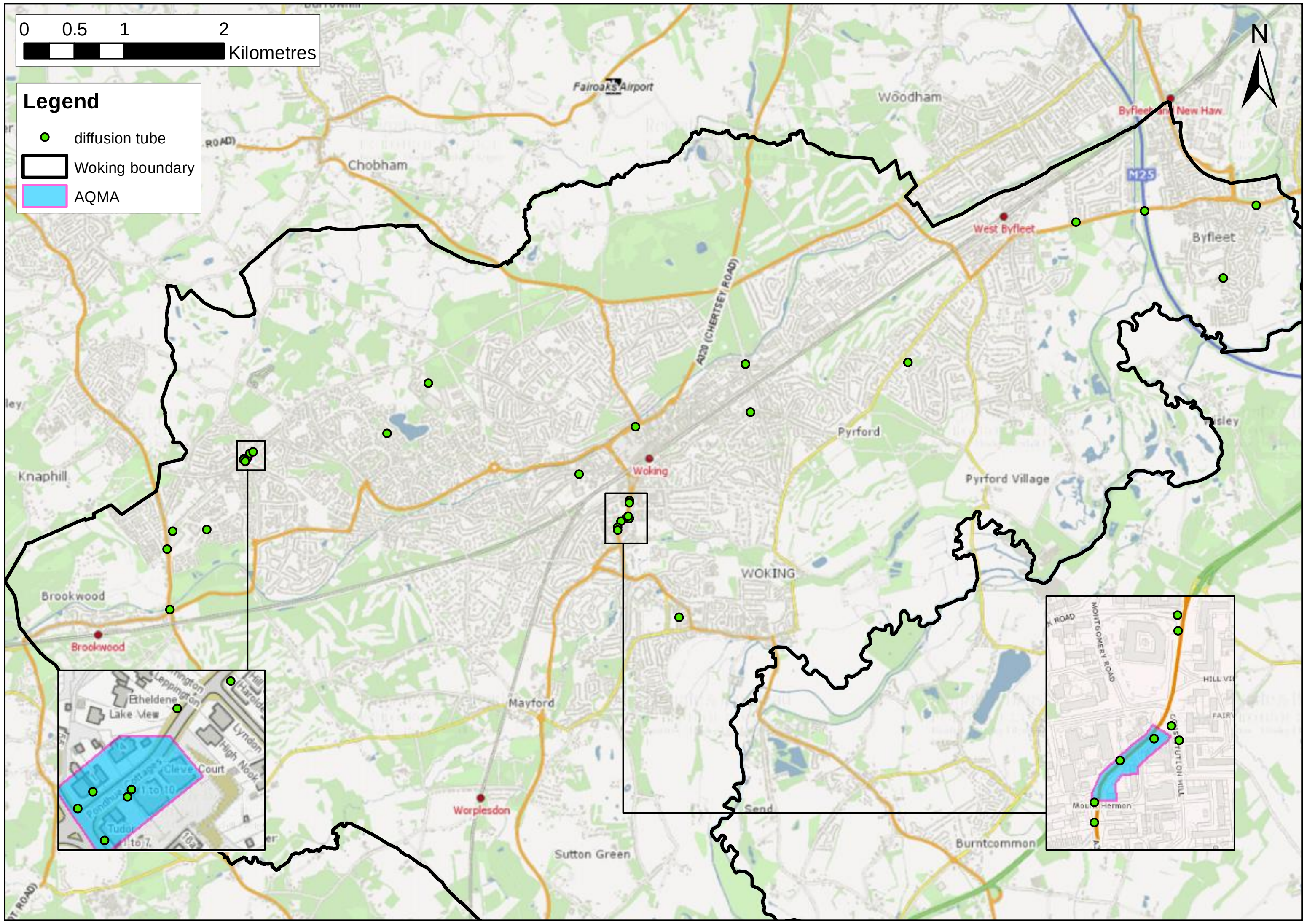


*Figure 4.12: Diffusion tubes and AQMAs, Woking*

# 5 Air quality modelling

## 5.1 Modelling software

All modelling was carried out using ADMS-Urban[2] version 4.2, developed by CERC. This model allows the effects of wider urban areas on local air quality to be taken into account.

## 5.2 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 roughness length of 0.5m was used for the dispersion site throughout the modelling, representing open suburbia.

The difference in land use at the meteorological station compared to the study area was taken into account by entering a different surface roughness for the meteorological station. See Section 5.4 for further details.

## 5.3 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 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. 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 minimum Monin-Obukhov length of 30 m was used in the modelling.

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

## 5.4 Meteorological data

A year of hourly sequential meteorological data measured at Heathrow Airport in 2017 was used for model verification and subsequent modelling.

Table 5-1 summarises the meteorological data from Heathrow Airport. To take account of the different surface characteristics at Heathrow Airport, compared to the modelled area, a surface roughness of 0.2 m was assumed for the meteorological station.

***Table 5-1: Summary of Heathrow meteorological data***

| Year | % of hours used | Parameter | Minimum | Maximum | Mean |
|---|---|---|---|---|---|
| 2017 | 99.7 | Temperature (°C) | -4 | 34 | 12.0 |
| | | Wind speed (m/s) | 0 | 17 | 4.1 |
| | | Cloud cover (oktas) | 0 | 8 | 5 |

The ADMS meteorological pre-processor, written by the UK Met Office, uses the data provided to calculate the parameters required by the program. Figure 5.1 presents a wind rose showing the frequency of occurrence of wind from different directions for a number of wind speed ranges for Heathrow Airport.

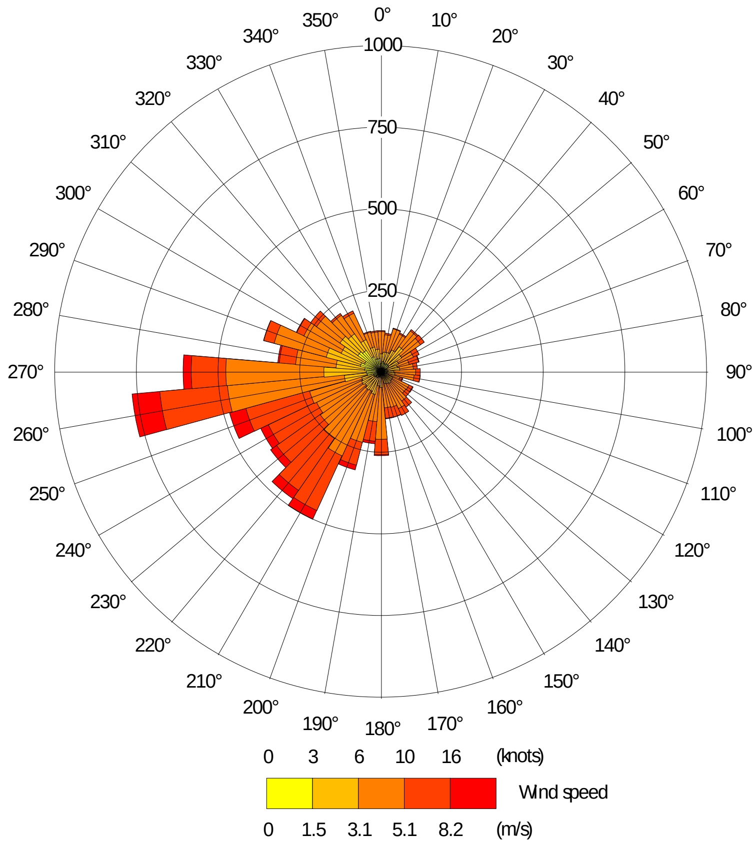


***Figure 5.1: Wind rose for Heathrow 2017***

## 5.5 Chemistry

The ADMS-Urban explicit chemistry scheme was used to model the interconversion between NO and $NO_2$, using wind dependent background concentrations derived from AURN rural monitoring sites. This approach allows for direct model verification against monitored concentrations for $NO_x$ and $NO_2$, with simultaneous consideration of source dependent primary $NO_2$.

## 5.6 Background data

Hourly background data for the modelled pollutants and sulphur dioxide and ozone were input to the model to represent the concentrations in the air being blown into the area. $NO_x$, $NO_2$, $SO_2$, $PM_{10}$, $PM_{2.5}$ and $O_3$ concentrations from Rochester Stoke, Chilbolton, Lullington Heath and Haringey Priory Park South for 2017 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.

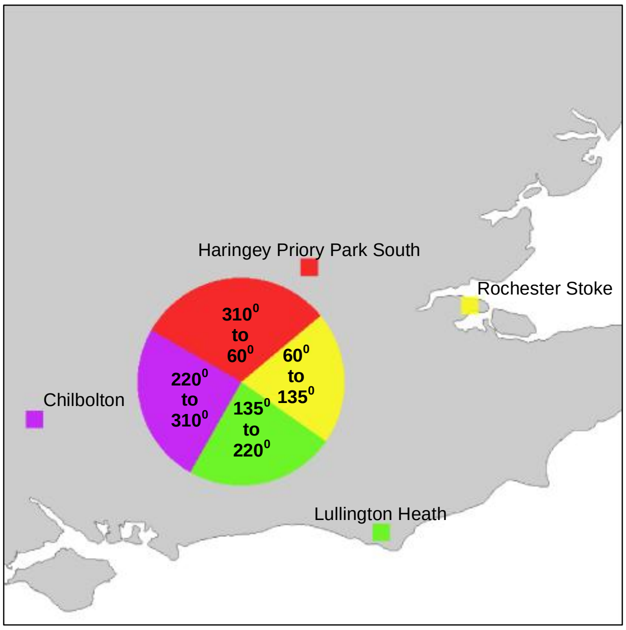


***Figure 5.2: Wind direction segments used to calculate background concentrations for $NO_x$, $NO_2$, $O_3$, $PM_{10}$, $PM_{2.5}$ and $SO_2$***

Table 5-2 summarises the annual statistics for background data used for the modelling, calculated using wind data from Heathrow Airport.

***Table 5-2: Summary of 2017 background data used in the modelling (µg/m³)***

| Statistic | $NO_x$ | $NO_2$ | $O_3$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ |
|---|---|---|---|---|---|---|
| Annual average | 17.5 | 12.0 | 51.3 | 14.8 | 8.8 | 0.9 |
| 99.79th percentile of hourly average | 392.4 | 80.0 | 111.8 | - | - | - |
| 90.41st percentile of 24-hour average | - | - | - | 26.0 | 19.0 | 1.4 |

## 5.7 Street canyons

The advanced street canyon module option in ADMS-Urban was used to modify the dispersion of pollutants from a road source according to the presence and properties of canyon walls on one or both sides of the road. Building footprint and height information was taken from OS Mastermap data, provided by Reigate and Banstead Borough Council. At some locations, the properties of canyons were altered due to inconsistencies between the width of the modelled road and the related canyon. Along the M3, street canyon parameters were altered to account for noise barriers on either side of the road, such as fences and hedges. These affect the dispersion of road emissions.

# 6 Emissions

Emission inventories were compiled for each of the scenarios modelled, using CERC's EMIT[3] emissions inventory tool, version 3.6.

## 6.1 Road transport

Emissions from road transport were calculated using an activity data approach, whereby Annual Average Daily Traffic flows (AADTs) for each road link were combined with emission factors and speed data to calculate emissions for each road link on a vehicle-by-vehicle basis. This methodology is described below.

### 6.1.1 Emission factors

Traffic emissions of $NO_x$, $NO_2$, $PM_{10}$ and $PM_{2.5}$ were calculated from traffic flows using EFT v8.0.1 emission factors based on Euro vehicle emissions categories. This dataset includes speed-emissions data that are based COPERT 5[4] emission factrors. EFT v8.0.1 include exhaust, brake, tyre and road wear for $PM_{10}$ and $PM_{2.5}$; resuspension emission factors were taken from a report produced by TRL Limited on behalf of Defra[5].

Note that there is large uncertainty surrounding the current emissions estimates of $NO_x$ from all vehicle types, in particular diesel vehicles; refer to, for example, an AQEG report from 2007 [6] and a Defra report from 2011[7]. In order to address this discrepancy, the $NO_x$ emission factors were modified based on published Remote Sensing Data (RSD)[8] for vehicle $NO_x$ emissions in London. Scaling factors were applied to each vehicle category and speed.

### 6.1.2 Activity data

Traffic activity data were derived the Surrey Traffic Model, supplemented by Department for Transport (DfT) count data and local data from borough council detailed and further assessments. The split between these traffic data sources is illustrated by Figure 6.1.

[3] http://cerc.co.uk/environmental-software/EMIT-tool.html
[4] http://www.emisia.com/copert/General.html
[5] Road vehicle non-exhaust particulate matter: final report on emission modelling, TRL Limited Project Report PPR110 http://uk-air.defra.gov.uk/reports/cat15/0706061624_Report2__Emission_modelling.PDF
[6] Trends in primary nitrogen dioxide in the UK
[7] Trends in $NO_x$ and $NO_2$ emissions and ambient measurements in the UK
[8] Carslaw, D and Rhys-Tyler, G 2013: New insights from comprehensive on-road measurements of $NO_x$, $NO_2$ and $NH_3$ from vehicle emission remote sensing in London, UK. *Atmos. Env.* **81** pp 339–347.

Surrey County Council provided AM peak, PM peak and inter-peak traffic flows and speeds, by vehicle type, from the Surrey Traffic Model for major roads across Surrey. The AM and PM peak flows were used to derive AADTs using conversion factors provided by Surrey County Council.

For each road, one of six conversion factors were applied depending on the type of road. Speeds used for the emission calculations for each road were derived by calculating a weighted average speeds, based on the flow of each vehicle throughout the day.

DfT provides traffic count data for the primary and strategic road network for the whole of the UK. Checking of traffic inputs during the model verification stage showed poor agreement between measured daily flows and the values derived from the Surrey Traffic Model on some motorways and major A roads. Therefore for the final emission calculations where DfT traffic counts were available, they were used in preference to values derived from the Surrey Traffic Model outputs.

Traffic inputs were refined, to use traffic flows and / or speeds from previous local assessments, where the values were significantly different to values calculated from the Surrey Traffic Model values. Local adjustments were based on traffic data reported in:

- Guildford Borough Council's Detailed Assessment for Compton Village[9];
- Woking Borough Council's Further Assessment for Anchor Hill[10]; and
- Woking Borough Council's Detailed Assessment for Guildford Road[11].

[9] http://www2.guildford.gov.uk/councilmeetings/documents/s9029/Item%2013%206-%20AQMA%20Compton%20-%20App%206%20-%20Compton%20AQAP%20Guildford_Draft1.pdf
[10] https://www.woking.gov.uk/sites/default/files/documents/environmentalservices/detailedassessmentforguildfordroad.pdf
[11] https://www.woking.gov.uk/sites/default/files/documents/environmentalservices/WBC_Guildford%20Rd_AQAP%20final%20report.pdf

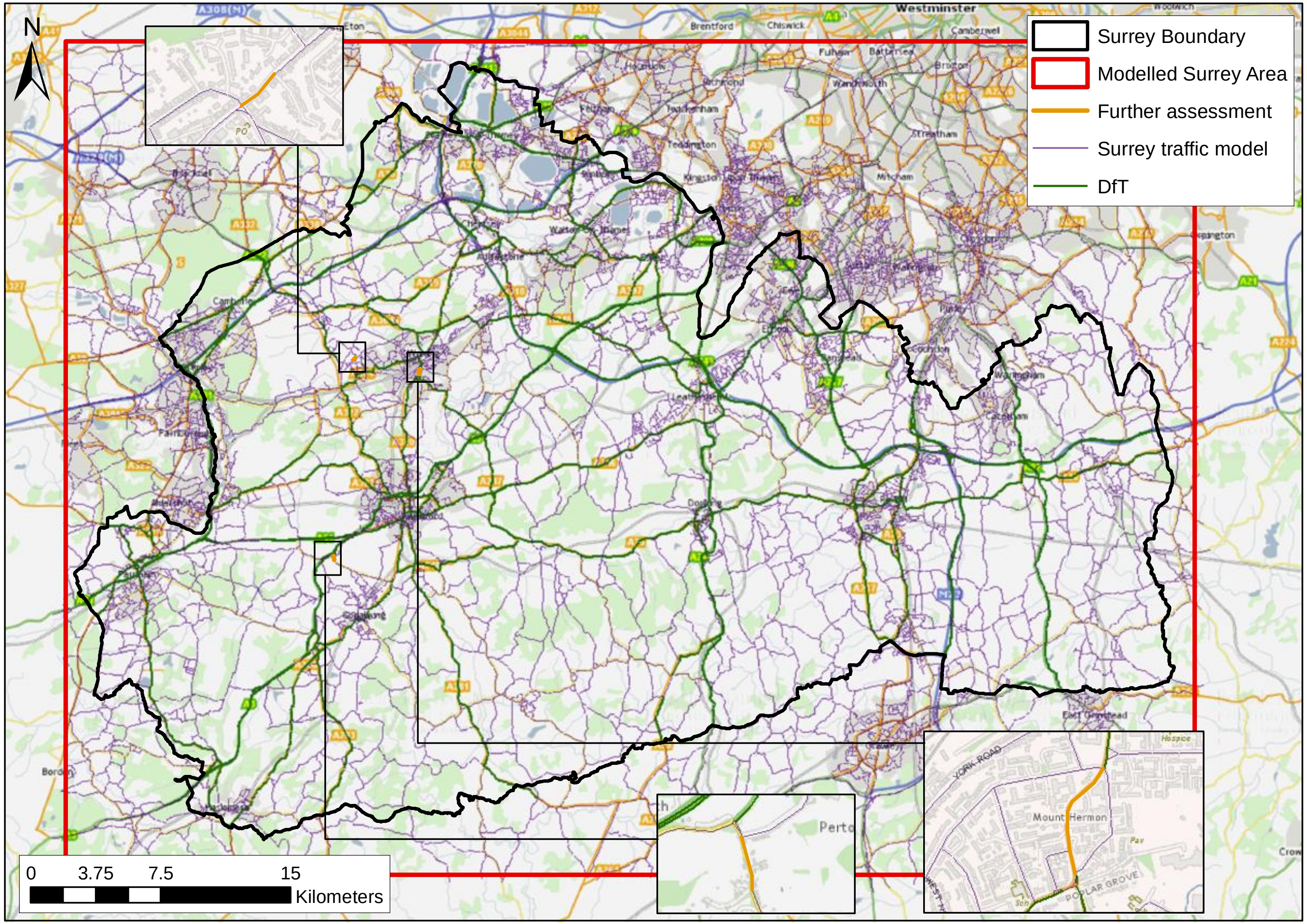


**Figure 6.1: Traffic activity data split between Surrey traffic model output and DfT count statistics**

### 6.1.3 Time-varying emissions

The variations of traffic flows during the day were taken into account by applying a diurnal profile to the road emissions. The profile was constructed by combining profiles derived from automatic traffic count (ATC) data for A25 Nutfield Road, provided by Surrey County Council, and average traffic distribution on all roads in Great Britain, as published by the DfT.[12] Averaging these two sets of profiles, generated a profile that was more consistent with the traffic flow conversion factors provided by Surrey County Council for all A & B roads in the county, leading to a greater confidence in the time-varying emissions profile used in the modelling. A comparison between the derived conversion factors for these profiles is shown in Table 6-1.

The calculated profile, shown in Figure 6.2, was applied to all modelled roads and grid sources, representing emissions aggregated on 1-km square basis, as described in Section 6.3.

***Table 6-1: Comparison of traffic flow conversion factors for variation of traffic flows during the day***

| | **Weekday to daily** | | **Weekday** | | | | | **AM & PM peak to AADT** |
|---|---|---|---|---|---|---|---|---|
| | **12hr to 24hr** | **24hr to 24hr** | **12hr to 24hr** | **AM peak to 24 hr** | **PM peak to 24 hr** | **AM peak spread** | **PM peak spread** | |
| DfT: UK roads | 1.20 | 0.94 | 1.28 | 14.00 | 12.89 | 0.35 | 0.35 | 6.31 |
| ATC – A25 Nutfiield Road | 1.13 | 0.94 | 1.20 | 10.84 | 10.87 | 0.40 | 0.39 | 5.12 |
| Diurnal profile used in model | 1.16 | 0.94 | 1.24 | 12.22 | 12.69 | 0.38 | 0.36 | 5.66 |
| Surrey CC: All A & B roads | 1.16 | 0.92 | 1.26 | 12.83 | 12.07 | 0.36 | 0.36 | 5.73 |

[12] https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra

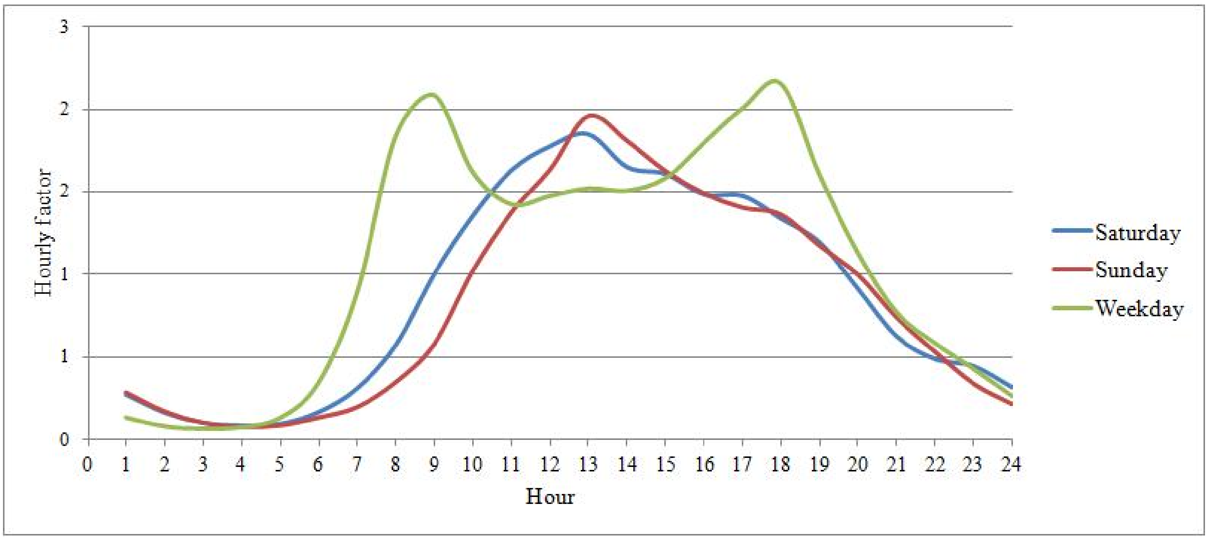


***Figure 6.2: Diurnal emission factor profile used for road and grid sources***

## 6.2 Industrial sources

The individual boroughs provided locations and parameters of 47 large industrial sources; including stack height, stack diameter, velocity, temperature and $NO_x$, $PM_{10}$ and $PM_{2.5}$ emissions. These large industrial sources were modelled as point sources.

## 6.3 Other emissions

Emissions from other sources across the modelling domain were taken from the National Atmospheric Emissions Inventory (NAEI) 2015. Emissions from all other source types were modelled as an aggregated grid source with a resolution of 1 km. The NAEI data include emissions from Heathrow Airport and Gatwick Airport, located on the border of Surrey. The Surrey modelled area extends from (48000, 12900) to (54500, 17700), this extent is shown in Figure 6.1

# 7 Model verification

The first stage of a modelling assessment is to model a current case in order to verify that the input data and model set-up are appropriate for the area, by comparing measured and modelled concentrations for local monitoring locations. The monitor locations used for this purpose are described in Section 4. Concentrations were calculated at these monitoring locations for 2017.

The model verification involves an iterative process to improve the model set-up, for better agreement between measured and modelled concentrations. Table 7-1 summarises the main changes made to the model during the model verification process.

***Table 7-1: Main changes to the model setup during the verification process***

| Verification version | Model changes |
|---|---|
| V1 | AADT for all 61,294 road links derived from Surrey Traffic model data.<br>Automated calculation of street canyon parameters on a Surrey-wide basis.<br>Detailed checking and adjustment, where necessary, of the modelled distances between road sources and monitoring locations.<br>Further manual changes to street canyons to ensure that monitoring locations were correctly located inside or outside of them. |
| V2 | AADT changed for 6,633 road links within the Surrey boundary, using DfT 2017 traffic counts. |
| V3 | Street canyon parameters altered to account for the impact of noise barriers (fence and hedges) on the dispersion of emissions from the M3. |
| V4 | AADT changed of 10 road links where local traffic flows have been reported in detailed and further assessments. |

Model verification was conducted using meteorological data from both Heathrow Airport and Gatwick Airport. Due to generally better agreement between modelled and monitored concentrations, in particular at continuous monitoring sites, the set-up using Heathrow Airport data was used for the main modelling.

A comparison of model verification results using Heathrow and Gatwick data is included in Appendix A. Full details of the model verification using Gatwick Airport data is provided in Appendix B, including a summary of the meteorological data and the background data calculated using Gatwick wind data.

Figure 7.1 presents a scatter plot of monitored and modelled annual average $NO_2$ concentrations at the locations of 367 diffusion tubes and nine continuous monitors across the Surrey boroughs using Heathrow Airport meteorological data. Table 7-2 summarises model verification statistics at these locations. These data are also presented as box plots in Figure 7.2, to show the spread of measured and modelled annual average $NO_2$ concentrations by borough.

A summary of all continuous monitoring data is provided in Table 7-3. Further analysis of monitored and modelled concentrations at continuous monitoring locations are provided in the box plots in Figure 7.3 to Figure 7.6, comparing range of hourly mean concentrations $NO_x$, $NO_2$, $PM_{10}$ and $PM_{2.5}$. Note, only hours were there is valid model and monitor output are compared for continuous monitors.

Modelled annual average $NO_2$ concentrations are within 25% of the monitored value at 277 of 376 locations (74%), showing generally good performance of the model set-up across Surrey.

Some of the highest monitored concentrations, typically representing busy junctions or congested roads, are underpredicted by the model. These underpredictions may be due to complex traffic characteristics, e.g. slow moving stop-start traffic, not being fully represented in the model inputs. Locations where this likely to be the case include RB136, located on the junction between Brighton Road and Star Lane, and RY23, located on the junction between Weir Road and Bridge Road. In addition, CH2, CH3 and LT1 along Guildford Road, Woking will be affected by congestion originating from diversions associated with development in the town centre[13].

Concentrations are overpredicted by the model at three types of locations: background locations where the lowest concentrations in Surrey are measured; some locations close to the M3 and M25 motorways; and close to Gatwick Airport. The model overpredictions at some background locations are due to the background inputs to the model being higher than measured values. Along motorways, the model set-up may not fully capture the shielding impact of noise barriers and other noise abatement features along these roads. Gatwick Airport emissions are included as part of aggregated 1 km grid emissions; this generalised treatment will lead to some overprediction of concentrations close to the airport, affecting modelled concentrations at the RG3 continuous monitor, collocated diffusion tubes RB99, RB100 and RB101, along with MV9.

Discrepancies between modelled and monitored concentrations also represent uncertainty in the monitored values. Diffusion tube measurements are less accurate than measurements from continuous monitors; therefore good model agreement at continuous monitor sites is typically a better indicator of performance than comparisons against diffusion tube measurements.

Overall the model set-up provides a level of agreement that gives confidence for Surrey-wide model outputs.

[13] https://www.woking.gov.uk/sites/default/files/documents/licencing/ASR_WBC_2018_Issued.pdf

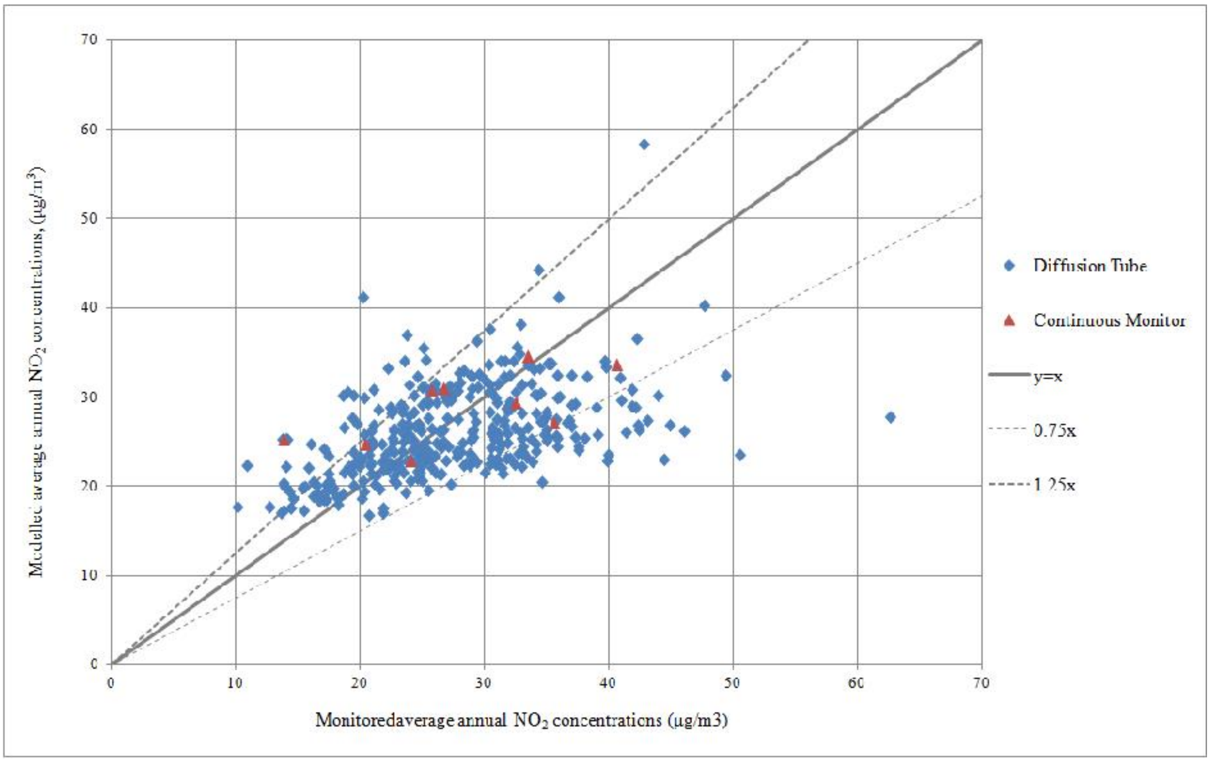


***Figure 7.1: Scatter plot of measured and modelled annual average $NO_2$ concentrations***

***Table 7-2: Model verification statistics for annual average $NO_2$ concentrations***

| **Heathrow** | **Min** | **Max** | **Mean** | **Count** | **Modelled / Monitored** | **<0.75** | **>0.75<1.25** | **>1.25** | **% >0.75<1.25** |
|---|---|---|---|---|---|---|---|---|---|
| Diffusion tubes | 16.7 | 58.3 | 26.1 | 367 | 1.00 | 56 | 269 | 42 | 73 |
| Continuous monitors | 22.8 | 34.5 | 28.8 | 9 | 1.09 | 0 | 8 | 1 | 89 |
| All monitors | 16.7 | 58.3 | 26.1 | 376 | 1.00 | 56 | 277 | 43 | 74 |

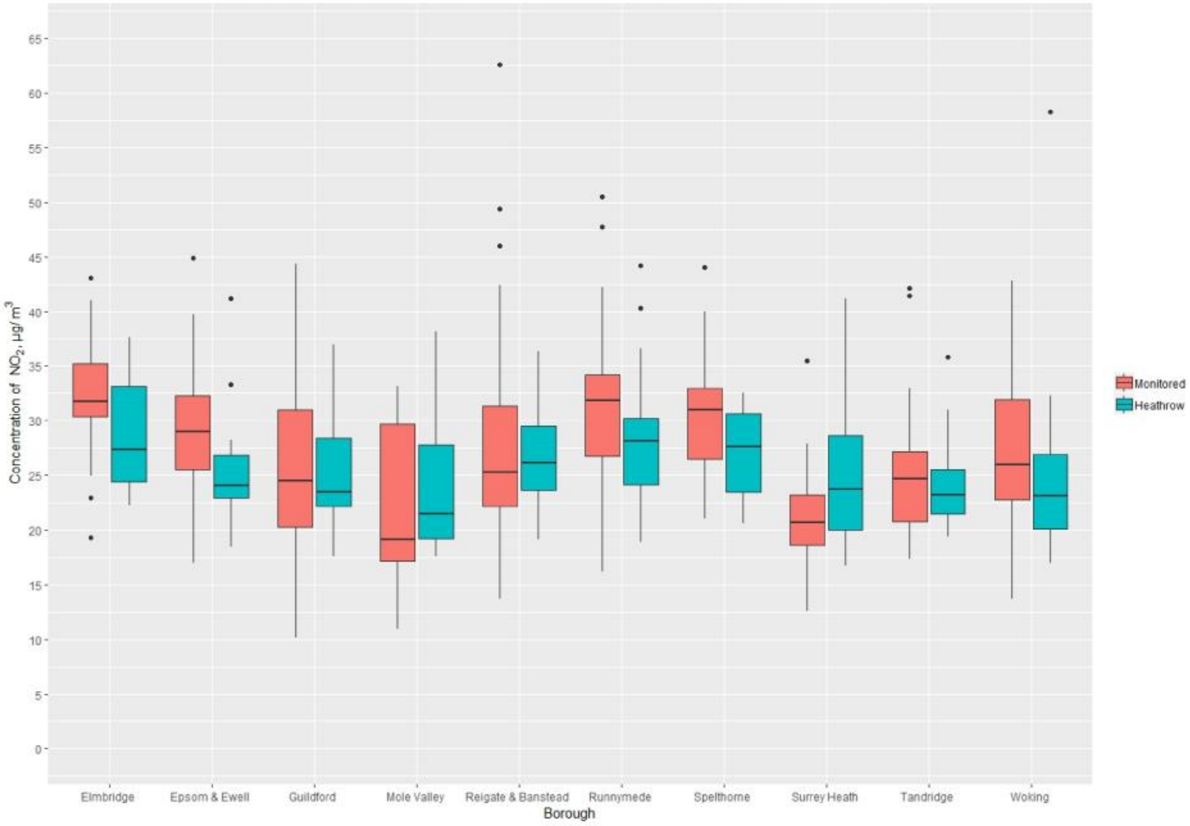


***Figure 7.2: Box plots showing the spread of measured and modelled annual average $NO_2$ concentrations by Surrey borough. In this plot 'outliers', outside the range of -/+ 1.5*(inter-quartile range), are presented as points***

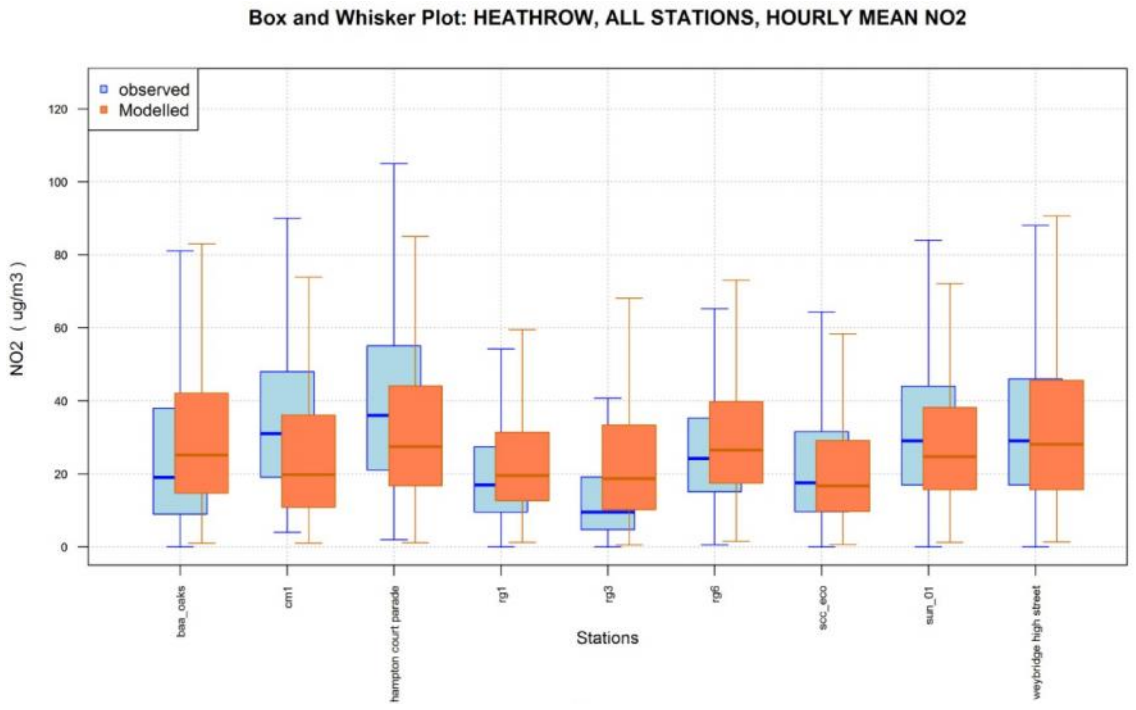


***Figure 7.3: Box plots of measured and modelled hourly mean $NO_2$ concentrations at continuous monitoring sites***

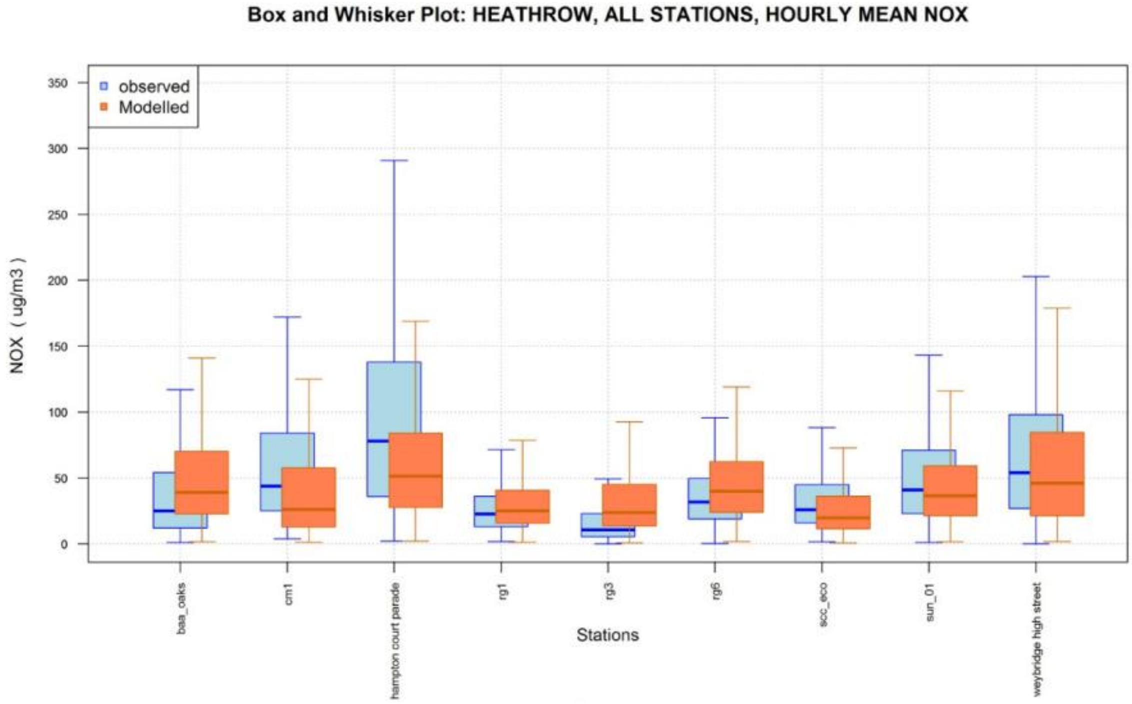


*Figure 7.4: Box plots of measured and modelled hourly mean $NO_x$ concentrations at continuous monitoring sites*

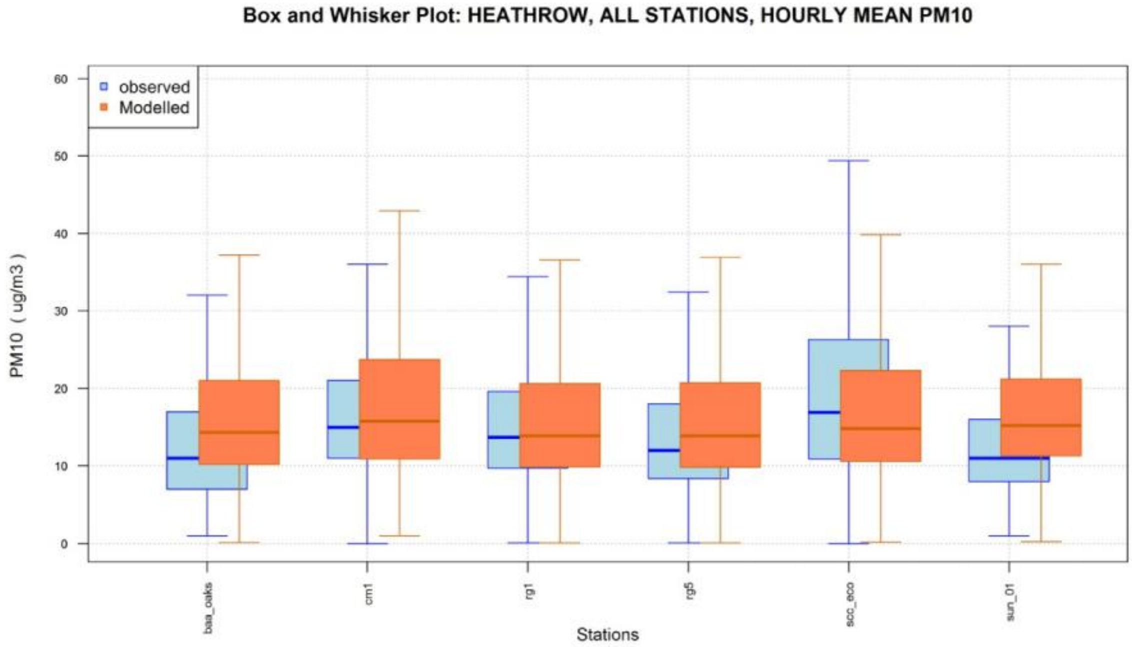


*Figure 7.5: Box plots of measured and modelled hourly mean $PM_{10}$ concentrations at continuous monitoring sites*

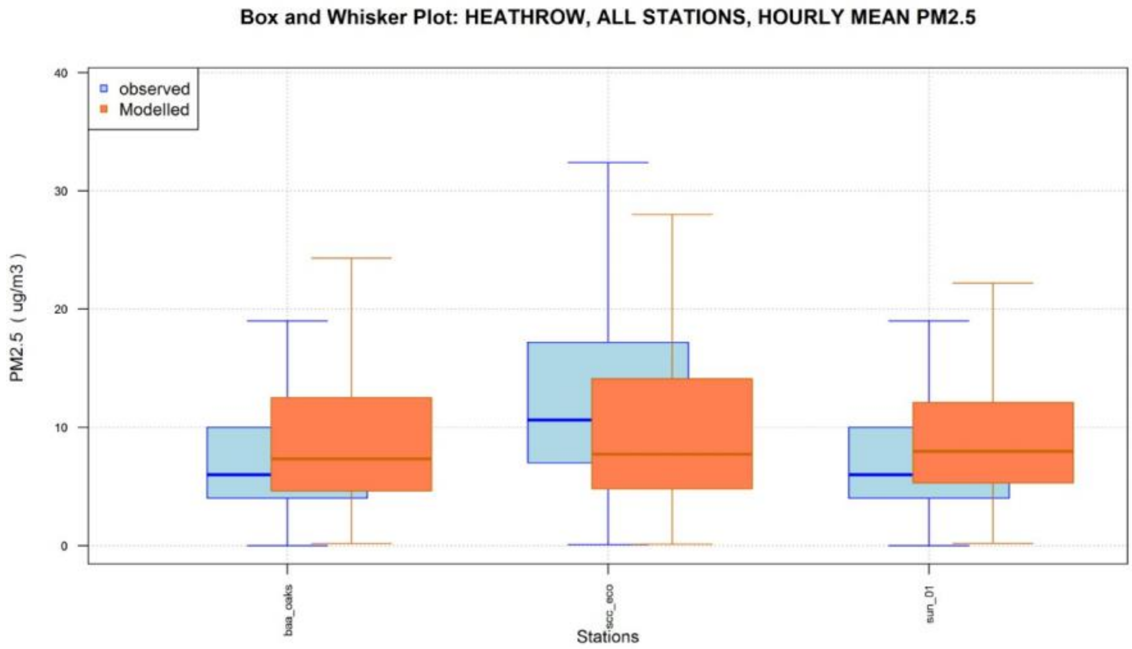


***Figure 7.6: Box plots of measured and modelled hourly mean $PM_{2.5}$ concentrations at continuous monitoring sites***

***Table 7-3: Measured and modelled annual average $NO_x$, $NO_2$, $PM_{10}$ and $PM_{2.5}$ concentrations at continuous monitoring sites***

| Site ID | Monitored concentration, µg/m³ | | | | Modelled concentration, µg/m³ | | | | Modelled / Monitored (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| BAA_OAKS | 47.1 | 25.8 | 14.1 | 9.2 | 62.0 | 30.6 | 17.8 | 11.0 | 132 | 119 | 126 | 119 |
| CM1 | 65.8 | 35.6 | 17.0 | - | 46.7 | 27.0 | 19.6 | - | 71 | 76 | 115 | - |
| Hampton Court Parade | 108.4 | 40.6 | - | - | 69.9 | 33.7 | - | - | 65 | 83 | - | - |
| RG1 | 34.1 | 20.4 | 16.2 | - | 38.5 | 24.7 | 17.5 | - | 113 | 121 | 108 | - |
| RG3 | 19.3 | 13.9 | - | - | 43.0 | 25.2 | - | - | 222 | 182 | - | - |
| RG5 | - | - | 15.2 | - | - | - | 17.5 | - | - | - | 115 | |
| RG6 | 46.1 | 26.7 | - | - | 55.2 | 30.9 | - | - | 120 | 116 | - | - |
| SCC_ECO | 44.2 | 24.1 | 20.7 | 14.5 | 35.3 | 22.8 | 18.6 | 12.1 | 80 | 95 | 90 | 83 |
| SUN_01 | 58.6 | 32.5 | 13.1 | 8.0 | 48.4 | 29.4 | 17.8 | 10.2 | 83 | 90 | 135 | 127 |
| Weybridge High Street | 77.5 | 33.5 | - | - | 66.8 | 34.5 | - | - | 86 | 103 | - | - |

# 8 Air quality maps

This section comprises county-wide air quality maps, for comparison against air quality objectives for $NO_2$, $PM_{10}$ and $PM_{2.5}$, outlined in Section 3. Annual mean $NO_2$, $PM_{10}$ and $PM_{2.5}$ maps for individual boroughs are presented in separate reports.

Contour plots of pollutant concentrations were generated using a model output on a 100 m regular grid across the region, along with additional output points along modelled roads to capture the steep concentration gradients at roadside. These model-calculated concentrations are used to generate 10 m resolution air quality maps in GIS software, using the Natural Neighbour interpolation method.

In the air quality maps, exceedences of the air quality objective are shown in orange and red, and pollutant concentrations below objectives are shown in blue, green and yellow.

Figure 8.1 presents a contour plot of the modelled annual mean $NO_2$ concentrations across Surrey for 2017. Modelled concentrations show exceedences of the 40 µg/m³ annual mean $NO_2$ objective along motorways and other busy roads.

Figure 8.2 presents a contour plot of the modelled 99.79$^{th}$ percentile of hourly mean $NO_2$ concentrations across Surrey for 2017. Modelled concentrations show exceedences of the 200 µg/m³ objective concentration are along the motorways, as well as stretches of other busy roads.

Figure 8.3 presents a contour plot of the modelled annual mean $PM_{10}$ concentrations across Surrey for 2017. There are no exceedences of the 40 µg/m³ annual mean $PM_{10}$ objective outside the footprint of modelled roads.

Figure 8.4 presents a contour plot of the modelled 90.41$^{st}$ 24-hourly mean $PM_{10}$ concentrations across Surrey for 2017. Modelled concentrations show exceedences of the 50 µg/m³ objective along motorways and busy A roads.

Figure 8.5 presents a contour plot of the modelled annual mean $PM_{2.5}$ concentrations across Surrey for 2017. Modelled concentrations show no exceedences of the 25 µg/m³ objective.

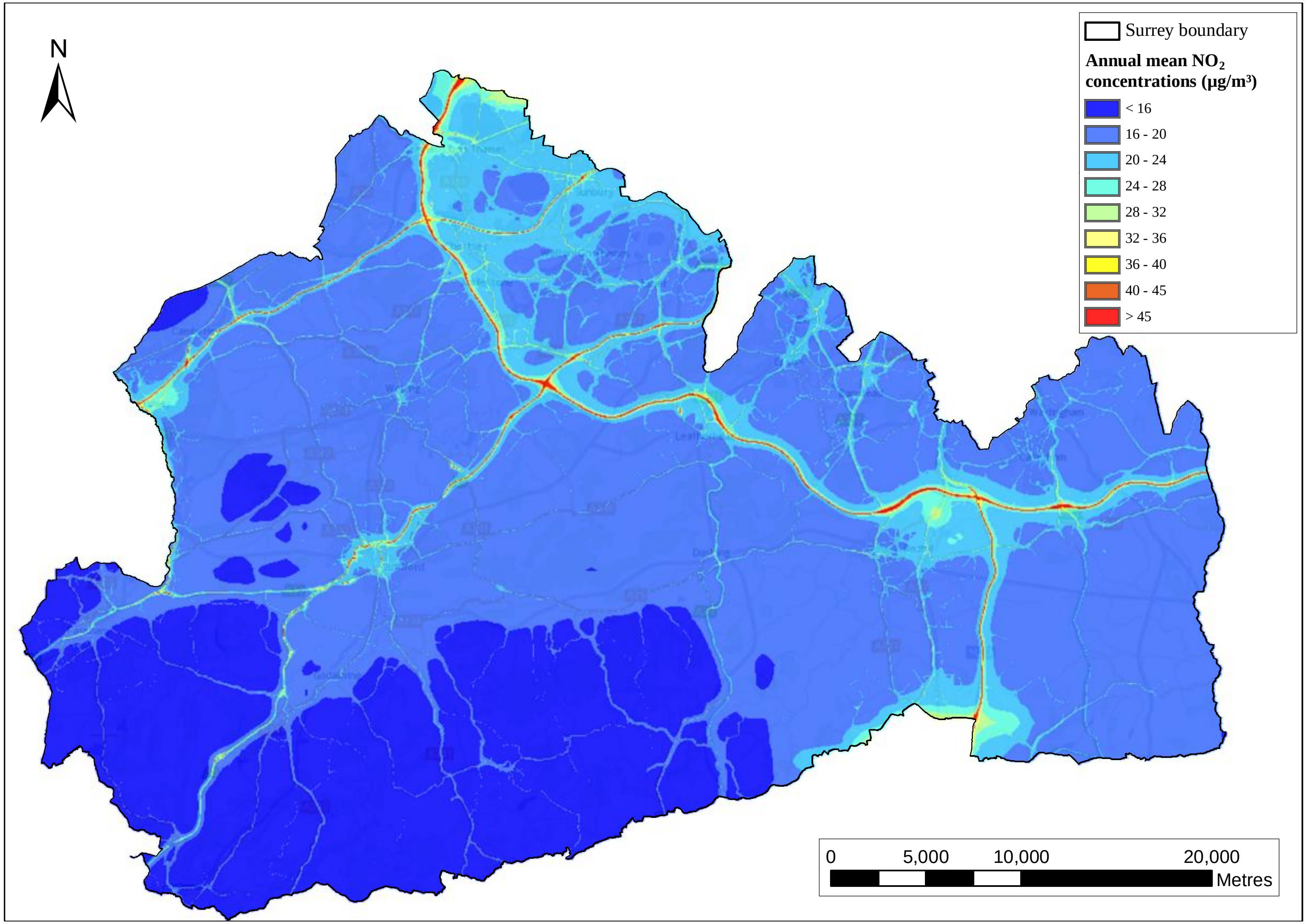


***Figure 8.1: Annual mean $NO_2$ concentrations, 2017 (µg/m³)***

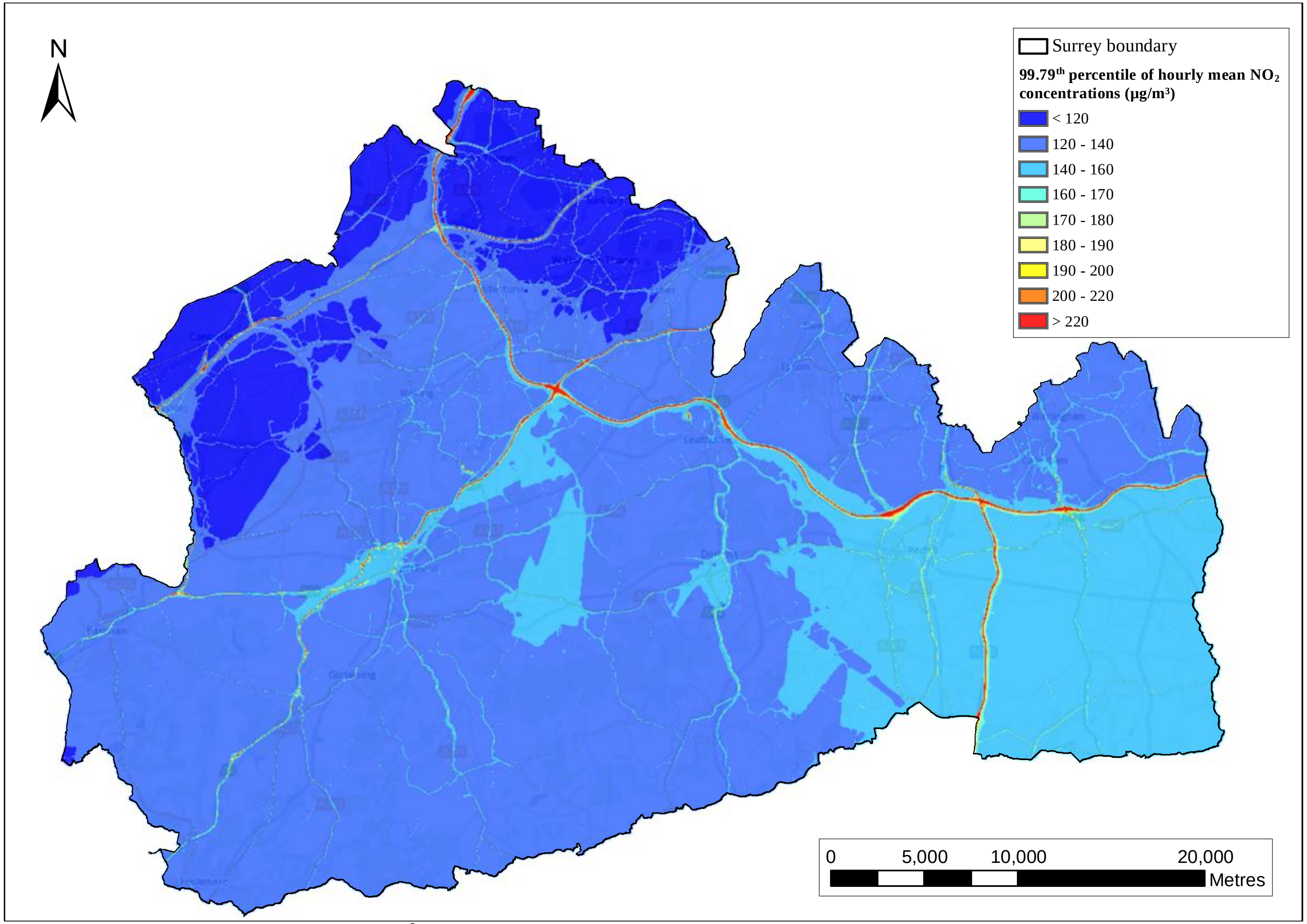


***Figure 8.2: 99.79th percentile of hourly mean $NO_2$ concentrations, 2017 (µg/m³)***

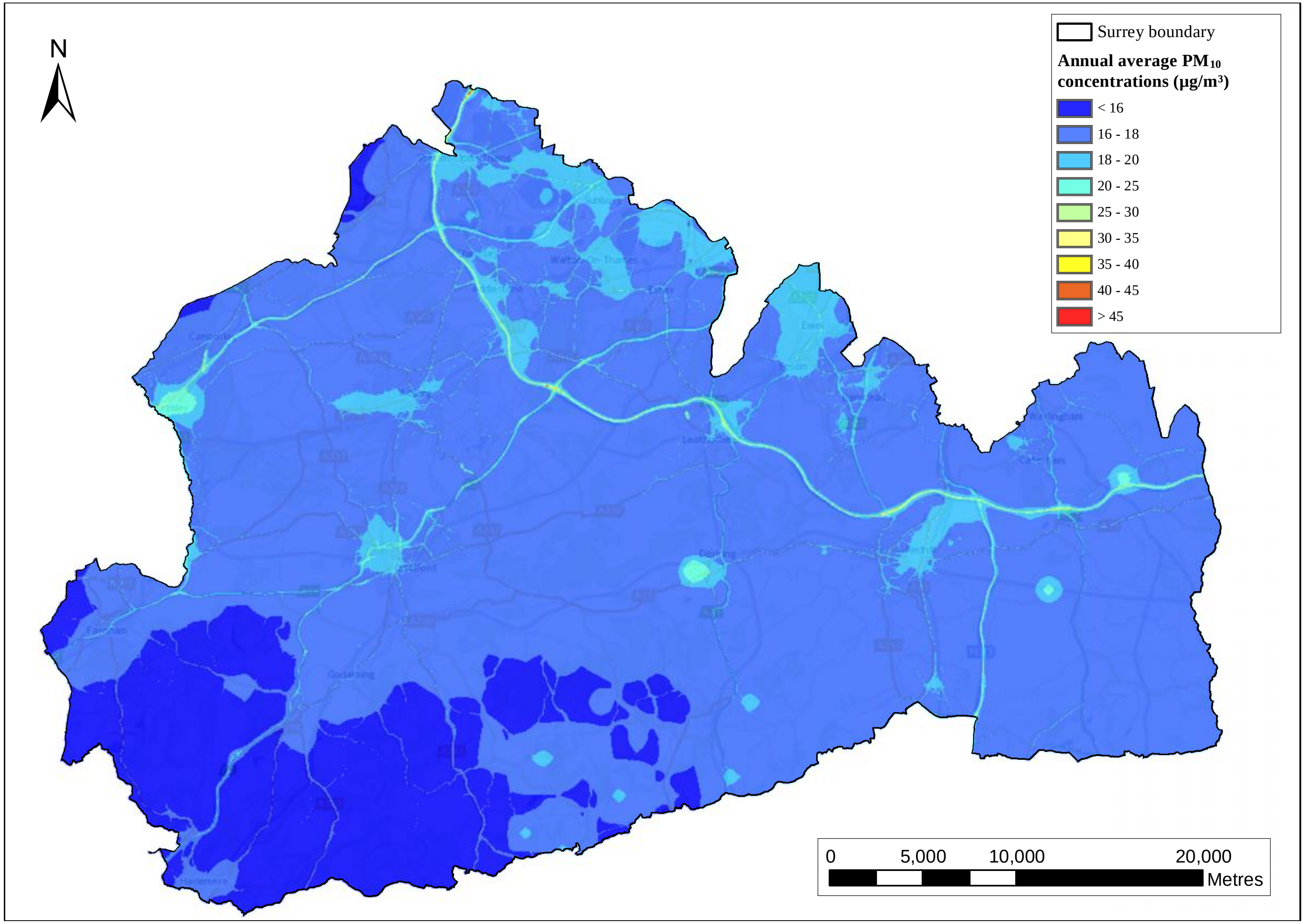


***Figure 8.3: Annual mean $PM_{10}$ concentrations, 2017 (µg/m³)***

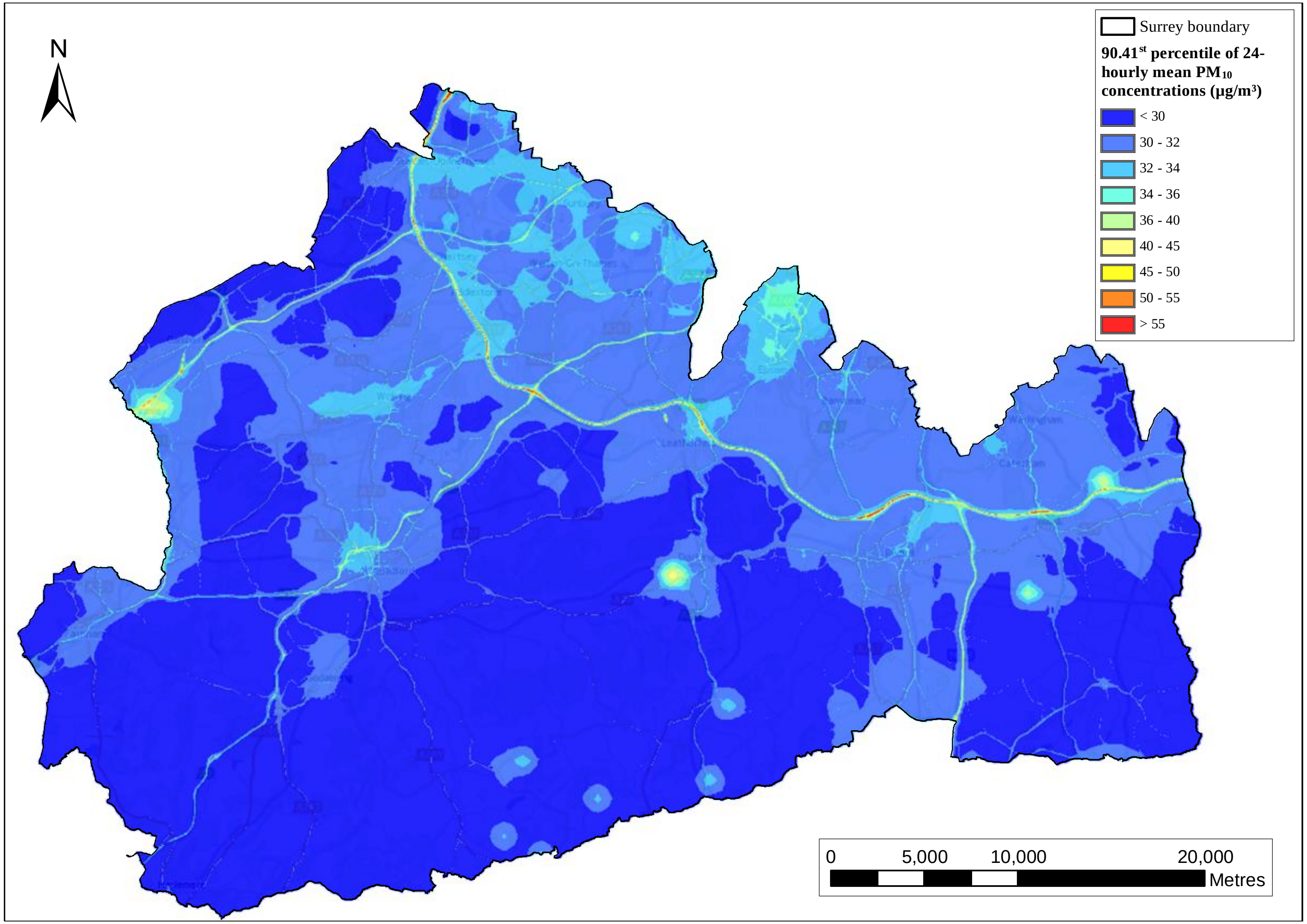


***Figure 8.4: 90.41st percentile of 24-hourly mean $PM_{10}$ concentrations, 2017 (µg/m³)***

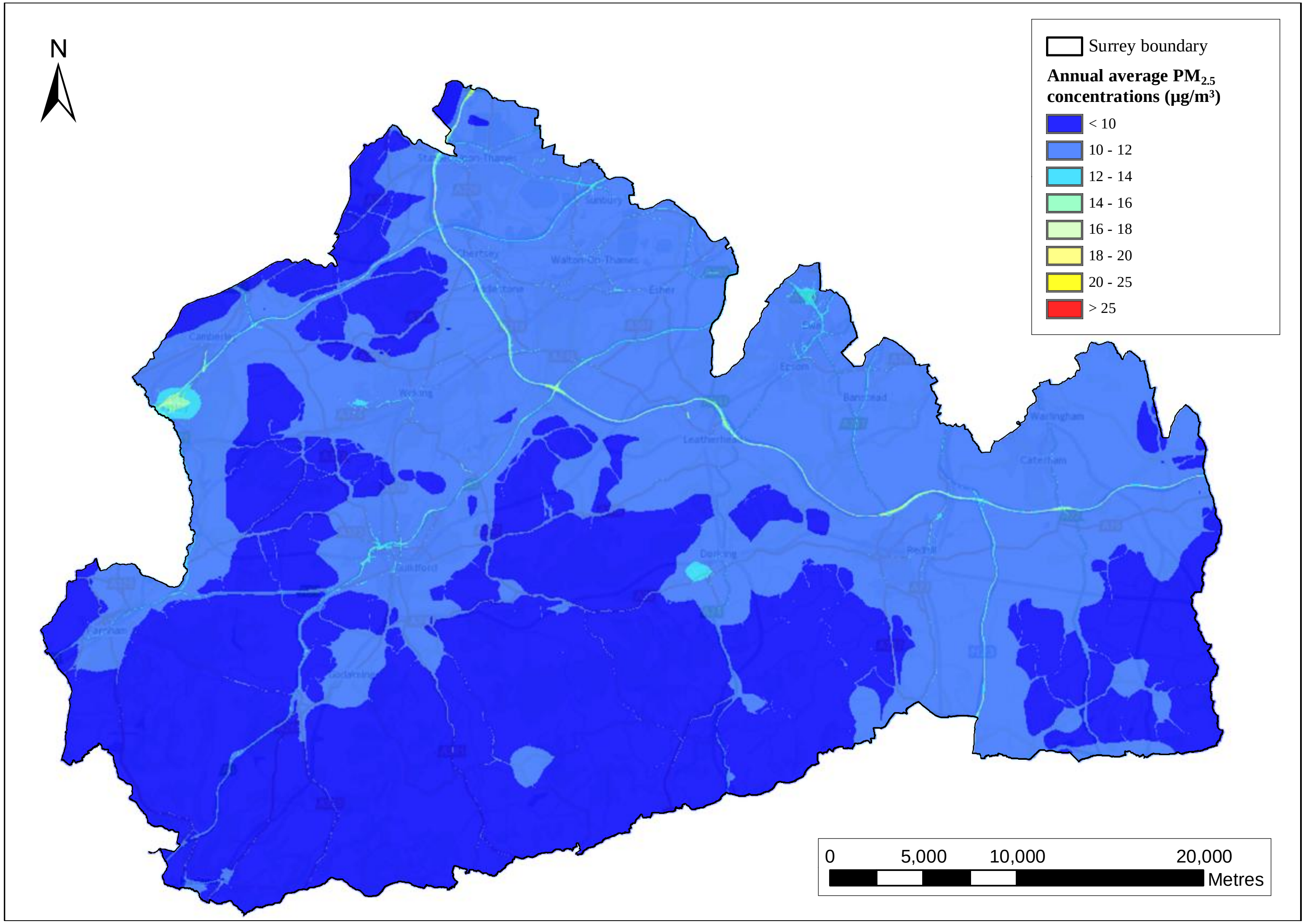


***Figure 8.5: Annual mean $PM_{2.5}$ concentrations, 2017 (µg/m³)***

# 9 Mortality burden calculations

This section summarises local mortality burden of air pollution calculations. It includes the calculation of the number of deaths attributable to air pollution, the associated life-years lost and economic cost.

The mortality burden is assessed using the approach set out in Appendix A of the Public Health England guidance *Estimating local mortality burdens associated with particulate air pollution (April 2014)*[14]. This guidance uses concentration response functions (CRFs) which relate the increased risk of mortality to a given change in pollutant concentrations; specifically, it assumes that an increment of 10 µg/m³ in the annual concentration of $PM_{2.5}$ will increase the mortality risk by 6%.

The mortality burden of air quality will actually be a consequence of exposure to both $NO_2$ and $PM_{2.5}$. The 2018 COMEAP report *Associations of long-term average concentrations of nitrogen dioxide with mortality*[15] recommends revised CRFs for anthropogenic $PM_{2.5}$ and $NO_2$ which are adjusted from the single-pollutant CRFs to avoid double counting air quality effects from different pollutants. The report recommends using pairs of CRFs for $PM_{2.5}$ and $NO_2$ taken from four studies, as shown in Table 9-1, with the results from the two pollutants added for each study.

***Table 9-1: Coefficients for use in burden calculations***

| Pollutant | Unadjusted coefficient | Jerrett et al (2013) | Fischer et al (2015) | Beelen et al (2014) | Crouse et al (2015) |
|---|---|---|---|---|---|
| $NO_2$ | 1.023 | 1.019 | 1.016 | 1.011 | 1.020 |
| $PM_{2.5}$ | 1.060 | 1.029 | 1.033 | 1.053 | 1.019 |

Mortality burdens calculations were carried out for Lower Layer Super Output Areas (LSOAs), each representing an area with a population of approximately 1,500. The Office for National Statistics (ONS) publishes population[16] and death[17] data split by age for each LSOA.

For each LSOA, the relative risk for each pollutant is calculated as

$$RR(c) = R^{c/10}$$

where *R* is the relative risk, as given in Table 9-1, and *c* is the average pollutant concentration for that LSOA calculated from the concentration contour maps, presented in Section 8.

[14] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PHE_CRCE_010.pdf
[15] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/734799/COMEAP_NO2_Report.pdf
[16] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/lowersuperoutputareamidyearpopulationestimates
[17] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/009235numberofdeathsregisteredineachlowersuperoutputareabysexandagedeathsregisteredin2017

The attributable fraction is then calculated as

$$AF = (RR-1)/RR$$

The number of attributable deaths in each LSOA was then calculated by multiplying the attributable fraction by the number of deaths over 30 years of age. The total number of attributable deaths for each local authority is the sum of the attributable deaths in each LSOA.

The total loss in life-years due to air pollution for each LSOA was calculated by multiplying the attributable deaths for each 5-year age band by the corresponding expected life expectancy for each age group. The life expectancy data are taken from the Public Health England Life Expectancy Calculator[18], which uses ONS population and deaths data as input.

The economic cost is calculated by multiplying the life-years lost by a value for a life year lost. The recommended value in the Defra guidance[19] of £42,780 at 2017 prices was used.

The mortality burdens by borough, provided in this report, were then calculated by aggregating the results for all LSOAs within each borough. All reported values are rounded to whole numbers. Ward level results are reported separately, for which the LSOAs results were aggregated by ward using ONS best fit lookup[20].

Table 9-2 summarises attributable deaths, life years lost and economic cost through $NO_2$ and $PM_{2.5}$ concentrations by borough, using unadjusted coefficients for each of the single pollutants. A further calculation relating to the economic cost of life years lost is also included for each of the separate pollutants.

Table 9-3 summarises attributable deaths, life years lost and economic cost through $NO_2$ and $PM_{2.5}$ concentrations by borough, using Fischer et al (2015) coefficients. A further calculation relating to the economic cost of life years lost is also included.

Table 9-4 summarises attributable deaths, life years lost and economic cost through $NO_2$ and $PM_{2.5}$ concentrations by borough, using Beelen et al (2014) coefficients. A further calculation relating to the economic cost of life years lost is also included.

Table 9-5 summarises attributable deaths, life years lost and economic cost through $NO_2$ and $PM_{2.5}$ concentrations by borough, using Crouse et al (2015) coefficients. A further calculation relating to the economic cost of life years lost is also included.

Table 9-6 summarises attributable deaths, life years lost and economic cost through $NO_2$ and $PM_{2.5}$ concentrations by borough, using Jerrett et al (2013) coefficients. A further calculation relating to the economic cost of life years lost is also included.

[18] https://fingertips.phe.org.uk/.../PHE%20Life%20Expectancy%20Calculator.xlsm
[19] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770649/impact-pathway-approach-guidance.pdf
[20] http://geoportal.statistics.gov.uk/datasets/lower-layer-super-output-area-2011-to-ward-2018-lookup-in-england-and-wales-v3

The calculated total life years lost in Surrey due to $NO_2$ and $PM_{2.5}$ concentrations range from 6,610 years to 8,059 years. The calculated total economic cost ranges from £283 million to £345 million.

Using the unadjusted coefficients for the separate pollutants, the life years lost resulting from $NO_2$ and $PM_{2.5}$ concentrations across Surrey are 5233 and 6200, respectively. The equivalent economic costs for $NO_2$ and $PM_{2.5}$ are £224 million and £265 million, respectively.

*Table 9-2: Summary of attributable deaths, life years lost and economic cost for $NO_2$ and $PM_{2.5}$ concentrations by borough using unadjusted coefficients*

| Borough | $NO_2$ | | | | | $PM_{2.5}$ | | | | | Total life years lost | Total economic cost (£) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | | |
| Elmbridge | 20.5 | 0.045 | 49 | 593 | 25,357,526 | 11.1 | 0.053 | 58 | 698 | 29,869,955 | 1,291 | 55,227,481 |
| Epsom and Ewell | 20.1 | 0.045 | 27 | 320 | 13,700,751 | 11.5 | 0.056 | 33 | 398 | 17,034,551 | 718 | 30,735,302 |
| Guildford | 19.0 | 0.042 | 45 | 558 | 23,858,735 | 10.7 | 0.051 | 55 | 678 | 28,998,352 | 1,236 | 52,857,086 |
| Mole Valley | 19.0 | 0.042 | 36 | 435 | 18,591,686 | 10.7 | 0.051 | 44 | 524 | 22,396,999 | 958 | 40,988,686 |
| Reigate and Banstead | 20.6 | 0.046 | 64 | 711 | 30,421,065 | 10.9 | 0.052 | 72 | 805 | 34,454,788 | 1,516 | 64,875,853 |
| Runnymede | 21.5 | 0.048 | 36 | 394 | 16,865,480 | 10.9 | 0.052 | 39 | 426 | 18,244,557 | 821 | 35,110,037 |
| Spelthorne | 22.4 | 0.050 | 44 | 525 | 22,469,203 | 11.2 | 0.054 | 48 | 570 | 24,389,831 | 1,095 | 46,859,034 |
| Surrey Heath | 20.1 | 0.045 | 34 | 394 | 16,858,630 | 11.0 | 0.053 | 40 | 469 | 20,056,469 | 863 | 36,915,098 |
| Tandridge | 19.5 | 0.043 | 35 | 418 | 17,882,645 | 10.5 | 0.050 | 41 | 482 | 20,602,534 | 900 | 38,485,179 |
| Waverley | 16.0 | 0.036 | 43 | 495 | 21,175,301 | 10.0 | 0.047 | 56 | 655 | 28,040,798 | 1,150 | 49,216,099 |
| Woking | 18.8 | 0.042 | 33 | 390 | 16,680,170 | 11.1 | 0.053 | 41 | 494 | 21,149,863 | 884 | 37,830,033 |
| Total | - | - | 445 | 5233 | 223,861,191 | - | - | 527 | 6200 | 265,238,697 | 11,433 | 489,099,888 |

*The pollutant concentrations presented are based on LSOA averaged concentrations and the attributable fractions and life years lost are calculated accordingly

*Table 9-3: Summary of attributable deaths, life years lost and economic cost for $NO_2$ and $PM_{2.5}$ concentrations by borough using Fischer et al (2015) coefficients*

| Borough | $NO_2$ | | | | | $PM_{2.5}$ | | | | | Total life years lost | Total economic cost (£) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | | |
| Elmbridge | 20.5 | 0.032 | 35 | 417 | 17,824,921 | 11.1 | 0.030 | 33 | 394 | 16,846,034 | 810 | 34,670,955 |
| Epsom & Ewell | 20.1 | 0.031 | 19 | 225 | 9,630,009 | 11.5 | 0.031 | 19 | 225 | 9,612,179 | 450 | 19,242,188 |
| Guildford | 19.0 | 0.030 | 32 | 392 | 16,763,900 | 10.7 | 0.029 | 31 | 382 | 16,345,903 | 774 | 33,109,804 |
| Mole Valley | 19.0 | 0.030 | 26 | 305 | 13,064,606 | 10.7 | 0.029 | 25 | 295 | 12,624,867 | 601 | 25,689,473 |
| Reigate and Banstead | 20.6 | 0.032 | 45 | 500 | 21,389,258 | 10.9 | 0.030 | 41 | 454 | 19,427,194 | 954 | 40,816,452 |
| Runnymede | 21.5 | 0.034 | 25 | 277 | 11,862,444 | 10.9 | 0.029 | 22 | 240 | 10,287,053 | 518 | 22,149,497 |
| Spelthorne | 22.4 | 0.035 | 31 | 369 | 15,806,811 | 11.2 | 0.031 | 27 | 322 | 13,757,475 | 691 | 29,564,286 |
| Surrey Heath | 20.1 | 0.031 | 24 | 277 | 11,850,254 | 11.0 | 0.030 | 23 | 264 | 11,310,743 | 541 | 23,160,997 |
| Tandridge | 19.5 | 0.031 | 25 | 294 | 12,567,679 | 10.5 | 0.028 | 23 | 271 | 11,610,548 | 565 | 24,178,227 |
| Waverley | 16.0 | 0.025 | 30 | 347 | 14,862,852 | 10.0 | 0.027 | 32 | 369 | 15,792,233 | 717 | 30,655,084 |
| Woking | 18.8 | 0.029 | 23 | 274 | 11,720,132 | 11.1 | 0.030 | 23 | 279 | 11,927,804 | 553 | 23,647,936 |
| Total | - | - | 313 | 3,678 | 157,342,867 | - | - | 297 | 3,496 | 149,542,033 | 7,174 | 306,884,900 |

*The pollutant concentrations presented are based on LSOA averaged concentrations and the attributable fractions and life years lost are calculated accordingly

*Table 9-4: Summary of attributable deaths, life years lost and economic cost for $NO_2$ and $PM_{2.5}$ concentrations by borough using Beelen et al (2014) coefficients*

| Borough | $NO_2$ | | | | | $PM_{2.5}$ | | | | | Total life years lost | Total economic cost (£) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | Concentrations (µg/m³) | Attributable fraction | Attributable Deaths | Life years lost | Economic cost (£) | | |
| Elmbridge | 20.5 | 0.022 | 24 | 289 | 12,346,890 | 11.1 | 0.0475 | 51 | 621 | 26,555,749 | 909 | 38,902,639 |
| Epsom & Ewell | 20.1 | 0.022 | 13 | 156 | 6,670,048 | 11.5 | 0.0494 | 30 | 354 | 15,146,527 | 510 | 21,816,575 |
| Guildford | 19.0 | 0.021 | 22 | 271 | 11,608,229 | 10.7 | 0.0455 | 49 | 603 | 25,777,396 | 874 | 37,385,625 |
| Mole Valley | 19.0 | 0.021 | 18 | 211 | 9,047,391 | 10.7 | 0.0455 | 39 | 465 | 19,909,296 | 677 | 28,956,687 |
| Reigate and Banstead | 20.6 | 0.022 | 31 | 346 | 14,818,304 | 10.9 | 0.0466 | 64 | 716 | 30,630,022 | 1,062 | 45,448,326 |
| Runnymede | 21.5 | 0.023 | 17 | 192 | 8,220,312 | 10.9 | 0.0463 | 34 | 379 | 16,219,233 | 571 | 24,439,545 |
| Spelthorne | 22.4 | 0.024 | 21 | 256 | 10,955,112 | 11.2 | 0.0481 | 42 | 507 | 21,684,524 | 763 | 32,639,636 |
| Surrey Heath | 20.1 | 0.022 | 16 | 192 | 8,208,181 | 11.0 | 0.0470 | 36 | 417 | 17,830,832 | 609 | 26,039,013 |
| Tandridge | 19.5 | 0.021 | 17 | 203 | 8,703,922 | 10.5 | 0.0446 | 36 | 428 | 18,313,016 | 632 | 27,016,937 |
| Waverley | 16.0 | 0.017 | 21 | 240 | 10,284,062 | 10.0 | 0.0422 | 50 | 583 | 24,920,582 | 823 | 35,204,644 |
| Woking | 18.8 | 0.020 | 16 | 190 | 8,115,712 | 11.1 | 0.0473 | 37 | 440 | 18,803,078 | 629 | 26,918,790 |
| Total | - | - | 217 | 2547 | 108,978,162 | - | - | 468 | 5512 | 235,790,256 | 8,059 | 344,768,418 |

*The pollutant concentrations presented are based on LSOA averaged concentrations and the attributable fractions and life years lost are calculated accordingly

*Table 9-5: Summary of attributable deaths, life years lost and economic cost for $NO_2$ and $PM_{2.5}$ concentrations by borough using Crouse et al (2015) coefficients*

| Borough | $NO_2$ | | | | | $PM_{2.5}$ | | | | | Total life years lost | Total economic cost (£) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrations (µg/m³) | Attributable fraction | Attributable deaths | Life years lost | Economic cost (£) | Concentrations (µg/m³) | Attributable fraction | Attributable Deaths | Life years lost | Economic cost (£) | | |
| Elmbridge | 20.5 | 0.040 | 43 | 518 | 22,148,554 | 11.1 | 0.018 | 19 | 230 | 9,828,813 | 747 | 31,977,368 |
| Epsom & Ewell | 20.1 | 0.039 | 23 | 280 | 11,966,481 | 11.5 | 0.018 | 11 | 131 | 5,609,791 | 411 | 17,576,272 |
| Guildford | 19.0 | 0.037 | 39 | 487 | 20,835,475 | 10.7 | 0.017 | 18 | 223 | 9,534,357 | 710 | 30,369,831 |
| Mole Valley | 19.0 | 0.037 | 32 | 380 | 16,236,635 | 10.7 | 0.017 | 14 | 172 | 7,363,936 | 552 | 23,600,571 |
| Reigate and Banstead | 20.6 | 0.040 | 56 | 621 | 26,573,932 | 10.9 | 0.017 | 24 | 265 | 11,333,366 | 886 | 37,907,298 |
| Runnymede | 21.5 | 0.042 | 31 | 344 | 14,734,858 | 10.9 | 0.017 | 13 | 140 | 6,001,204 | 485 | 20,736,061 |
| Spelthorne | 22.4 | 0.043 | 38 | 459 | 19,632,227 | 11.2 | 0.018 | 16 | 188 | 8,027,452 | 647 | 27,659,680 |
| Surrey Heath | 20.1 | 0.039 | 30 | 344 | 14,724,961 | 11.0 | 0.017 | 13 | 154 | 6,599,042 | 498 | 21,324,003 |
| Tandridge | 19.5 | 0.038 | 31 | 365 | 15,618,115 | 10.5 | 0.016 | 13 | 158 | 6,771,424 | 523 | 22,389,539 |
| Waverley | 16.0 | 0.031 | 37 | 432 | 18,483,797 | 10.0 | 0.016 | 19 | 215 | 9,207,092 | 647 | 27,690,889 |
| Woking | 18.8 | 0.037 | 29 | 341 | 14,566,604 | 11.1 | 0.018 | 14 | 163 | 6,959,188 | 503 | 21,525,792 |
| Total | - | - | 389 | 4570 | 195,521,638 | - | - | 173 | 2039 | 87,235,665 | 6,610 | 282,757,304 |

*The pollutant concentrations presented are based on LSOA averaged concentrations and the attributable fractions and life years lost are calculated accordingly

*Table 9-6: Summary of attributable deaths, life years lost and economic cost for $NO_2$ and $PM_{2.5}$ concentrations by borough using Jerrett et al (2013) coefficients*

| Borough | $NO_2$ | | | | | $PM_{2.5}$ | | | | | Total life years lost | Total economic cost (£) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Concentrations (µg/m³) | Attributable fraction | Attributable Deaths | Life years lost | Economic cost (£) | Concentrations (µg/m³) | Attributable fraction | Attributable Deaths | Life years lost | Economic cost (£) | | |
| Elmbridge | 20.5 | 0.038 | 41 | 493 | 21,072,493 | 11.1 | 0.027 | 29 | 347 | 14,860,060 | 840 | 35,932,554 |
| Epsom & Ewell | 20.1 | 0.037 | 22 | 266 | 11,384,960 | 11.5 | 0.028 | 17 | 198 | 8,479,675 | 464 | 19,864,636 |
| Guildford | 19.0 | 0.035 | 37 | 463 | 19,821,949 | 10.7 | 0.025 | 27 | 337 | 14,417,750 | 800 | 34,239,699 |
| Mole Valley | 19.0 | 0.035 | 30 | 361 | 15,447,070 | 10.7 | 0.025 | 22 | 260 | 11,135,650 | 621 | 26,582,720 |
| Reigate and Banstead | 20.6 | 0.038 | 53 | 591 | 25,283,706 | 10.9 | 0.026 | 36 | 401 | 17,136,317 | 992 | 42,420,023 |
| Runnymede | 21.5 | 0.040 | 30 | 328 | 14,020,157 | 10.9 | 0.026 | 19 | 212 | 9,073,983 | 540 | 23,094,140 |
| Spelthorne | 22.4 | 0.041 | 36 | 437 | 18,680,483 | 11.2 | 0.027 | 24 | 284 | 12,135,893 | 720 | 30,816,376 |
| Surrey Heath | 20.1 | 0.037 | 28 | 327 | 14,009,495 | 11.0 | 0.026 | 20 | 233 | 9,977,234 | 561 | 23,986,729 |
| Tandridge | 19.5 | 0.036 | 29 | 347 | 14,858,852 | 10.5 | 0.025 | 20 | 239 | 10,240,605 | 587 | 25,099,457 |
| Waverley | 16.0 | 0.030 | 35 | 411 | 17,582,034 | 10.0 | 0.024 | 28 | 326 | 13,927,537 | 737 | 31,509,571 |
| Woking | 18.8 | 0.035 | 27 | 324 | 13,858,042 | 11.1 | 0.026 | 21 | 246 | 10,521,603 | 570 | 24,379,645 |
| Total | - | - | 370 | 4348 | 186,019,243 | - | - | 262 | 3083 | 131,906,307 | 7,432 | 317,925,550 |

*The pollutant concentrations presented are based on LSOA averaged concentrations and the attributable fractions and life years lost are calculated accordingly

# 10 Source apportionment

Apportionment of emissions and concentrations by source group is presented in this section. The first section presents apportionment of emissions from sources within the Surrey modelled area and the second section presents source apportionment of concentrations summarised by borough.

More detailed source apportionment of concentrations is reported separately, to show the concentration breakdown at each of the 222 receptor locations provided by the borough councils.

## 10.1 Emissions

Figure 10.1 shows the breakdown of Surrey $NO_x$ emissions by each major source group. The majority of $NO_x$ emissions (53%) are from road sources. Other sources, from NAEI data, represent 44% of $NO_x$ emissions in Surrey; this group includes the emissions from sources such as other transport and machinery (65%), combustion in commercial, residential and agricultural sectors (27%) and combustion in industry (7%).

Road transport $NO_x$ emissions by vehicle type is shown in Figure 10.2. The largest contributions to road transport $NO_x$ emissions are from light diesel vehicles (73%), corresponding to the Diesel Cars (34%) and LGV (39%) source apportionment groups; note the LGV group contains both petrol and diesel light goods vehicles, of which 97% are assumed to be diesel in the EFT fleet projections used in the emission calculations.

The proportion $NO_x$ emitted as $NO_2$, known as primary $NO_2$, will vary by vehicle type. Primary $NO_2$ percentages by vehicle type for 2017 are shown in Table 10-1. Highest $NO_2$ percentages are for the $NO_x$ emissions from light diesel vehicles, which along with Figure 10.2; indicate that these vehicles will have the largest direct contribution to $NO_2$ concentrations.

***Table 10-1: Primary $NO_2$ percentage for Surrey road transport $NO_x$ emissions by vehicle type***

| Petrol Cars and Motorcycles | Diesel Cars | LGVs | Buses and Coaches | Rigid HGVs | Articulated HGVs | All vehicles |
|---|---|---|---|---|---|---|
| 5% | 35% | 34% | 10% | 10% | 9% | 27% |

Figure 10.3 shows the contribution to $PM_{10}$ emissions within Surrey by each major source group. Compared to the $NO_x$ emissions breakdown the proportion of $PM_{10}$ emissions attributed to road emissions is significantly smaller (24%). The largest emissions come from other sources (75%) such as commercial, residential and agricultural sectors (67%), production processes (12%) and other transport and machinery (6%).

A breakdown of road transport exhaust $PM_{10}$ emissions by vehicle type is shown in Figure 10.4; similar to the breakdown of $NO_x$ emissions by vehicle type, exhaust $PM_{10}$ emissions are dominated by light diesel vehicle emissions. However, as shown by Figure 10.5 road transport $PM_{10}$ emissions are dominated by non-exhaust emissions such as brake wear (32%) and tyre wear (23%); only 12% of road transport $PM_{10}$ emissions in Surrey are attributed to exhaust emissions.

The apportionment of $PM_{2.5}$ emissions are shown in Figure 10.6 to Figure 10.8. The breakdown of $PM_{2.5}$ is similar to the breakdown of $PM_{10}$ emissions: 82% of emissions stem from other sources such as commercial, residential and agricultural sectors (79%), other transport and machinery (7%) and other sources and sinks (4%). 17% of Surrey emissions are attributed to road transport, these road transport emissions are dominated by non-exhaust emissions (78%). Road transport exhaust emissions are dominated by light diesel vehicles (74%). Note that resuspension does not contribute to $PM_{2.5}$ emissions.

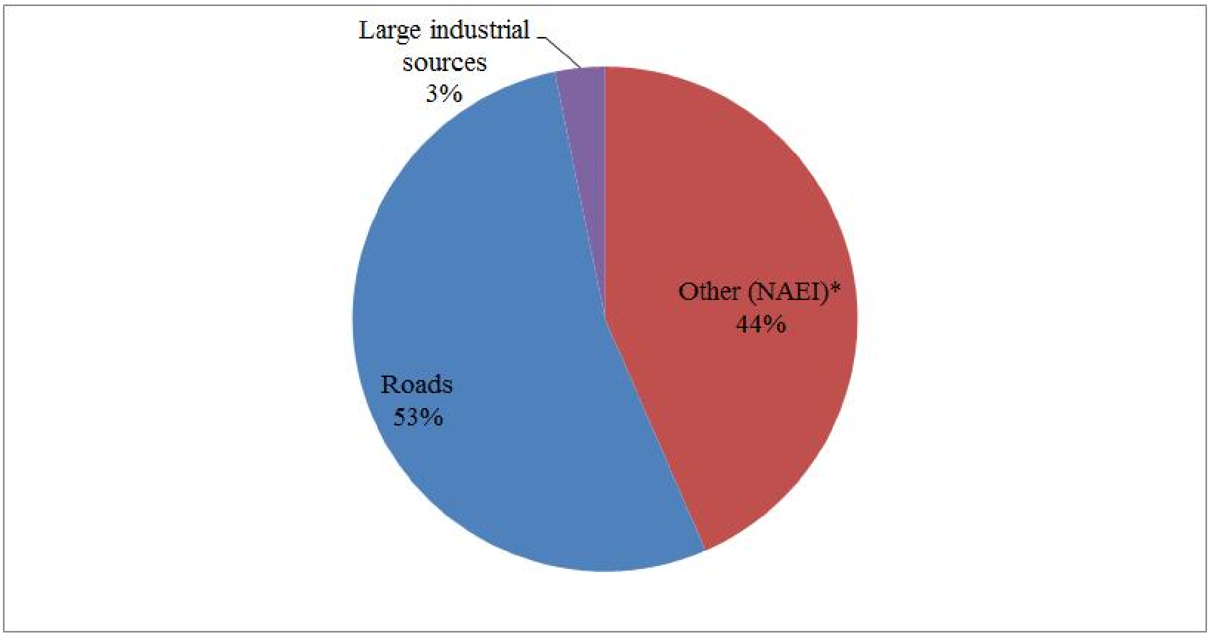


***Figure 10.1: Surrey $NO_x$ emissions by major source group. *See Section 10.1 for details of Other (NAEI) group***

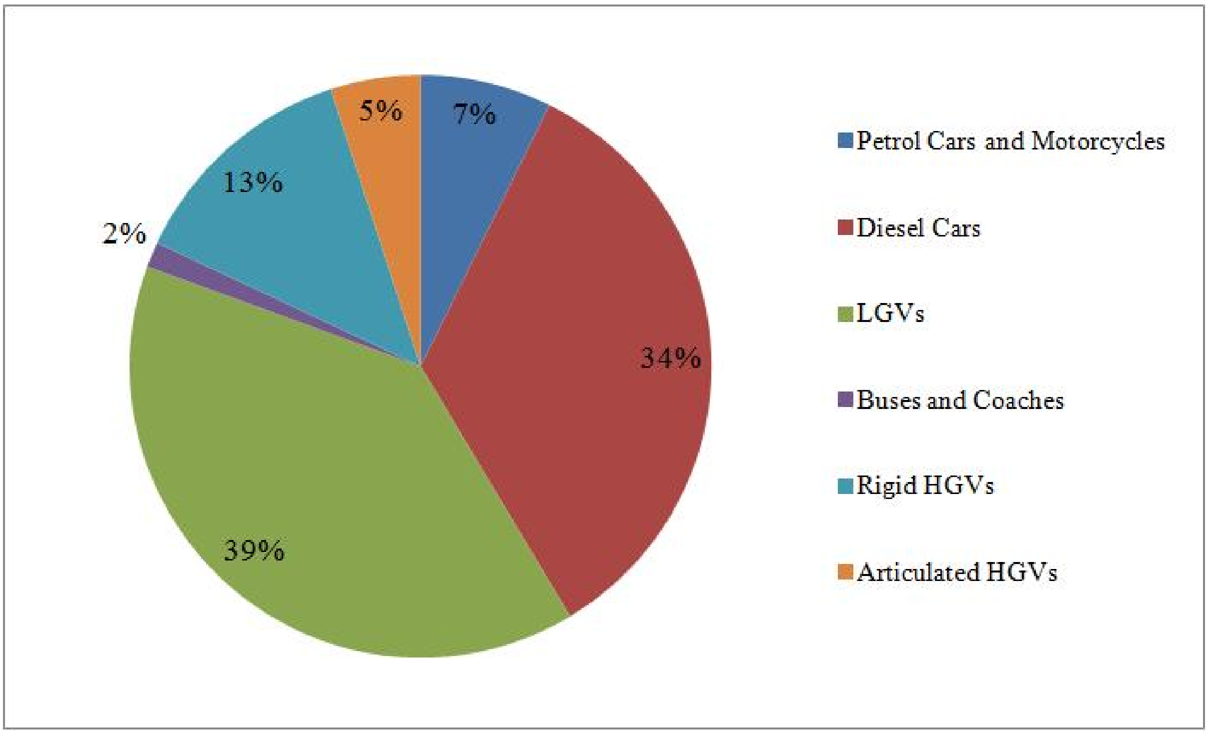


***Figure 10.2: Surrey road transport $NO_x$ emissions by vehicle category***

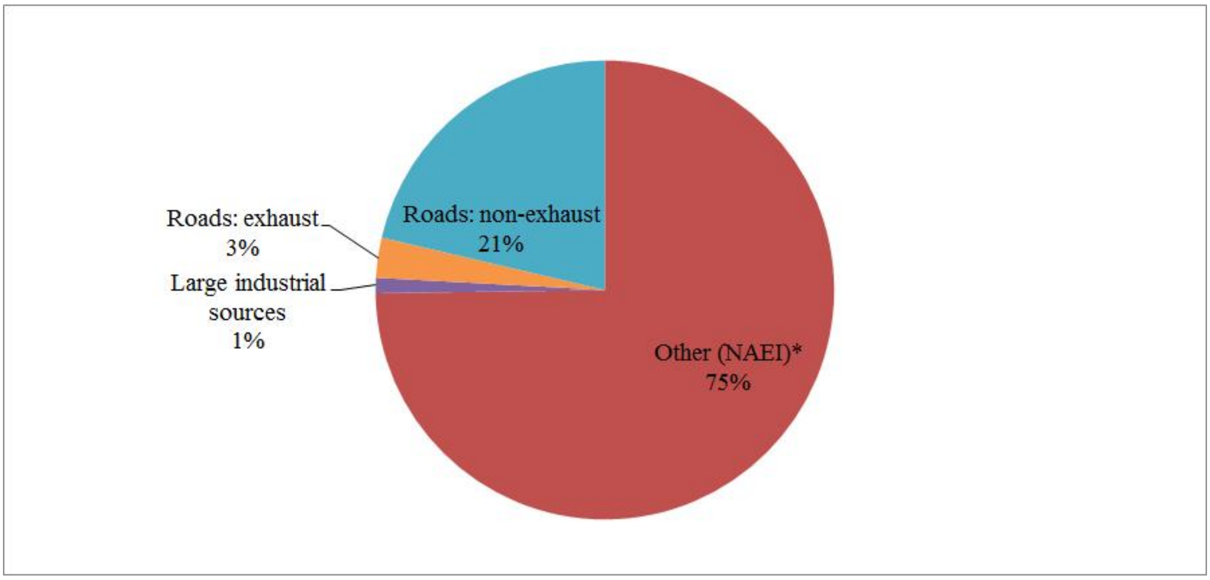


***Figure 10.3: Surrey $PM_{10}$ emissions by major source group. *See Section 10.1 for details of Other (NAEI) group***

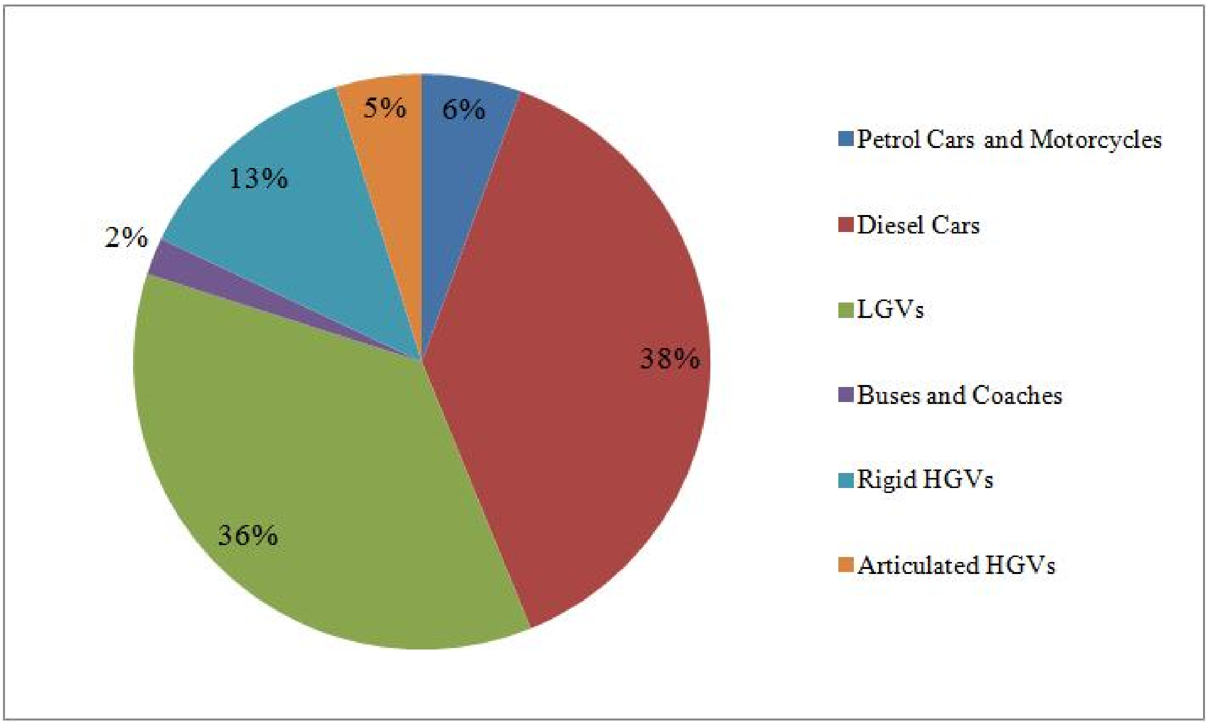


***Figure 10.4: Surrey road transport exhaust $PM_{10}$ emissions by vehicle category***

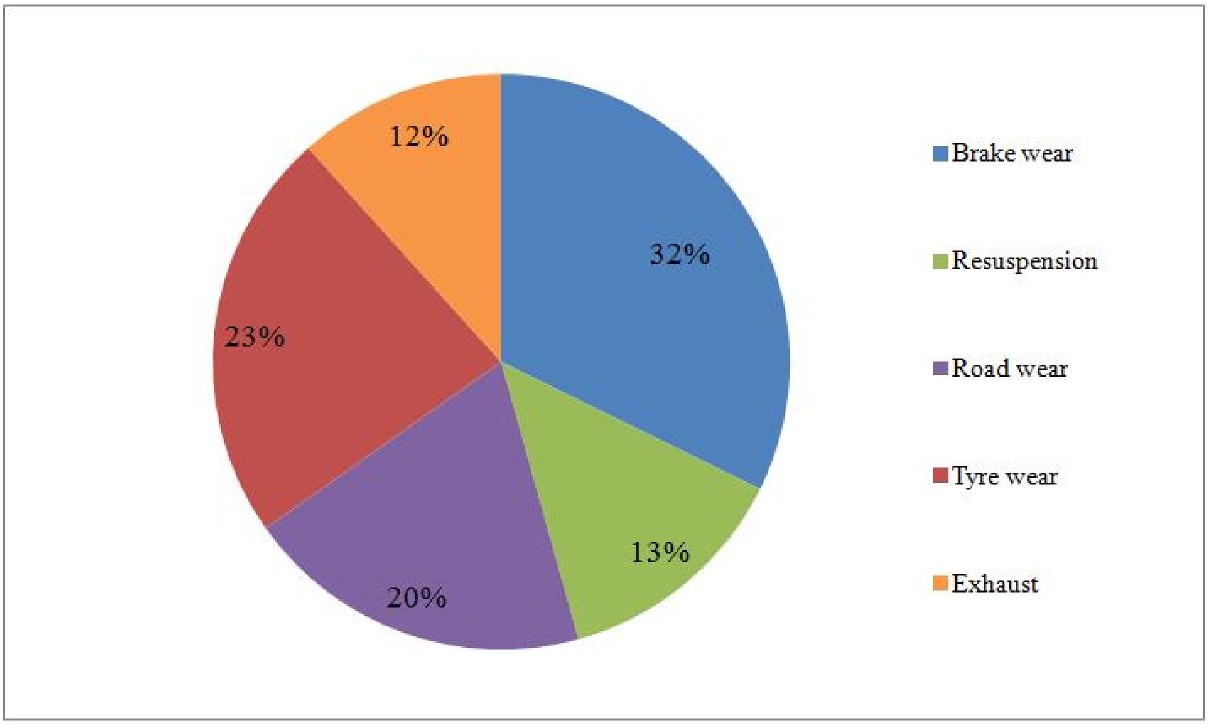


***Figure 10.5: Surrey Road transport $PM_{10}$ emissions by exhaust and non-exhaust components***

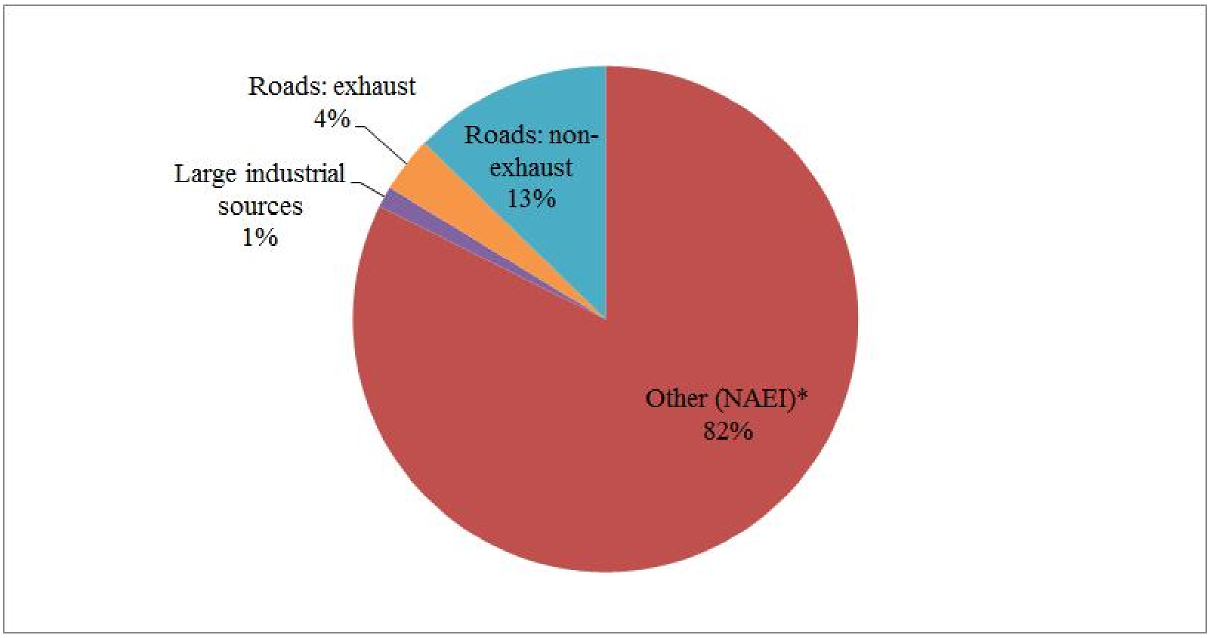


***Figure 10.6: Surrey $PM_{2.5}$ emissions by major source group. *See Section 10.1 for details of Other (NAEI) group***

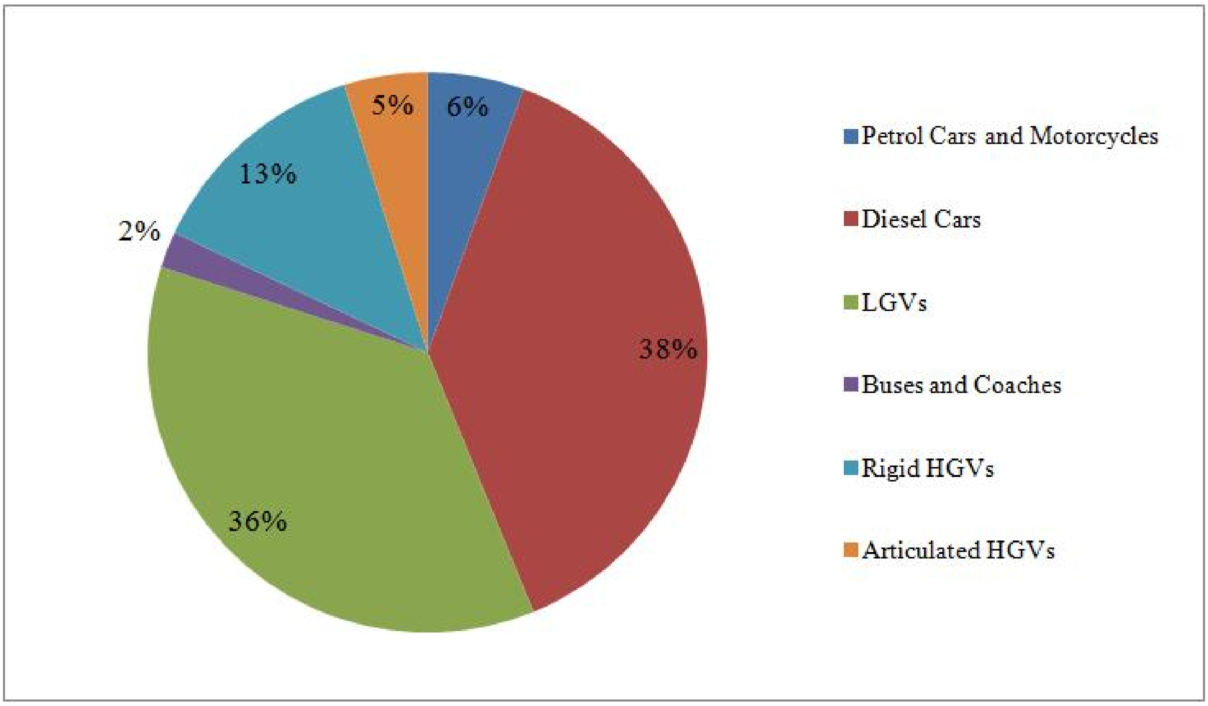


***Figure 10.7: Surrey road transport exhaust $PM_{2.5}$ emissions by vehicle category***

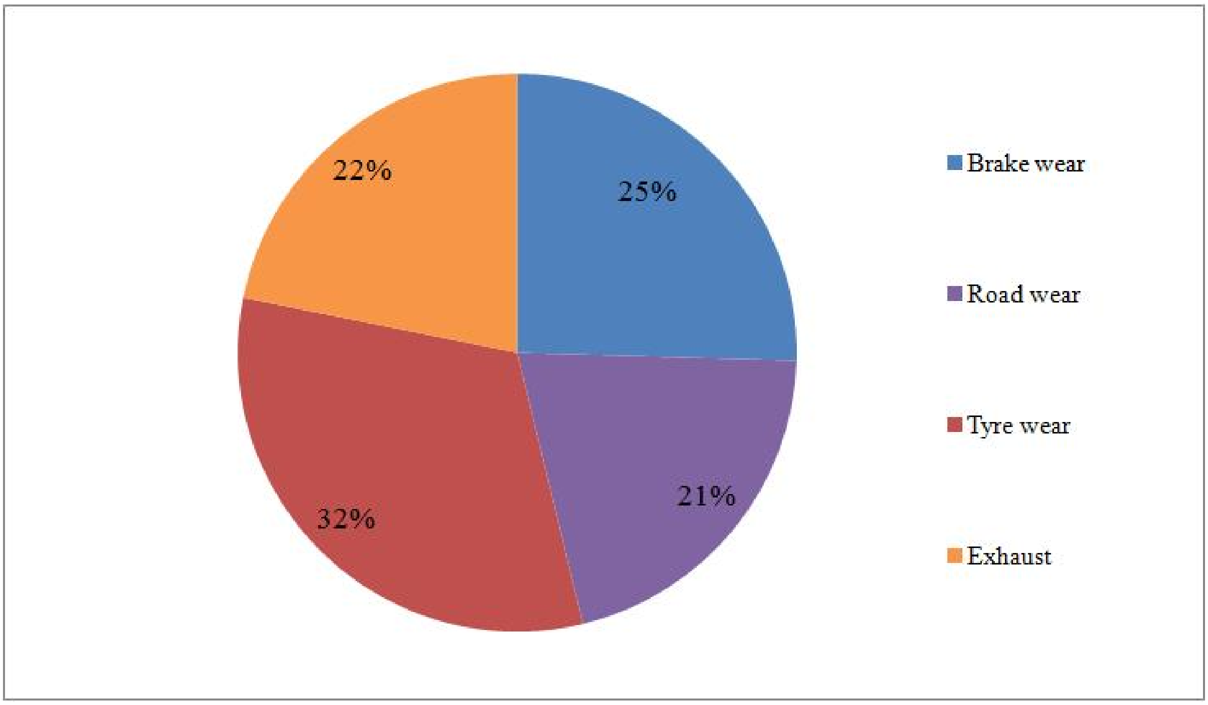


***Figure 10.8: Surrey road transport $PM_{2.5}$ emissions by exhaust and non-exhaust components***

## 10.2 Concentrations

The apportionment of modelled concentrations was carried out for 222 receptor locations provided by the borough councils, representing a mixture of roadside and urban background locations. Note that none of these receptor locations are located in Runnymede. It should be further noted that the proportion of site types for each borough is not comparable, for example, some boroughs focused on source apportionment sites by roadsides.

In this report, source apportionment concentrations averaged by borough are presented. Concentrations for individual source apportionment locations are reported in a separate report for each borough.

Figure 10.9 presents total $NO_x$ concentrations by major source group, including background concentrations from outside of Surrey. Of sources within Surrey, road transport is the largest contributor to $NO_x$ concentrations across all boroughs, contributing an average of 49% of total $NO_x$ concentrations.

The average contribution of other sources to $NO_x$ concentrations is higher in Spelthorne (23%) compared to the average of all other boroughs (11%). This is due to the proximity of some of the source apportionment locations to Heathrow Airport.

Road transport $NO_x$ concentrations split by vehicle category are presented in Figure 10.10. The borough average breakdowns of concentrations are largely in line with the Surrey-wide breakdown of emissions by vehicle type shown in Figure 10.2.

A summary of $NO_x$ source apportionment is provided in Table 10-2.

Note that the contribution of different source groups to the total $NO_2$ concentration cannot be quantified because of the non-linearity nature of the chemical reactions which take place in the atmosphere. The contribution of different source groups to total $NO_2$ concentrations will be related to the contribution of each group to the total $NO_x$ concentrations and the proportion of $NO_x$ emissions emitted as $NO_2$ (primary $NO_2$).

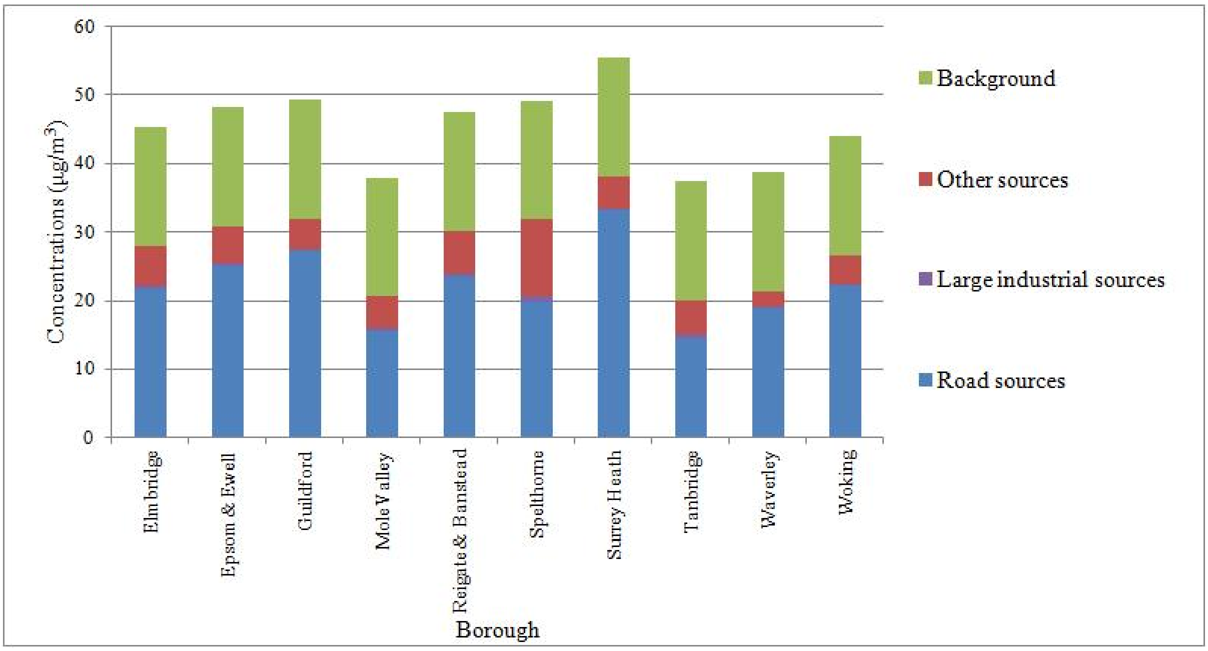


***Figure 10.9: $NO_x$ concentrations by major source group, averaged by borough***

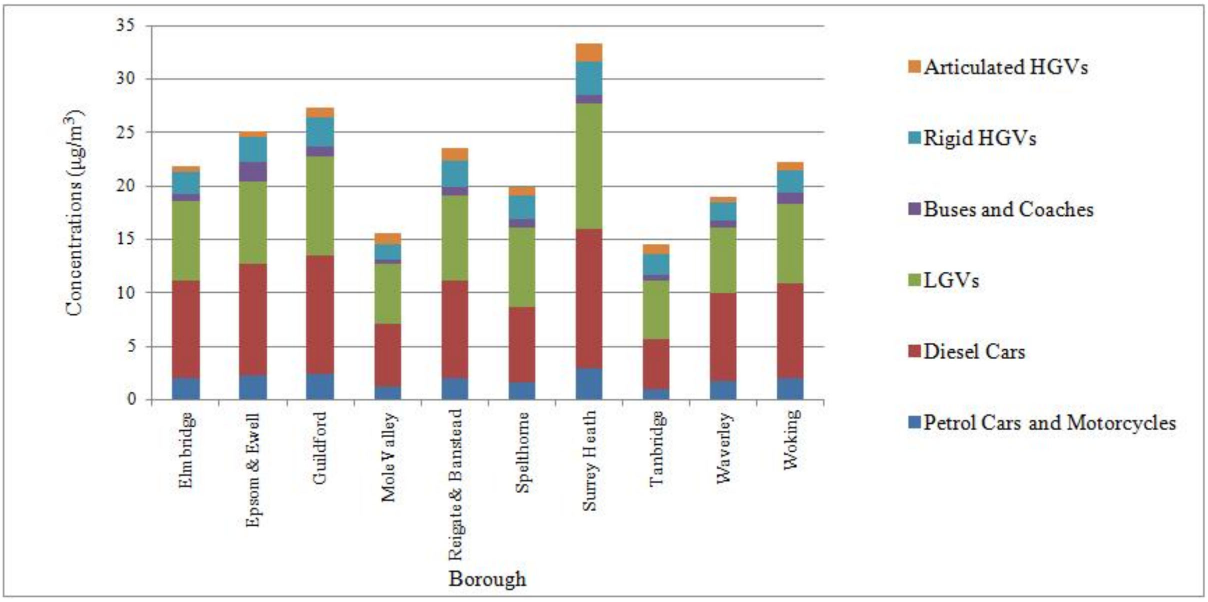


***Figure 10.10: Road transport $NO_x$ concentrations by vehicle category, averaged by borough***

*Table 10-2: Summary of $NO_x$ concentration source apportionment, averaged by borough*

| $NO_x$ (µg/m³) | Type of source apportionment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Source type | | | | Vehicle type | | | | | |
| **Borough** | **Road sources** | **Other sources** | **Background** | **Large industrial sources** | **Petrol Cars & Motorcycles** | **Diesel Cars** | **LGVs** | **Buses & Coaches** | **Rigid HGVs** | **Articulated HGVs** |
| Elmbridge | 21.9 | 5.6 | 17.4 | 0.4 | 2.0 | 9.1 | 7.4 | 0.7 | 2.1 | 0.5 |
| Epsom & Ewell | 25.1 | 5.4 | 17.4 | 0.3 | 2.3 | 10.4 | 7.7 | 1.8 | 2.3 | 0.6 |
| Guildford | 27.3 | 4.4 | 17.4 | 0.2 | 2.4 | 11.1 | 9.3 | 0.9 | 2.7 | 0.9 |
| Mole Valley | 15.6 | 4.7 | 17.4 | 0.3 | 1.2 | 5.8 | 5.7 | 0.4 | 1.4 | 1.1 |
| Reigate & Banstead | 23.6 | 6.2 | 17.4 | 0.5 | 2.0 | 9.2 | 7.9 | 0.8 | 2.5 | 1.2 |
| Spelthorne | 19.9 | 11.1 | 17.4 | 0.8 | 1.5 | 7.2 | 7.4 | 0.8 | 2.2 | 0.9 |
| Surrey Heath | 33.3 | 4.6 | 17.4 | 0.2 | 2.9 | 13.2 | 11.7 | 0.8 | 3.0 | 1.7 |
| Tandridge | 14.6 | 4.9 | 17.4 | 0.5 | 1.0 | 4.7 | 5.4 | 0.6 | 2.0 | 0.9 |
| Waverley | 19.0 | 2.3 | 17.4 | 0.1 | 1.8 | 8.2 | 6.2 | 0.6 | 1.7 | 0.5 |
| Woking | 22.2 | 4.2 | 17.4 | 0.2 | 2.0 | 9.0 | 7.4 | 1.0 | 2.1 | 0.8 |

Figure 10.11 presents total $PM_{10}$ concentrations by major source group. For all boroughs, background concentrations from outside the modelled Surrey area are the largest contributor to total $PM_{10}$ concentrations; across the source apportionment locations, sources within Surrey represent an average of 21% of total $PM_{10}$ concentrations.

Exhaust road transport $PM_{10}$ concentrations split by vehicle category are shown in Figure 10.12. Non-exhaust sources are the major contributor (88%) to road transport $PM_{10}$ concentrations, as illustrated by Figure 10.13.

A summary of $PM_{10}$ source apportionment is provided in Table 10-3.

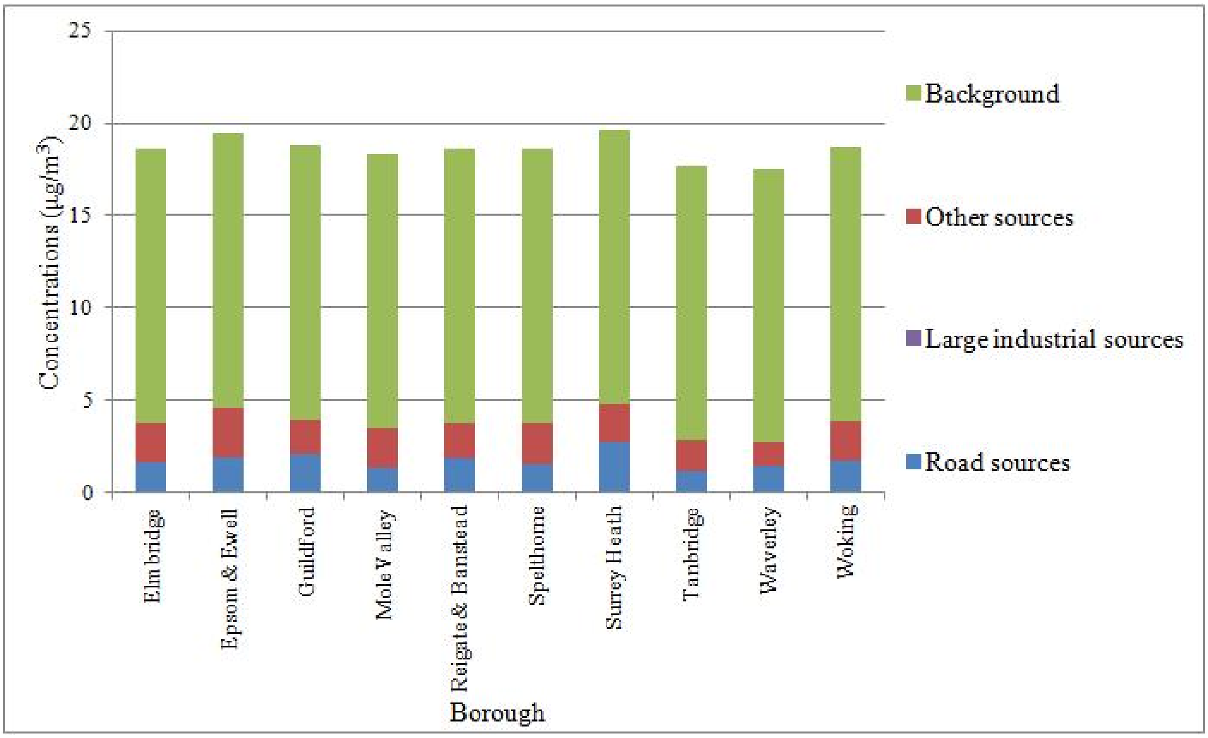


***Figure 10.11: $PM_{10}$ concentrations by major source group, averaged by borough***

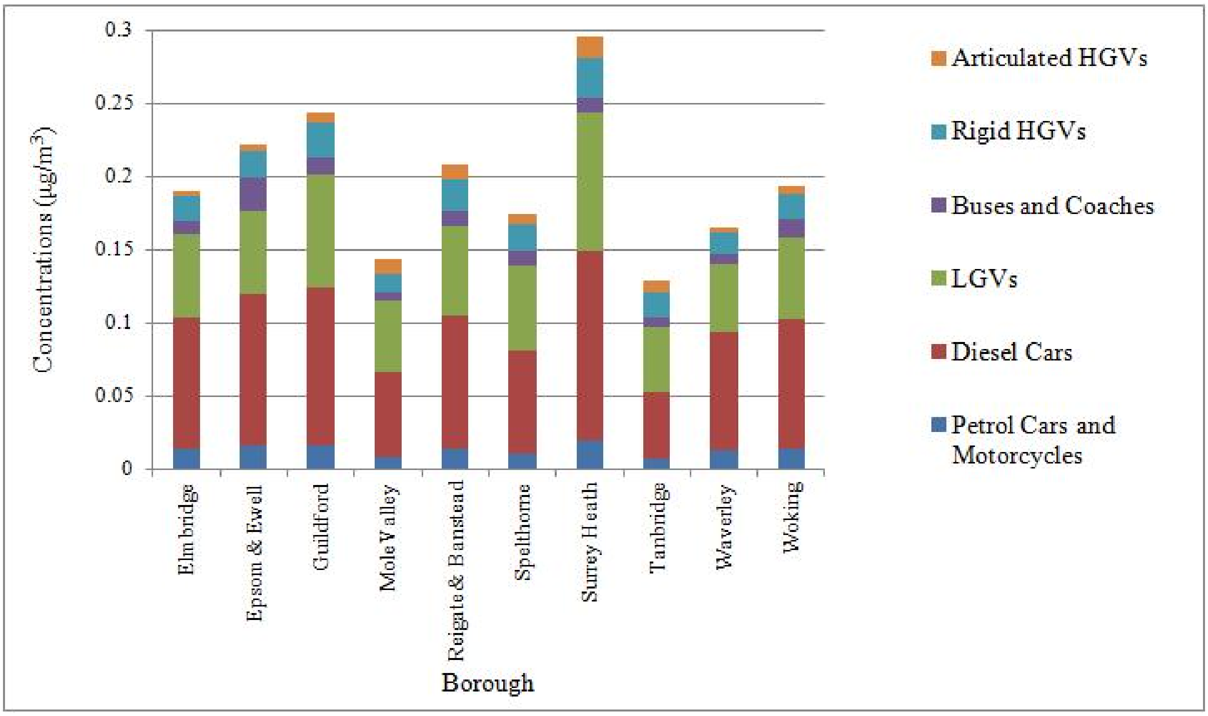


***Figure 10.12: Road transport exhaust $PM_{10}$ concentrations by vehicle category, averaged by borough***

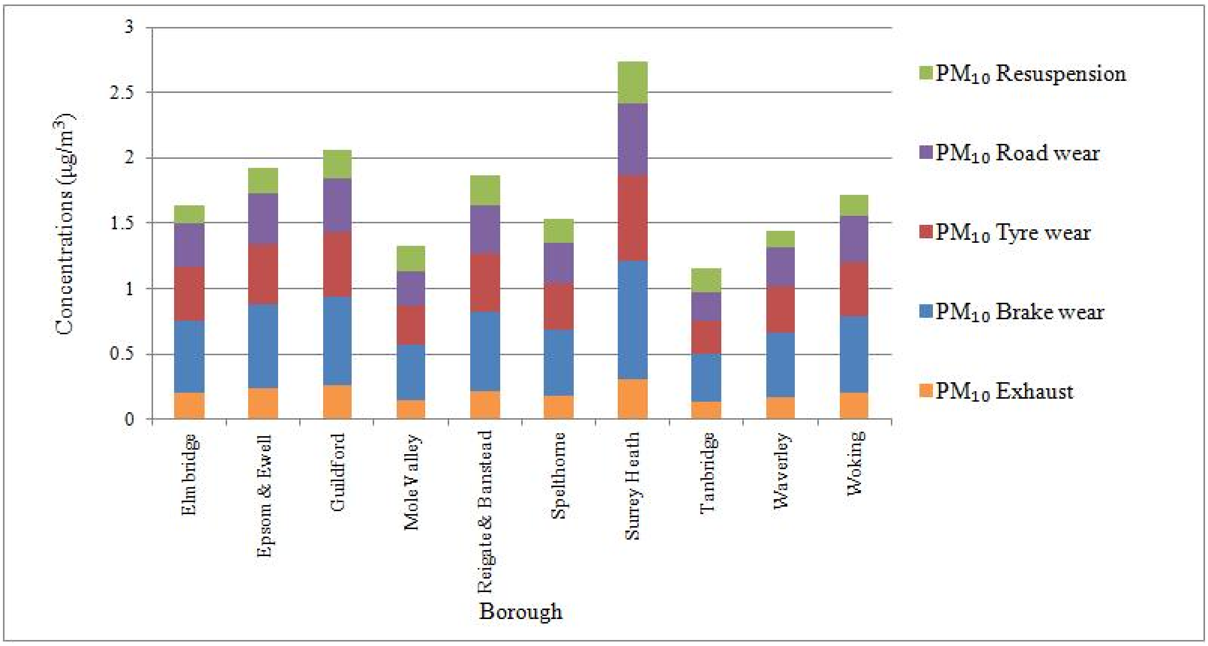


***Figure 10.13: Road transport $PM_{10}$ concentrations by exhaust and non-exhaust components, averaged by borough***

***Table 10-3: Summary of $PM_{10}$ concentration source apportionment, averaged by borough***

| $PM_{10}$ (µg/m³) | Type of source apportionment | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Source type | | | | Road transport - exhaust by vehicle type | | | | | | Road transport - non-exhaust | | | |
| **Receptor** | **Road sources** | **Other sources** | **Background** | **Large industrial sources** | **Petrol Cars & Motorcycles** | **Diesel Cars** | **LGVs** | **Buses & Coaches** | **Rigid HGVs** | **Articulated HGVs** | **$PM_{10}$ Brake wear** | **$PM_{10}$ Tyre wear** | **$PM_{10}$ Resuspension** | **$PM_{10}$ Road wear** |
| Elmbridge | 1.6 | 2.1 | 14.8 | <0.1 | 0.02 | 0.09 | 0.06 | <0.01 | 0.02 | <0.01 | 0.6 | 0.4 | 0.1 | 0.3 |
| Epsom & Ewell | 1.9 | 2.7 | 14.8 | <0.1 | 0.02 | 0.11 | 0.06 | 0.02 | 0.02 | <0.01 | 0.6 | 0.5 | 0.2 | 0.4 |
| Guildford | 2.1 | 1.9 | 14.8 | <0.1 | 0.02 | 0.11 | 0.08 | 0.01 | 0.02 | <0.01 | 0.7 | 0.5 | 0.2 | 0.4 |
| Mole Valley | 1.3 | 2.1 | 14.8 | <0.1 | <0.01 | 0.06 | 0.05 | <0.01 | 0.01 | 0.01 | 0.4 | 0.3 | 0.2 | 0.3 |
| Reigate & Banstead | 1.9 | 1.9 | 14.8 | <0.1 | 0.02 | 0.09 | 0.07 | 0.01 | 0.02 | 0.01 | 0.6 | 0.4 | 0.2 | 0.4 |
| Spelthorne | 1.5 | 2.2 | 14.8 | <0.1 | 0.01 | 0.07 | 0.06 | 0.01 | 0.02 | <0.01 | 0.5 | 0.4 | 0.2 | 0.3 |
| Surrey Heath | 2.7 | 2.1 | 14.8 | <0.1 | 0.02 | 0.14 | 0.10 | 0.01 | 0.03 | 0.02 | 0.9 | 0.7 | 0.3 | 0.5 |
| Tandridge | 1.2 | 1.7 | 14.8 | <0.1 | <0.01 | 0.05 | 0.05 | <0.01 | 0.02 | <0.01 | 0.4 | 0.3 | 0.2 | 0.2 |
| Waverley | 1.4 | 1.3 | 14.8 | <0.1 | 0.01 | 0.08 | 0.05 | <0.01 | 0.01 | <0.01 | 0.5 | 0.4 | 0.1 | 0.3 |
| Woking | 1.7 | 2.1 | 14.8 | <0.1 | 0.01 | 0.09 | 0.06 | 0.01 | 0.02 | <0.01 | 0.6 | 0.4 | 0.2 | 0.4 |

Figure 10.14 presents total $PM_{2.5}$ concentrations by major source group. In line with the breakdown of $PM_{10}$ concentrations, background concentrations from outside Surrey are the largest contributor to total $PM_{2.5}$ concentrations.

Exhaust road transport $PM_{10}$ concentrations split by vehicle category are shown in Figure 10.15. Non-exhaust sources are the major contributor to road transport $PM_{2.5}$ concentrations, as illustrated in Figure 10.16.

A summary of $PM_{2.5}$ source apportionment is provided in Table 10-4.

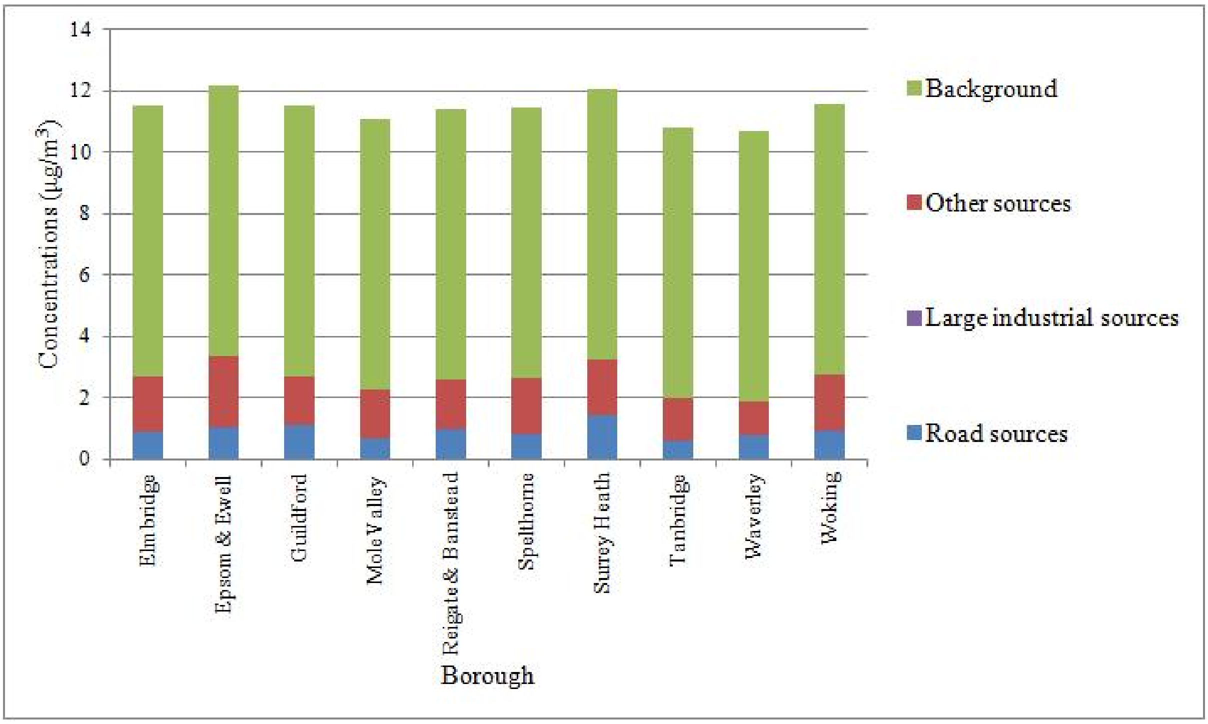


***Figure 10.14: $PM_{2.5}$ concentrations by major source group, averaged by borough***

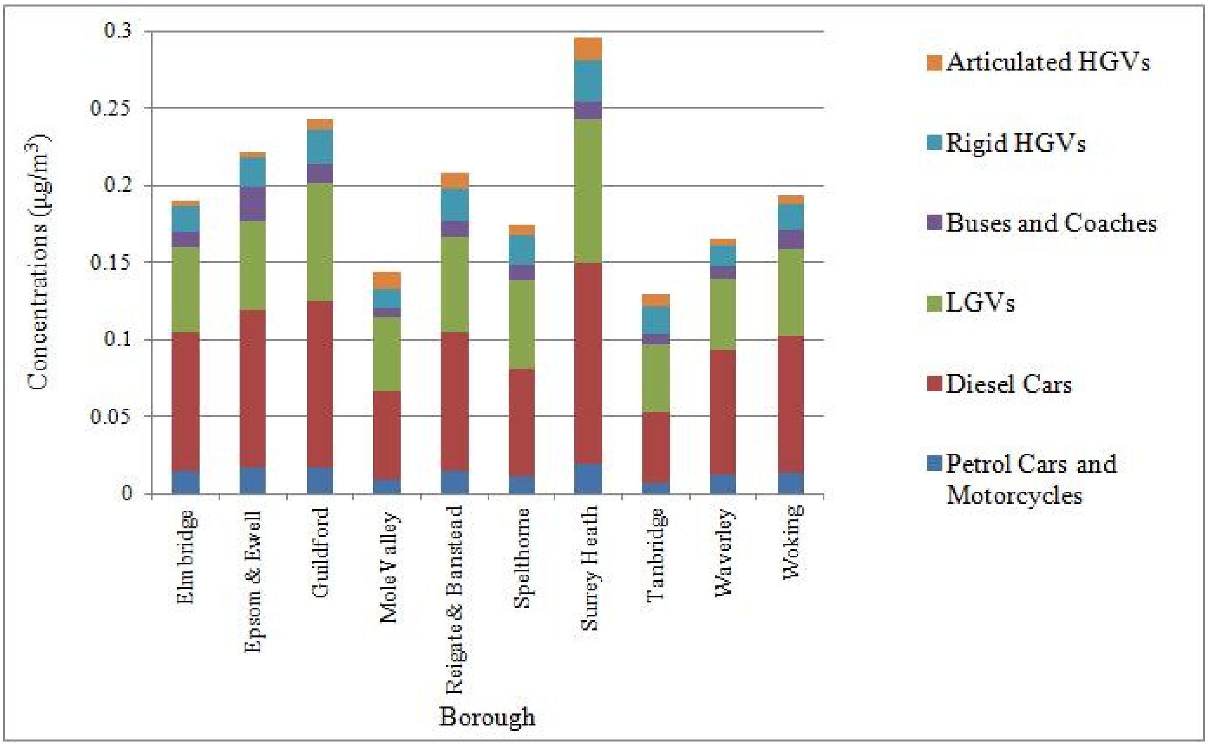


***Figure 10.15: Road transport exhaust $PM_{2.5}$ concentrations by vehicle category, averaged by borough***

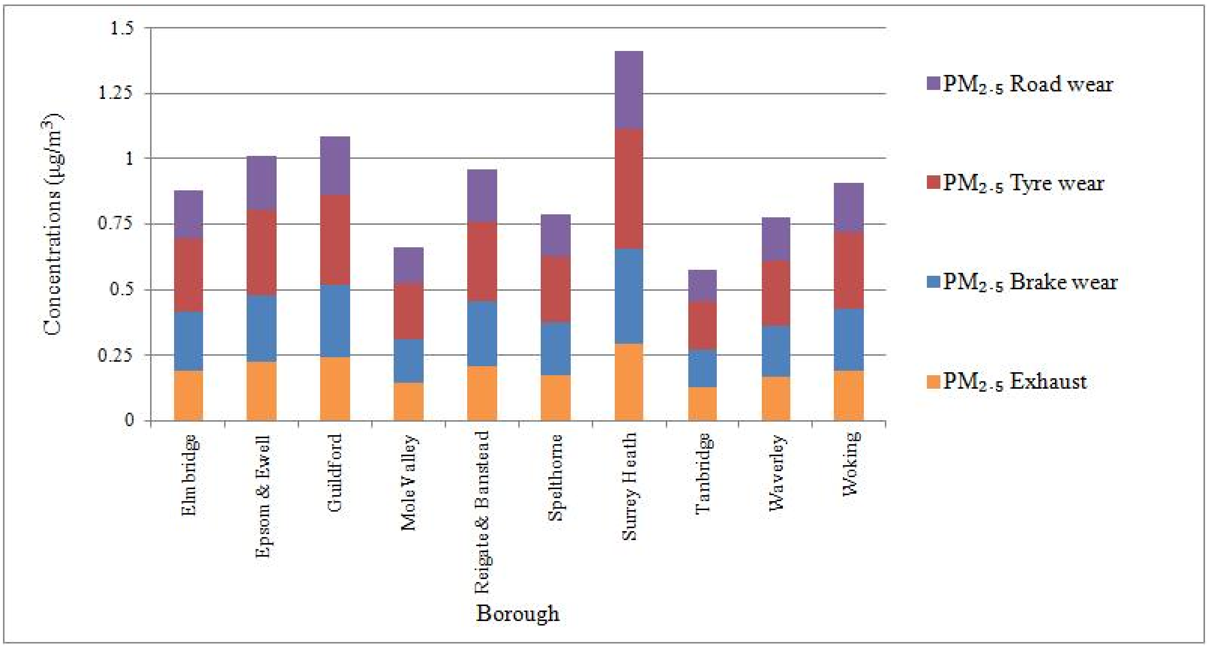


***Figure 10.16: Road transport $PM_{2.5}$ concentrations by exhaust and non-exhaust components, averaged by borough***

***Table 10-4: Summary of $PM_{2.5}$ concentration source apportionment, averaged by borough***

| $PM_{2.5}$ (µg/m³) | Type of source apportionment | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Source type | | | | Road transport - exhaust by vehicle type | | | | | | Road transport - non-exhaust | | |
| **Receptor** | **Road sources** | **Other sources** | **Background** | **Large industrial sources** | **Petrol Cars & Motorcycles** | **Diesel Cars** | **LGVs** | **Buses & Coaches** | **Rigid HGVs** | **Articulated HGVs** | **$PM_{2.5}$ Brake wear** | **$PM_{2.5}$ Tyre wear** | **$PM_{2.5}$ Road wear** |
| Elmbridge | 0.9 | 1.8 | 8.8 | <0.1 | 0.01 | 0.09 | 0.06 | <0.01 | 0.02 | <0.01 | 0.2 | 0.3 | 0.2 |
| Epsom & Ewell | 1.0 | 2.3 | 8.8 | <0.1 | 0.02 | 0.10 | 0.06 | 0.02 | 0.02 | <0.01 | 0.3 | 0.3 | 0.2 |
| Guildford | 1.1 | 1.6 | 8.8 | <0.1 | 0.02 | 0.11 | 0.08 | 0.01 | 0.02 | <0.01 | 0.3 | 0.3 | 0.2 |
| Mole Valley | 0.7 | 1.6 | 8.8 | <0.1 | <0.01 | 0.06 | 0.05 | <0.01 | 0.01 | 0.01 | 0.2 | 0.2 | 0.1 |
| Reigate & Banstead | 1.0 | 1.6 | 8.8 | <0.1 | 0.01 | 0.09 | 0.06 | <0.01 | 0.02 | 0.01 | 0.2 | 0.3 | 0.2 |
| Spelthorne | 0.8 | 1.8 | 8.8 | <0.1 | 0.01 | 0.07 | 0.06 | <0.01 | 0.02 | <0.01 | 0.2 | 0.3 | 0.2 |
| Surrey Heath | 1.4 | 1.8 | 8.8 | <0.1 | 0.02 | 0.13 | 0.09 | 0.01 | 0.03 | 0.01 | 0.4 | 0.5 | 0.3 |
| Tandridge | 0.6 | 1.4 | 8.8 | <0.1 | <0.01 | 0.05 | 0.04 | <0.01 | 0.02 | <0.01 | 0.1 | 0.2 | 0.1 |
| Waverley | 0.8 | 1.1 | 8.8 | <0.1 | 0.01 | 0.08 | 0.05 | <0.01 | 0.01 | <0.01 | 0.2 | 0.3 | 0.2 |
| Woking | 0.9 | 1.8 | 8.8 | <0.1 | 0.01 | 0.09 | 0.06 | 0.01 | 0.02 | <0.01 | 0.2 | 0.3 | 0.2 |

# 11 Discussion

Air quality modelling has been carried out for $NO_2$, $PM_{10}$ and $PM_{2.5}$ using ADMS-Urban (version 4.2). This has been carried out to assess relevant pollutant concentrations throughout Surrey in 2017 against the air quality objectives. The detailed modelling is supplemented by mortality burden calculations and source apportionment.

Model verification was carried out to ensure a suitable model set-up for detailed modelling; this was done by comparing modelled concentrations with measured data from diffusion tubes and continuous monitors at a variety of site types throughout Surrey. The model verification shows a generally good performance of the model set-up across Surrey, with modelled annual average $NO_2$ concentrations falling within 25% of the monitored values at 74% of the locations.

The model was run to produce contour plots of annual mean $NO_2$, 99.79$^{th}$ percentile of hourly mean $NO_2$, annual mean $PM_{10}$, 90.41$^{st}$ percentile of 24-hourly mean $PM_{10}$ and annual mean $PM_{2.5}$ concentrations.

This modelling predicts exceedences for three of the five air quality objectives, along motorways and stretches of busy roads. The exceptions are annual mean $PM_{10}$ concentrations, which has no exceedences outside the footprint of modelled roads and $PM_{2.5}$ which has no exceedences across Surrey.

The health impacts associated with air quality across Surrey and the contributions from each borough and ward have been assessed by calculating the number of attributable deaths and corresponding life-years lost due to $NO_2$ and $PM_{2.5}$ concentrations. The methodology used for these calculations is outlined in Appendix A of the Public Health England guidance *Estimating local mortality burdens associated with particulate air pollution (April 2014)*. Using this approach along with four studies suggesting a range of CRF pairs, the combined health impacts of $NO_2$ and $PM_{2.5}$ were calculated to be in a range of 6,610 and 8,059 life-years lost which equates to an economic cost between £283 million and £345 million in 2017. Using the unadjusted value, the lowest life years lost were calculated to be 5233, resulting from $NO_2$ concentrations. This equates to an economic cost of £224 million.

Source apportionment has been carried out across Surrey, calculating the contributions of each major source group to $NO_x$, $PM_{10}$ and $PM_{2.5}$ pollutant emissions and resulting concentrations.

$NO_x$ emissions within Surrey are dominated by road transport, specifically light diesel vehicles; in addition the primary $NO_2$ proportion for these vehicle types is higher than for other vehicles. $NO_x$ concentrations within Surrey are greatest from road transport. The distribution of vehicle type concentrations is in line with breakdown of vehicle type emissions.

$PM_{10}$ and $PM_{2.5}$ emissions within Surrey are largely dominated by other emissions from NAEI data. The largest contributor to both $PM_{10}$ and $PM_{2.5}$ concentrations is background concentrations, from outside Surrey.

# APPENDIX A: Model verification data

Appendix A presents a comparison of model verification results using Heathrow Airport and Gatwick Airport meteorological data. Table A.1 is a summary table of monitored and modelled concentrations using the two sets of meteorological data for all monitoring sites.

***Table A.1: Monitored and modelled $NO_2$ concentrations at monitoring locations***

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| Hampton Court Parade | 40.6 | 36.8 | 33.7 | 91% | 83% | Elmbridge |
| Weybridge High St | 33.5 | 38.6 | 34.5 | 115% | 103% | Elmbridge |
| Esher 1 | 37.5 | 26.6 | 24.4 | 71% | 65% | Elmbridge |
| Esher 4 | 33.7 | 29.0 | 25.2 | 86% | 75% | Elmbridge |
| Esher 5 | 43.1 | 32.9 | 27.4 | 76% | 64% | Elmbridge |
| Esher 7 | 39.6 | 40.8 | 34.0 | 103% | 86% | Elmbridge |
| Esher 8 | 39.1 | 28.2 | 25.8 | 72% | 66% | Elmbridge |
| Esher 9 | 29.0 | 28.6 | 26.3 | 99% | 91% | Elmbridge |
| Esher 10 | 28.8 | 26.0 | 23.7 | 90% | 82% | Elmbridge |
| Esher 11 | 33.1 | 26.8 | 24.5 | 81% | 74% | Elmbridge |
| Esher 13 | 31.9 | 32.4 | 28.9 | 102% | 91% | Elmbridge |
| Hampton court 1 | 35.8 | 32.9 | 29.9 | 92% | 84% | Elmbridge |
| Hinchley wood 1 | 35.8 | 26.7 | 24.4 | 75% | 68% | Elmbridge |
| Hinchley wood 2 | 31.2 | 26.4 | 24.2 | 85% | 78% | Elmbridge |
| Molesey 1 | 28.5 | 24.3 | 22.6 | 85% | 79% | Elmbridge |
| Hampton court 5 | 25.6 | 26.7 | 23.8 | 104% | 93% | Elmbridge |
| Molesey 8 | 31.5 | 29.9 | 27.3 | 95% | 87% | Elmbridge |
| Molesey 9 | 32.7 | 26.0 | 23.7 | 80% | 72% | Elmbridge |
| Molesey 10 | 27.8 | 26.2 | 23.9 | 94% | 86% | Elmbridge |
| Hampton court 2 | 35.2 | 36.9 | 33.8 | 105% | 96% | Elmbridge |
| Hampton court 3 | 35.3 | 36.9 | 33.8 | 105% | 96% | Elmbridge |
| Hampton court 4 | 35.1 | 36.9 | 33.8 | 105% | 96% | Elmbridge |
| Walton 3 | 30.4 | 24.3 | 22.5 | 80% | 74% | Elmbridge |
| Walton 5 | 27.8 | 30.0 | 27.5 | 108% | 99% | Elmbridge |
| Walton 8 | 30.9 | 24.6 | 22.5 | 80% | 73% | Elmbridge |
| Walton 9 | 30.5 | 25.1 | 23.2 | 82% | 76% | Elmbridge |
| Walton 10 | 33.5 | 30.9 | 26.6 | 92% | 79% | Elmbridge |
| Walton 11 | 30.9 | 32.6 | 29.8 | 106% | 96% | Elmbridge |
| Weybridge 1 | 30.4 | 42.4 | 37.6 | 139% | 124% | Elmbridge |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| Weybridge 4 | 30.6 | 28.3 | 25.9 | 92% | 85% | Elmbridge |
| Weybridge 5 | 34.4 | 37.7 | 33.2 | 110% | 97% | Elmbridge |
| Weybridge 6 | 28.4 | 39.8 | 32.9 | 140% | 116% | Elmbridge |
| Weybridge 7 | 41.0 | 32.6 | 29.6 | 80% | 72% | Elmbridge |
| Weybridge 8 | 35.9 | 27.6 | 25.4 | 77% | 71% | Elmbridge |
| Weybridge 9 | 22.9 | 24.6 | 22.2 | 107% | 97% | Elmbridge |
| Weybridge 10 | 31.6 | 38.1 | 34.0 | 121% | 108% | Elmbridge |
| Weybridge 11 | 31.2 | 38.1 | 34.0 | 122% | 109% | Elmbridge |
| Weybridge 12 | 32.3 | 38.1 | 34.0 | 118% | 105% | Elmbridge |
| Cobham 1 | 30.4 | 33.2 | 31.3 | 109% | 103% | Elmbridge |
| Cobham 6 | 24.9 | 27.6 | 26.1 | 111% | 105% | Elmbridge |
| Cobham 7 | 32.5 | 32.7 | 30.5 | 101% | 94% | Elmbridge |
| Downside 3 | 19.3 | 31.6 | 27.7 | 164% | 144% | Elmbridge |
| EE1 | 34.2 | 26.5 | 24.7 | 77% | 72% | Epsom & Ewell |
| EE3 | 17.0 | 19.3 | 18.4 | 114% | 108% | Epsom & Ewell |
| EE6 | 31.6 | 27.9 | 26.8 | 88% | 85% | Epsom & Ewell |
| EE7 | 35.9 | 43.9 | 41.2 | 122% | 115% | Epsom & Ewell |
| EE9 | 23.4 | 22.4 | 21.6 | 96% | 92% | Epsom & Ewell |
| EE10 | 44.9 | 28.5 | 26.8 | 63% | 60% | Epsom & Ewell |
| EE14 | 25.6 | 24.3 | 22.9 | 95% | 89% | Epsom & Ewell |
| EE16 | 31.0 | 25.5 | 23.0 | 82% | 74% | Epsom & Ewell |
| EE17 | 30.6 | 26.0 | 24.3 | 85% | 79% | Epsom & Ewell |
| EE22 | 39.7 | 34.8 | 33.3 | 88% | 84% | Epsom & Ewell |
| EE36 | 26.5 | 25.7 | 24.3 | 97% | 92% | Epsom & Ewell |
| EE38 | 25.4 | 25.9 | 23.7 | 102% | 93% | Epsom & Ewell |
| EE39 | 27.9 | 25.2 | 23.7 | 90% | 85% | Epsom & Ewell |
| EE42 | 29.1 | 30.6 | 28.2 | 105% | 97% | Epsom & Ewell |
| EE43 | 28.8 | 24.4 | 22.3 | 85% | 77% | Epsom & Ewell |
| EE45 | 22.8 | 25.6 | 23.8 | 112% | 104% | Epsom & Ewell |
| EE47 | 24.8 | 24.3 | 23.2 | 98% | 94% | Epsom & Ewell |
| EE48 | 29.3 | 24.7 | 22.8 | 84% | 78% | Epsom & Ewell |
| EE49 | 28.9 | 26.9 | 25.2 | 93% | 87% | Epsom & Ewell |
| EE50 | 36.8 | 28.9 | 27.4 | 79% | 74% | Epsom & Ewell |
| GUL_GD1 | 28.9 | 34.5 | 32.4 | 119% | 112% | Guildford |
| GUL_GD2 | 30.6 | 27.0 | 26.1 | 88% | 85% | Guildford |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| GUL_GD3 | 17.5 | 24.0 | 23.4 | 137% | 134% | Guildford |
| GUL_GD6 | 10.1 | 17.5 | 17.6 | 173% | 174% | Guildford |
| GUL_GD9 | 17.1 | 25.2 | 24.2 | 147% | 142% | Guildford |
| GUL_GD10 | 15.4 | 20.7 | 19.8 | 134% | 129% | Guildford |
| GUL_GD11 | 24.3 | 29.7 | 25.1 | 122% | 103% | Guildford |
| GUL_GD13 | 31.1 | 34.2 | 31.4 | 110% | 101% | Guildford |
| GUL_GD14 | 32.0 | 30.8 | 29.0 | 96% | 91% | Guildford |
| GUL_GD15 | 27.8 | 32.5 | 30.7 | 117% | 110% | Guildford |
| GUL_C4 | 39.9 | 23.1 | 22.9 | 58% | 57% | Guildford |
| GUL_C9 | 44.4 | 23.3 | 23.0 | 52% | 52% | Guildford |
| GUL_C10 | 31.8 | 23.4 | 23.1 | 74% | 73% | Guildford |
| GUL_SH1 | 35.8 | 26.6 | 25.7 | 74% | 72% | Guildford |
| GUL_RP1 | 27.6 | 35.0 | 30.3 | 127% | 110% | Guildford |
| GUL_RP2 | 23.8 | 37.8 | 36.9 | 159% | 155% | Guildford |
| GUL_WS1 | 13.8 | 20.5 | 20.3 | 149% | 147% | Guildford |
| GUL_WP1 | 25.4 | 24.3 | 23.0 | 96% | 91% | Guildford |
| GUL_ASH1 | 17.6 | 21.6 | 20.6 | 123% | 117% | Guildford |
| GUL_ASH2 | 22.4 | 32.7 | 28.8 | 146% | 129% | Guildford |
| GUL_send1 | 22.2 | 23.1 | 22.0 | 104% | 99% | Guildford |
| GUL_send2 | 20.7 | 24.9 | 23.5 | 120% | 114% | Guildford |
| GUL_WCL | 20.1 | 19.5 | 18.7 | 97% | 93% | Guildford |
| GUL_T1 | 22.9 | 21.5 | 20.4 | 94% | 89% | Guildford |
| GUL_STN | 24.7 | 24.9 | 22.5 | 101% | 91% | Guildford |
| GUL_FRH1 | 34.5 | 28.7 | 27.2 | 83% | 79% | Guildford |
| MV1 | 24.4 | 26.8 | 26.7 | 110% | 109% | Mole Valley |
| MV2 | 20.2 | 20.6 | 20.5 | 102% | 101% | Mole Valley |
| MV3 | 16.9 | 19.5 | 19.0 | 115% | 112% | Mole Valley |
| MV4 | 14.4 | 17.7 | 17.6 | 123% | 122% | Mole Valley |
| MV6 | 30.3 | 34.0 | 33.6 | 112% | 111% | Mole Valley |
| MV7 | 17.2 | 20.6 | 19.3 | 120% | 112% | Mole Valley |
| MV8 | 18.1 | 21.0 | 18.8 | 116% | 104% | Mole Valley |
| MV9 | 10.9 | 25.9 | 22.4 | 238% | 206% | Mole Valley |
| MV10 | 32.9 | 42.3 | 38.1 | 129% | 116% | Mole Valley |
| MV12 | 29.5 | 33.9 | 31.1 | 115% | 105% | Mole Valley |
| MV13 | 33.1 | 24.1 | 23.7 | 73% | 72% | Mole Valley |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| MV14 | 17.7 | 20.5 | 19.5 | 116% | 110% | Mole Valley |
| RG1 | 20.4 | 28.7 | 24.7 | 141% | 121% | Reigate & Banstead |
| RG3 | 13.9 | 24.9 | 25.2 | 179% | 181% | Reigate & Banstead |
| RG6 | 26.7 | 34.8 | 30.9 | 130% | 116% | Reigate & Banstead |
| RB1 | 32.4 | 26.1 | 26.6 | 81% | 82% | Reigate & Banstead |
| RB3 | 17.6 | 21.2 | 20.3 | 120% | 115% | Reigate & Banstead |
| RB8 | 17.8 | 20.3 | 19.8 | 114% | 111% | Reigate & Banstead |
| RB9 | 16.6 | 19.6 | 19.1 | 118% | 115% | Reigate & Banstead |
| RB11 | 22.8 | 30.2 | 26.2 | 132% | 115% | Reigate & Banstead |
| RB12 | 28.3 | 26.2 | 22.4 | 93% | 79% | Reigate & Banstead |
| RB13 | 19.9 | 25.7 | 22.2 | 129% | 112% | Reigate & Banstead |
| RB17 | 14.0 | 20.1 | 19.9 | 144% | 142% | Reigate & Banstead |
| RB18 | 22.6 | 26.9 | 25.4 | 119% | 112% | Reigate & Banstead |
| RB19 | 23.5 | 30.3 | 28.8 | 129% | 123% | Reigate & Banstead |
| RB20 | 32.8 | 39.3 | 34.8 | 120% | 106% | Reigate & Banstead |
| RB21 | 34.1 | 25.2 | 23.9 | 74% | 70% | Reigate & Banstead |
| RB22 | 19.7 | 28.9 | 27.0 | 147% | 137% | Reigate & Banstead |
| RB23 | 16.2 | 21.1 | 20.5 | 130% | 127% | Reigate & Banstead |
| RB24 | 21.1 | 28.7 | 24.7 | 136% | 117% | Reigate & Banstead |
| RB25 | 21.8 | 28.7 | 24.7 | 132% | 113% | Reigate & Banstead |
| RB26 | 20.9 | 28.7 | 24.7 | 137% | 118% | Reigate & Banstead |
| RB27 | 25.3 | 37.2 | 34.2 | 147% | 135% | Reigate & Banstead |
| RB29 | 24.8 | 29.0 | 26.7 | 117% | 108% | Reigate & Banstead |
| RB30 | 24.3 | 32.5 | 30.1 | 134% | 124% | Reigate & Banstead |
| RB31 | 16.0 | 23.2 | 24.8 | 145% | 155% | Reigate & Banstead |
| RB33 | 21.1 | 29.2 | 26.8 | 138% | 127% | Reigate & Banstead |
| RB34 | 24.1 | 22.8 | 23.0 | 95% | 95% | Reigate & Banstead |
| RB36 | 20.3 | 33.4 | 30.0 | 165% | 148% | Reigate & Banstead |
| RB37 | 24.0 | 35.4 | 31.4 | 148% | 131% | Reigate & Banstead |
| RB39 | 25.1 | 40.3 | 35.5 | 161% | 141% | Reigate & Banstead |
| RB40 | 20.3 | 29.3 | 25.8 | 144% | 127% | Reigate & Banstead |
| RB43 | 23.3 | 29.3 | 29.0 | 126% | 124% | Reigate & Banstead |
| RB44 | 30.8 | 26.2 | 25.3 | 85% | 82% | Reigate & Banstead |
| RB45 | 28.0 | 24.6 | 23.8 | 88% | 85% | Reigate & Banstead |
| RB46 | 35.9 | 34.8 | 32.4 | 97% | 90% | Reigate & Banstead |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| RB47 | 35.0 | 26.4 | 26.4 | 75% | 75% | Reigate & Banstead |
| RB49 | 42.4 | 29.7 | 26.3 | 70% | 62% | Reigate & Banstead |
| RB50 | 26.1 | 28.0 | 24.8 | 107% | 95% | Reigate & Banstead |
| RB51 | 20.8 | 26.2 | 22.4 | 126% | 108% | Reigate & Banstead |
| RB52 | 24.7 | 27.1 | 23.2 | 110% | 94% | Reigate & Banstead |
| RB53 | 25.3 | 29.2 | 25.0 | 115% | 99% | Reigate & Banstead |
| RB54 | 23.4 | 29.0 | 25.0 | 124% | 107% | Reigate & Banstead |
| RB55 | 22.8 | 30.5 | 26.4 | 134% | 116% | Reigate & Banstead |
| RB56 | 24.0 | 31.8 | 27.8 | 133% | 116% | Reigate & Banstead |
| RB57 | 26.2 | 33.3 | 29.4 | 127% | 112% | Reigate & Banstead |
| RB58 | 26.8 | 33.9 | 30.0 | 126% | 112% | Reigate & Banstead |
| RB59 | 27.8 | 35.3 | 31.4 | 127% | 113% | Reigate & Banstead |
| RB60 | 27.3 | 33.4 | 29.6 | 122% | 108% | Reigate & Banstead |
| RB61 | 22.6 | 32.3 | 28.5 | 143% | 126% | Reigate & Banstead |
| RB64 | 22.1 | 27.5 | 23.5 | 124% | 106% | Reigate & Banstead |
| RB65 | 22.4 | 26.5 | 22.6 | 118% | 101% | Reigate & Banstead |
| RB66 | 21.8 | 26.7 | 22.7 | 122% | 104% | Reigate & Banstead |
| RB68 | 24.0 | 29.7 | 25.8 | 124% | 108% | Reigate & Banstead |
| RB69 | 26.5 | 30.1 | 26.0 | 114% | 98% | Reigate & Banstead |
| RB70 | 24.3 | 28.1 | 24.1 | 116% | 99% | Reigate & Banstead |
| RB72 | 22.2 | 26.5 | 22.5 | 119% | 101% | Reigate & Banstead |
| RB73 | 22.0 | 26.1 | 22.3 | 119% | 101% | Reigate & Banstead |
| RB74 | 22.5 | 31.8 | 28.2 | 141% | 125% | Reigate & Banstead |
| RB75 | 23.9 | 30.4 | 26.6 | 127% | 111% | Reigate & Banstead |
| RB76 | 20.1 | 26.9 | 22.9 | 134% | 114% | Reigate & Banstead |
| RB77 | 20.9 | 26.5 | 22.5 | 127% | 108% | Reigate & Banstead |
| RB78 | 27.0 | 34.4 | 30.5 | 127% | 113% | Reigate & Banstead |
| RB81 | 30.9 | 23.1 | 22.4 | 75% | 72% | Reigate & Banstead |
| RB82 | 33.8 | 24.7 | 22.7 | 73% | 67% | Reigate & Banstead |
| RB95 | 25.2 | 24.4 | 23.1 | 97% | 92% | Reigate & Banstead |
| RB98 | 25.8 | 30.6 | 26.5 | 119% | 103% | Reigate & Banstead |
| RB99 | 14.1 | 24.9 | 25.2 | 177% | 179% | Reigate & Banstead |
| RB100 | 13.7 | 24.9 | 25.2 | 182% | 184% | Reigate & Banstead |
| RB101 | 14.0 | 24.9 | 25.2 | 178% | 180% | Reigate & Banstead |
| RB102 | 20.9 | 27.9 | 24.5 | 133% | 117% | Reigate & Banstead |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| RB104 | 34.7 | 26.8 | 27.3 | 77% | 79% | Reigate & Banstead |
| RB105 | 39.0 | 29.9 | 28.8 | 77% | 74% | Reigate & Banstead |
| RB106 | 29.3 | 29.2 | 27.2 | 100% | 93% | Reigate & Banstead |
| RB107 | 26.1 | 23.6 | 23.4 | 90% | 90% | Reigate & Banstead |
| RB109 | 32.5 | 23.0 | 22.4 | 71% | 69% | Reigate & Banstead |
| RB110 | 29.3 | 39.5 | 36.3 | 135% | 124% | Reigate & Banstead |
| RB111 | 30.3 | 32.5 | 30.6 | 107% | 101% | Reigate & Banstead |
| RB113 | 27.1 | 32.7 | 31.2 | 121% | 115% | Reigate & Banstead |
| RB115 | 30.5 | 29.5 | 30.6 | 97% | 100% | Reigate & Banstead |
| RB116 | 31.9 | 29.0 | 28.8 | 91% | 90% | Reigate & Banstead |
| RB117 | 35.1 | 27.9 | 25.5 | 79% | 73% | Reigate & Banstead |
| RB118 | 31.5 | 22.5 | 21.4 | 71% | 68% | Reigate & Banstead |
| RB120 | 32.9 | 27.0 | 26.1 | 82% | 79% | Reigate & Banstead |
| RB122 | 31.5 | 34.4 | 32.3 | 109% | 103% | Reigate & Banstead |
| RB123 | 35.8 | 29.0 | 27.5 | 81% | 77% | Reigate & Banstead |
| RB124 | 34.5 | 32.6 | 30.4 | 94% | 88% | Reigate & Banstead |
| RB125 | 34.9 | 27.1 | 25.8 | 78% | 74% | Reigate & Banstead |
| RB136 | 49.4 | 36.0 | 32.4 | 73% | 66% | Reigate & Banstead |
| RB137 | 42.3 | 29.4 | 26.8 | 70% | 63% | Reigate & Banstead |
| RB140 | 25.5 | 29.8 | 27.6 | 117% | 108% | Reigate & Banstead |
| RB141 | 23.7 | 24.4 | 22.8 | 103% | 96% | Reigate & Banstead |
| RB145 | 33.7 | 33.1 | 31.5 | 98% | 93% | Reigate & Banstead |
| RB146 | 40.9 | 34.8 | 32.2 | 85% | 79% | Reigate & Banstead |
| RB147 | 16.5 | 21.2 | 20.1 | 128% | 122% | Reigate & Banstead |
| RB148 | 62.6 | 30.5 | 27.8 | 49% | 44% | Reigate & Banstead |
| RB149 | 46.0 | 31.2 | 26.1 | 68% | 57% | Reigate & Banstead |
| RB150 | 37.5 | 25.3 | 24.1 | 67% | 64% | Reigate & Banstead |
| RB151 | 33.3 | 27.0 | 23.3 | 81% | 70% | Reigate & Banstead |
| RB152 | 33.4 | 37.0 | 33.6 | 111% | 101% | Reigate & Banstead |
| RB153 | 29.0 | 26.7 | 26.0 | 92% | 90% | Reigate & Banstead |
| RB167 | 24.9 | 24.9 | 23.1 | 100% | 93% | Reigate & Banstead |
| RB174 | 31.1 | 30.8 | 25.9 | 99% | 83% | Reigate & Banstead |
| RB175 | 30.6 | 31.1 | 26.6 | 102% | 87% | Reigate & Banstead |
| RB176 | 25.4 | 33.7 | 29.6 | 133% | 117% | Reigate & Banstead |
| RB177 | 24.9 | 35.6 | 31.1 | 143% | 125% | Reigate & Banstead |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| RB178 | 25.6 | 34.7 | 30.9 | 136% | 121% | Reigate & Banstead |
| RB179 | 25.3 | 34.7 | 30.9 | 137% | 122% | Reigate & Banstead |
| RB180 | 25.9 | 34.7 | 30.9 | 134% | 119% | Reigate & Banstead |
| RY4 | 17.5 | 23.5 | 21.5 | 134% | 123% | Runnymede |
| RY14 | 47.7 | 43.7 | 40.3 | 92% | 84% | Runnymede |
| RY19 | 34.3 | 50.1 | 44.2 | 146% | 129% | Runnymede |
| RY21 | 34.1 | 30.1 | 28.1 | 88% | 82% | Runnymede |
| RY23 | 50.5 | 26.3 | 23.5 | 52% | 47% | Runnymede |
| RY25 | 29.6 | 36.3 | 32.5 | 123% | 110% | Runnymede |
| RY26 | 42.2 | 40.6 | 36.6 | 96% | 87% | Runnymede |
| RY33 | 31.0 | 34.5 | 29.4 | 111% | 95% | Runnymede |
| RY34 | 22.5 | 26.9 | 24.1 | 120% | 107% | Runnymede |
| RY39 | 23.4 | 34.2 | 28.3 | 146% | 121% | Runnymede |
| RY40 | 16.2 | 20.5 | 18.9 | 127% | 117% | Runnymede |
| RY43 | 36.6 | 29.6 | 27.1 | 81% | 74% | Runnymede |
| RY44 | 27.1 | 27.2 | 24.4 | 100% | 90% | Runnymede |
| RY45 | 37.3 | 28.5 | 25.5 | 76% | 68% | Runnymede |
| RY53 | 34.2 | 33.0 | 30.2 | 96% | 88% | Runnymede |
| RY54 | 30.4 | 30.3 | 28.2 | 100% | 93% | Runnymede |
| RY55 | 33.1 | 26.1 | 23.7 | 79% | 72% | Runnymede |
| RY59 | 31.8 | 31.3 | 28.7 | 98% | 90% | Runnymede |
| RY60 | 32.6 | 38.5 | 35.6 | 118% | 109% | Runnymede |
| RY61 | 31.4 | 27.2 | 24.7 | 87% | 79% | Runnymede |
| RY62 | 33.9 | 36.2 | 33.1 | 107% | 98% | Runnymede |
| RY64 | 25.8 | 24.4 | 22.1 | 95% | 86% | Runnymede |
| RY65 | 26.7 | 28.7 | 25.0 | 107% | 94% | Runnymede |
| RY66 | 24.8 | 25.8 | 23.6 | 104% | 95% | Runnymede |
| RYMV | 32.1 | 31.9 | 28.7 | 99% | 89% | Runnymede |
| BAA_Oaks | 25.8 | 34.6 | 30.6 | 134% | 119% | Spelthorne |
| SUN_01 | 32.5 | 36.7 | 29.4 | 113% | 91% | Spelthorne |
| SCC_ECO | 24.1 | 24.8 | 22.8 | 103% | 95% | Spelthorne |
| SP1 | 28.0 | 26.8 | 24.0 | 96% | 86% | Spelthorne |
| SP3 | 31.0 | 30.7 | 27.6 | 99% | 89% | Spelthorne |
| SP4 | 27.0 | 30.1 | 27.6 | 111% | 102% | Spelthorne |
| SP5 | 37.0 | 29.6 | 26.8 | 80% | 72% | Spelthorne |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| SP6 | 24.0 | 23.0 | 20.6 | 96% | 86% | Spelthorne |
| SP10 | 35.0 | 30.2 | 27.9 | 86% | 80% | Spelthorne |
| SP11 | 35.0 | 27.8 | 25.1 | 79% | 72% | Spelthorne |
| SP12 | 31.0 | 25.9 | 23.0 | 84% | 74% | Spelthorne |
| SP14 | 25.0 | 31.7 | 29.1 | 127% | 116% | Spelthorne |
| SP16 | 26.0 | 34.7 | 30.7 | 133% | 118% | Spelthorne |
| SP17 | 26.0 | 34.7 | 30.7 | 133% | 118% | Spelthorne |
| SP18 | 27.0 | 34.7 | 30.7 | 129% | 114% | Spelthorne |
| SP19 | 32.0 | 35.9 | 32.5 | 112% | 102% | Spelthorne |
| SP20 | 32.0 | 25.2 | 23.1 | 79% | 72% | Spelthorne |
| SP21 | 26.0 | 24.5 | 21.5 | 94% | 83% | Spelthorne |
| SP23 | 23.0 | 25.5 | 21.9 | 111% | 95% | Spelthorne |
| SP24 | 27.0 | 33.2 | 29.5 | 123% | 109% | Spelthorne |
| SP26 | 28.0 | 34.4 | 31.6 | 123% | 113% | Spelthorne |
| SP27 | 31.0 | 29.0 | 25.6 | 94% | 83% | Spelthorne |
| SP28 | 35.0 | 31.7 | 28.3 | 91% | 81% | Spelthorne |
| SP29 | 44.0 | 34.1 | 30.1 | 78% | 68% | Spelthorne |
| SP31 | 36.0 | 33.4 | 30.1 | 93% | 84% | Spelthorne |
| SP32 | 29.0 | 29.0 | 25.4 | 100% | 88% | Spelthorne |
| SP33 | 34.0 | 36.4 | 30.3 | 107% | 89% | Spelthorne |
| SP34 | 38.0 | 28.5 | 25.4 | 75% | 67% | Spelthorne |
| SP35 | 37.0 | 35.8 | 29.1 | 97% | 79% | Spelthorne |
| SP36 | 40.0 | 25.3 | 23.5 | 63% | 59% | Spelthorne |
| SP38 | 24.0 | 25.8 | 22.9 | 108% | 95% | Spelthorne |
| SP39 | 25.0 | 25.0 | 22.3 | 100% | 89% | Spelthorne |
| SP41 | 30.0 | 23.9 | 21.6 | 80% | 72% | Spelthorne |
| SP43 | 33.0 | 38.4 | 31.4 | 116% | 95% | Spelthorne |
| SP44 | 33.0 | 38.4 | 31.4 | 116% | 95% | Spelthorne |
| SP45 | 33.0 | 38.4 | 31.4 | 116% | 95% | Spelthorne |
| SP46 | 31.0 | 28.0 | 25.4 | 90% | 82% | Spelthorne |
| SP47 | 25.0 | 24.6 | 22.4 | 98% | 90% | Spelthorne |
| SP48 | 30.0 | 35.9 | 31.9 | 120% | 106% | Spelthorne |
| SP49 | 29.0 | 42.1 | 32.3 | 145% | 111% | Spelthorne |
| SP50 | 33.0 | 31.2 | 28.2 | 95% | 85% | Spelthorne |
| SP51 | 37.0 | 36.4 | 32.4 | 98% | 88% | Spelthorne |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| SP52 | 32.0 | 32.1 | 29.5 | 100% | 92% | Spelthorne |
| SP53 | 29.0 | 25.9 | 23.4 | 89% | 81% | Spelthorne |
| SP55 | 33.0 | 26.4 | 23.8 | 80% | 72% | Spelthorne |
| SP56 | 21.0 | 25.5 | 24.7 | 121% | 118% | Spelthorne |
| SP57 | 33.0 | 23.9 | 22.2 | 72% | 67% | Spelthorne |
| CM1 | 35.6 | 35.3 | 27.0 | 99% | 76% | Surrey Heath |
| SH1 | 14.3 | 23.2 | 19.4 | 162% | 136% | Surrey Heath |
| SH2 | 18.6 | 22.2 | 19.2 | 119% | 103% | Surrey Heath |
| SH3 | 12.6 | 20.3 | 17.7 | 161% | 140% | Surrey Heath |
| SH4 | 20.7 | 17.6 | 16.7 | 85% | 81% | Surrey Heath |
| SH5 | 18.6 | 38.6 | 30.2 | 208% | 162% | Surrey Heath |
| SH6 | 19.5 | 21.6 | 20.0 | 111% | 103% | Surrey Heath |
| SH7 | 27.9 | 37.3 | 32.7 | 134% | 117% | Surrey Heath |
| SH8 | 15.8 | 27.4 | 22.0 | 173% | 139% | Surrey Heath |
| SH9 | 15.6 | 24.3 | 20.0 | 156% | 128% | Surrey Heath |
| SH10 | 21.2 | 22.2 | 20.2 | 105% | 95% | Surrey Heath |
| SH11 | 21.3 | 24.0 | 21.1 | 113% | 99% | Surrey Heath |
| SH12 | 21.6 | 22.0 | 19.6 | 102% | 91% | Surrey Heath |
| SH13 | 20.0 | 25.4 | 23.2 | 127% | 116% | Surrey Heath |
| SH14 | 21.5 | 31.3 | 28.6 | 146% | 133% | Surrey Heath |
| SH15 | 23.8 | 35.3 | 27.0 | 148% | 113% | Surrey Heath |
| SH16 | 24.3 | 35.2 | 28.3 | 145% | 116% | Surrey Heath |
| SH17 | 14.6 | 19.8 | 18.7 | 136% | 128% | Surrey Heath |
| SH20 | 16.7 | 19.7 | 18.4 | 118% | 110% | Surrey Heath |
| SH21 | 13.8 | 18.3 | 17.3 | 133% | 125% | Surrey Heath |
| SH22 | 24.7 | 35.3 | 27.0 | 143% | 109% | Surrey Heath |
| SH23 | 17.3 | 20.8 | 19.5 | 120% | 113% | Surrey Heath |
| SH24 | 22.2 | 35.6 | 33.2 | 160% | 150% | Surrey Heath |
| SH25 | 23.4 | 35.3 | 27.0 | 151% | 115% | Surrey Heath |
| SH26 | 21.3 | 23.3 | 20.1 | 109% | 94% | Surrey Heath |
| SH27 | 23.2 | 24.7 | 22.7 | 106% | 98% | Surrey Heath |
| SH28 | 19.5 | 25.8 | 23.7 | 132% | 122% | Surrey Heath |
| SH29 | 14.0 | 26.7 | 22.2 | 191% | 159% | Surrey Heath |
| SH30 | 23.6 | 35.1 | 34.0 | 149% | 144% | Surrey Heath |
| SH31 | 19.0 | 39.3 | 30.5 | 207% | 161% | Surrey Heath |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| SH32 | 21.1 | 39.6 | 30.8 | 188% | 146% | Surrey Heath |
| SH33 | 24.6 | 41.1 | 32.3 | 167% | 131% | Surrey Heath |
| SH34 | 18.7 | 33.3 | 26.6 | 178% | 142% | Surrey Heath |
| SH35 | 19.5 | 32.5 | 30.1 | 167% | 154% | Surrey Heath |
| SH36 | 20.2 | 44.9 | 41.2 | 222% | 204% | Surrey Heath |
| SH37 | 20.9 | 32.6 | 26.1 | 156% | 125% | Surrey Heath |
| SH38 | 23.8 | 28.8 | 25.3 | 121% | 106% | Surrey Heath |
| TD5 | 29.0 | 31.0 | 31.0 | 107% | 107% | Tandridge |
| TD7 | 19.4 | 21.6 | 21.4 | 111% | 110% | Tandridge |
| TD8 | 19.3 | 21.7 | 21.7 | 112% | 112% | Tandridge |
| TD9 | 17.3 | 20.0 | 20.3 | 116% | 117% | Tandridge |
| TD14 | 26.9 | 24.8 | 22.8 | 92% | 85% | Tandridge |
| TD19 | 20.9 | 28.4 | 25.1 | 136% | 120% | Tandridge |
| TD23 | 23.4 | 25.0 | 23.9 | 107% | 102% | Tandridge |
| TD25 | 18.7 | 23.0 | 21.5 | 123% | 115% | Tandridge |
| TD26 | 23.4 | 29.6 | 26.0 | 126% | 111% | Tandridge |
| TD27 | 28.8 | 30.2 | 30.0 | 105% | 104% | Tandridge |
| TD28 | 27.8 | 23.9 | 23.2 | 86% | 84% | Tandridge |
| TD30 | 21.8 | 21.2 | 21.7 | 97% | 100% | Tandridge |
| TD31 | 19.6 | 24.0 | 22.5 | 123% | 115% | Tandridge |
| TD32 | 22.0 | 22.2 | 22.1 | 101% | 101% | Tandridge |
| TD33 | 25.0 | 22.5 | 20.6 | 90% | 82% | Tandridge |
| TD34 | 20.3 | 19.5 | 19.4 | 96% | 96% | Tandridge |
| TD35 | 26.7 | 26.8 | 26.2 | 100% | 98% | Tandridge |
| TD36 | 24.8 | 23.3 | 21.6 | 94% | 87% | Tandridge |
| TD37 | 19.1 | 22.9 | 22.1 | 120% | 116% | Tandridge |
| TD38 | 25.1 | 25.2 | 24.5 | 100% | 98% | Tandridge |
| TD39 | 26.5 | 21.4 | 21.4 | 81% | 81% | Tandridge |
| TD40 | 33.0 | 25.7 | 25.4 | 78% | 77% | Tandridge |
| TANWI_001 | 23.2 | 22.6 | 22.1 | 97% | 95% | Tandridge |
| TANWI_002 | 31.4 | 22.6 | 22.1 | 72% | 70% | Tandridge |
| TANWI_003 | 42.1 | 30.2 | 28.9 | 72% | 69% | Tandridge |
| TANWI_004 | 26.0 | 33.2 | 31.6 | 128% | 121% | Tandridge |
| TANWI_005 | 41.4 | 27.0 | 26.1 | 65% | 63% | Tandridge |
| TANWI_006 | 24.6 | 24.6 | 24.0 | 100% | 98% | Tandridge |

| Site ID | Concentration, µg/m³ | | | Gatwick Modelled / Monitored ratio | Heathrow Modelled / Monitored ratio | Borough |
|---|---|---|---|---|---|---|
| | Monitored | Gatwick | Heathrow | | | |
| WOK_LTK | 24.6 | 23.1 | 21.6 | 94% | 88% | Woking |
| WOK_LT1 | 34.6 | 21.8 | 20.5 | 63% | 59% | Woking |
| WOK_M25 | 42.8 | 65.7 | 58.3 | 154% | 136% | Woking |
| WOK_CR | 20.9 | 23.1 | 21.4 | 111% | 102% | Woking |
| WOK_RC | 18.2 | 18.8 | 17.9 | 103% | 98% | Woking |
| WOK_AH1 | 34.6 | 31.0 | 27.2 | 90% | 79% | Woking |
| WOK_AH2 | 31.9 | 29.5 | 25.9 | 92% | 81% | Woking |
| WOK_AH3 | 22.8 | 28.4 | 25.0 | 125% | 110% | Woking |
| WOK_AH4 | 27.3 | 22.8 | 20.2 | 84% | 74% | Woking |
| WOK_AH5 | 26.4 | 27.2 | 24.6 | 103% | 93% | Woking |
| WOK_AH6 | 29.1 | 27.9 | 25.5 | 96% | 88% | Woking |
| WOK_LGR | 23.7 | 20.1 | 19.2 | 85% | 81% | Woking |
| WOK_LD | 17.3 | 19.6 | 18.5 | 113% | 107% | Woking |
| WOK_VW | 31.9 | 30.7 | 28.4 | 96% | 89% | Woking |
| WOK_BD | 15.5 | 18.4 | 17.3 | 119% | 112% | Woking |
| WOK_BR | 24.6 | 22.2 | 20.9 | 90% | 85% | Woking |
| WOK_BR1 | 22.8 | 22.2 | 20.5 | 97% | 90% | Woking |
| WOK_PR | 22.8 | 23.4 | 21.2 | 103% | 93% | Woking |
| WOK_GR | 26.4 | 22.3 | 21.3 | 84% | 81% | Woking |
| WOK_MR | 31.9 | 27.2 | 24.9 | 85% | 78% | Woking |
| WOK_MR2 | 28.2 | 27.2 | 24.9 | 96% | 88% | Woking |
| WOK_CH | 37.3 | 33.2 | 29.2 | 89% | 78% | Woking |
| WOK_CH2 | 41.9 | 31.4 | 29.0 | 75% | 69% | Woking |
| WOK_CH3 | 41.9 | 33.0 | 30.8 | 79% | 74% | Woking |
| WOK_CH4 | 38.2 | 34.9 | 32.3 | 91% | 85% | Woking |
| WOK_TC | 26.4 | 27.1 | 26.3 | 103% | 100% | Woking |
| WOK_OR | 25.5 | 21.0 | 19.6 | 82% | 77% | Woking |
| WOK_YR | 24.6 | 28.5 | 26.8 | 116% | 109% | Woking |
| WOK_YR1 | 25.5 | 31.4 | 29.2 | 123% | 115% | Woking |
| WOK_TW | 13.7 | 18.1 | 17.0 | 132% | 124% | Woking |
| WOK_CW | 21.8 | 18.0 | 17.0 | 83% | 78% | Woking |
| WOK_BW | 21.8 | 18.7 | 17.6 | 86% | 81% | Woking |

# Appendix B: Model verification using Gatwick Airport meteorological data

Appendix B presents figures and tables for model verification data using Gatwick Airport meteorological data. Appendix B consists of:

1. Figure B.1: Presents a wind rose showing the frequency of occurrence of wind from different directions for a number of wind speed ranges for Gatwick Airport
2. Table B.1: Summarises the meteorological data from Gatwick Airport. To take account of the different surface characteristics at Gatwick, compared to the modelled area, a surface roughness of 0.2m was assumed for the meteorological station
3. Table B.2: Summarises background data calculated using Gatwick wind data
4. Figure B.2: A scatter plot modelled against monitored $NO_2$ concentrations at all monitoring sites
5. Table B.3: A summary of statistics by type of monitor
6. Figure B.3: A box plots comparing the spread of modelled against monitored hourly mean $NO_2$ concentrations at continuous monitoring sites.
7. Figure B.4: A box plots comparing the spread of modelled against monitored hourly mean $NO_x$ concentrations at continuous monitoring sites.
8. Figure B.5: A box plots comparing the spread of modelled against monitored hourly mean $PM_{10}$ concentrations at continuous monitoring sites.
9. Figure B.6: A box plots comparing the spread of modelled against monitored hourly mean $PM_{2.5}$ concentrations at continuous monitoring sites
10. Table B.4: A table summarising monitored and modelled $NO_x$, $NO_2$, $PM_{10}$ and $PM_{2.5}$ for all continuous monitoring sites. Using Gatwick meteorological data.

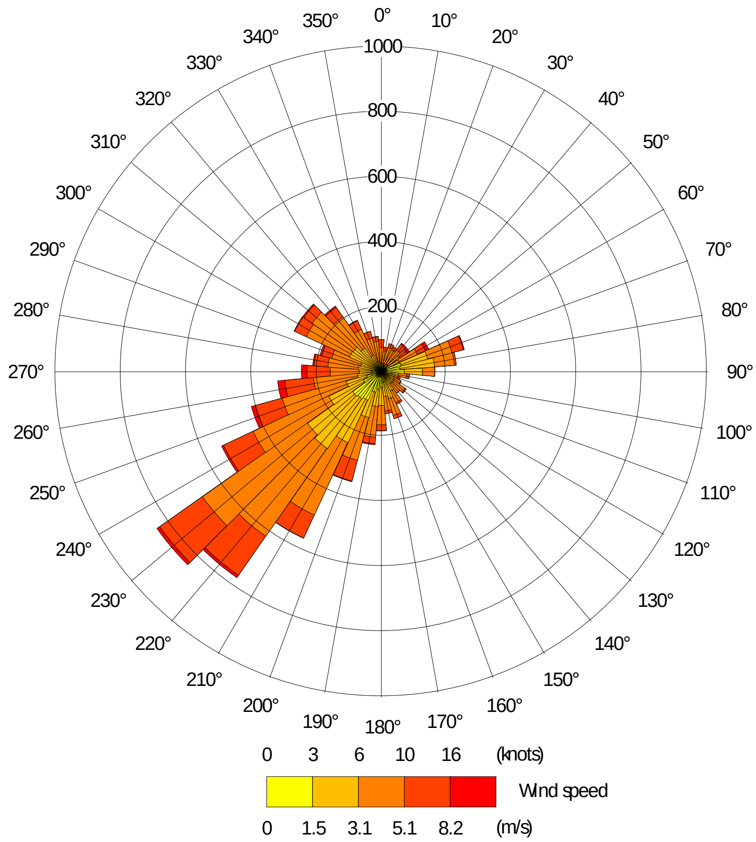


***Figure B.1: Wind rose for Gatwick 2017***

***Table B.1: Summary of Gatwick Airport meteorological data***

| Year | % of hours used | Parameter | Minimum | Maximum | Mean |
|---|---|---|---|---|---|
| 2017 | 99.7 | Temperature (°C) | -6 | 32 | 11.3 |
| | | Wind speed (m/s) | 0 | 16.5 | 3.5 |
| | | Cloud cover (oktas) | 0 | 8 | 3 |

***Table B.2: Summary of 2017 background data (µg/m$^3$), calculated using wind data from Gatwick Airport***

| Statistic | $NO_x$ | $NO_2$ | $O_3$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ |
|---|---|---|---|---|---|---|
| Annual average | 15.5 | 11.7 | 52.0 | 14.7 | 8.7 | 0.9 |
| 99.79$^{th}$ percentile of hourly average | 255.2 | 74.6 | 112.4 | - | - | - |
| 90.41$^{st}$ percentile of 24-hour average | - | - | - | 26.5 | 18.8 | 1.4 |

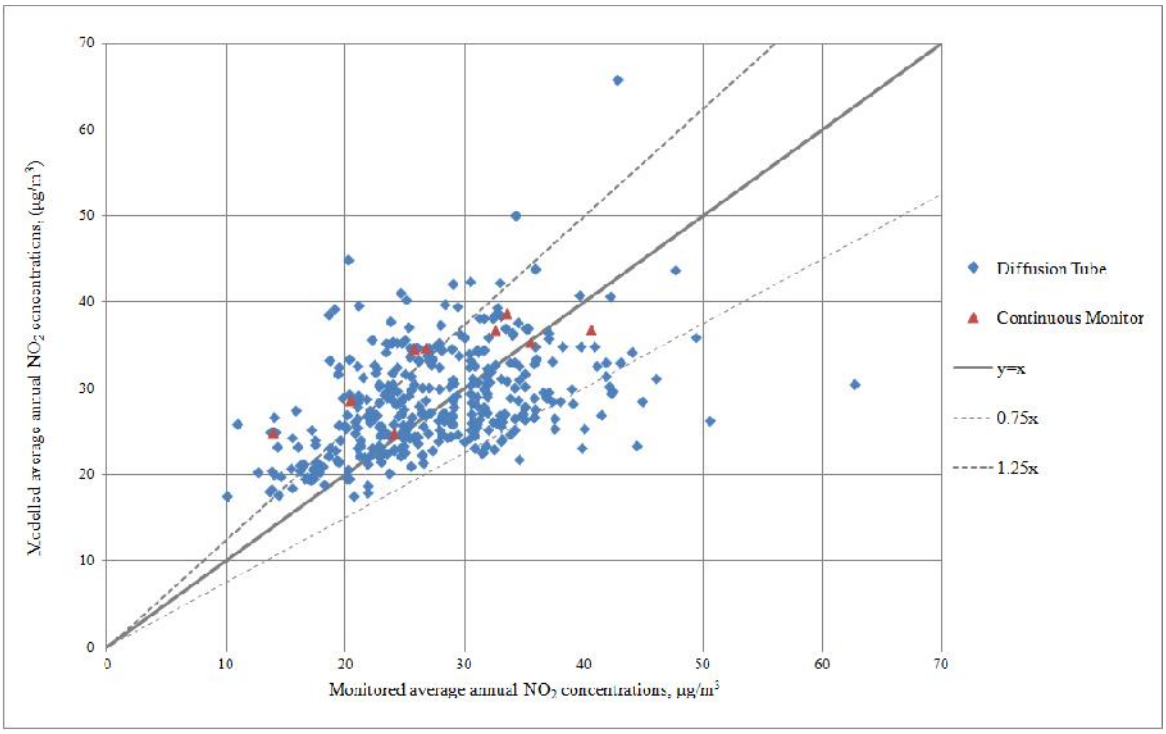


***Figure B.2: Surrey measured and modelled annual average $NO_2$ concentrations using Gatwick meteorological data***

***Table B.3: Model verification statistics for $NO_2$ concentrations using Gatwick Airport meteorological data***

| Gatwick | Min | Max | Mean | Count | Modelled / Monitored | <0.75 | >0.75 <1.25 | >1.25 | % >0.75<1.25 |
|---|---|---|---|---|---|---|---|---|---|
| Diffusion tubes | 17.5 | 65.7 | 28.7 | 367 | 1.10 | 29 | 245 | 93 | 67 |
| Continuous monitors | 24.8 | 38.6 | 32.8 | 9 | 1.23 | 0 | 5 | 4 | 56 |
| All monitors | 17.5 | 65.7 | 28.8 | 376 | 1.10 | 29 | 250 | 97 | 67 |

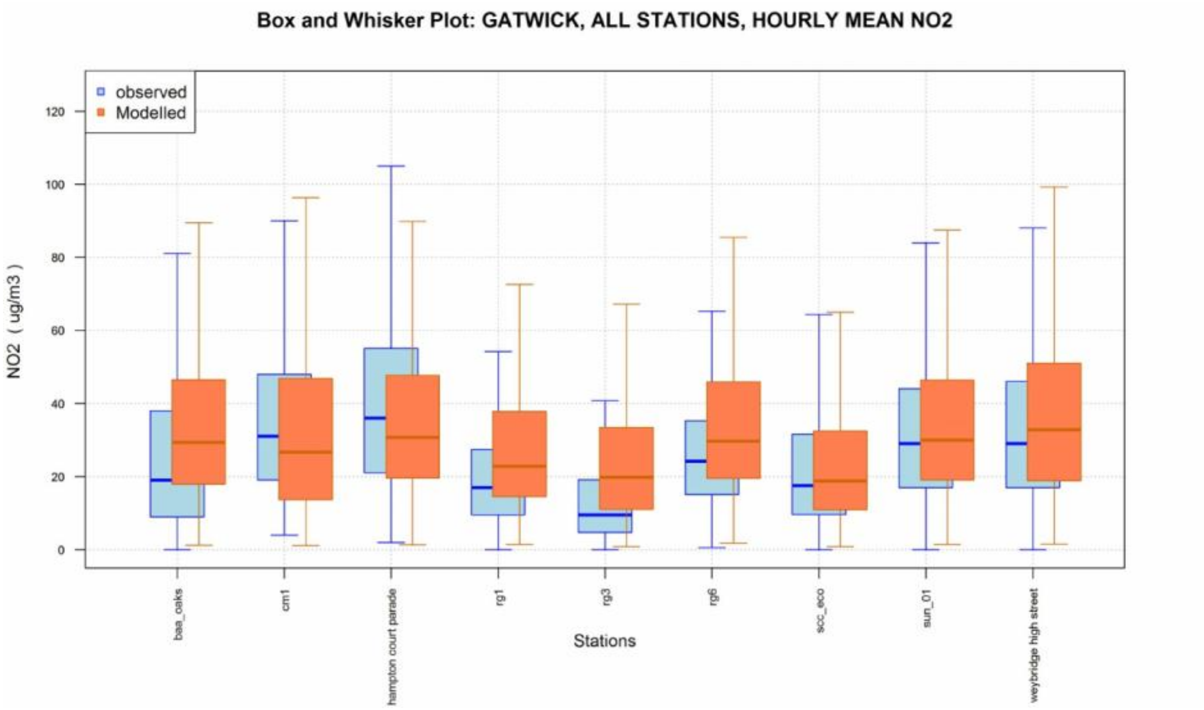


***Figure B.3: Surrey measured and modelled annual average $NO_2$ concentrations at continuous monitoring sites using Gatwick meteorologcial data***

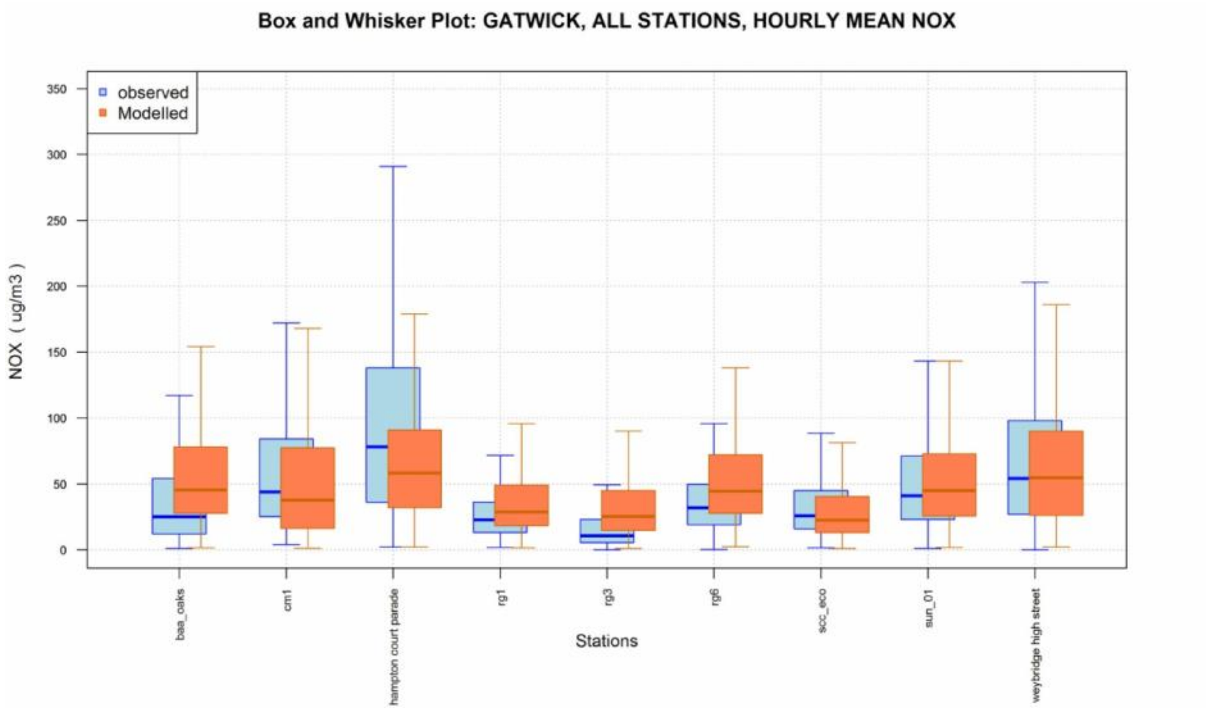


*Figure B.4: Surrey measured and modelled annual average $NO_x$ concentrations at continuous monitoring sites using Gatwick meteorologcial data*

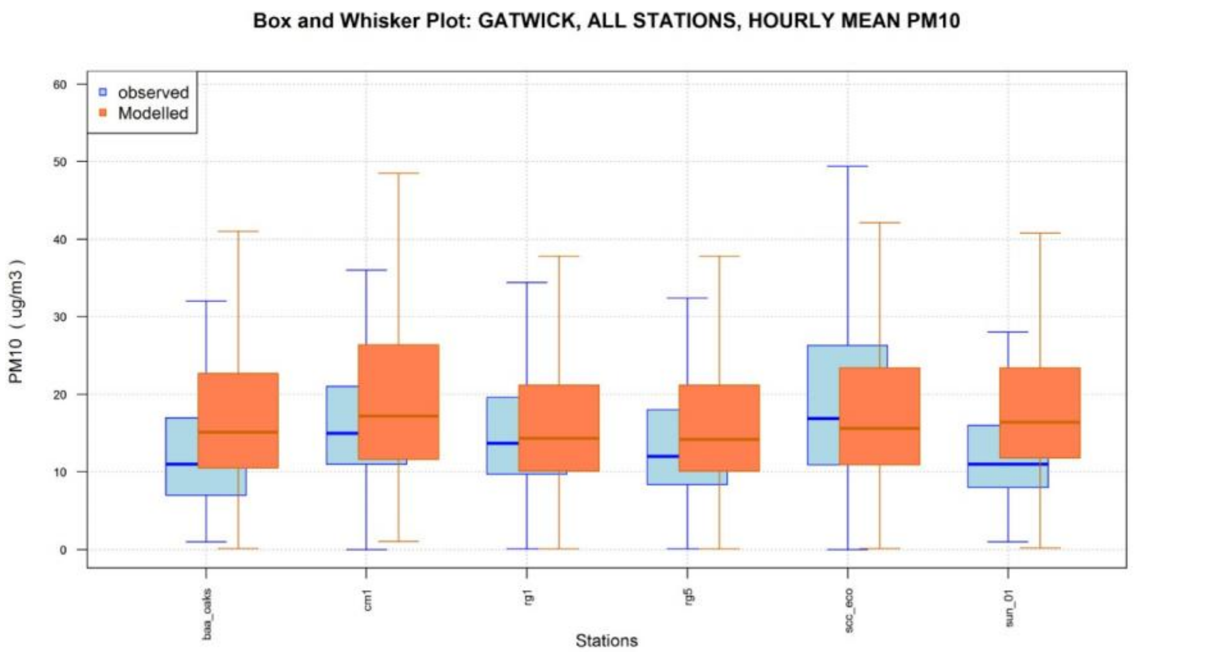


*Figure B.5: Surrey measured and modelled annual average $PM_{10}$ concentrations at continuous monitoring sites using Gatwick meteorological data*

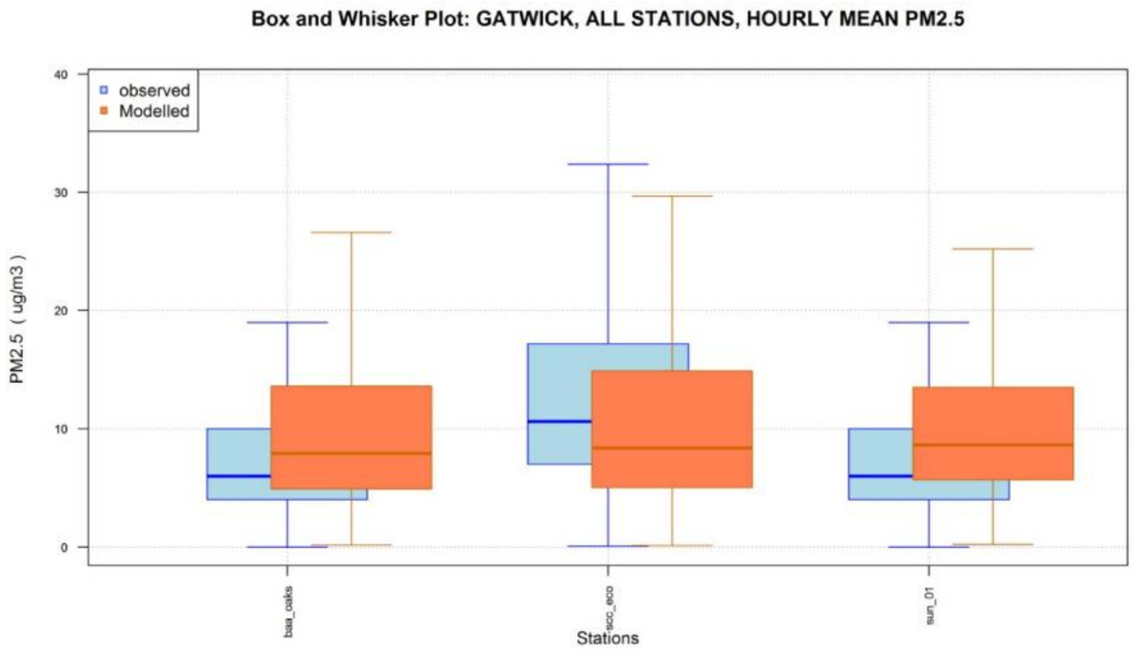


***Figure B.6: Surrey measured and modelled annual average $PM_{2.5}$ concentrations at continuous monitoring sites using Gatwick meteorological data***

***Table B.4: Surrey measured and modelled annual average $NO_x$, $NO_2$, $PM_{10}$ and $PM_{2.5}$ concentrations at continuous monitoring sites using Gatwick meteorological data***

| Site ID | Monitored concentration, µg/m³ | | | | Modelled concentration, µg/m³ | | | | Modelled / Monitored (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ | $NO_x$ | $NO_2$ | $PM_{10}$ | $PM_{2.5}$ |
| BAA_Oaks | 47.1 | 25.8 | 14.1 | 9.2 | 67.3 | 34.6 | 19.2 | 12.0 | 143 | 134 | 136 | 131 |
| CM1 | 65.8 | 35.6 | 17.0 | - | 61.5 | 35.3 | 22.0 | - | 93 | 99 | 129 | - |
| Hampton Court Parade | 108.4 | 40.6 | - | - | 73.6 | 36.8 | - | - | 68 | 91 | - | - |
| RG1 | 34.1 | 20.4 | 16.2 | - | 43.8 | 28.7 | 17.7 | - | 128 | 141 | 109 | - |
| RG3 | 19.3 | 13.9 | - | - | 39.0 | 24.9 | - | - | 202 | 180 | - | - |
| RG5 | - | - | 15.2 | - | - | - | 17.7 | - | - | - | 116 | - |
| RG6 | 46.1 | 26.7 | - | - | 62.0 | 34.8 | - | - | 135 | 130 | - | - |
| SCC_ECO | 44.2 | 24.1 | 20.7 | 14.5 | 35.8 | 24.8 | 19.8 | 12.9 | 81 | 103 | 95 | 89 |
| SUN_01 | 58.6 | 32.5 | 13.1 | 8.0 | 60.9 | 36.7 | 19.6 | 11.3 | 104 | 113 | 149 | 141 |
| Weybridge High Street | 77.5 | 33.5 | - | - | 70.3 | 38.6 | - | - | 91 | 115 | - | - |

# APPENDIX C: Summary of ADMS-Urban

ADMS-Urban is a scientifically advanced but practical air pollution modelling tool, which has been developed to provide high resolution calculations of pollution concentrations for all sizes of study area relevant to the urban environment. The model can be used to look at concentrations near a single road junction or over a region extending across the whole of a major city. ADMS-Urban has been extensively used for the Review and Assessment of Air Quality carried out by Local Authorities in the UK and for a wide range of planning and policy studies across the world. The following is a summary of the capabilities and validation of ADMS-Urban. More details can be found on the CERC web site at www.cerc.co.uk.

ADMS-Urban is a development of the Atmospheric Dispersion Modelling System (ADMS), which has been developed to investigate the impacts of emissions from industrial facilities. ADMS-Urban allows full characterisation of the wide variety of emissions in urban areas, including an extensively validated road traffic emissions model. It also includes a number of other features, which include consideration of:

- the effects of vehicle movement on the dispersion of traffic emissions;
- the behaviour of material released into street-canyons;
- the chemical reactions occurring between nitrogen oxides, ozone and Volatile Organic Compounds (VOCs);
- the pollution entering a study area from beyond its boundaries;
- the effects of complex terrain on the dispersion of pollutants; and
- the effects of a building on the dispersion of pollutants emitted nearby.

Further details of these features are provided below.

Studies of extensive urban areas are necessarily complex, requiring the manipulation of large amounts of data. To allow users to cope effectively with this requirement, ADMS-Urban runs in Windows 10, Windows 8, Windows 7 and Windows Vista environments. The manipulation of data is further facilitated by the possible integration of ADMS-Urban with a Geographical Information System (GIS) (MapInfo, ArcGIS, or the ADMS-Mapper) and the CERC Emissions Inventory Toolkit, EMIT.

***Dispersion Modelling***

ADMS and ADMS-Urban use boundary layer similarity profiles to parameterise the variation of turbulence with height within the boundary layer, and the use of a skewed-Gaussian distribution to determine the vertical variation of pollutant concentrations in the plume under convective conditions.

The main dispersion modelling features of ADMS-Urban are as follows:

- ADMS-Urban is an **advanced dispersion model** in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the surface. This method supersedes methods based on Pasquill Stability Categories, as used in, for example, Caline and ISC. Concentrations are calculated hour by hour and are fully dependent on prevailing weather conditions.
- For convective conditions, a **non-Gaussian vertical profile of concentration** allows for the skewed nature of turbulence within the atmospheric boundary layer, which can lead to high concentrations near to the source.
- A **meteorological pre-processor** calculates boundary layer parameters from a variety of input data, typically including date and time, wind speed and direction, surface temperature and cloud cover. Meteorological data may be raw, hourly averaged or statistically analysed data.

***Emissions***

Emissions into the atmosphere across an urban area typically come from a wide variety of sources. There are likely to be industrial emissions from chimneys as well as emissions from road traffic and domestic heating systems. To represent the full range of emissions configurations, the explicit source types available within ADMS-Urban are:

- **Roads**, for which emissions are specified in terms of vehicle flows and the additional initial dispersion caused by moving vehicles is also taken into account.
- **Industrial points**, for which plume rise and stack downwash are included in the modelling.
- **Areas**, where a source or sources is best represented as uniformly spread over an area.
- **Volumes**, where a source or sources is best represented as uniformly spread throughout a volume.

In addition, sources can also be modelled as a regular grid of emissions. This allows the contributions of large numbers of minor sources to be efficiently included in a study while the majority of the modelling effort is used for the relatively few significant sources.

ADMS-Urban can be used in conjunction with CERC's Emissions Inventory Toolkit, EMIT, which facilitates the management and manipulation of large and complex data sets into usable emissions inventories.

***Presentation of Results***

The results from the model can be based on a wide range of averaging times, and include rolling averages. Maximum concentration values and percentiles can be calculated where appropriate meteorological input data have been input to the model. This allows ADMS-Urban to be used to calculate concentrations for direct comparison with existing air quality limits, guidelines and objectives, in whatever form they are specified.

ADMS-Urban can be integrated with the ArcGIS or MapInfo to facilitate both the compilation and manipulation of the emissions information required as input to the model and the interpretation and presentation of the air quality results provided.

***Complex Effects - Street Canyons***

ADMS-Urban incorporates two methods for representing the effect of street canyons on the dispersion of road traffic emissions: a basic canyon method based on the *Operational Street Pollution Model (OSPM)*[21], developed by the Danish National Environmental Research Institute (NERI); and an advanced street canyon module, developed by CERC. The basic canyon model was designed for simple symmetric canyons with height similar to width and assumes that road traffic emissions originate throughout the base of the canyon, i.e. that the emissions are spread across both the road and neighbouring pavements.

The advanced canyon model[22] was developed to overcome these limitations and is our model of choice. It represents the effects of channelling flow along and recirculating flow across a street canyon, dispersion out of the canyon through gaps in the walls, over the top of the buildings or out of the end of the canyon. It can take into account canyon asymmetry and restricts the emissions area to the road carriageway.

***Complex Effects - Chemistry***

ADMS-Urban includes the *Generic Reaction Set (GRS)*[23] atmospheric chemistry scheme. The original scheme has seven reactions, including those occurring between nitrogen oxides and ozone. The remaining reactions are parameterisations of the large number of reactions involving a wide range of Volatile Organic Compounds (VOCs). In addition, an eighth reaction has been included within ADMS-Urban for the situation when high concentrations of nitric oxide (NO) can convert to nitrogen dioxide ($NO_2$) using molecular oxygen.

In addition to the basic GRS scheme, ADMS-Urban also includes a trajectory model[24] for use when modelling large areas. This permits the chemical conversions of the emissions and background concentrations upwind of each location to be properly taken into account.

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[21] Hertel, O., Berkowicz, R. and Larssen, S., 1990, 'The Operational Street Pollution Model (OSPM).' *18th International meeting of NATO/CCMS on Air Pollution Modelling and its Applications.* Vancouver, Canada, pp741-749.

[22] Hood C, Carruthers D, Seaton M, Stocker J and Johnson K, 2014. *Urban canopy flow field and advanced street canyon modelling in ADMS-Urban.*16th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Varna, Bulgaria, September 2014. http://www.harmo.org/Conferences/Proceedings/_Varna/publishedSections/H16-067-Hood-EA.pdf

[23] Venkatram, A., Karamchandani, P., Pai, P. and Goldstein, R., 1994, 'The Development and Application of a Simplified Ozone Modelling System.' *Atmospheric Environment,* Vol 28, No 22, pp3665-3678.

[24] Singles, R.J., Sutton, M.A. and Weston, K.J., 1997, 'A multi-layer model to describe the atmospheric transport and deposition of ammonia in Great Britain.' In: *International Conference on Atmospheric Ammonia: Emission, Deposition and Environmental Impacts. Atmospheric Environment*, Vol 32, No 3.

### *Complex Effects - Terrain*

As well as the effect that complex terrain has on wind direction and, consequently, pollution transport, it can also enhance turbulence and therefore increase dispersion. These effects are taken into account in ADMS-Urban using the FLOWSTAR[25] model developed by CERC.

### *Data Comparisons – Model Validation*

ADMS-Urban is a development of the Atmospheric Dispersion Modelling System (ADMS), which is used throughout the UK by industry and the Environment Agency to model emissions from industrial sources. ADMS has been subject to extensive validation, both of individual components (e.g. point source, street canyon, building effects and meteorological pre-processor) and of its overall performance.

ADMS-Urban has been extensively tested and validated against monitoring data for large urban areas in the UK and overseas, including London, Birmingham, Manchester, Glasgow, Riga, Cape Town, Hong Kong and Beijing, during projects supported by local governments and research organisations. A summary of published model validation studies is available at www.cerc.co.uk/Validation, with other publications available at www.cerc.co.uk/publications.

[25] Carruthers D.J., Hunt J.C.R. and Weng W-S. 1988. 'A computational model of stratified turbulent airflow over hills – FLOWSTAR I.' Proceedings of Envirosoft. In: *Computer Techniques in Environmental Studies,* P. Zanetti (Ed) pp 481-492. Springer-Verlag.