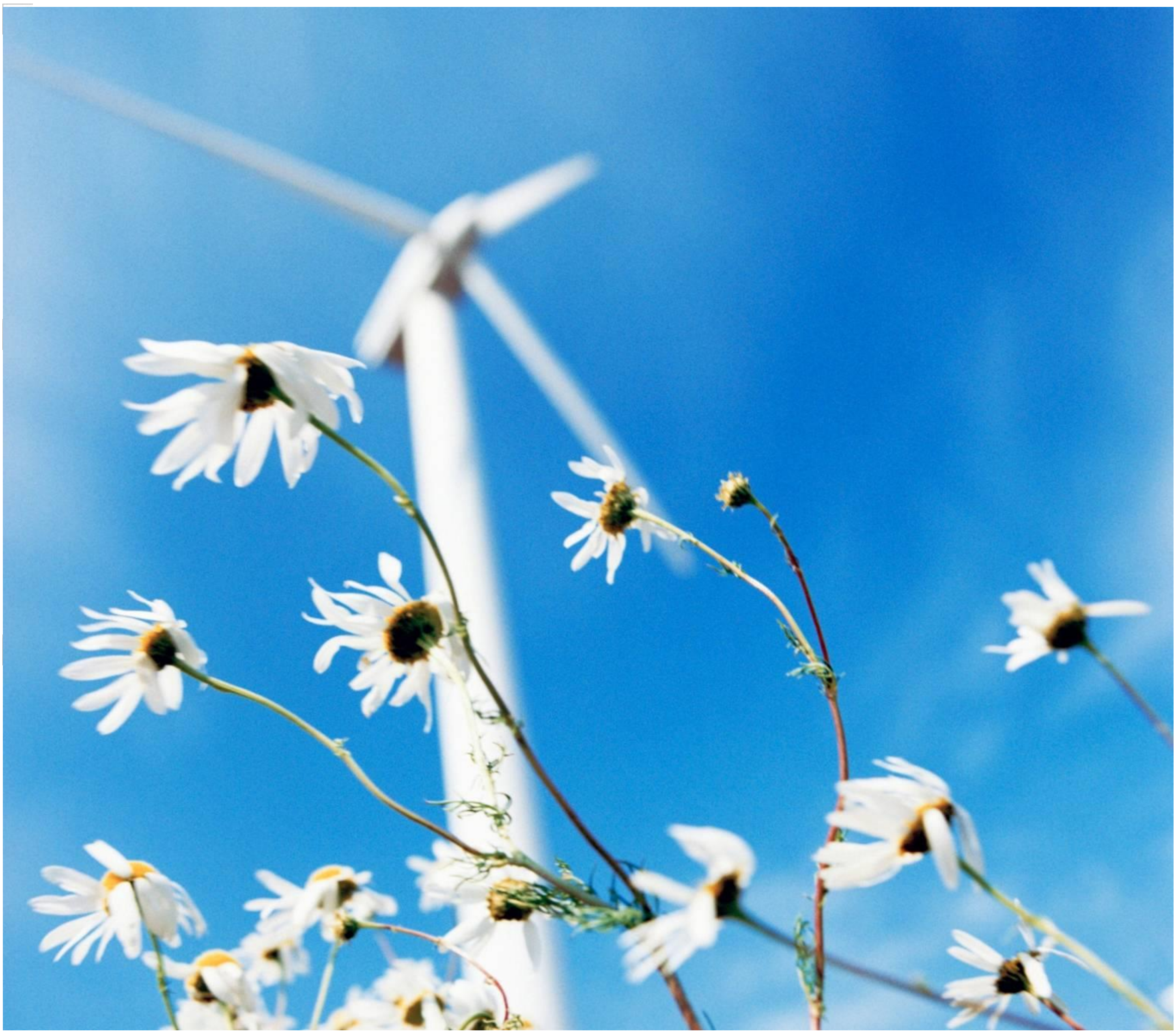
London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2015



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London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2015

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Capabilities on project:
Environment

1 Introduction

AECOM was commissioned by the London Borough of Lewisham to install and maintain a network of NO_2 diffusion tubes to assess the spatial variation of nitrogen dioxide (NO_2) concentration within the Borough. The diffusion tube network comprises of 34 NO_2 diffusion tubes at 32 locations. One of these locations is a triplicate site and the remaining locations are single sites. The diffusion tubes were exposed for periods of between 4 and 5 weeks in accordance with the UK NO_2 Survey Timetable. The results of the survey provide Lewisham Borough Council with valuable monitoring data for use in their Local Air Quality Review and Assessment (LAQM) process.

This report outlines the results of the survey for January 2015 to December 2015, inclusive. The spatial variation in NO_2 concentration throughout the Borough is discussed and the annual mean values for each location are compared against the annual mean objective for NO_2 to indicate locations that may be likely to exceed the objective. Monthly concentrations are examined for evidence of seasonal trends.

2 Legislative Background

Limit values and air quality objectives for nitrogen dioxide and oxides of nitrogen (NO_X) were set out in the First Daughter Directive (1999/30/EC) and subsequent revisions. An annual mean NO_2 objective was set at 40 µg/m^3 to be achieved by 1st January 2010. A 200 µg/m^3 hourly mean standard not to be exceeded more than 18 hours per year was also outlined, to be achieved by the same compliance date. These objectives were reiterated in the 2008 Directive on ambient air quality and cleaner air for Europe (2008/50/EC).

The UK has published its own Air Quality Strategy[1], which detailed the UK's position on nitrogen dioxide. The UK air quality objectives differ from the European objectives only in their compliance dates; the UK objectives were to be achieved by the end of 2005. European and UK air quality objectives have also been set for oxides of nitrogen for the protection of vegetation and ecosystems. A summary of the principal air quality objectives for NO_2 and NO_X is given in Table 1.

Table 1 UK and EU Air Quality Objectives for NO_2 and NO_X

Pollutant	UK Air Quality Objectives		
	Standard / Concentration	**Measured as**	**Date to be achieved by and maintained thereafter**
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times a year	1 Hour Mean	31.12.2005
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (for the protection of vegetation)	30 µg/m^3	Annual Mean	31.12.2000
	EU Air Quality Objectives		
	Standard / Concentration	**Measured as**	**Date to be achieved by and maintained thereafter**
Nitrogen Dioxide	200 µg/m^3 not to be exceeded more than 18 times per year	1 Hour Mean	1 January 2010
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (assuming as nitrogen dioxide)	30 µg/m^3	Annual Mean	19 July 2001

[1] Defra, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, 2007.

3 Monitoring Methodology

3.1 Description of Network

The Lewisham Diffusion Tube Network has been maintained by AECOM since January 2011. In 2011, the network consisted of 47 locations, in which one of these was a triplicate co-located site at the automatic monitoring stations in New Cross Road and the remaining were single sites, using a total 49 diffusion tubes. In 2012, the network was reduced to 34 diffusion tubes at 32 locations, comprising of single tubes at 31 locations and triplicates co-located at the New Cross Road continuous monitoring station. During 2015, diffusion tubes throughout the Borough have been deployed and collected at 4 to 5 weeks intervals in accordance with the UK NO_2 Diffusion Tube calendar[2].

The locations of the diffusion tubes are geographically illustrated in Appendix A.

3.2 Procedures and Site Changes

All diffusion tubes used in the network were stored in a refrigerator prior to deployment and after collection to reduce the possibility of degradation of the chemicals involved. Tubes subject to contamination (e.g. spider webs, foreign bodies, etc.) or vandalised have also been excluded from the final dataset.

In January 2015, the diffusion tube at Lawn Terrace (LWS 016) was moved to Montpelier Vale, on a lamppost outside the Aqua restaurant, for the start of the 2015 annual monitoring period.

3.3 Tube Preparation, Analysis and Laboratory QA/QC

The diffusion tubes were supplied and analysed by Gradko International Ltd, using a 50% triethanolamine (TEA) in acetone method. Gradko participates in the AIR Proficiency Testing (PT) scheme for diffusion tubes, operated by LGC Standards and supported by the Health and Safety Laboratory (HSL), which provides a Quality Assurance / Quality Control (QA/QC) framework for local authorities carrying out diffusion tube monitoring as a part of their local air quality management process. The percentage of results submitted from Gradko International Ltd which were subsequently determined to be satisfactory was 100% for all tests in AIR-PT Rounds AR001-AR010 (April 2014 - November 2015)[3].

3.4 Factors Affecting Diffusion Tube Performance

NO_2 diffusion tubes are an indicative monitoring technique, as they do not offer the same accuracy as the reference method for NO_2, the automatic chemiluminescent analyser. NO_2 diffusion tubes are affected by several factors, which may cause them to exhibit bias relative to the reference technique.

Over-estimation may be attributed to one of the following three interfering factors:

- The shortening of the diffusive path length caused by the wind;
- The blocking of UV light resulting in reduced NO_2 photolysis in the tube; and
- The interference effects of peroxyacetyl nitrate (PAN).

Under-estimation can be caused by the following factors:

- Increasing exposure period, and is thought to be due to degradation of the absorbed nitrate with time;
- Insufficient extraction of nitrite from the meshes;
- The photochemical degradation of the triethanolamine-nitrite complex by light, although this is minimised by the use of opaque end-caps; and

[2] Defra, Local Air Quality Management, Diffusion Tubes, Nitrogen Dioxide Diffusion Tube Monitoring, Calendar of Suggested Exposure Periods 2015. Available at http://laqm.defra.gov.uk/diffusion-tubes/data-entry.html
[3] Summary of Laboratory Performance in AIR NO2 Proficiency Testing
Scheme for Rounds AR001-AR010. Available at: http://laqm.defra.gov.uk/documents/LAQM-WASP-Round-124-and-AIR-PT-Rounds-1--10-(March-2014--November-2015)-NO2-report.pdf

- The solution used. For example, 50% solution of TEA in water has been reported to lead to comparatively reduced NO_2 uptake.

There are a number of additional factors that may also affect diffusion tube performance including time of the year, the exposure setting (i.e. sheltered or open sites), the proximity to roads, the preparation method and analytical laboratory used, the exposure concentration and the ratio of NO_2 to NO_X.

3.5 Data Validation and Data QA / QC

Validation of diffusion tube readings is vital to ensure public confidence in the measurements produced. Validation is achieved through the following steps described in sub-sections below.

3.5.1 Blanks

The laboratory reserved a set of diffusion tubes for use as laboratory blanks for each dispatches of tubes to the user. These are kept in sealed containers in a refrigerator and analysed with the exposed tubes to provide a measure of nitrite concentration on unexposed tubes.

One travelling blank was taken to site during each of the monthly changeovers. These tubes accompany the user during tubes changeover but are not themselves exposed. The purpose of using field blanks is to identify possible contamination of the tubes during transportation or in storage by the user.

Laboratory and field blanks were routinely screened by AECOM to ensure quality of data. Neither the laboratory blanks nor the travel blank results were subtracted from the results of exposed tubes, in accordance to the Local Air Quality Management Technical Guidance (LAQM.TG(09))[4] and the Diffusion Tube Practical Guidance.

3.5.2 Rejection of Diffusion Tube Results

Diffusion tube results obtained for each month were checked to meet the following criteria for inclusion in the final dataset:

- Correct calculation of exposure hours;
- Concentrations less than 3 $\mu g/m^3$ were rejected as these concentrations are unlikely to occur in an urban area.
- Concentrations at the high end were not routinely rejected unless good evidence can be shown to prove the spurious results.
- Exposure records were checked for possible explanation of any unusual results (e.g. foreign objects, bonfires, pollution episodes, construction works, tampering, etc.).
- For triplicate site, diffusion tube that exhibits poor precision (>20%) was excluded from the final dataset. For single sites, professional judgement was used to accept or reject the results based on observations made during site visits.

3.5.3 Bias Adjustment Factor

Diffusion tube monitoring is indicative and does not offer the same accuracy as the reference method for monitoring NO_2 i.e. using an automatic chemiluminescent analyser. Several factors could affect NO_2 concentrations measured with diffusion tubes, which may cause them to exhibit bias (over-read or under-read readings) relative to the reference method (see Section 3.4). To correct this bias, comparison of the NO_2 concentration as measured by diffusion tubes is made with continuous monitoring data to derive a bias-adjustment factor.

Bias adjustment factor can be obtained using the Nitrogen Dioxide Diffusion Tube Bias Adjustment spreadsheet[5], which is updated periodically and collates the bias-adjustment factors obtained in co-location studies conducted

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[4] Defra, Local Air Quality Management Technical Guidance LAQM.TG(09), 2009.

[5] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet (Version 03/16). Available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

nationally. It can also be derived locally through co-location of diffusion tubes with automatic analysers and compared the results obtained from both methods of monitoring.

Further details of the monitoring sites used and the derivation of the factor can be found in Appendix B and Appendix C. The local bias factor was applied to all diffusion tube results in the period unless indicated otherwise.

3.6 Site Designations

3.6.1 Site Designations

The designation of site types is used to compare different locations statistically. Sites were categorised as kerbside, roadside, near road (intermediate) and urban background sites according to the definitions given in Defra's Local Air Quality Management Technical Guidance (TG.16), April 2016[6]. These definitions are reproduced in Table 2 below.

Table 2 Site Type Designation Criteria

Type	Definition
Urban Centre	An urban location representative of typical population exposure in towns or city centres, for example, pedestrian precincts and shopping areas.
Urban Background	An urban location distanced from sources and therefore broadly representative of city-wide background conditions, e.g. urban residential areas. For example: > 50m from any major source of NO_2, such as multi-storey car parks; > 30m from any very busy road (> 30000 vehicles per day); > 20m from any busy road (10000 – 30000 vehicles per day); > 10m from any main road (quiet roads e.g. within residential estates are acceptable; and > 5m from any area where vehicles are likely to be idling.
Suburban	A location type situated in a residential area on the outskirts of a town or city
Roadside	A site sampling typically 1-5m of the kerb of a busy road (can be up to 15 m from kerb in some cases)
Kerbside	A site sampling within 1m of the kerb of a busy road
Industrial	An area where industrial sources make an important contribution to the total pollution burden
Rural	An open countryside location, in an area of low population density distanced as far as possible from roads, populated and industrial areas
Other	Any special source-orientated or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels

[6] Defra, Local Air Quality Management Technical Guidance (TG.16), April 2016

4 Results and Discussion

4.1 Data Capture

Data capture rates for the Lewisham Diffusion Tube Survey Network during 2014 were high, achieving an overall average of 96% for all site types. The lowest data capture for any site was 83% (2 months missing of out 12), which was reported at L2 (Bronze Street), L6 (Le May Avenue), L12 (Montague Avenue), SCH13 (Christ Church School, Perry Vale) and LWS 007 (New Cross AQM). There were 21 sites with 100% data capture.

Sites recording lower than 100% data capture were as a result of tubes being stolen, clips being vandalised or data not being included in the final dataset (see Section 3.5.2).

4.2 Bias Adjustment

4.2.1 Local Bias Adjustment Factor

The co-location site annual mean NO_2 concentrations measured by the diffusion tubes and the continuous monitors are displayed in Table 3.

The AEA Diffusion Tube Precision Accuracy Bias Spreadsheet[7] tool was used to calculate the local bias adjustment factor for the co-location site. Continuous monitoring data was sourced from the London Air Quality Network (LAQN) website[8]. Further details can be found in Appendix C.

The complete diffusion tube results without the application of a bias adjustment factor can be found in Appendix B.

Table 3 Comparisons of Diffusion Tube Measurement and Continuous Monitors at Co-located Site

Site Name	2015 Annual Mean NO_2 Concentration (µg/m^3)	
	Unadjusted Diffusion Tube	Continuous Monitor
Lewisham – New Cross	48.9	48.3

Monthly readings from the diffusion tubes were compared with concentration at Lewisham New Cross (Figure 1). An average bias adjustment factor of 1.02 was obtained. However, in calculating the local bias adjustment factor, it was clear that during the first three months, the monthly mean NO_2 concentrations reported by the automatic monitor (New Cross AQMS) were much greater than the monthly mean diffusion tube NO_2 concentrations, in contrast to the rest of the year when the diffusion tube NO_2 concentrations were greater than those from the AQMS. At locations close to sources of NO_X such as roadside and kerbside sites, within-tube chemical reactions of NO and O_3 have been found to result in over-reading in relation to reference method[9], and therefore the results shown in Figure 1 only resemble the expected pattern from April onwards.

4.2.2 National Bias Adjustment Factor

Although the local bias adjustment factor is greater than the local factors derived in recent years, it was recommended that the bias adjustment factor obtained from national co-location studies[10] be calculated, due to the contrast between the ratio of diffusion tube to AQMS concentrations for the first 3 months, compared to the rest of the year (as shown in Figure 1). The national bias adjustment factor for 2014 is 0.95 for the laboratory and preparation method, based on 9 studies (spreadsheet version 03/16).

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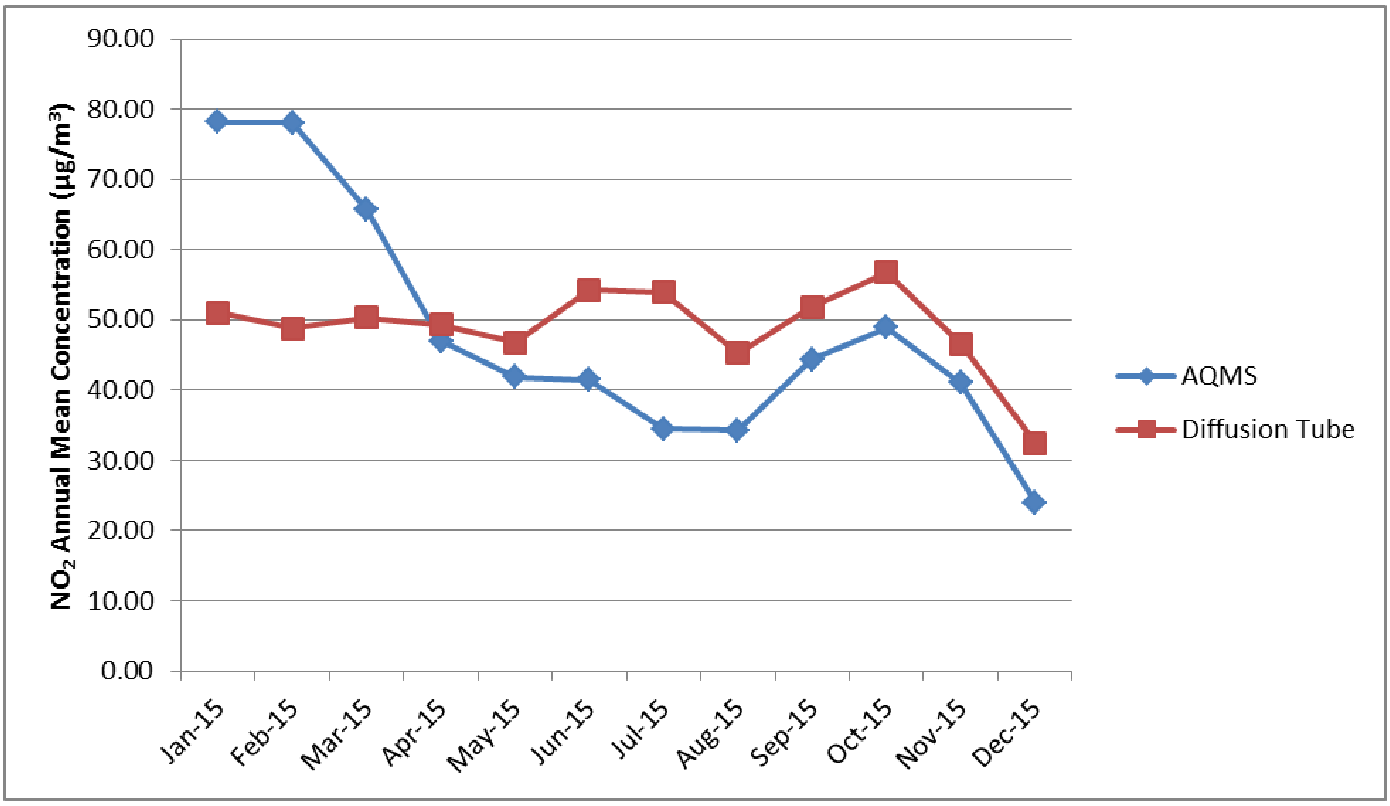
[7] AEA Diffusion Tube Precision Accuracy Bias Spreadsheet. Downloaded from http://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html 27/05/2016.

[8] London Air Quality Network Website. Available at http://www.londonair.org.uk.

[9] Cape, J.N., Review of the Use of Passive Diffusion Tubes for Measuring Concentrations of Nitrogen Dioxide in Air, 2005. Available at http://uk-air.defra.gov.uk/reports/cat05/0810141025_NO2_review.pdf

[10] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet, Spreadsheet Version Number: 03/14. Available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Figure 1: Comparisons of Chemiluminescent Analyser and Diffusion Tube Measurements at AQMS New Cross for 2015



4.3 Annual Mean NO_2 Concentrations

The mean NO_2 concentration over the whole network during 2015 was 37.0 µg/m^3 or, after applying a local bias adjustment of 1.02, 37.7 µg/m^3. The mean concentration calculated using the national bias adjustment factor was 35.1 µg/m^3; below the annual mean NO_2 objective of 40 µg/m^3. The maximum annual mean NO_2 concentration was measured at the LWS017 site at 9 Baring Road (58.6 µg/m^3 using the co-location study bias adjustment factor, or 54.6 µg/m^3 using the national bias adjustment factor). The second highest annual mean NO_2 concentration was measured at LWS016 at Montpelier Vale (57.1 µg/m^3 – co-location study bias adjusted or 53.2 µg/m^3 – national bias adjusted). LWS017 and LWS016 are both roadside sites.

Table 4 Annual Mean NO_2 Concentration (Bias Adjusted), 2015

Site Type	Annual Mean NO_2 Concentration (µg/m^3)		
	Raw	Bias Adjusted, using New Cross Co-located Tubes (Factor = 1.02)	Bias Adjusted, using National Bias Adjustment Factor (Factor = 0.95)
All Sites	37.0	37.7	35.1
Roadside	42.6	43.5	40.5
Urban Background	28.7	29.3	27.3

4.3.1 Comparison with Limit Values and Objectives

The air quality objectives and limit values of relevance to NO_2 in the UK are detailed in Section 2. The results in Table 4, obtained after applying the co-location study adjustment factor, indicate that the annual mean NO_2 objective of 40 µg/m^3 was not generally exceeded within the diffusion tube network during 2015. However, from Appendix B, it can be seen that bias-adjusted annual mean NO_2 concentrations, obtained after applying the co-location adjustment factor, were greater than 40 µg/m^3 at 14 of the 32 diffusion tube locations. Similarly, results based on the national bias adjustment factor show that 12 sites exceeded the NO_2 annual mean objective. These results may be partly due to the fact that concentrations at urban background sites were often considerably below the annual mean objective, whilst roadside sites generally exceeded the annual mean objective.

A report issued by Air Quality Consultants[11] analysed the relationship between annual mean and hourly mean NO_2 concentrations, concluding that locations where the annual mean concentration is greater than 60 µg/m^3 may be susceptible to breaches of the hourly mean objective (hourly mean NO_2 concentration of 200 µg/m^3 or more not to be exceeded more than 18 occasions per year). After bias adjustment, there are no sites with measured NO_2 concentrations greater than 60 µg/m^3 in 2015.

[11] Air Quality Consultants (2007). Deriving NO_2 from NO_X for Air Quality Assessments of Roads.

4.3.2 Seasonal Variation

The seasonal variation in NO_2 concentrations during 2015 are shown in Table 5 and Figure 2. Due to seasonal variations in the bias adjustment that can occur at diffusion tube sites, the results that have been presented are the raw concentrations with no bias adjustment applied.

The highest mean concentration occurred in October followed by September and then February at roadside sites. For urban background sites, the highest mean concentrations were measured during October and then January and February. Mean NO_2 concentrations were lowest in December, May and July for all site types.

Table 5 Monthly Mean NO_2 Concentrations in Lewisham, 2015 (µg/m^3; Unadjusted)

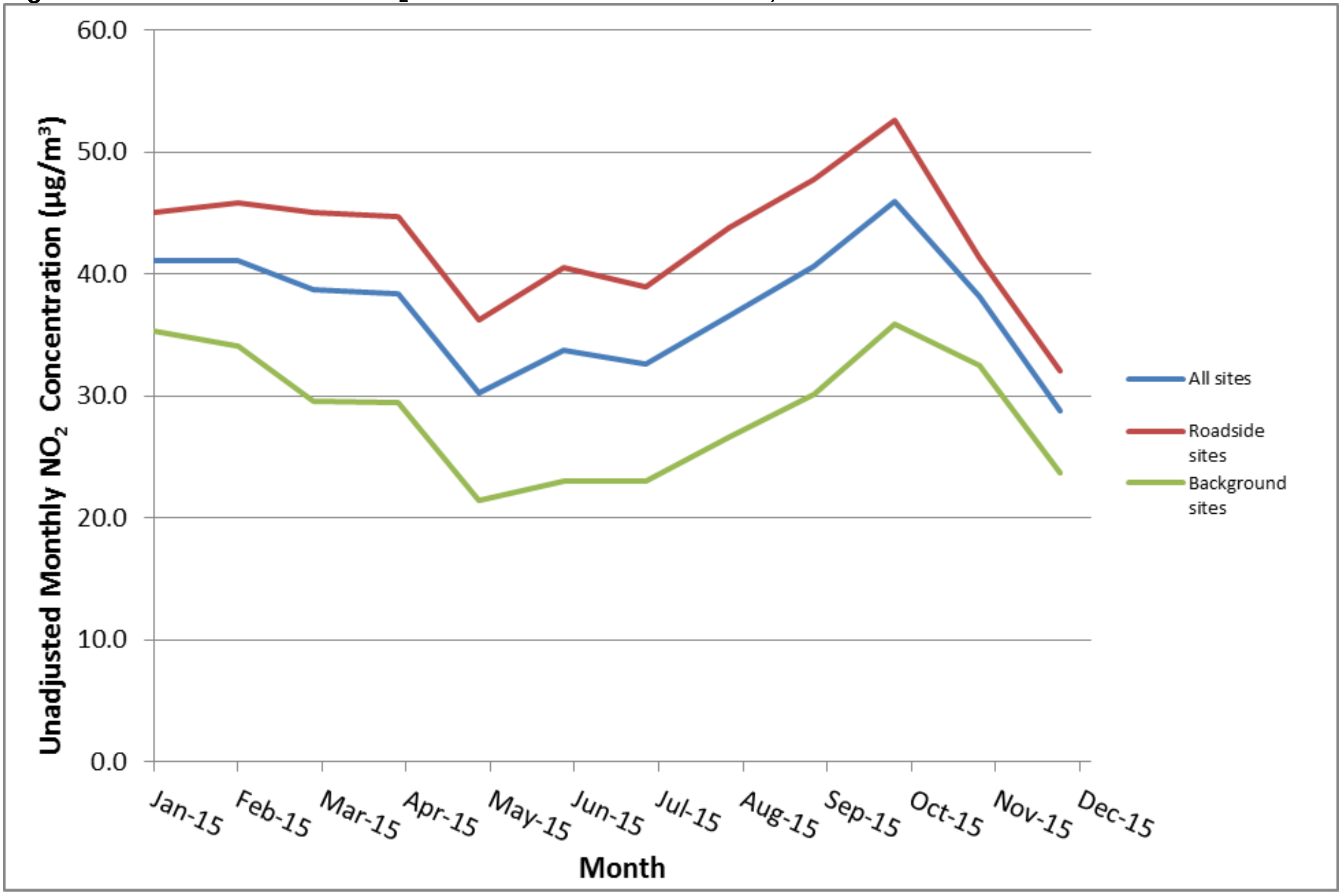
Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All Sites	**41.1**	**41.1**	38.8	38.4	30.2	33.7	32.6	36.6	**40.6**	**46.0**	38.1	28.8
Roadside	**45.0**	**45.9**	**45.0**	**44.7**	36.3	**40.5**	38.9	**43.8**	**47.8**	**52.7**	**41.4**	32.1
Urban Background	35.4	34.1	29.6	29.4	21.4	23.0	23.0	26.6	30.2	35.9	32.5	23.7

Table 6 Unadjusted Winter and Summer Period Mean Concentrations in Lewisham, 2015

Site Type	Winter Mean Concentration (October – March) (µg/m^3)	Summer Mean Concentration (April – September) (µg/m^3)	Ratio Winter : Summer
All Sites	39.0	35.4	1.1
Roadside	**43.7**	**42.0**	1.0
Urban Background	31.9	25.6	1.2

Table 6 shows that the ratio of winter to summer mean NO_2 concentration was 1.0 for roadside sites, indicating mean concentrations were similar in the winter and summer periods. The urban background sites display a higher winter: summer ratio compared to roadside sites indicating higher mean concentrations in winter than in summer periods. The value was 1.2 in 2015. For all sites, collectively, the ratio of winter to summer mean NO_2 concentration was 1.1.

Figure 2: Seasonal Trend of NO_2 Concentrations in Lewisham, 2015



4.4 Historical Trends

Table 7 summarises the results of the Lewisham Tube Network by site type from 2012 to 2015, results for each site in 2015 are detailed in Appendix B. These results have been bias adjusted and the factors can be found in Appendix C Table 9. Measurements from the past year showed a decrease in annual mean NO_2 concentration across the network between 2014 and 2015 when considering the national bias adjusted concentrations, for which the national bias adjustment factors in both years were very similar. Considering just the local bias adjustment factor, NO_2 concentrations increased in 2015 relative to 2014, although as previously discussed, the local bias adjustment factor is higher than in previous years.

Table 7 Annual Mean NO_2 Concentration (bias-adjusted) by Site Type, 2012 – 2015

Site Type	Bias Adjusted Annual Mean NO_2 Concentration (µg/m^3)					
	2012		2013		2014	
	Bias Adjusted using New Cross Co-located tubes (Factor = 0.79)	Bias Adjusted using National Bias Adjustment factor (Factor = 1.01)	Bias Adjusted using New Cross Co-located tubes (Factor = 0.93)	Bias Adjusted using National Bias Adjustment factor (Factor =1.0)	Bias Adjusted using New Cross Co-located tubes (Factor = 0.82)	Bias Adjusted using National Bias Adjustment factor (Factor =0.97)
All Sites	31.7	**40.6**	39.1	**42.0**	33.1	38.8
Roadside	35.9	**46.0**	**44.0**	**47.7**	37.6	**44.2**
Urban Background	25.6	32.7	31.9	33.7	26.5	31.3
Site Type	**Bias Adjusted Annual Mean NO_2 Concentration (µg/m^3)**					
	2015					
	Bias Adjusted using New Cross Co-located tubes (Factor = 1.02)	**Bias Adjusted using National Bias Adjustment factor (Factor = 0.95)**				
All Sites	37.7	35.1				
Roadside	**43.5**	**40.5**				
Urban Background	29.3	27.3				

5 Conclusions

The main conclusions of the 2015 Lewisham Diffusion Tube Network study are:

- The mean NO_2 concentration for the whole network, based on local bias adjustment factor was 37.7 µg/m^3 or 35.1 µg/m^3 based on the national bias adjustment factor.

NO_2 concentrations were greatest at roadside monitoring locations, followed by urban background sites. The highest annual mean NO_2 concentration in 2015 was measured at site LWS017 (9 Baring Road). The mean concentration was 58.6 µg/m^3 based on local bias adjustment factor, or 54.6 µg/m^3 using the national bias adjustment factor. The second highest annual mean NO_2 concentration occurred at LWS016 at Montpelier Value with a value of 57.1 µg/m^3 after applying the local bias adjustment factor or 53.2 µg/m^3 – national bias adjusted.

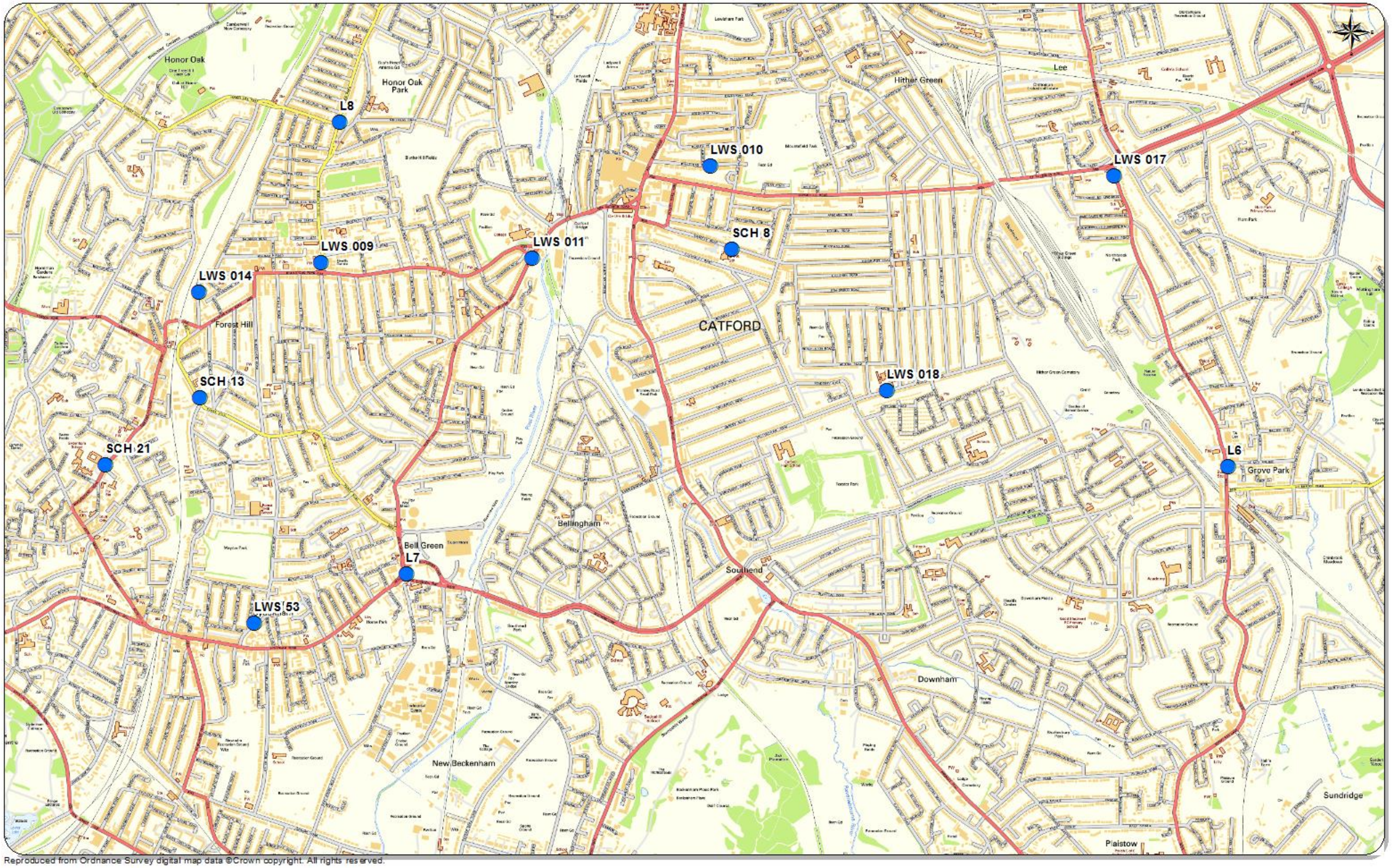
- The mean roadside NO_2 concentration across the network was 43.5 µg/m^3, based on the local bias adjustment factor, or 40.5 µg/m^3 based on the national bias adjustment factor, and the mean urban background concentration was 29.3 µg/m^3 using the local bias adjustment factor or 27.3 µg/m^3 using the national bias adjustment factor.
- Results based on the local adjustment factor show that 14 diffusion tube locations recorded annual mean NO_2 concentrations exceeding the annual mean NO_2 objective of 40 µg/m^3. Results obtained after applying the national bias adjustment factor show that 12 sites exceeded the annual mean NO_2 objective.

Appendices

Capabilities on project:
Environment

Appendix A: Diffusion Tube Monitoring Locations in Lewisham

Figure 3: LB of Lewisham Diffusion Tube Network (South) in 2015



Client: London Borough Of Lewisham
Title: Diffusion Tube Locations

● 2015 Diffusion Tubes

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Figure 4: LB of Lewisham Diffusion Tube Network (North) in 2015

Client: **London Borough Of Lewisham**

Title: **Diffusion Tube Locations**

● 2015 Diffusion Tubes

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Appendix B: Monitored NO_2 Concentrations

Table 8 Lewisham Diffusion Tube Network 2015 – Raw and Bias Adjusted Results

Ref	Location	X	Y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 1.02)	Bias-Adjusted[b] (Factor = 0.95)	
L1	Chubworthy Street / Sanford Street SE14 6HD	536109	177580	Roadside	32	33	31	92
L2	Bronze Street / Creekside SE8 3DX	537540	177439	Urban Background	28	28	26	83
L3	Oxestalls Road / Grove Street SE8 3QQ	536561	178471	Urban Background	34	34	32	100
L4	Plough Way / Grove Street SE16 7FH	536534	178926	Urban Background	34	34	32	100
L5	307 Lee High Road SE12 8RU	539678	175050	Roadside	33	33	31	100
L6	Baring Road / Le May Avenue SE12 0DU	540615	172337	Urban Background	34	35	33	83
L7	65 Bell Green SE26 5SJ	536556	171810	Roadside	**47**	**48**	**45**	100
L8	107 Stondon Park SE23 1LD	536229	174032	Roadside	**41**	**42**	39	100
L9	Adelaide Avenue / Ladywell Road SE13 7HS	537500	174925	Roadside	37	38	35	100
L10	Bexley Court, Whitburn Road SE13 7UQ	538062	175085	Roadside	39	39	37	92
L11	Lewisham Road / Sparta Street SE13 7QP	537965	176617	Roadside	35	36	34	92
L12	Montague Avenue SE4 1YP	537132	175353	Urban Background	26	27	25	83
LWS 53	50 Mayow Road SE26 4JA	535804	171567	Urban Background	27	27	25	100
LWS 002	24 Boyne Road SE13 5AL	538482	175792	Urban Background	29	30	28	100
LWS 003	155 Lewisham Road SE13 7PZ	538237	176101	Roadside	**46**	**47**	**43**	100
LWS 004	122 Loampit Vale SE13 7SN	537740	175930	Roadside	**48**	**49**	**45**	100

Ref	Location	X	Y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 1.02)	Bias-Adjusted[b] (Factor = 0.95)	
LWS005 LWS006 LWS007	272 New Cross Road SE14 5DS	536246	176934	Roadside	**49**	**50**	**46**	94
LWS 008	New Cross Road / Hatcham Park Road SE14 5DG	535746	176969	Roadside	**42**	**43**	**40**	92
LWS 009	10-18 Brockley Rise SE23 1JN	536133	173341	Roadside	**49**	**50**	**47**	100
LWS 010	68 Ringstead Road SE6 2BS	538060	173816	Urban Background	30	30	28	100
LWS 011	33b Catford Hill SE6 4NU	538007	176517	Roadside	**51**	**52**	**48**	100
LWS 014	8 Stanstead Road SE23 1BW	535530	173198	Urban Background	23	23	22	100
LWS 015	205 Shardeloes Road SE4 1BE	536527	175935	Roadside	**46**	**47**	**44**	92
LWS 016	Montpelier Vale, SE3 0TA	539604	176090	Roadside	**56**	**57**	**53**	100
LWS 017	9 Baring Road SE12 OJP (Baring Road / Westhorne Avenue)	540051	173769	Roadside	**57**	**59**	**55**	100
LWS 018	Hazelbank Road / Birkhall Road SE6 1TG	538930	172713	Urban Background	32	32	30	92
SCH 8	147 Sangley Road SE6 2DY	538165	173406	Roadside	28	29	27	100
SCH 13	Perry Vale / Dacres Road SE23 2NE	535535	172679	Roadside	32	32	30	83
SCH 16	85 Howson Road / Whitbread Road SE4 2AU	536399	175150	Urban Background	23	24	22	100
SCH 18	Clyde Street / Larch Close SE8 5TW	536944	177665	Urban Background	28	29	27	92
SCH 20	Lewisham High Street / Romborough Way	537979	174792	Roadside	**41**	**42**	39	100
SCH 21	Dartmouth Road / Round Hill SE26 4RD	535071	172346	Urban Background	26	27	25	100

Note: [a] Bias adjustment factor is calculated based on results from Lewisham,-New Cross monitoring station. [b] National Bias adjustment factor. * Annualised according to Defra Guidance LAQM.TG(09)

Appendix C: Diffusion Tube Bias Adjustment

A local bias adjustment factor was calculated in order to apply bias correction to the raw diffusion tube results for 2015. Triplicate tubes were co-located alongside the continuous NO_2 monitoring sites in New Cross Road (LW2), and this site has been used to calculate the bias adjustment factor 2015.

The continuous monitoring site listed above is part of the London Air Quality Network (LAQN reference is given in brackets). NO_2 concentration data from the continuous monitoring sites between 07/01/2015 and 05/01/2016 to cover the period of diffusion tube monitoring was collated. Period mean NO_2 concentrations were calculated for each diffusion tube exposure period during 2015. Data capture statistics for the same periods were also determined.

The continuous monitoring data and raw triplicate tube concentrations were inputted into the Bias Adjustment Calculator tool to calculate bias adjustment factors

The bias adjustment calculations for the monitoring site are shown in Figure 4. Table 9 provides a summary of the bias factor calculated for the site, and the comparison with national bias adjustment factors for the past years are also shown.

Table 9 Summary of Local and National Bias Adjustment Factors for Lewisham NO_2 Diffusion Tube Surveys, 2009 to 2015

Year	Mean Local Factor	National Factor[a]
2009	0.84	0.97
2010	0.69	1.03
2011	0.59	0.95
2012	0.79	1.01
2013	0.93	1.00
2014	0.82	0.97
2015	1.02	0.95

Notes: [a] National factor obtained from Bias Adjustment Factor spreadsheet[3] version 03/16 based on Gradko as the analysing laboratory using the 50% TEA in acetone method;

Capabilities on project:
Environment

Figure 4: Local Bias Adjustment Factor Calculation, Lewisham – New Cross (LW2)

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 µgm^{-3}	Tube 2 µgm^{-3}	Tube 3 µgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	07/01/2015	04/02/2015	52.6	49.5	50.8	51	1.5	3	3.8	78.18	99.55	Good	Good
2	04/02/2015	04/03/2015	49.5	48.5	48.4	49	0.6	1	1.5	78.03	82.74	Good	Good
3	04/03/2015	31/03/2015	56.5	47.0	47.3	50	5.4	11	13.4	65.63	99.54	Good	Good
4	31/03/2015	30/04/2015	47.3	51.2		49	2.8	6	24.7	47.00	99.86	Good	Good
5	30/04/2015	27/05/2015	47.3	46.2	46.7	47	0.6	1	1.4	41.82	99.07	Good	Good
6	27/05/2015	02/07/2015	54.6	53.9	54.1	54	0.3	1	0.8	41.44	100.00	Good	Good
7	02/07/2015	29/07/2015	50.8	55.3	55.9	54	2.8	5	7.0	34.51	99.85	Good	Good
8	29/07/2015	27/08/2015	46.9	44.1	44.8	45	1.4	3	3.5	34.29	100.00	Good	Good
9	27/08/2015	30/09/2015	53.4	50.3	61.2	55	5.6	10	13.9	44.36	60.66	Good	or Data Capture
10	30/09/2015	28/10/2015	57.6	56.0	56.9	57	0.8	1	2.0	48.91	72.92	Good	or Data Capture
11	28/10/2015	02/12/2015	47.9	44.6	47.3	47	1.8	4	4.4	41.02	100.00	Good	Good
12	02/12/2015	05/01/2016	31.0	31.5	34.7	32	2.0	6	5.0	23.96	100.00	Good	Good
13													

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

Overall survey --> Good precision | Good Overall DC

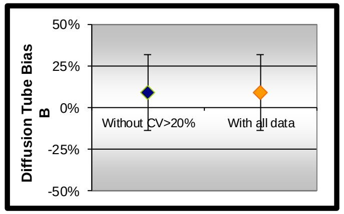
Site Name/ ID:

Precision 12 out of 12 periods have a CV smaller than 20%

(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval)	
without periods with CV larger than 20%	
Bias calculated using 10 periods of data	
Bias factor A	1.02 (0.82 - 1.32)
Bias B	-2% (-24% - 21%)
Diffusion Tubes Mean:	48 µgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	49 µgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	49 (39 - 63) µgm^{-3}

Accuracy (with 95% confidence interval)	
WITH ALL DATA	
Bias calculated using 10 periods of data	
Bias factor A	1.02 (0.82 - 1.32)
Bias B	-2% (-24% - 21%)
Diffusion Tubes Mean:	48 µgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	49 µgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	49 (39 - 63) µgm^{-3}



Jaume Targa, for AEA
Version 04 - February 2011

Figure 5: National Bias Adjustment Factor Calculation

National Diffusion Tube Bias Adjustment Factor Spreadsheet | **Spreadsheet Version Number: 03/16**

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadhseet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated at the end of June 2016
LAQM Helpdesk Website

The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.

Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.

Step 1: Select the Laboratory that Analyses Your Tubes from the Drop-Down List. If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List. If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List. If a year is not shown, we have no data[2]

Step 4: **Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.**
If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@uk.bureauveritas.com or 0800 0327953

Analysed By[1]	Method (To undo your selection, choose (All) from the pop-up list)	Year[5] (To undo your selection, choose (All))	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (μg/m³)	Automatic Monitor Mean Conc. (Cm) (μg/m³)	Bias (B)	Tube Precision[6]	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	50% TEA in acetone	2015	R	Bedford Borough Council	12	35	33	6.4%	G	**0.94**
Gradko	50% TEA in acetone	2015	UB	Norwich City Council	9	12	12	-3.3%	G	**1.03**
Gradko	50% TEA in acetone	2015	R	West Berkshire Council	11	38	35	10.7%	G	**0.90**
Gradko	50% TEA in acetone	2015	R	East Hampshire District Council	11	22	20	9.5%	G	**0.91**
Gradko	50% TEA in acetone	2015	R	LB Haringey	12	37	40	-9.1%	S	**1.10**
Gradko	50% TEA in acetone	2015	KS	London Borough of Croydon	12	54	52	4.7%	G	**0.96**
Gradko	50% TEA in acetone	2015	B	London Borough of Richmond upon Thames	12	21	21	-0.2%	G	**1.00**
Gradko	50% TEA in acetone	2015	R	London Borough of Richmond upon Thames	12	36	33	8.9%	G	**0.92**
Gradko	50% TEA in acetone	2015	KS	Marylebone Road Intercomparison	12	86	81	6.4%	G	**0.94**
Gradko	50% TEA in acetone	2015	UI	Middlesbrough	11	16	14	11.7%	G	**0.90**
Gradko	50% TEA in acetone	2015	SI	Redcar & Cleveland	12	12	12	0.1%	G	**1.00**
Gradko	50% TEA in acetone	2015	R	West Dorset District Council	12	12	11	15.5%	G	**0.87**
Gradko	50% TEA in acetone	2015	R	Worthing Borough Council	11	42	37	14.5%	G	**0.87**
Gradko	50% TEA in acetone	2015	R	Royal Borough of Windsor and Maidenhead	12	34	37	-8.4%	G	**1.09**
Gradko	50% TEA in acetone	2015	R	Royal Borough of Windsor and Maidenhead	12	40	38	4.2%	G	**0.96**
Gradko	50% TEA in acetone	2015		**Overall Factor[3] (15 studies)**				Use		**0.95**