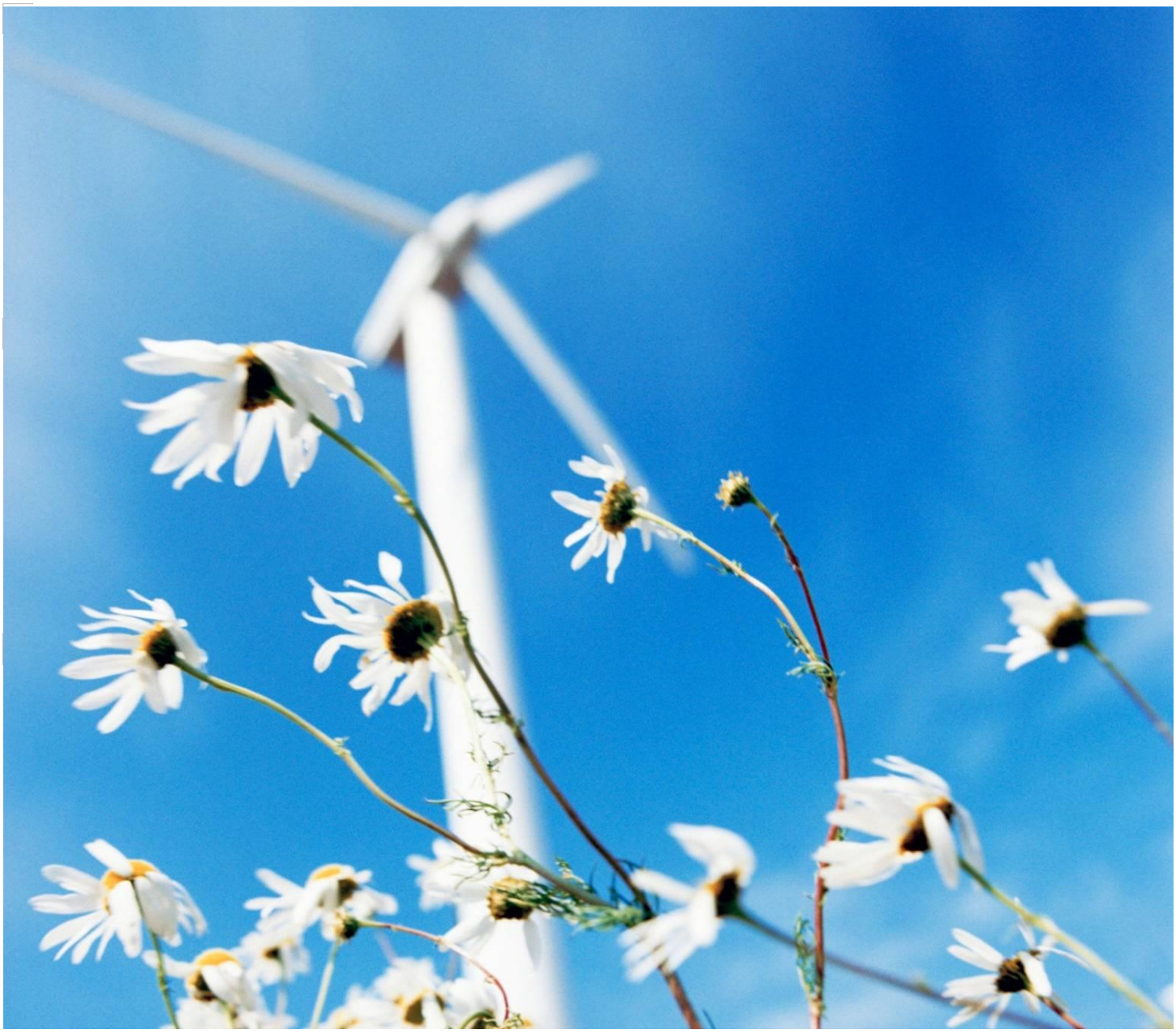
London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2014



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London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2014

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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 2014 to December 2014, 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 triplicate co-located at New Cross Road continuous monitoring station. During 2014, 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 June, July and August 2014, no access was granted to the diffusion tube at Dartmouth Road, located within the school grounds, due to construction works being conducted on site. This tube was relocated in October 2014 to be at a more accessible location, within the school fence line but at the entrance of the school.

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 Health and Safety Laboratory's (HSL) Workplace Analysis Scheme for Proficiency (WASP) programme for diffusion tubes, 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 Rounds 117-124 (April 2012 -March 2014)[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 chemiluminescence 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 2014. Available at http://laqm.defra.gov.uk/diffusion-tubes/data-entry.html

[3] Summary of Laboratory Performance in WASP NO2 Proficiency Testing Scheme for Rounds 117-124. Available at: http://laqm.defra.gov.uk/documents/LAQM-WASP-Rounds-117-124-(April-2012--March-2014)-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 µg/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 chemiluminescence 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

[4] Defra, Local Air Quality Management Technical Guidance LAQM.TG(09), 2009.
[5] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet (Version 03/15). 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 the "Practical Guidance for Diffusion Tube Monitoring" [6] report. These definitions are reproduced in Table 2 below.

Table 2 Site Type Designation Criteria

Type	Definition
Kerbside	Within 1m of the kerb.
Roadside	1-5m from the kerb edge.
Intermediate (or 'Near Road' sites)	More than 5m from the kerb of a busy road but air quality is likely to be affected by the nearby busy road.
Urban Background	> 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.

[6] Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users. AEA Techonology, February 2008.

4 Results and Discussion

4.1 Data Capture

Data capture rates for the Lewisham Diffusion Tube Survey Network during 2014 were generally high, achieving an overall average of 95% for all site types. The lowest data capture was reported for the tubes at Sydenham School (SCH021) with 58% and at Whitburn Road (L10) with 67% capture rate (Appendix B). The tube sited at Sydenham School location was found missing in May and building work prevented access in the months June-August and October. The tube was re-located in October to ensure further building work did not influence data capture. The tube at Whitburn Road was found missing in the months September-December 2014. The results from these locations have been annualised in accordance with Defra Guidance LAQM.TG(09) (Appendix C).

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 bias adjustment factors 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. An average bias adjustment factor of 0.82 was obtained and this value has been applied to all diffusion tube concentrations unless otherwise stated. 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	2014 Annual Mean NO_2 Concentration ($\mu g/m^3$)	
	Unadjusted Diffusion Tube	Continuous Monitor
Lewisham – New Cross	**51.5**	**42.1**

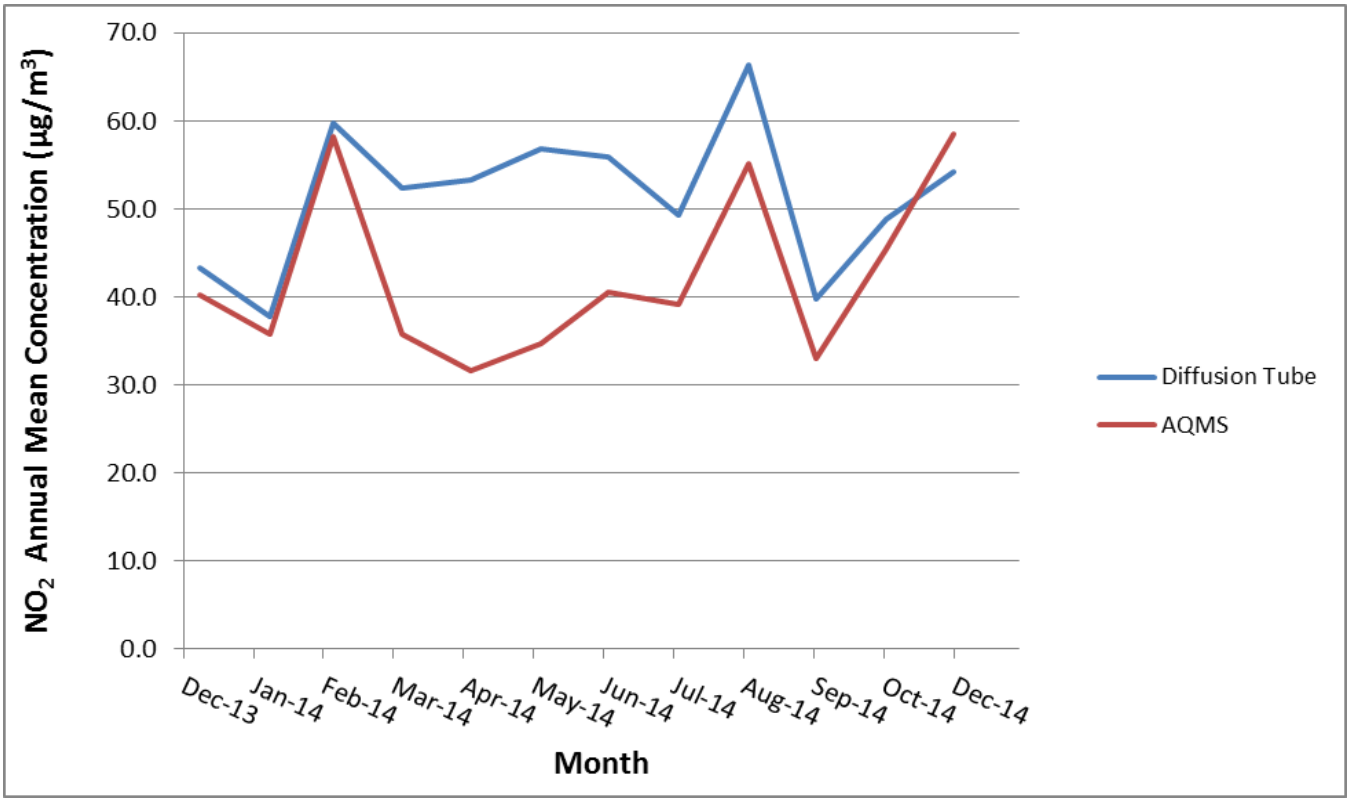
Monthly readings from the diffusion tubes were compared with concentration at Lewisham New Cross (Figure 1). This illustrates an over-reading by the tube with results being higher than the continuous analyser for several months. The exceptions to this are the first three months of 2014 and December 2014, where diffusion tubes were in good agreement with the continuous analyser concentration. The positive bias exhibited by the diffusion tubes at this location may be due to turbulence and inhomogeneities of sampled air. At locations close to sources of NO 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].

[7] AEA Diffusion Tube Precision Accuracy Bias Spreadsheet. Downloaded from http://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html 17/02/2015.
[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

4.2.2 National Bias Adjustment Factor

Due to the low value of the local bias adjustment factors in previous years, it was recommended that the bias adjustment factor obtained from national co-location studies[10] be calculated. The national bias adjustment factor for 2014 is 0.97 for the laboratory and preparation method, based on 9 studies (spreadsheet version 03/15).

Figure 1: Comparisons of Chemiluminescence and Diffusion Tube Measurements at AQMS New Cross for 2014



[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

4.3 Annual Mean NO_2 Concentrations

The mean NO_2 concentration over the whole network during 2014 was 40.0 µg/m^3 or, after applying a local bias adjustment of 0.82, 33.1 µg/m^3. The mean concentration calculated using the national bias adjustment factor was 38.8 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 L7 site at 65 Bell Green (46.8 µg/m^3 using the co-location study bias adjustment factor, or 55.4 µg/m^3 using the national bias adjustment factor). The second highest annual mean NO_2 concentration was measured LWS011 at Catford Hill (46.6 µg/m^3 – co-location study bias adjusted or 55.1 µg/m^3 – national bias adjusted). L7 and LWS011 are both roadside sites.

Table 4 Annual Mean NO_2 Concentration (Bias Adjusted), 2014

Site Type	Annual Mean NO_2 Concentration (µg/m^3)		
	Raw	Bias Adjusted, using New Cross Co-located Tubes (Factor = 0.82)	Bias Adjusted, using National Bias Adjustment Factor (Factor = 0.97)
All Sites	**40.0**	33.1	38.8
Roadside	**45.9**	37.6	**44.2**
Urban Background	32.3	26.5	31.3

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 2014. From Appendix B, it can be seen that at 7 of the 32 diffusion tube locations, the bias-adjusted annual mean NO_2 concentrations obtained after applying the co-location adjustment factor was greater than 40 µg/m^3. On the other hand, results based on the national bias adjustment factor, show that 13 sites exceeded the NO_2 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 2014.

4.3.2 Seasonal Variation

The seasonal variation in NO_2 concentrations during 2014 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 March followed by September and November at roadside sites. For urban background sites, the highest mean concentrations were measured during March and November. Mean NO_2 concentration was the lowest in August for all site types.

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

Table 5 Monthly Mean NO_2 Concentrations in Lewisham, 2014 (µg/m^3; Unadjusted)

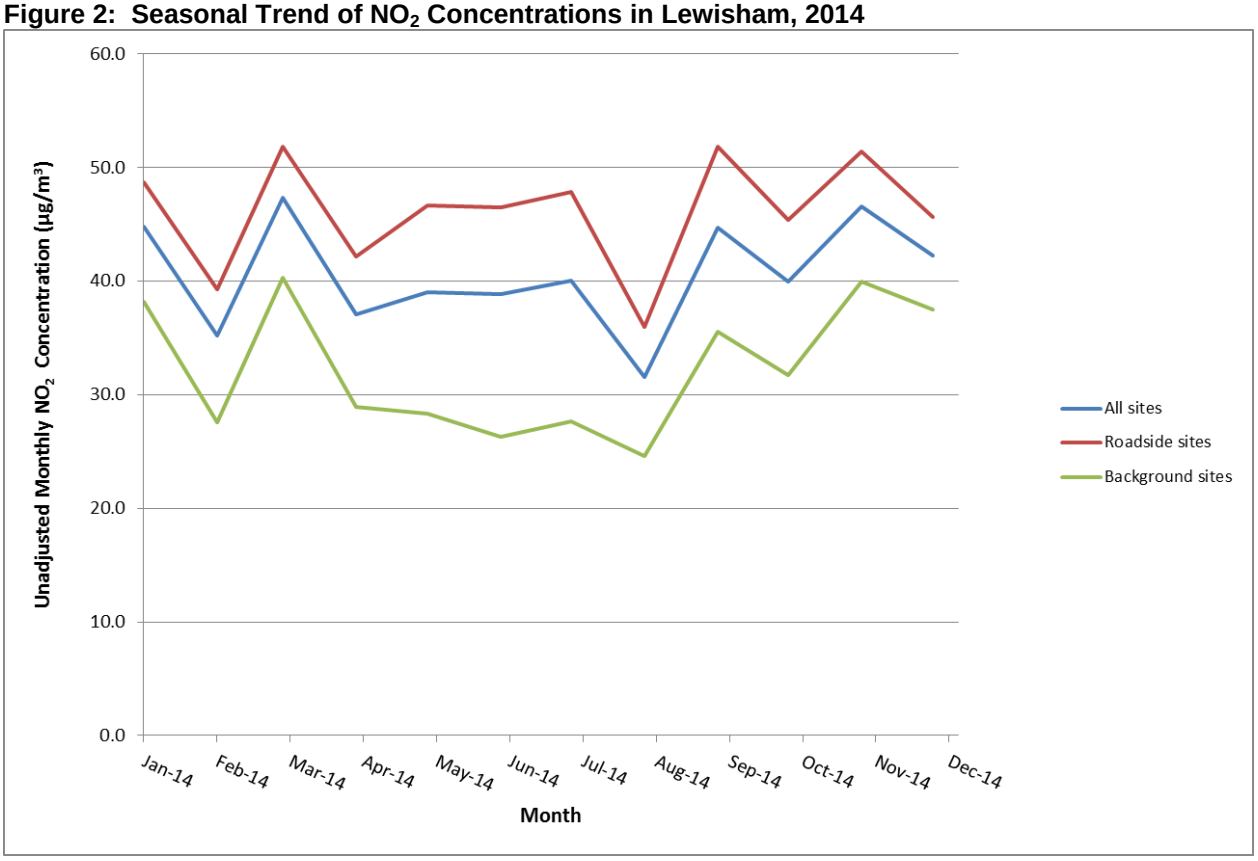
Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All Sites	**44.8**	35.3	**47.4**	37.0	39.1	38.9	40.0	31.6	**44.8**	39.9	**46.6**	**42.3**
Roadside	**48.7**	39.3	**51.9**	**42.2**	**46.6**	**46.5**	**47.9**	36.0	**51.8**	**45.4**	**51.4**	**45.7**
Urban Background	38.1	27.5	**40.3**	28.9	28.3	26.3	27.7	24.6	35.5	31.7	40.0	37.5

Table 6 Unadjusted Winter and Summer Period Mean Concentrations in Lewisham, 2014

Site Type	Winter Mean Concentration (October – March) (µg/m^3)	Summer Mean Concentration (April – September) (µg/m^3)	Ratio Winter : Summer
All Sites	42.7	38.6	1.1
Roadside	47.1	45.2	1.0
Urban Background	35.9	28.6	1.3

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 1.3 in 2014. 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, 2014



4.4 Historical Trends

Table 7 summarises the results of the Lewisham Tube Network by site type from 2012 to 2014, results for each site in 2014 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 an decrease in annual mean NO_2 concentration across the network between 2013 and 2014, with the network annual mean NO_2 concentration decreasing from 39.1 µg/m^3 in 2013 to 33.1 µg/m in 2014 – local bias adjusted, and from 42.0 µg/m^3 in 2013 to 38.8 µg/m^3 in 2014 - national bias adjusted.

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Table 7 Annual Mean NO_2 Concentration (bias-adjusted) by Site Type, 2012 – 2014

Site Type	Bias Adjusted Annual Mean NO_2 Concentration ($\mu g/m^3$)					
	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

5 Conclusions

The main conclusions of the 2014 Lewisham Diffusion Tube Network study are:

- The mean NO_2 concentration for the whole network, based on local bias adjustment factor was 33.1 µg/m^3 or 38.8 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 2014 was measured at site L7 (65 Bell Green). The mean concentration was 46.8 µg/m^3 based on local bias adjustment factor, or 55.4 µg/m^3 using the national bias adjustment factor. The second highest annual mean NO_2 concentration occurred at LWS011 at Catford Hill with a value of 46.6 µg/m^3 after applying the local bias adjustment factor or 55.1 µg/m^3 – national bias adjusted.

- The mean roadside NO_2 concentration across the network was 37.6 µg/m^3, based on the local bias adjustment factor, or 44.2 µg/m^3 based on the national bias adjustment factor, and the mean urban background concentration was 26.5 µg/m^3 using the local bias adjustment factor or 31.3 µg/m^3 using the national bias adjustment factor.
- Results based on the local adjustment factor show that 7 diffusion tube locations recorded annual mean NO_2 concentrations exceeding the annual mean NO_2 objective of 40 µg/m^3. While results obtained after applying the national bias adjustment factor show that 13 sites exceeded the annual mean NO_2 objective.

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Appendices

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Appendix A: Diffusion Tube Monitoring Locations in Lewisham

Figure 3: LB of Lewisham Diffusion Tube Network in 2014

Client: London Borough Of Lewisham
Title: Diffusion Tube Locations

2014 Diffusion Tubes

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Figure 4: LB of Lewisham Diffusion Tube Network in 2014

Client: London Borough Of Lewisham
Title: Diffusion Tube Locations

2014 Diffusion Tubes

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Appendix B: Monitored NO_2 Concentrations

Table 8 Lewisham Diffusion Tube Network 2014 – 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 = 0.82)	Bias-Adjusted[b] (Factor = 0.97)	
L1	Chubworthy Street / Sanford Street SE14 6HD	536109	177580	Roadside	39	32	38	83
L2	Bronze Street / Creekside SE8 3DX	537540	177439	Urban Background	30	25	29	100
L3	Oxestalls Road / Grove Street SE8 3QQ	536561	178471	Urban Background	37	30	36	100
L4	Plough Way / Grove Street SE16 7FH	536534	178926	Urban Background	36	29	35	100
L5	307 Lee High Road SE12 8RU	539678	175050	Roadside	39	32	38	100
L6	Baring Road / Le May Avenue SE12 0DU	540615	172337	Urban Background	37	30	36	92
L7	65 Bell Green SE26 5SJ	536556	171810	Roadside	**57**	**47**	**55**	100
L8	107 Stondon Park SE23 1LD	536229	174032	Roadside	**43**	36	**42**	100
L9	Adelaide Avenue / Ladywell Road SE13 7HS	537500	174925	Roadside	**42**	35	**41**	100
L10	Bexley Court, Whitburn Road SE13 7UQ	538062	175085	Roadside	40	34*	**40***	**67**
L11	Lewisham Road / Sparta Street SE13 7QP	537965	176617	Roadside	40	33	39	100
L12	Montague Avenue SE4 1YP	537132	175353	Urban Background	31	26	30	75
LWS 53	50 Mayow Road SE26 4JA	535804	171567	Urban Background	29	24	28	92
LWS 002	24 Boyne Road SE13 5AL	538482	175792	Urban Background	32	26	31	100
LWS 003	155 Lewisham Road SE13 7PZ	538237	176101	Roadside	**48**	39	**46**	100
LWS 004	122 Loampit Vale SE13 7SN	537740	175930	Roadside	**54**	**44**	**53**	100

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Ref	Location	X	Y	Site Type	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Data Capture (%)
					Raw	Bias-Adjusted[a] (Factor = 0.82)	Bias-Adjusted[b] (Factor = 0.97)	
LWS005 LWS006 LWS007	272 New Cross Road SE14 5DS	536246	176934	Roadside	**52**	**42**	**50**	100
LWS 008	New Cross Road / Hatcham Park Road SE14 5DG	535746	176969	Roadside	**45**	37	**44**	100
LWS 009	10-18 Brockley Rise SE23 1JN	536133	173341	Roadside	**56**	**46**	**55**	100
LWS 010	68 Ringstead Road SE6 2BS	538060	173816	Urban Background	33	27	32	92
LWS 011	33b Catford Hill SE6 4NU	538007	176517	Roadside	**57**	**47**	**55**	100
LWS 014	8 Stanstead Road SE23 1BW	535530	173198	Urban Background	26	22	25	100
LWS 015	205 Shardeloes Road SE4 1BE	536527	175935	Roadside	**55**	**45**	**54**	100
LWS 016	Lee Road / Lawn Terrace, SE3 9LJ	539645	175941	Roadside	37	31	36	92
LWS 017	9 Baring Road SE12 OJP (Baring Road / Westhorne Avenue)	540051	173769	Roadside	**53**	**43**	**51**	100
LWS 018	Hazelbank Road / Birkhall Road SE6 1TG	538930	172713	Urban Background	37	30	36	92
SCH 8	147 Sangley Road SE6 2DY	538165	173406	Roadside	34	28	33	92
SCH 13	Perry Vale / Dacres Road SE23 2NE	535535	172679	Roadside	32	26	31	100
SCH 16	85 Howson Road / Whitbread Road SE4 2AU	536399	175150	Urban Background	26	22	26	92
SCH 18	Clyde Street / Larch Close SE8 5TW	536944	177665	Urban Background	32	26	31	100
SCH 20	Lewisham High Street / Romborough Way	537979	174792	Roadside	**46**	38	**45**	100
SCH 21	Dartmouth Road / Round Hill SE26 4RD	535071	172346	Urban Background	35	27*	33*	**58**

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)

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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 2014. 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 2014.

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 08/01/2014 and 07/01/2015 to cover the period of diffusion tube monitoring was collated. Period mean NO_2 concentrations were calculated for each diffusion tube exposure period during 2014. 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, 2008 to 2014

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

Notes: [a] National factor obtained from Bias Adjustment Factor spreadsheet[3] version 03/15 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

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
1	08/01/2014	07/02/2014	43.8	42.8	43.4	43	0.5	1	1.2
2	07/02/2014	04/03/2014	35.3	38.6	39.7	38	2.3	6	5.7
3	04/03/2014	03/04/2014	53.2	63.6	62.3	60	5.7	9	14.1
4	03/04/2014	29/04/2014	50.4	49.2	57.7	52	4.6	9	11.4
5	29/04/2014	30/05/2014	52.1	51.7	56.0	53	2.4	4	5.9
6	30/05/2014	01/07/2014	55.8	57.8	57.0	57	1.0	2	2.6
7	01/07/2014	01/08/2014	60.3	63.6	43.9	56	10.5	19	26.1
8	01/08/2014	27/08/2014	45.3	51.9	50.9	49	3.6	7	8.9
9	27/08/2014	30/09/2014	66.1	67.3	65.4	66	0.9	1	2.3
10	30/09/2014	30/10/2014	40.6	42.3	36.3	40	3.1	8	7.7
11	30/10/2014	04/12/2014	50.0	48.2	48.4	49	1.0	2	2.5
12	04/12/2014	07/01/2015	54.9	54.7	53.1	54	1.0	2	2.4
13									

Automatic Method

Period Mean	Data Capture (% DC)
40.1951	100
35.7163	100
58.2031	99.583911
35.8063	99.36
32	100
35	100
41	100
39	99.679487
55	100
33	100
45.4848	99.642857
58.5912	100

Data Quality Check

Tubes Precision Check	Automatic Monitor Data
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good
Good	Good

(Ctrl)

Overall survey --> precision: Good | Overall

(Check average CV & DC from Accuracy calculations)

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

Site Name/ ID:

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

Accuracy (with 95% confidence interval) without periods with CV larger than 20%

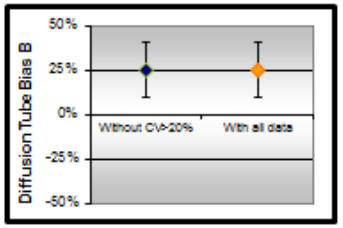
Bias calculated using 12 periods of data

Bias factor A	0.82 (0.73 - 0.94)
Bias B	22% (6% - 37%)
Diffusion Tubes Mean:	51 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	42 μgm^{-3}
Data Capture for periods used:	100%
Adjusted Tubes Mean:	42 (38 - 48) μgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA

Bias calculated using 12 periods of data

Bias factor A	0.82 (0.73 - 0.94)
Bias B	22% (6% - 37%)
Diffusion Tubes Mean:	51 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	42 μgm^{-3}
Data Capture for periods used:	100%
Adjusted Tubes Mean:	42 (38 - 48) 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: 03/15

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 2015
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	2014	R	Reading Borough Council	11	42	41	3.6%	G	**0.97**
Gradko	50% TEA in acetone	2014	R	Worthing Borough Council	12	43	51	-15.2%	G	**1.18**
Gradko	50% TEA in acetone	2014		**Overall Factor[3] (9 studies)**				**Use**		**0.97**

Seasonal Adjustment

Where data capture is less than 75% (found in 2014 at diffusion tube locations SCH21 and L10), the results have been annualised. Mean concentrations for the period covered by the diffusion tube monitoring and annual mean NO_2 concentrations have been collated from three nearby background continuous monitoring sites measuring NO_2 and with data capture rates greater than 90%. The average of the ratios between the period mean NO_2 concentrations and the annual mean NO_2 concentrations have been used to determine an adjustment factor, which has then been applied to the diffusion tube monitoring data to provide estimates of annual mean NO_2 concentrations at those locations.

Summary of 2014 Regional AURN NO_2 Data

Site	Data Capture	AURN 2014 Annual Mean
Lewisham, Catford	98	53
Bexley West	98	27
Horseferry Road	97	39

Seasonal Adjustment of NO_2 Diffusion Tubes

Site	Data Capture*	Sampled Period	Monitored Mean	AURN Period Mean	Ratio	Seasonally Adjusted Mean
L10	67%	Jan-Aug 2014	40.2	38.7	1.03	41.5

Capabilities on project:
Environment

Seasonal Adjustment of NO_2 Diffusion Tubes						
Site	**Data Capture***	**Sampled Period**	**Monitored Mean**	**AURN Period Mean**	**Ratio**	**Seasonally Adjusted Mean**
SCH21	58%	Jan-April, Sept, Nov-Dec 2014	35.0	41.8	0.94	32.8

* Data Capture based on a period of 12 months.