London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2013

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London Borough of Lewisham Nitrogen Dioxide Diffusion Tube Survey 2012

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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 2013 to December 2013, 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 2013, 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 July 2013, the diffusion tubes at Dartmouth Road, was relocated due to construction works being conducted on site. In July 2013, it was found that the post on which the tube was located had been removed by construction workers. The tube was temporarily placed next to previous location for July 2013 prior to a more suitable location being sought in August. The tube is now located 15-20 metres along the fence line within the school grounds, a similar distance from the road.

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 between Round 120 (Jan-March 2013) and Round 121 (April-June 2012)[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;

[2] Defra, Local Air Quality Management, Diffusion Tubes, Nitrogen Dioxide Diffusion Tube Monitoring, Calendar of Suggested Exposure Periods 2013. Available at http://laqm.defra.gov.uk/documents/NO2-Calendar-2013.pdf

[3] Summary of Laboratory Performance in WASP NO2 Proficiency Testing Scheme for Rounds 114-121. Available at: http://laqm.defra.gov.uk/documents/LAQM-WASP-Rounds-114-121-(July-2011--June-2013)-NO2-report.pdf

- The photochemical degradation of the triethanolamine-nitrite complex by light, although this is minimised by the use of opaque end-caps; and
- 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.

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.

[5] Defra, National Diffusion Tube Bias Adjustment Factor Spreadsheet (Version 03/13). Available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

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

4 Results and Discussion

4.1 Data Capture

Data capture rates for the Lewisham Diffusion Tube Survey Network during 2013 were generally high, achieving an overall average of 97% for all site types. The lowest data capture was reported for the tubes at Sydenham School (SCH021) with 83% and at St Mary Magdalen's RC (SCH016) with 75% capture rate (Appendix B). The tube sited at Sydenham School location was found missing in January and June; while the tube at St Mary Magdalen's RC was found missing in March, August and October.

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]. It should be noted that the continuous monitoring data used in the bias adjustment calculations have not been ratified for the entirety of 2013 and may therefore be subject to change. Further details can be found in Appendix C. An average bias adjustment factor of 0.93 (provisional as data from continuous monitoring station have not been fully ratified) 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 Collocated Site

Site Name	2013 Annual Mean NO_2 Concentration (µg/m^3)	
	Unadjusted Diffusion Tube	Continuous Monitor
Lewisham – New Cross	**53.7**	**50.4**

Note: Continuous monitoring results at Lewisham New Cross have not been fully ratified.

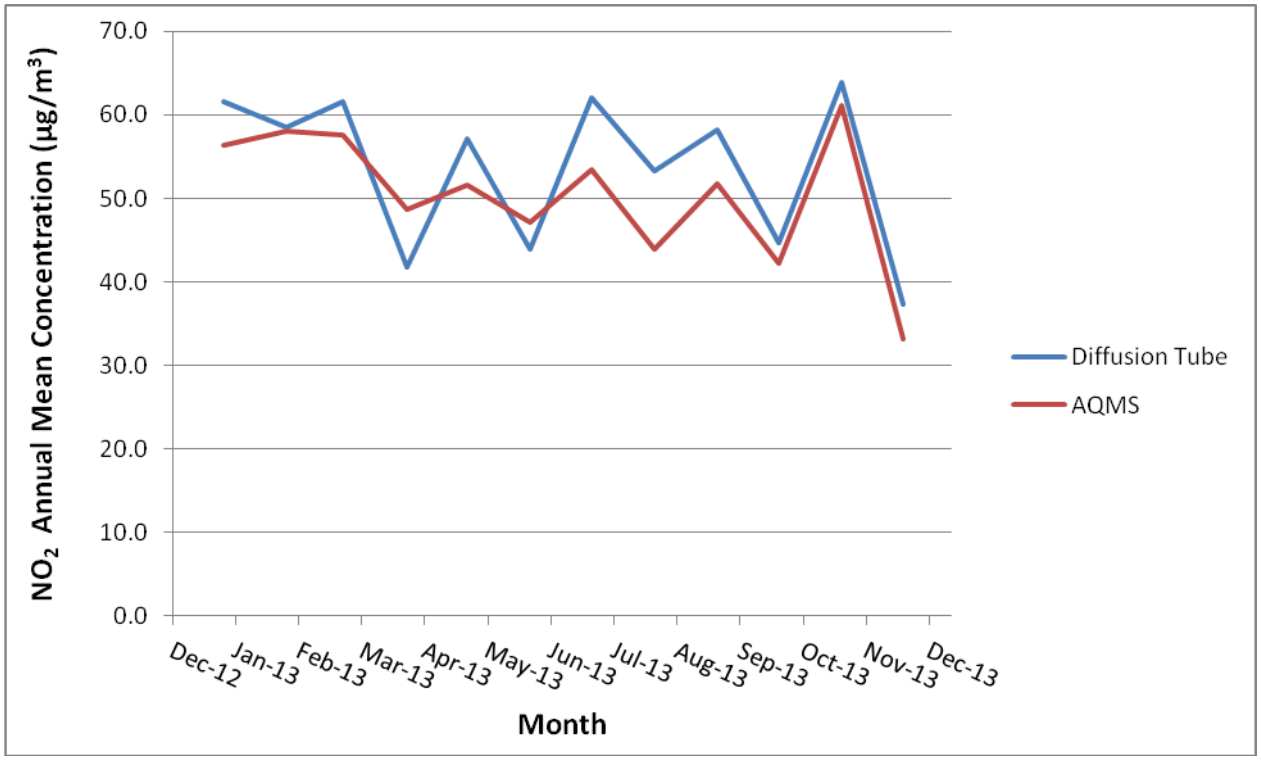
Monthly readings from the diffusion tubes were compared with concentration at Lewisham New Cross (Figure 1). This illustrates an over-reading by the tube with results being higher than the continuous analyser for several months. The exceptions to this are in May 2013 where diffusion tubes results were in lower than at the monitoring station and the final three months of 2013 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 11/02/2014.
[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 year, it was recommended that the bias adjustment factor obtained from national co-location studies[10] be used. The national bias adjustment factor for 2013 is 1.00 for the laboratory and preparation method, based on 17 studies (spreadsheet version 03/14).

Figure 1: Comparisons of Chemiluminescence and Diffusion Tube Measurements at AQMS New Cross for 2013



[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 2013 was 42.0 µg/m^3 or, after applying a local bias adjustment of 0.93, 39.1 µg/m^3. The mean concentration calculated using the national bias adjustment factor was above the annual mean NO_2 objective of 40 µg/m^3, but below the annual mean objective after applying the local bias adjustment factor. The maximum annual mean NO_2 concentration was measured at LWS017 site in Baring Road (57.5 µg/m^3 using the co-location study bias adjustment factor, or 61.9 µg/m^3 using the national bias adjustment factor). The second highest annual mean NO_2 concentration was measured LWS011 at Catford Hill (55.7 µg/m^3 – co-location study bias adjusted or 59.9 µg/m^3 – national bias adjusted). LWS017 and LWS011 are both roadside sites.

Table 4 Annual Mean NO_2 Concentration (Bias Adjusted), 2013

Site Type	Annual Mean NO_2 Concentration (µg/m^3)		
	Raw	Bias adjusted, using New Cross co-location tubes (Factor = 0.93)	Bias adjusted, using National Bias Adjustment Factor (Factor = 1.00)
All Sites	42.0	39.1	42.0
Roadside	47.7	44.4	47.7
Urban Background	33.7	31.3	33.7

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 40µg/m^3 was not generally exceeded within the diffusion tube network during 2013. From Appendix B, it can be seen that at 12 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 14 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). There is one roadside site with measured NO_2 concentrations greater than 60 µg/m^3 (LWS 011) in 2013 and a further which measured roadside NO_2 concentrations of 59.9 µg/m^3 (LWS 017), using the national adjustment factor. Using the Defra fall off of NO_2 with distance from the road calculator[12], the relevant exposure of the nearest receptor can be calculated. This shows that relevant exposure for both locations has an annual mean concentration below the indicative 60 µg/m^3 value (51.5 µg/m^3 at LWS 017 and at 52.3 µg/m^3 LWS 011). However, concentrations remain above the annual mean limit of 40 µg/m^3.

[11] Air Quality Consultants (2007). Deriving NO_2 from NO_X for Air Quality Assessments of Roads.
[12] Nitrogen dioxide fall off with distance calculator http://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html

4.3.2 Seasonal Variation

The seasonal variation in NO_2 concentrations during 2013 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 November followed by January and February at roadside sites. For urban background sites, the highest mean concentration was measured during the same months as the roadside sites. Mean NO_2 concentration was the lowest in April for all site types.

Table 5 Monthly Mean NO_2 Concentrations in Lewisham, 2013 (µg/m^3; Unadjusted)

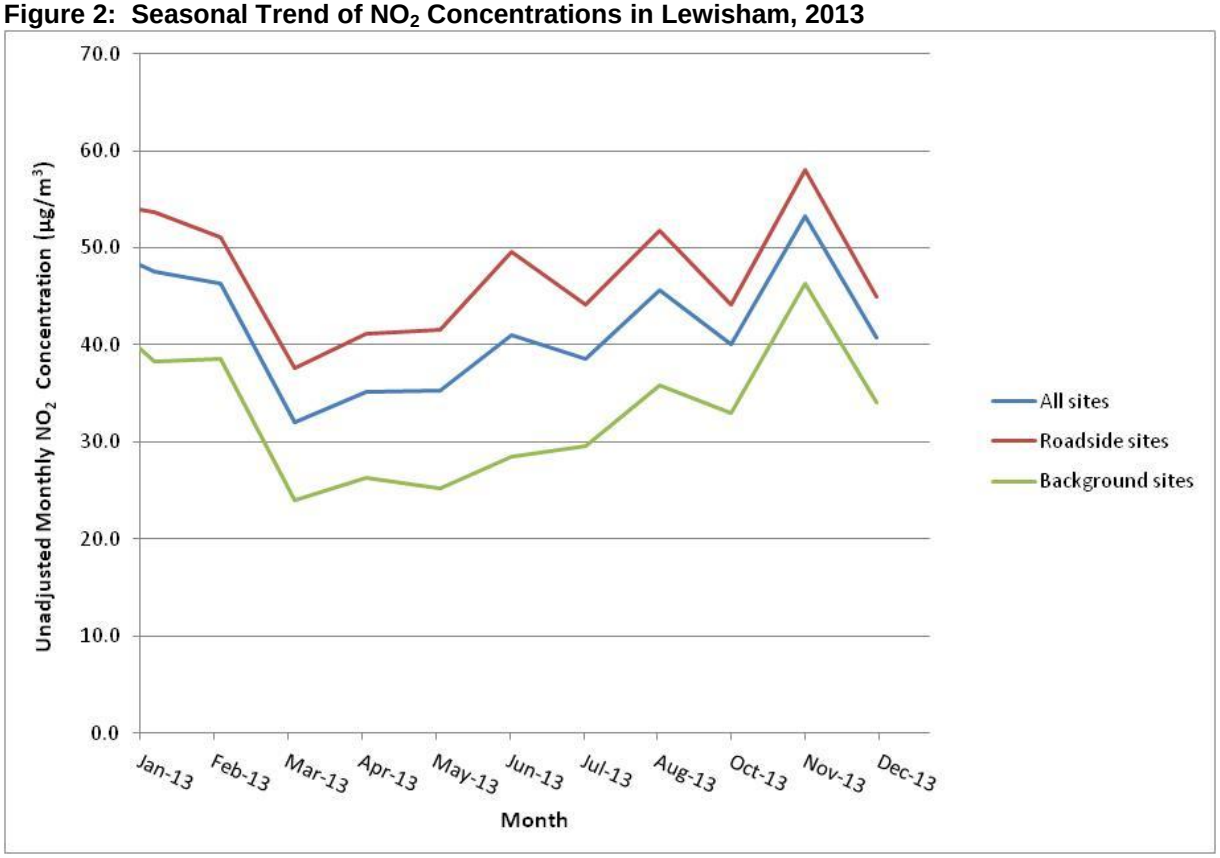
Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All Sites	51.1	47.5	46.3	32.1	35.1	35.3	41.1	38.5	45.6	40.0	53.3	40.8
Roadside	55.0	53.6	51.2	37.6	41.2	41.6	49.6	44.2	51.8	44.1	58.1	44.9
Urban Background	45.1	38.3	38.5	24.1	26.3	25.2	28.5	29.5	35.9	33.0	46.4	34.1

Table 6 Unadjusted Winter and Summer Period Mean Concentrations in Lewisham, 2013

Site Type	Winter Mean Concentration (October – March) (µg/m^3)	Summer Mean Concentration (April – September) (µg/m^3)	Ratio Winter : Summer
All Sites	46.5	37.9	1.2
Roadside	51.2	44.3	1.2
Urban Background	39.2	28.3	1.4

Table 6 shows that the ratio of winter to summer mean NO_2 concentration was 1.2 for roadside sites, indicating higher mean concentrations in the winter than summer periods. The urban background sites display a higher winter: summer ratio compared to roadside sites. The value was 1.4 in 2013. For all sites, collectively, the ratio of winter to summer mean NO_2 concentration was 1.2.

Figure 2: Seasonal Trend of NO_2 Concentrations in Lewisham, 2013



4.4 Historical Trends

Table 7 summarises the results of the Lewisham Tube Network by site type from 2012 to 2013, results for each site 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 increase in annual mean NO_2 concentration across the network between 2012 and 2013, with the network annual mean NO_2 concentration increasing from 31.7 µg/m^3 in 2012 to 39.1 µg/m in 2013 – local bias adjusted, and from 40.6 µg/m^3 in 2012 to 42.0 µg/m^3 in 2013 - national bias adjusted.

Table 7 Annual Mean NO_2 Concentration (bias-adjusted) by Site Type, 2012 – 2013

Site Type	Bias Adjusted Annual Mean NO_2 Concentration ($\mu g/m^3$)			
	2012		2013	
	Bias adjusted using New Cross co-location tubes (Factor = 0.79)	Bias adjusted using National Bias Adjustment factor (Factor = 1.01)	Bias adjusted using New Cross co-location tubes (Factor = 0.93)	Bias adjusted using National Bias Adjustment factor (Factor =1.0)
All Sites	31.7	**40.6**	39.1	**42.0**
Roadside	35.9	**46.0**	**44.0**	**47.7**
Urban Background	25.6	32.7	31.9	33.7

5 Conclusions

The main conclusions of the 2013 Lewisham Diffusion Tube Network study are:

- The mean NO_2 concentration for the whole network, based on local bias adjustment factor was 39.1 µg/m^3 or 42.0 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 2013 was measured at LWS017 site in Baring Road. The mean concentration is 57.5 µg/m^3 based on local bias adjustment factor, or 61.9 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 55.7 µg/m^3 after applying the local bias adjustment factor or 59.9 µg/m^3 – national bias adjusted.

- The mean roadside NO_2 concentration across the network was 44.0 µg/m^3, based on the local bias adjustment factor, or 47.7 µg/m^3 based on the national bias adjustment factor, and the mean urban background concentration was 31.9 µg/m^3 using provisional bias adjustment factor or 33.7 µg/m^3 using the national bias adjustment factor.
- Results based on the local adjustment factor show that 12 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 14 sites exceeded the annual mean NO_2 objective.

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Appendix A: Diffusion Tube Monitoring Locations in Lewisham

Figure 3: LB of Lewisham Diffusion Tube Network in 2013

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 2013

Client: London Borough Of Lewisham
Title: Diffusion Tube Locations

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Appendix B: Monitored NO_2 Concentrations

Table 8 Lewisham Diffusion Tube Network 2013 – 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 = 0.93)	Bias-Adjusted[b] (Factor = 1.00)	
L1	Lamp post,1-16 Chubworthy Street	536111	177579	Roadside	38.6	35.9	38.6	100
L2	Façade Bronze Street/Creekside	537549	177444	Urban Background	29.6	27.6	29.6	100
L3	Lamp post, 20 Oxestalls Road/Grove Street	536558	178470	Urban Background	37.1	34.5	37.1	92
L4	Lamp post, Plough Way/Grove Street	536542	178921	Urban Background	37.3	34.7	37.3	100
L5	Façade305 Lee High Road	539664	175061	Roadside	**43.3**	**40.2**	**43.3**	100
L6	Drainpipe 2a Baring Road/Le May Avenue	540618	172340	Urban Background	38.3	35.6	38.3	92
L7	Façade 65 Bell Green	536555	171804	Roadside	**53.8**	**50.1**	**53.8**	100
L8	Façade 107 Stondon Park	536229	174021	Roadside	**48.6**	**45.2**	**48.6**	100
L9	Façade Adelaide Avenue/Ladywell Road	537491	174913	Roadside	**40.5**	37.7	**40.5**	100
L10	Façade Bentley Court, Whitburn Road (moved to Lamp post 2)	538101	175073	Roadside	**46.2**	**43.0**	**46.2**	100
L11	Lamp post Lewisham Road/Sparta Street	538007	176517	Roadside	**47.4**	**44.0**	**47.4**	92
L12	Footpath, Montague Avenue	537147	175353	Urban Background	34.9	32.4	34.9	100
SCH008	Holy Cross	537817	173323	Roadside	33.3	30.9	33.3	100
SCH013	Christchurch	535563	172740	Roadside	34.3	31.9	34.3	100
SCH016	St Mary Magdalen's RC	536412	175131	Urban Background	29.5	27.5	29.6	75
SCH018	Grinling Gibbons	536924	177707	Urban Background	31.6	29.4	31.6	100
SCH020	St Mary's CE	538025	174749	Roadside	**51.0**	47.5	**51.0**	92

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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 = 0.93)	Bias-Adjusted[b] (Factor = 1.00)	
SCH021	Sydenham School	535028	172327	Urban Background	34.0	31.7	34.1	83
LWS053	Drainpipe on property (50 Mayow Road)	535798	171576	Urban Background	33.3	31.0	33.3	92
LWS002	Lamp post 23 Boyne Road	538475	175785	Urban Background	34.7	32.3	34.7	100
LWS003	Drainpipe, 155 Lewisham Road	538220	176100	Roadside	**47.6**	**44.3**	**47.6**	100
LWS004	Gaspipe,122 Loampit Vale	537740	155920	Roadside	**58.6**	**54.5**	**58.6**	100
LWS005, LWS006, LWS007	Automatic monitoring station, New Cross Road	536241	176932	Roadside	**53.7**	**49.9**	**53.7**	100
LWS008	Signpost outside The Five Bells PH, Hatcham Park Road	535759	176982	Roadside	**44.7**	**41.6**	**44.7**	100
LWS009	15 Brockley Rise	536130	173337	Roadside	**54.0**	**50.2**	**54.0**	100
LWS010	Lamp post 68 Ringstead Road	538055	173810	Urban Background	33.5	31.1	33.5	92
LWS11	Lamp post 33B Catford Hill	537180	173370	Roadside	**59.9**	**55.7**	**59.9**	100
LWS014	Downpipe to 8 Stanstead Road	535536	173192	Urban Background	27.5	25.6	27.5	100
LWS015	Lamp post 205 Shardloes Road	536523	175925	Roadside	**51.9**	**48.3**	**51.9**	100
LWS016	20 Selwyn Court, Lawn Terrace	539640	175934	Roadside	37.2	34.6	37.2	100
LWS017	Roadsign, 7 Baring Road	540037	173748	Roadside	**61.9**	**57.5**	**61.9**	100
LWS018	Torridon Junior School	538960	172740	Urban Background	36.3	33.7	36.3	100

Note: [a] Bias adjustment factor is provisional, calculated based on provisional results from Lewisham,-New Cross monitoring station. [b] National Bias adjustment factor. [c] LWS005 data capture was 92%.

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 2013. 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 2013.

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 04/01/2013 and 08/01/2014 to cover the period of diffusion tube monitoring was collated. Period mean NO_2 concentrations were calculated for each diffusion tube exposure period during 2013. 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[3] 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 2012

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

Notes: [a] National factor obtained from Bias Adjustment Factor spreadsheet[3] version 03/14 based on Gradko as the analysing laboratory using the 50% TEA in acetone method; [b] Provisional mean local factor has been calculated based on LW2 data that has not been fully ratified at the time of writing.

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	04/01/2013	01/02/2013	62.7	63.5	58.7	62	2.5	4	6.3	56.38	100.00	Good	Good
2	01/02/2013	01/03/2013	60.6	57.3	57.4	58	1.9	3	4.7	58.13	93.60	Good	Good
3	01/03/2013	26/03/2013	68.0	63.0	53.9	62	7.1	12	17.7	57.60	99.50	Good	Good
4	26/03/2013	24/04/2013	48.6	38.3	38.6	42	5.9	14	14.6	48.68	100.00	Good	Good
5	24/04/2013	30/05/2013	61.6	58.0	51.7	57	5.0	9	12.4	51.56	99.88	Good	Good
6	28/06/2013	30/07/2013	66.3	57.6	62.4	62	4.4	7	10.9	53.37	100.00	Good	Good
7	30/07/2013	03/09/2013	56.3	51.2	52.3	53	2.7	5	6.7	44.00	99.76	Good	Good
8	03/09/2013	04/10/2013	59.4	63.5	51.9	58	5.9	10	14.6	51.74	100.00	Good	Good
9	04/10/2013	01/11/2013	45.1	44.8	43.9	45	0.6	1	1.6	42.16	81.40	Good	Good
10	01/11/2013	06/12/2013	61.8	63.3	66.5	64	2.4	4	5.9	61.07	100.00	Good	Good
11	06/12/2013	08/01/2014	34.9	37.8	39.2	37	2.2	6	5.5	33.18	100.00	Good	Good
12													
13													
											Overall survey -->	Good	Good

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

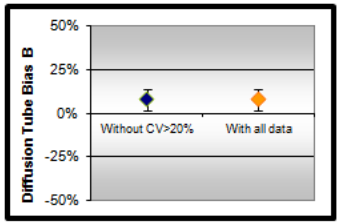
Site Name/ ID:	Lewisham New Cross Gate

Precision	11 out of 11 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 11 periods of data	
Bias factor A	0.93 (0.88 - 0.99)
Bias B	8% (1% - 14%)
Diffusion Tubes Mean:	55 μgm^{-3}
Mean CV (Precision):	7
Automatic Mean:	51 μgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	51 (48 - 54) μgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA	
Bias calculated using 11 periods of data	
Bias factor A	0.93 (0.88 - 0.99)
Bias B	8% (1% - 14%)
Diffusion Tubes Mean:	55 μgm^{-3}
Mean CV (Precision):	7
Automatic Mean:	51 μgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	51 (48 - 54) μgm^{-3}



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