Lewisham Nitrogen Dioxide Diffusion Tube Survey 2020

London Borough of Lewisham

Project Number: 60194269

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Quality information

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Contents

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) concentrations within the borough. Following the addition of 16 new locations in 2018, and the decommissioning of Stanstead Road (L25), monitoring was carried out at 50 locations at the start of 2020. 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.

Since September 2020, 51 new locations have been added, giving a total of 101 monitoring locations. The 51 new sites (hereafter referred to as the 'New Survey') were commissioned as part of some modal filters work being undertaken by LBL's transport department, in order to understand the impact of the works on air quality. This new commission also required the production of a quarterly report summarising the New Survey, so that LBL are informed as early as possible of the potential impacts. These new locations will therefore not be reported in this annual report.

This report outlines the results of the original survey for January 2020 to December 2020, inclusive. The spatial variation in NO_2 concentration throughout the borough is discussed and the annual mean concentrations 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 and Table 2.

Table 1: UK 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	31st December 2005
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (for the protection of vegetation)	30 µg/m^3	Annual Mean	31st December 2000

Table 2: EU Air Quality Objectives for NO_2 and NO_x

Pollutant	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 a year	1 Hour Mean	1st January 2010
	40 µg/m^3	Annual Mean	
Nitrogen Oxides (assuming as nitrogen dioxide)	30 µg/m^3	Annual Mean	19th 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 49 diffusion tubes across 47 sites, including a triplicate co-located site at the automatic monitoring station in New Cross Road, and the remainder single tube sites. In 2012, the network was reduced to 34 diffusion tubes at 32 sites, comprising single tubes at 31 sites and triplicates co-located at the New Cross Road continuous monitoring station. During December 2016, 2 new sites were commissioned at Kender Primary School and Deptford Park Primary School. In October 2017 a new site was also added at St James Hatcham Primary School. In 2018, 16 new sites were added, and one existing site removed, bringing the total number of sites up to 50. Finally, in September 2020, 51 New Survey locations were added across the borough, taking the total number of sites up to 101, though the results for the additional 51 sites are presented in a separate quarterly report.

The locations of the diffusion tubes are shown in Appendix A. Detailed listing of all monitoring sites from 2011 to present including those added or removed are shown in Appendix D.

3.2 Procedures and Site Changes

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].

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 been excluded from the final dataset.

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 by Gradko International Ltd that were subsequently determined to be satisfactory was 75% in AIR-PT Round AR036 (January 2020-February 2020) and 75% for AIR-PT Round AR040 (September – October 2020). No results were reported for AIR-PT Rounds AR037 (May 2020 – June 2020) and AR039 (July 2020 – August 2020)[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;

[2] Defra, Local Air Quality Management, Diffusion Tubes, Nitrogen Dioxide Diffusion Tube Monitoring, Calendar of Suggested Exposure Periods. Available at http://laqm.defra.gov.uk/diffusion-tubes/data-entry.html
[3] Summary of Laboratory Performance in AIR NO_2 Proficiency Testing Scheme. Available at: https://laqm.defra.gov.uk/assets/laqmno2performancedatauptooctober2020v1.pdf

- 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
- 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 dispatch 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 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 Defra and the GLA's London Local Air Quality Management Technical Guidance (LLAQM.TG(19))[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 they were spurious results;
- Exposure records were checked for possible explanation of any unusual results (e.g. foreign objects, bonfires, pollution episodes, construction works, tampering, etc; and
- For a triplicate site, diffusion tubes that exhibit poor precision (>20%) were 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.

[4] Defra & the GLA, London Local Air Quality Management Technical Guidance LLAQM.TG(19).

Bias adjustment factors 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 nationally. It can also be derived locally through co-location of diffusion tubes with automatic analysers and comparison of 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.

3.5.4 Annualisation Factor

Where data capture is less than 75% of a full calendar year (less than 9 months), the mean should be "annualised" – i.e. adjusted using the methodology outlined in LLAQM.TG(19)[4] before being compared to annual mean objectives. The sites requiring annualisation were L17, L18 and L19, which is the co-located triplicate site at Lewisham – New Cross. These sites each had a data capture of <75%. To carry out annualisation the following continuous Urban Background monitors were used; Lambeth – Streatham Green, Lewisham – Honour Oak Park and Lewisham – Deptford.

3.6 Site Designations

The designation of site types is used to compare different locations statistically. Sites were categorised as kerbside, roadside, and urban background sites according to the definitions given in LLAQM.TG(19)[4]. These definitions are reproduced in Table 3 below.

Table 3: Site 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

[5] Defra, Diffusion tube bias adjustment spreadsheet March 2021, available at: https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

4. Results and Discussion

4.1 Data Capture

Data capture rates for the Lewisham Diffusion Tube Survey Network during 2020 were high, achieving an overall average of 85.3% for all site types. The lowest annual data capture for any site was 67% (4 months missing out of 12), at sites L17, L18, and L19 respectively (New Cross AQMS). As data capture was above 75% for all other sites, annualisation of data was therefore only required for the triplicate at New Cross AQMS.

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). Also, due to the COVID-19 pandemic, Gradko Laboratory closed during May 2020, which meant exposed tubes could not be replaced. Diffusion tubes were collected for April and stored until the Gradko Laboratory reopened for analysis. New tubes were installed in June.

4.2 Bias Adjustment

4.2.1 Local Bias Adjustment Factor

The co-location site's annual mean NO_2 concentrations measured by the diffusion tubes and the continuous monitors are displayed in Table 4.

The AEA Diffusion Tube Precision Accuracy Bias Spreadsheet[6] 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[7]. 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 4: Comparison of Diffusion Tube Measurement and Continuous Monitors at Co-located Site

Site Name	2020 Annual Mean NO_2 Concentration ($\mu g/m^3$)	
	Unadjusted Diffusion Tube	Continuous Monitor
Lewisham – New Cross	36.7	29.5

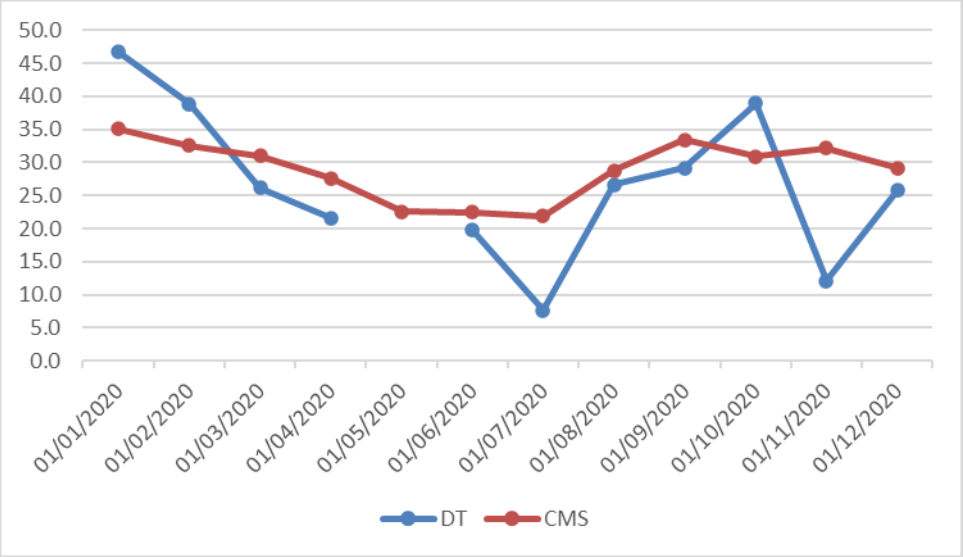
Monthly readings from the triplicate diffusion tubes were compared with the concentration at Lewisham New Cross (Figure 1). An average bias adjustment factor of 0.78 was obtained. It can be seen that for 8 months of the year, the monthly average diffusion tube concentration was greater than the monthly average concentration recorded by the New Cross AQMS, although during January, February and October this was reversed. In general, 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[8]. Note that data capture for the triplicate site was lower than 75%.

4.2.2 National Bias Adjustment Factor

The national bias adjustment factor for 2020 is 0.82 for the laboratory and preparation method, based on 14 studies (spreadsheet version 03/21). Based primarily on the fact that the national factor was greater than the local factor, and the fact the co-location diffusion tubes had data capture <75%, it was recommended that the national bias adjustment factor was used in 2020, to ensure a more conservative estimate was obtained of annual mean NO_2 concentrations from the diffusion tubes.

[6] AEA Diffusion Tube Precision Accuracy Bias Spreadsheet. Downloaded from http://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html
[7] London Air Quality Network Website. Available at http://www.londonair.org.uk.
[8] 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

Figure 1: Comparison of Diffusion Tube Measurement and Continuous Monitors at Co-located Site



4.3 Annual Mean NO_2 Concentrations

The mean NO_2 concentration over the whole network during 2020 was 23.3 µg/m^3 applying the local bias adjustment factor of 0.82. The mean concentration calculated using the local bias adjustment factor was 22.2 µg/m^3. Using either bias adjustment factor, the mean concentration across the whole network is below the annual mean NO_2 objective of 40 µg/m^3. The maximum annual mean NO_2 concentration, after application of the national bias adjustment factor, was measured at the L51 site at 290 Brownhill Road, South Circular (34.0 µg/m^3).

Table 5: Annual Mean NO_2 Concentration (Bias Adjusted), 2020

Site Type	Annual Mean NO_2 Concentration (µg/m^3)		
	Raw	Bias Adjusted, using New Cross Co-located Tubes (Factor = 0.78)	Bias Adjusted, using National Bias Adjustment Factor (Factor = 0.82)
All Sites	28.4	22.2	23.3
Roadside	31.8	24.8	26.0
Urban Background	24.2	18.8	19.8

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 Table 1. The results in Table 5, obtained after applying the national bias adjustment factor, indicate that the annual mean NO_2 objective of 40 µg/m^3 was not exceeded by the mean diffusion tube network concentration during 2020.

Where diffusion tube locations are not representative of relevant exposure (for example, where a tube is kerbside, but residential facades are several metres back from the kerb), annual mean NO_2 concentrations can be distance-corrected to take into account the fall-off in concentration away from the kerb. Appendix B presents the full set of diffusion tube results including distance-corrected concentrations. When considering the national bias-adjusted diffusion tube results, there are no locations that, when distance-corrected to the nearest relevant exposure, exceed the annual mean objective.

A report issued by Air Quality Consultants[9] 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 2020.

4.3.2 Seasonal Variation

The seasonal variation in NO_2 concentrations during 2020 are shown in Table 6. Due to seasonal variations in the bias adjustment that can occur at diffusion tube sites, the results presented in Table 6 are the raw concentrations with no bias adjustment applied.

The highest mean concentrations occurred in November, December and January at roadside and urban background sites. Mean NO_2 concentrations were lowest in the summer months for all site types.

Table 6: Monthly Mean NO_2 Concentrations in Lewisham, 2020 (µg/m^3; Unadjusted)

Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All Sites	35.8	26.6	28.6	25.2		23.4	19.0	26.4	29.5	28.9	36.7	30.8
Roadside	38.6	28.8	31.6	27.8		27.9	22.1	30.8	32.7	32.1	39.4	33.5
Urban Background	31.9	23.2	24.2	21.0		17.9	15.0	20.2	24.7	24.5	33.5	27.8

Table 7: Unadjusted Winter and Summer Period Mean Concentrations in Lewisham, 2020

Site Type	Winter Mean Concentration (October – March) (µg/m^3)	Summer Mean Concentration (April – September) (µg/m^3)	Ratio Winter : Summer
All Sites	31.2	24.7	1.26
Roadside	34.0	28.2	1.20
Urban Background	27.5	19.8	1.39

Table 7 shows that the ratio of winter to summer mean NO_2 concentration was 1.2 for roadside sites, indicating mean concentrations were higher in the winter than the summer period. The urban background sites display a greater winter: summer ratio compared to roadside sites with a value of 1.39 in 2020. For all sites, collectively, the ratio of winter to summer mean NO_2 concentration was 1.26.

4.4 Historical Trends

Table 8 summarises the results of the Lewisham Tube Network by site type from 2014 to 2020; results for each site in 2020 are detailed in Appendix B. These results have been bias-adjusted using the factors derived in Appendix C.

Measurements from the past year showed a decrease in annual mean NO_2 concentration across the network between 2019 and 2020. The impact of the COVID-19 pandemic on these results is discussed in the LB Lewisham 2021 ASR.

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

Table 8: Annual Mean NO_2 Concentration (bias-adjusted) by Site Type, 2015 – 2020

Site Type	Bias Adjusted Annual Mean NO_2 Concentration ($\mu g/m^3$)					
	2015		2016		2017	
	Bias Adjusted using New Cross Co-located tubes (Factor = 1.02)	Bias Adjusted using New Cross Co-located tubes (Factor = 1.02)	Bias Adjusted using New Cross Co-located tubes (Factor = 0.92)	Bias Adjusted using National Bias Adjustment factor (Factor = 1.03	Bias Adjusted using New Cross Co-located tubes (Factor = 1.00)	Bias Adjusted using National Bias Adjustment factor (Factor = 0.97)
All Sites	37.7	37.7	34.5	38.7	35.5	34.4
Roadside	**43.5**	**43.5**	39.4	**44.1**	**40.1**	38.9
Urban Background	29.3	29.3	27.4	30.7	29.9	29.0

Site Type	Bias Adjusted Annual Mean NO_2 Concentration ($\mu g/m^3$)					
	2018		2019		2020	
	Bias Adjusted using New Cross Co-located tubes (Factor = 0.91)	Bias Adjusted using National Bias Adjustment factor (Factor = 0.92)	Bias Adjusted using New Cross Co-located tubes (Factor = 0.91)	Bias Adjusted using National Bias Adjustment factor (Factor = 0.87)	Bias Adjusted using New Cross Co-located tubes (Factor = 0.78)	Bias Adjusted using National Bias Adjustment factor (Factor = 0.82)
All Sites	31.5	31.9	29.6	28.3	22.2	23.3
Roadside	35.7	36.1	33.2	31.8	24.8	26.0
Urban Background	26.2	26.5	25.0	23.9	18.8	19.8

5. Conclusions

The main conclusions of the 2020 Lewisham Diffusion Tube Network study are:

- The raw mean NO_2 concentration for the whole network was 28.4 $\mu g/m^3$. Adjusted using the national adjustment factor, this was 23.3 $\mu g/m^3$;
- NO_2 concentrations were greatest at roadside monitoring locations, and lowest at urban background sites, as would be expected;
- The maximum annual mean NO_2 concentration was measured at the L51 site at 290 Brownhill Road, South Circular (34.0 $\mu g/m^3$);
- The mean roadside NO_2 concentration across the network was 26.0 $\mu g/m^3$ based on the national bias adjustment factor and the mean urban background concentration was 19.8 $\mu g/m^3$;
- Results based on applying either the national or local adjustment factor showed no diffusion tube locations exceeding the annual mean NO_2 objective;
- When correcting for distance between the monitoring location and the nearest receptor, no locations of relevant exposure exceed the objective, using either bias adjustment factor; and
- None of the locations recorded an annual mean above 60 $\mu g/m^3$, indicating that it is unlikely that the short-term objective was exceeded in 2020.

Appendix A: Diffusion Tube Locations

Figure 2: LB Lewisham Diffusion Tube Network (South) in 2020

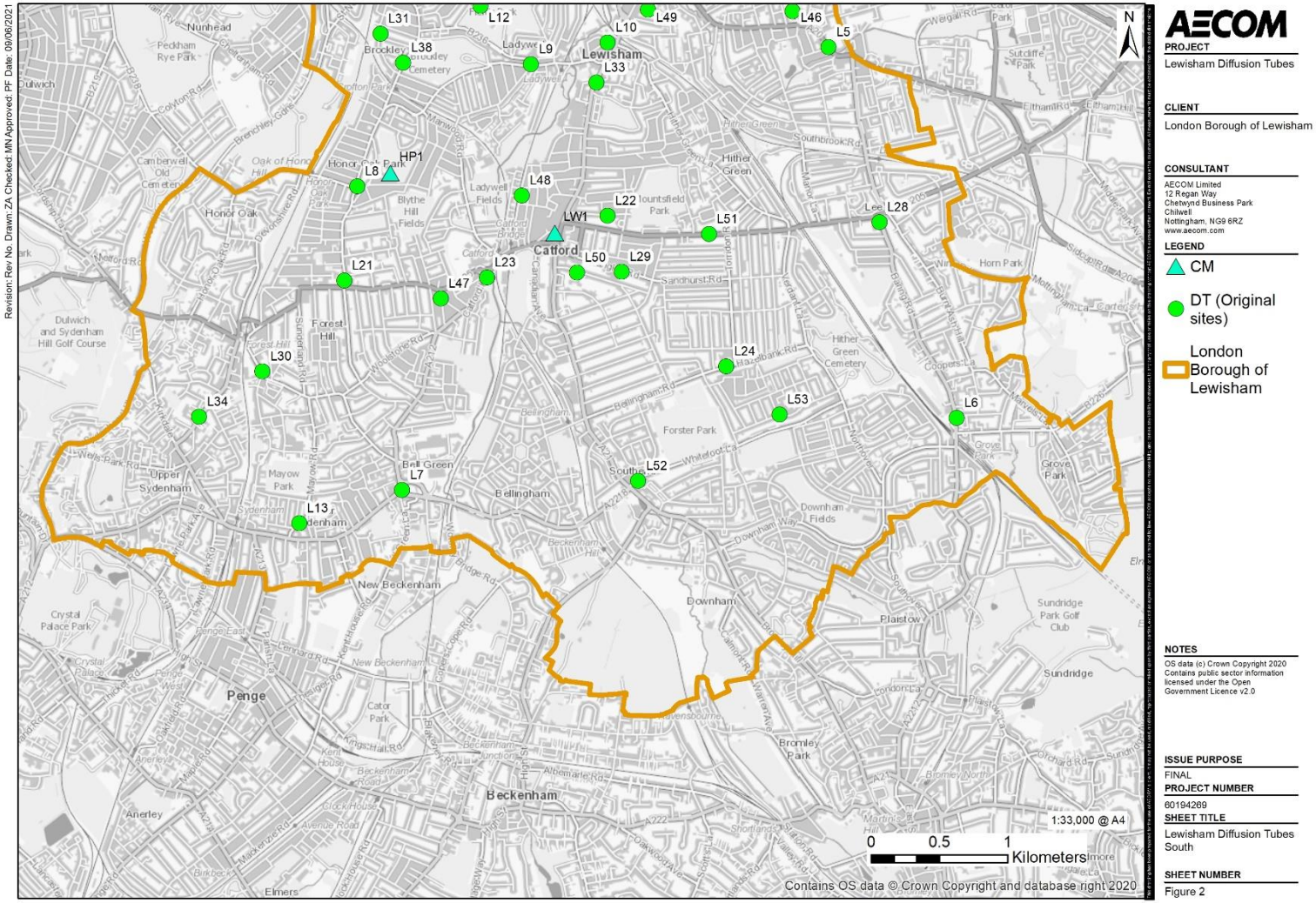
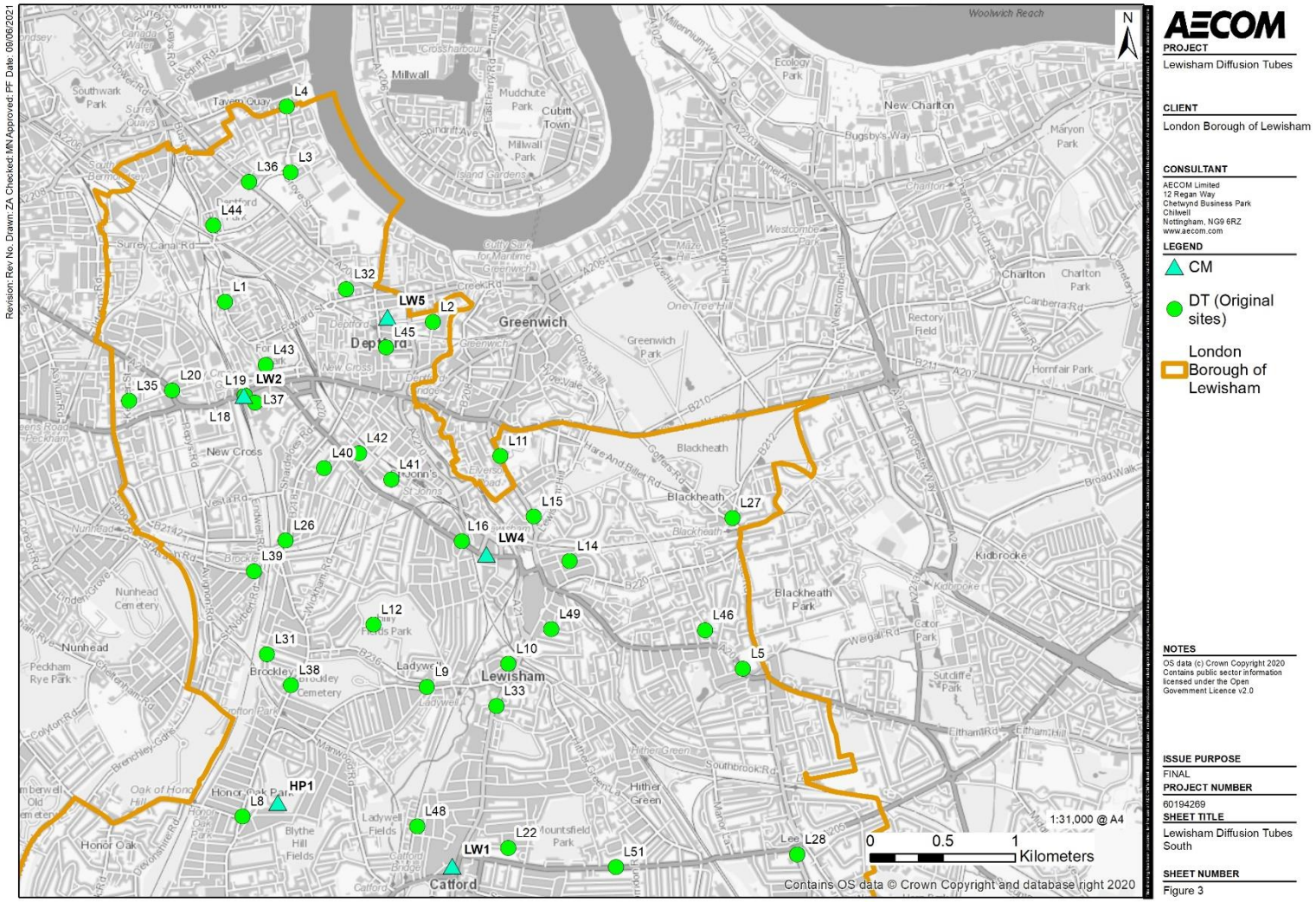


Figure 3: LB Lewisham Diffusion Tube Network (North) in 2020



Appendix B: Diffusion Tube Results

Table 9: Lewisham Diffusion Tube Network 2020 – Raw and Bias Adjusted Results

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
L1	L1	Chubworthy Street	536109	177580	Roadside	92	26.7	20.8	21.9	-	Monitored concentration below background
L2	L2	Bronze Street	537540	177439	Urban Background	83	24.5	19.1	20.1	*	-
L3	L3	Grove Street	536561	178471	Urban Background	92	25.1	19.6	20.6	*	-
L4	L4	Plough Way	536534	178926	Urban Background	92	25.8	20.1	21.1	*	-
L5	L5	Lee High Road	539678	175050	Roadside	92	26.6	20.8	21.8	*	-
L6	L6	Le May Avenue	540615	172337	Urban Background	92	26.9	21.0	22.1	*	-
L7	L7	Bell Green	536556	171810	Roadside	83	39.6	30.9	32.5	*	-
L8	L8	Stondon Park	536229	174032	Roadside	92	29.9	23.3	24.5	*	-
L9	L9	Ladywell Road	537500	174925	Roadside	75	31.3	24.4	25.7	*	-
L10	L10	Whitburn Road	538062	175085	Roadside	83	30.2	23.5	24.7	24.6	-

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
L11	L11	Sparta St, opp Morden Mount School	538007	176517	Roadside	83	28.8	22.5	23.6	23.3	
L12	L12	Hilly Fields	537132	175353	Urban Background	83	23.7	18.5	19.4	*	
SCH 8	L29	Holy Cross School	538165	173406	Roadside	83	24.8	19.4	20.4	*	
SCH 13	L30	St George's CofE School	535535	172679	Roadside	92	24.0	18.7	19.7	-	Monitored concentration below background
SCH 16	L31	St Mary Magdalen's School	536399	175150	Urban Background	92	21.7	16.9	17.8	*	
SCH 18	L32	Grinling Gibbons School	536944	177665	Urban Background	92	25.2	19.6	20.7	*	
SCH 20	L33	St Mary's Lewisham School	537979	174792	Roadside	83	34.4	26.9	28.2	*	
SCH 21	L34	Sydenham School	535071	172346	Urban Background	92	22.3	17.4	18.3	*	

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
SCH 22	L35	Kender Primary School	535447	176897	Roadside	92	24.2	18.9	19.9	*	
SCH 23	L36	Deptford Park School	536275	178405	Roadside	83	32.1	25.1	26.3	*	
SCH 24	L37	St James Hatcham School	536317	176883	Urban Background	92	23.9	18.7	19.6	*	
LWS 53	L13	Mayow Road	535804	171567	Urban Background	83	23.7	18.5	19.5	*	
LWS 002	L14	Boyne Road	538482	175792	Urban Background	92	26.0	20.3	21.4	*	
LWS 003	L15	Lewisham Road	538237	176101	Roadside	92	32.8	25.6	26.9	*	
LWS 004	L16	Loampit Vale	537740	175930	Roadside	83	36.0	28.1	29.5	*	
LWS 005	L17	New Cross AQMS	536246	176934	Roadside	67	37.0	26.4	27.7	*	
LWS 006	L18	New Cross AQMS	536246	176934	Roadside	67	37.7	28.6	30.1	*	
LWS 007	L19	New Cross AQMS	536246	176934	Roadside	67	35.2	26.7	28.1	*	

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
LWS 008	L20	Hatcham Park Road	535746	176969	Roadside	83	31.2	24.4	25.6	25.5	
LWS 009	L21	Brockley Rise	536133	173341	Roadside	92	36.7	28.6	30.1	*	
LWS 010	L22	Ringstead Road	538060	173816	Urban Background	75	26.8	20.9	22.0	*	
LWS 011	L23	Catford Hill	537178	173365	Roadside	83	36.5	28.5	29.9	26.3	
LWS 015	L26	Shardeloes Road	536527	175935	Roadside	92	36.3	28.3	29.8	26.8	
LWS 016	L27	Montpelier Vale	539605	176090	Roadside	92	38.1	29.7	31.2	28.5	
LWS 017	L28	Baring Road	540051	173769	Roadside	92	40.7	31.7	33.4	27.2	
LWS 018	L24	Torridon School Hazelbank Road	538930	172713	Urban Background	75	29.4	22.9	24.1	*	
L38	L38	Beecroft Primary School	536564	174937	Roadside	92	27.4	21.4	22.5	21.7	
L39	L39	John Stainer Primary School	536308	175721	Roadside	92	27.8	21.7	22.8	22.1	

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
L40	L40	Myatt Garden Primary School	536792	176432	Urban Background	75	21.6	16.9	17.7	*	
L41	L41	Ashmead Primary School	537256	176353	Urban Background	92	21.4	16.7	17.6	*	
L42	L42	Lucas Vale Primary School	537032	176534	Urban Background	83	25.1	19.6	20.6	*	
L43	L43	Childeric Primary School	536389	177144	Urban Background	92	24.7	19.2	20.2	*	
L44	L44	Sir Francis Drake Primary School	536028	178107	Roadside	83	31.8	24.8	26.1	25.9	
L45	L45	Tidemill Academy	537219	177264	Roadside	92	24.9	19.4	20.4	-	Monitored concentration below background
L46	L46	St Margaret Lee Primary School	539416	175315	Urban Background	92	23.0	17.9	18.8	*	

Original Site Name	New Site Name	Address	X	Y	Site Type	Data Capture	Raw	Locally Adjusted	Nationally Adjusted	Distance Corrected	Comment
L47	L47	Rathfern Primary School	536839	173211	Roadside	83	24.9	19.4	20.4	20.4	
L48	L48	Holbeach Primary School	537433	173965	Urban Background	75	24.9	19.4	20.4	*	
L49	L49	St Saviours RC Primary School	538358	175324	Urban Background	83	24.8	19.3	20.3	*	
L50	L50	Rushey Green Primary School	537836	173400	Urban Background	83	21.7	16.9	17.8	*	
L51	L51	290 Brownhill Road S Circular	538803	173683	Roadside	75	41.5	32.4	34.0	28.2	
L52	L52	St John CofE School	538285	171877	Roadside	83	33.2	25.9	27.3	25.8	
L53	L53	Greenvale School	539319	172362	Urban Background	83	19.4	15.1	15.9	*	

* Sites at relevant exposure or urban background locations are not included

Appendix C: Diffusion Tube Bias Adjustment

Table 10: Summary of Local and National Bias Adjustment Factors for Lewisham NO_2 Diffusion Tube Surveys, 2009 to 2020

Site Type	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
2016	0.92	1.03
2017	1.00	0.97
2018	0.91	0.92
2019	0.91	0.87
2020	0.78	0.82

Notes: [a] National factor obtained from Bias Adjustment Factor spreadsheet[3] version 03/21 based on Gradko as the analysing laboratory using the 50% TEA in acetone method

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	Automatic Method: Period Mean	Automatic Method: Data Capture (% DC)	Data Quality Check: Tubes Precision Check	Data Quality Check: Automatic Monitor Data
1	07/01/2020	04/02/2020	47.9	47.5	44.7	47	1.7	4	4.3	35.0895	94.612069	Good	Good
2	04/02/2020	03/03/2020	39.8	40.8	36.1	39	2.4	6	6.1	32.5171	97.805876	Good	Good
3	03/03/2020	02/04/2020		39.1	39.3	39	0.1	0	1.2	30.9518	98.02152	Good	Good
4	02/04/2020	04/05/2020	32.7		31.9	32	0.6	2	5.1	27.566	97.884803	Good	Good
5	05/06/2020	02/07/2020		35.8	23.4	30	8.8	30	78.7	22.42450	97.608947	Poor Precision	Good
6	02/07/2020	29/07/2020	22.8							21.85075	93.629808		Good
7	29/07/2020	02/09/2020		39.6	40.3	40	0.5	1	4.3	28.73214	97.804672	Good	Good
8	02/09/2020	01/10/2020	41.2	46.4		44	3.6	8	32.7	33.40877	97.809695	Good	Good
9	01/10/2020	06/11/2020	40.0	36.9	39.9	39	1.8	5	4.4	30.86592	97.772635	Good	Good
10	06/11/2020	02/12/2020	36.2							32.1205	97.51702		Good
11	02/12/2020	06/01/2021	35.7	15.3	26.3	26	10.2	40	25.3	29.1452	94.495686	Poor Precision	Good
12													
13													
											Overall survey -->	Good precision	Good Overall

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

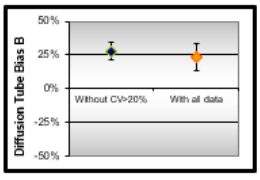
(Check average CV & DC from Accuracy calculations)

Site Name/ ID: New Cross AQMS

Precision: 7 out of 9 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval) without periods with CV larger than 20%
Bias calculated using 7 periods of data
Bias factor A 0.78 (0.74 - 0.83)
Bias B 28% (21% - 34%)
Diffusion Tubes Mean: 40 µgm^{-3}
Mean CV (Precision): 4
Automatic Mean: 31 µgm^{-3}
Data Capture for periods used: 97%
Adjusted Tubes Mean: 31 (30 - 33) µgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA
Bias calculated using 9 periods of data
Bias factor A 0.81 (0.75 - 0.88)
Bias B 24% (14% - 34%)
Diffusion Tubes Mean: 37 µgm^{-3}
Mean CV (Precision): 11 caution
Automatic Mean: 30 µgm^{-3}
Data Capture for periods used: 97%
Adjusted Tubes Mean: 30 (28 - 33) µgm^{-3}



Jaume Targa, for AEA
Version 04 - February 2011

Figure 5: National Bias Adjustment Factor Calculator

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 03/21

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 2021

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@bureauveritas.com or 0800 0327953

Analysed By[1]	Method (To make your selection, choose [All] from the pop-up list)	Year[1] (To make 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[5]	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	50% TEA in Acetone	2020	UC	Falkirk Council	10	33	26	24.9%	G	0.80
Gradko	20% TEA in water	2020	R	Gedling Borough Council	10	31	25	24.1%	G	0.81
Gradko	50% TEA in Acetone	2020	UB	Falkirk Council	11	16	12	33.6%	G	0.75
Gradko	50% TEA in acetone	2020	UB	Middlesbrough	10	17	12	44.3%	G	0.69
Gradko	50% TEA in acetone	2020	R	Royal Borough of Windsor and Maidenhead	12	29	25	17.3%	G	0.85
Gradko	50% TEA in acetone	2020	R	Royal Borough of Windsor and Maidenhead	12	24	22	11.7%	G	0.90
Gradko	20% TEA in water	2020	R	SOUTHAMPTON CITY COUNCIL	12	37	27	37.1%	G	0.73
Gradko	50% TEA in acetone	2020	SU	Redcar & Cleveland Borough Council	11	16	13	23.4%	P	0.81
Gradko	20% TEA in water	2020	R	Fareham Borough Council	10	25	14	77.4%	G	0.56
Gradko	20% TEA in water	2020	R	Fareham Borough Council	12	30	22	35.1%	G	0.74
Gradko	20% TEA in water	2020	R	Fareham Borough Council	10	22	17	26.5%	G	0.79
Gradko	50% TEA in acetone	2020	R	Neuham	10	29	24	18.2%	G	0.85
Gradko	50% TEA in acetone	2020	R	Sandwell MBC	12	34	27	26.9%	G	0.79
Gradko	50% TEA in acetone	2020	B	Sandwell MBC	9	14	11	23.0%	S	0.81
Gradko	50% TEA in acetone	2020	R	Sandwell MBC	11	25	23	9.4%	S	0.91
Gradko	50% TEA in acetone	2020	UB	Sandwell Metropolitan Borough Council	11	21	19	9.4%	G	0.91
Gradko	20% TEA in water	2020	R	SOUTHAMPTON CITY COUNCIL	11	32	31	4.9%	G	0.95
Gradko	20% TEA in water	2020	KS	Marylebone Road Intercomparison	12	57	43	33.3%	G	0.75
Gradko	50% TEA in acetone	2020	KS	Marylebone Road Intercomparison	12	57	43	33.0%	G	0.75
Gradko	20% TEA in water	2020	R	Bath & North East Somerset	11	32	29	13.0%	G	0.89
Gradko	20% TEA in water	2020	R	Gateshead Council	12	22	17	28.1%	G	0.78
Gradko	20% TEA in water	2020	R	Gateshead Council	12	23	21	11.6%	G	0.90
Gradko	20% TEA in water	2020	R	Gateshead Council	10	26	25	6.5%	G	0.94
Gradko	20% TEA in water	2020	R	Gateshead Council	12	28	21	30.5%	G	0.77
Gradko	20% TEA in water	2020	R	Gateshead Council	12	31	32	-3.4%	G	1.03
Gradko	50% TEA in acetone	2020	R	Landan Borough of Richmand upan Thames	12	22	20	9.4%	G	0.91
Gradko	50% TEA in acetone	2020	B	Landan Borough of Richmand upan Thames	9	19	16	20.3%	G	0.83
Gradko	20% TEA in water	2020	R	Luton Borough Council	9	38	28	33.8%	G	0.75
Gradko	20% TEA in water	2020	R	Nattingham City Council	12	31	34	-8.5%	G	1.09
Gradko	20% TEA in water	2020	R	Dudley MBC	13	33	28	19.9%	G	0.83
Gradko	20% TEA in water	2020	UB	Dudley MBC	13	23	14	61.2%	G	0.62
Gradko	20% TEA in water	2020	R	Dudley MBC	13	44	34	30.6%	G	0.77
Gradko	20% TEA in water	2020		**Overall Factor[3] (18 studies)**				Use		0.81
Gradko	50% TEA in acetone	2020		**Overall Factor[3] (14 studies)**				Use		0.82

Appendix D: Diffusion Tube Locations – 2011 to Present

Table 11: Diffusion Tube Locations

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
L1	L1	Chubworthy Street	536109	177580	Roadside	2011	-	Representative of Chubworthy Street
L10	L10	Whitburn Road	538062	175085	Roadside	2011	-	Representative of Lewisham High Street
L11	L11	Sparta St, opp Morden Mount School	538007	176517	Roadside	2011	-	Located near school
L12	L12	Hilly Fields	537132	175353	Urban Background	2011	-	Representative of Hilly Fields
L2	L2	Bronze Street	537540	177439	Urban Background	2011	-	Representative of Sue Godfrey Local Nature Reserve
L3	L3	Grove Street	536561	178471	Urban Background	2011	-	Representative of Deptford Park Primary School
L38	L38	Beecroft Primary School	536564	174937	Roadside	2018	-	Located near school
L39	L39	John Stainer Primary School	536308	175721	Roadside	2018	-	Located near school
L4	L4	Plough Way	536534	178926	Urban Background	2011	-	Representative of South Docks

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
L40	L40	Myatt Garden Primary School	536792	176432	Urban Background	2018	-	Located near school
L41	L41	Ashmead Primary School	537256	176353	Urban Background	2018	-	Located near school
L42	L42	Lucas Vale Primary School	537032	176534	Urban Background	2018	-	Located near school
L43	L43	Childeric Primary School	536389	177144	Urban Background	2018	-	Located near school
L44	L44	Sir Francis Drake Primary School	536028	178107	Roadside	2018	-	Located near school
L45	L45	Tidemill Academy	537219	177264	Roadside	2018	-	Located near school
L46	L46	St Margaret Lee Primary School	539416	175315	Urban Background	2018	-	Located near school
L47	L47	Rathfern Primary School	536839	173211	Roadside	2018	-	Located near school
L48	L48	Holbeach Primary School	537433	173965	Urban Background	2018	-	Located near school
L49	L49	St Saviours RC Primary School	538358	175324	Urban Background	2018	-	Located near school
L5	L5	Lee High Road	539678	175050	Roadside	2011	-	Considered worst case location in local area due to A20

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
L50	L50	Rushey Green Primary School	537836	173400	Urban Background	2018	-	Located near school
L51	L51	290 Brownhill Road S Circular	538803	173683	Roadside	2018	-	Considered worst case location in local area due to A205
L52	L52	St John CofE School	538285	171877	Roadside	2018	-	Located near school
L53	L53	Greenvale School	539319	172362	Urban Background	2018	-	Located near school
L6	L6	Le May Avenue	540615	172337	Urban Background	2011	-	Representative of Baring Road
L7	L7	Bell Green	536556	171810	Roadside	2011	-	Considered worst case location in local area due to A212 and A2218
L8	L8	Stondon Park	536229	174032	Roadside	2011	-	Representative of Stondon Park
L9	L9	Ladywell Road	537500	174925	Roadside	2011	-	Representative of Ladywell Road
LWS 002	L14	Boyne Road	538482	175792	Urban Background	2011	-	Representative of Boyne Road
LWS 003	L15	Lewisham Road	538237	176101	Roadside	2011	-	Representative of Lewisham Road
LWS 004	L16	Loampit Vale	537740	175930	Roadside	2011	-	Representative of Loampit Vale

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
LWS 005	L17	New Cross AQMS	536246	176934	Roadside	2011	-	Representative of New Cross AQMS
LWS 006	L18	New Cross AQMS	536246	176934	Roadside	2011	-	Representative of New Cross AQMS
LWS 007	L19	New Cross AQMS	536246	176934	Roadside	2011	-	Representative of New Cross AQMS
LWS 008	L20	Hatcham Park Road	535746	176969	Roadside	2011	-	Representative of Hatcham Park Road
LWS 009	L21	Brockley Rise	536133	173341	Roadside	2011	-	Representative of Brockley Rise
LWS 010	L22	Ringstead Road	538060	173816	Urban Background	2011	-	Representative of Ringstead Road
LWS 011	L23	Catford Hill	537178	173365	Roadside	2011	-	Representative of Catford Hill
LWS 015	L26	Shardeloes Road	536527	175935	Roadside	2011	-	Representative of Shardeloes Road
LWS 016	L27	Montpelier Vale	539605	176090	Roadside	2011	-	Representative of Montpelier Vale
LWS 017	L28	Baring Road	540051	173769	Roadside	2011	-	Representative of Baring Road
LWS 018	L24	Torridon School Hazelbank Road	538930	172713	Urban Background	2011	-	Located near school

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
LWS 53	L13	Mayow Road	535804	171567	Urban Background	2011	-	Representative of Mayow Road
SCH 13	L30	St George's CofE School	535535	172679	Roadside	2011	-	Located near school
SCH 16	L31	St Mary Magdalen's School	536399	175150	Urban Background	2011	-	Located near school
SCH 18	L32	Grinling Gibbons School	536944	177665	Urban Background	2011	-	Located near school
SCH 20	L33	St Mary's Lewisham School	537979	174792	Roadside	2011	-	Located near school
SCH 21	L34	Sydenham School	535071	172346	Urban Background	2011	-	Located near school
SCH 22	L35	Kender Primary School	535447	176897	Roadside	2016	-	Located near school
SCH 23	L36	Deptford Park School	536275	178405	Roadside	2016	-	Located near school
SCH 24	L37	St James Hatcham School	536317	176883	Urban Background	2017	-	Located near school
SCH 8	L29	Holy Cross School	538165	173406	Roadside	2011	-	Located near school
LWS 014	L25	Downpipe to 8 Stanstead Road	535536	173192	Urban Background	2011	2018	Representative of Stanstead Road

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
SCH 1	-	All Saints Primary School	539250	176402	Urban Background	2011	2012	Located near school
SCH 2	-	Lee Manor	539348	174477	Urban Background	2011	2012	Located near school
SCH 3	-	Cooper's Lane	540545	172840	Urban Background	2011	2012	Located near school
SCH 4	-	Launcelot	540149	171652	Urban Background	2011	2012	Located near school
SCH 5	-	Bonus Pastor	539063	171632	Urban Background	2011	2012	Located near school
SCH 6	-	Forster Park	539369	172480	Urban Background	2011	2012	Located near school
SCH 7	-	Sandhurst Juniors & Infants	539089	173398	Urban Background	2011	2012	Located near school
SCH 9	-	Catford High School	538456	172426	Urban Background	2011	2012	Located near school
SCH 10	-	Athelney JMI	537453	172410	Urban Background	2011	2012	Located near school
SCH 11	-	St Michael's CE	536245	171849	Urban Background	2011	2012	Located near school
SCH 12	-	St William of York	536241	173493	Urban Background	2011	2012	Located near school

Original Site Name	New Site Name	Address	X	Y	Site Type	Date of Diffusion Tube Added	Date of Diffusion Tube Removed	Reasoning behind location
SCH 14	-	Perrymount	535862	172685	Urban Background	2011	2012	Located near school
SCH 15	-	Holbeach	537438	173941	Urban Background	2011	2012	Located near school
SCH 17	-	Turnham	536118	175119	Urban Background	2011	2012	Located near school
SCH 19	-	St Saviour's	538311	175304	Urban Background	2011	2012	Located near school

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