LONDON BOROUGH OF EALING

NITROGEN DIOXIDE DIFFUSION TUBE SURVEY 2009

BV/AQ/AGGX0902/PB/2646

September 2010

BUREAU VERITAS

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Document Control Sheet

Issue/Revision	Issue 1	Revision 1	Revision 2	Final
Remarks				
Date	July 2010	July 2010	September	
Submitted to		John Freeman	John Freeman	
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Approved by	Yasmin Vawda	Yasmin Vawda	Yasmin Vawda	
Signature				
Project number	AGGX1347565	AGGX1347565	AGGX1347565	
File reference	BV/AQ/PB/2646	BV/AQ/PB/2646/R1	BV/AQ/PB/2646/R2	

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Executive Summary

The Ealing Nitrogen Dioxide Diffusion Tube Network was established to provide spatial and temporal information on the nitrogen dioxide concentrations in the Borough. The Network is now comprised of 96 sites and supplements continuous chemiluminenscent analysers at four locations within the Borough which are part of the London Air Quality Network. Bureau Veritas acquired the stewardship of the Diffusion Tube Network in April 2008.

Diffusion tubes are a recognised indicative and inexpensive method for assessing NO_2 concentrations. The factors that can influence tube performance are discussed.

This report covers the period January to December 2009 and provides the measured annual mean concentration for the diffusion tubes in the Network. A comparison is made with historic data from 2001 to 2008. Historic data were recalculated for the 2008 report to bring the reporting in line with the calendar year.

During 2009, seven new sites were introduced to address specific issues of air quality within the Borough. Data capture was greater than 75% for most sites and greater than 90% at 53 of the 96 sites.

In line with the new Practical Guidance released in February 2008, the site designations have been reclassified in this report into four categories: kerbside, roadside, near roadside and urban background.

The report compares the data with the existing Air Quality Strategy policy framework. The majority of sites (when bias corrected) preach the Air Quality Standards and EC Daughter Directive objectives and limits.

Recommendations have been made for improvements in the quality of the data from the Network in relation to re-evaluating the current monitoring locations.

1 Introduction

1.1 The Ealing Nitrogen Dioxide Diffusion Tube Network.

The diffusion tube network is maintained to determine both the spatial and temporal variation of nitrogen dioxide (NO_2) concentrations throughout the Borough. These measurements both supplement and complement the real-time continuous monitoring that is undertaken at four locations; either as part of the AURN network (Acton Town Hall) or the London Air Quality Network (Ealing Town Hall, Southall and Hanger Lane Gyratory).

1.2 Scope of Report

This report covers the 12 month period January – December 2009 and examines the annual means and variation within and between locations. Bias correction calculations were performed on all data. Comparisons are made with historic data from the same monitoring locations.

2 Policy Framework

The European First Air Quality Daughter Directive (1999/30/EC) and its revisions set out the first limits for the annual and hourly mean concentrations for nitrogen dioxide. These standards were aimed to be met by January 2010. The CAFÉ Directive 2008 (2008/50/EC)[1] superseded the earlier directives and re-affirmed the achievement dates and concentrations. The Air Quality Standards relevant to the UK were published in The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Originally published in 1997 these standards have been subsequently updated[2] but have always retained the two objectives for hourly and annual mean concentrations.

Table 1 Air Quality Standard Objectives for Nitrogen Dioxide

Legislation	Concentration	Measurement	Achievement Date
EU CAFÉ Directive			
Hourly	200 µg/m³ with maximum 18 exceedence per annum	1-hour Mean	January 2010
Annual	40µg/m³	Annual Mean	January 2010
Vegetation	30µg/m³	Annual Mean NOx	July 2010
Air Quality Standards 2007			
Hourly	200 µg/m³ with maximum 18 exceedences per annum	1-hour Mean	January 2010
Hourly Upper Assessment Threshold	70% limit value (140µg/m³) with maxmumum 18 exceedences per year	1-hour Mean	January 2010
Hourly Lower Assessment Threshold	50% of limit value (100 µg/m³) with maximum 18 exceedences per year	1-hour Mean	January 2010
Annual	40µg/m³	Annual Mean	January 2010
Annual Upper Threshold	80% of limit value (32 µg/m³)	Annual Mean	January 2010
Annual Lower Threshold	65% of limit value (26 µg/m³)	Annual Mean	January 2010

[1] EU (2008) Directive 2008/50/EC Ambient Air Quality and Cleaner Air For Europe
[2] DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland – Working Together for Clean Air, Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

3 Methodology

3.1 Procedures

Bureau Veritas acquired the stewardship of the Ealing Diffusion Tube Network in 2008 from Faber Maunsell, with the first month's deployment in April 2008. During the period January to December 2009, 109 tubes were deployed as single or triplicate tubes at 89 existing and long term locations. The number of sites increased in July and August 2009 such that 116 tubes were exposed in the last 6 months of 2009, across 96 monitoring locations. Tubes were installed/ collected every 4-5 weeks as dictated by the UK NO_2 Diffusion tube calendar (AEAT, 2009). Until 2005, this formed the basis of the National Diffusion Tube Network. The calendar is still produced every year by AEAT to provide consistency in deployment and comparability within and between monitoring programmes. Tubes with exposure periods outside the calendar and those with contaminants e.g. webs, have been removed from the data set.

3.2 Tube Preparation and Analysis

The diffusion tubes were prepared according to both UKAS accreditation and the Harmonisation Practical Guidance published February 2008 (AEAT). Tubes used during 2009 were prepared using 20% v/v triethanolamine in water to maintain consistency with previous years' monitoring programmes and required by London Borough of Ealing. The tubes were transported to and from the laboratory in cooler boxes and refrigerated before deployment and after collection. This minimises any thermal destabilisation or secondary chemical reactions.

3.3 Laboratory Quality Assurance / Quality Control

The tubes were supplied by Gradko International Ltd, which is a member of the Diffusion Tube Harmonisation Working Party. The EU CAFE Directive mandated that data derived from diffusion tube monitoring must demonstrate an accuracy within ± 25%. Gradko participate in both the Health and Safety Laboratory WASP programme (HSE, 2009) and the AEA Network Field Inter-Comparison Exercise. The laboratory WASP ratings changed in 2009 to a rolling performance index based on z-scores with three categories: "satisfactory", "adequate" and "unsatisfactory". For the testing rounds which took place in 2009, Gradko was rated as "satisfactory". The Field Intercomparison Exercise comprises monthly co-located triplicates to determine the co-efficient of variation (CoV) using the bias adjustment calculation spreadsheet; the criterion for performance is that the mean annual CoV should not exceed 10%. The results of the Intercomparison criteria are shown in Table 2

Table 2 Summary of NO_2 Field Inter-comparison Results 2009

Annual Mean Bias		Precision	
AEA Perfomance Target	Gradko Annual Mean Bias	AEA Performance Target	Gradko Precision
±25%	13%	10%	4%

3.4 Data Validation

In Ealing, there are four continuous monitoring stations operated under the aegis of the London Air Quality Network or the Automatic Urban Network. These are located at Ealing Town Hall (No. 51), Acton Town Hall (No. 55), Fernlea House (No. 85) and Blair Peach School in Southall (No. 89). Triplicate diffusion tubes were co-located at each of these sites so bias-correction factors could be derived. However, Fernlea House acts as a co-location triplicate for the Hangar Lane automatic monitoring site. In order that the set can be categorized as co-located the tubes need to be sited within 1m of the sampling inlet of the automatic analyzer. The tubes are located further than this distance and therefore the site cannot, strictly speaking, be deemed as co-located.

3.5 Site Changes

In the monitoring year, 2009, a small number of site changes occurred. Seven new sites were installed during the year. Site N1 was installed in July at 326 Western Avenue on the building façade. Sites N2 to N7 were installed in the vicinity of Haven Green in Ealing; as follows:

- N2 21 Haven Lane on the building facade
- N3 1a Haven Green on a lamppost
- N4 the middle of Haven Green on lamppost
- N5 on lamppost KC384 on Haven Green opposite 27 Haven Green
- N6 on lamppost 500 opposite 6 Castlebar Road
- N7 in Gordon Road on lamppost KC2 adjacent to the rear of 6 Haven Green

4 Factors affecting Diffusion Tube Performance

Diffusion tubes are an effective and relatively inexpensive method for determining spatial variation. However, they do not perform to the same accuracy as the chemiluminescent analyser, which is identified by the EU as the reference method of the measurement for ambient nitrogen dioxide concentrations. Numerous studies have been undertaken to explore the factors affecting diffusion tube performance. These have focused on exposing diffusion tubes alongside chemiluminescence monitors. The results have observed that measurements by diffusion tubes over-estimate (positive bias) or underestimate (negative bias) the true ambient NO_2 concentrations. The various mechanisms[3] [4] that have been proposed to explain the over- and under-estimation of NO_2 concentrations by diffusion tubes include:

Over-estimation of ambient NO_2 concentrations

- Higher wind speeds can generate turbulence in the entrance of the diffusion tube causing a shortening of the diffusion tube length.
- Reduced NO_2 photolysis in the tube by the blocking of UV light by the tube material.
- Interference effects of the secondary particulate compound peroxyacteyl nitrate (PAN).
- Very high concentrations may occur due to sample contamination.

- Under-estimation of ambient NO_2 concentrations
- Insufficient extraction of nitrite from the grids.
- Incorrect standard solution used for calibration.
- Increased exposure time that is thought to cause the degradation of absorbed nitrite over time.
- Very low concentrations may result from the grid disruption or loss; which are both outside the control of the analytical laboratory.

Factors that have been suggested to influence diffusion tube performance[5] include:

- The laboratory preparing and analysing the tubes.
- Time of year.
- The exposure setting – sheltered or exposed.
- The exposure location – roadside or background.
- The tube preparation method.
- The exposure concentration and NO_2/NO_x ratio.

5 Results

5.1 Site Designations

In order to statistically compare locations within the Borough tube locations were separated into different classifications. The definitions have changed since the inception of the Diffusion Tube Network. The two most recent classification schemes are shown below; Tables 3 and 4 contain the definitions by which monitoring locations classified in this report, for background sites the highlighted definition was applied. The geographic location of sites is shown in Appendix 1 and the addresses in Appendix 3.

[3] Air Quality Expert Group (2004) Report on Nitrogen Dioxide in the United Kingdom, Appendix 4
[4] AEA (February 2008) Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guide for Laboratories and Users
[5] Compilation of Diffusion Tube Co-location Studies Carried out by Local Authorities, 2002, Air Quality Consultants

Table 3 Advice from the Air Quality Archive (2007)

Type	Definition
Roadside	1 – 5m from a busy road – formerly "kerbside"
Intermediate	20 – 30m from the same or equivalent road. This category ceased to be used in December 2000, although it remains useful to distinguish sites which fall between roadside and background
Background	>50m from any busy road

Table 4 Current Advice from the Practical Guidance (AEA, 2008)

Type	Definition
Kerbside	< 1m from a busy road
Roadside	1 – 5m from busy road / kerb edge
Near roadside	> 5m from a main road and where air quality is affected by the proximity to the major road
Urban background	>50m from a major source (e.g. car parks), > 30m from a very busy road (30,000 + vehicles per day), >20m from medium sources (e.g. petrol stations), >10m from any main road, or > 5m from places where engines may be idling.

5.2 Data Capture

Data capture for the period April to December was variable, overall it was 91%. During this period 8 sites recorded a capture rate of less than 75%; one was site 64 which suffered persistent losses (50% data capture) throughout 2009, due to access issues during school holidays.

The remaining 7 sites are the new sites N1 to N7 which were introduced in the network in July and August 2009. The complete annual data set is shown in Appendix 3.

A comparison with historic data capture is shown in Table 5. The classifications of monitoring sites differ from previous reports and covers the calendar year (not April to March) as previously reported. To make a near-comparison possible, kerbside and roadside sites were grouped together. Data capture including the new sites in 2009 is shown in brackets.

Table 5 Average Data Capture Rates for the Ealing NO_2 Diffusion Tube Network

Site Type	Percentage Data Capture (%)				
	2005	2006	2007	2008	2009
All sites	94.1	96.1	93.4	91.4	93.7 (90.8)
Roadside (& kerbside)	97.2	96.5	96.4	94.7	96.0 (90.7)
Urban background	90.1	90.1	87.5	86.1	89.6 (89.6)
Intermediate (& near roadside)	95.3	98.8	95.9	90.9	94.3 (91.7)

5.3 Bias Correction Adjustment

Diffusion tubes are an indicative technique for monitoring concentrations of nitrogen dioxide and are best used to complement continuous monitors as required by Local Air Quality Management Technical Guidance (2009). Bias-correction factors were calculated for three co-located monitoring sites: Ealing Town Hall, Acton Town Hall and Blair Peach School. The Hanger Lane / Fernlea House, cannot be used for the purposes of bias-correction, although ideally suited to monitor the heavily trafficked A40/ A406 interchange, as the diffusion tubes are located more than 1m from the continuous analyser inlet[6].

Bias corrections for the three sites were determined using the AEA Diffusion Tube Precision Accuracy Bias (DIFTPAB) spreadsheet available from the Review and Assessment website. Unless indicated

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

otherwise continuous monitoring data from LAQN (ERG, 2009) are fully ratified until 31st December 2009. Acton Town Hall data capture for individual months January, July, September and December was below 75% and poor overall data capture was indicated at Blair Peach and Ealing Town Hall. The calculation summary data are shown in Appendix 2.

Therefore, the bias correction factors used were derived from the Review and Assessment spreadsheet (version 310310.xls), shown in Table 7; a breakdown of sites used in shown in Appendix 2.

Table 6 Local Bias Correction Factors 2009

Site Name	Site Type	Bias Ratio
Ealing Town Hall, New Broadway	Near Roadside	**0.66**
Acton Town Hall, High Street, Acton	Roadside / Kerbside	1.13
Blair Peach School, Southall	Urban background	**0.95**

Table 7 Bias Correction Factors used for 2009 Data

Number of Studies Used	Site Type	Bias Ratio
20 Studies	Roadside & Kerbside	**0.89**
2 Studies	Urban Centre (near Road)	**0.90**
2 Studies	Urban Background	**1.02**

5.4 Average NO_2 Concentrations

Annual average bias corrected concentrations were highest at roadside; the average being 50.7. Overall, Ealing would not meet the AQS objective of 40 µg/m³. The data are shown in Table 8.

Table 8 Mean bias corrected NO_2 Concentrations (µg/m³)

Site	Mean Annual NO_2 Concentration (µg/m³)
All sites	46.2
Kerbside	49.8
Roadside	50.7
Near road	48.1
Urban Background	43.9

5.5 Temporal Variation

Table 9 shows the average whole year mean concentrations of the thirteen long-term sites.

Figure 5.1 shows the variation over time (2001 – 2009) of uncorrected concentrations at all thirteen long term sites in Ealing. The annual average was recalculated in 2008 to bring the historical records in line with the chronological year.

A slight upward trend is visible over with marked increases notable for all sites in 2003 and for Ealing Town Hall and Fernlea House in 2008. The results for 2009 show a return to trend for most sites and marked increases in concentrations at Witten Avenue East and 11 Uxbridge Road. Significant decreases from 2008 were recorded at Ealing Town Hall and Fernlea House.

Table 9 Mean Uncorrected Concentrations (µg/m³) of Long TermSites

Year	All sites	Percent Change – Year on Year
2001	29.5	-
2002	39.3	33.4
2003	53.7	36.4
2004	49.6	-7.6
2005	49.6	0.0
2006	48.4	-2.4
2007	53.5	10.4
2008	55.8	4.3
2009	51.7	-7.3

5.6 Seasonal Variation

Table 10 shows the seasonal variation during January – December 2009.

The bias correction factors have not been applied to the monthly results due to the natural seasonal variation that can occur at sites. The highest concentrations were recorded in February 2009 which is consistent with previous years.

Table 10 Monthly Mean NO_2 Concentrations (µg/m³) 2009

Site Type	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
All sites	67.75	63.97	56.22	55.86	43.81	44.87	47.18	37.98	44.11	54.08	51.48	55.82
Kerbside	68.53	67.05	64.12	62.85	49.24	53.91	52.85	40.54	48.84	59.25	57.18	61.52
Roadside	77.73	64.29	61.24	62.28	49.53	50.88	55.11	45.22	47.56	61.00	58.98	60.24
Near road	65.98	76.48	54.14	63.73	44.18	47.04	48.97	37.81	40.16	51.48	49.34	57.55
Urban Background	58.90	52.16	50.53	39.68	35.72	35.02	35.92	29.55	40.96	46.49	42.15	47.62

The ratio of the winter mean (Jan – Mar and Oct to Dec) to the summer mean (Apr – Sept) for 2009 is 1.27. By classification the ratios are: Kerbside 1.23, Roadside 1.23, Near road 1.26 and for Urban Background 1.37. These are greater than in 2008 and indicate an increase in winter mean concentrations compared to 2008.

5.7 Variation by Height

Wendover Court, adjacent to the A40 Westway dual carriageway is a long term site with tubes exposed on four levels, corresponding to each storey of the building.

Bias corrected indicative results for 2009 are shown in Table 11. Only complete data sets for each month were included to demote seasonal bias. The data were bias corrected using the Roadside factor.

The highest concentration was recorded at ground floor; the lowest on the top floor. This is different to 2008 when the highest annual mean concentration was recorded on the second floor. The variation between the highest and lowest period concentrations is 4.8% for 2009; lower than in previous years.

Table 11 NO_2 Concentrations at Wendover Court

Floor	Mean Annual NO_2 Concentration (µg/m³)
Mean	57.56
Top Floor	55.71
2nd Floor	58.01
1st Floor	57.99
Ground Floor	58.54

5.8 Comparison with Objectives

As shown in Table 1 there is EU and AQS Objectives that are applicable to the UK.
Table 12 shows the total number of sites within each classification which breach the objectives for nitrogen dioxide. Sites that have less than 75% data capture have been excluded.

Table 12 Sites Breaching the AQS Objective (40 µg/m³)

Site Type	Number of sites (all 2009)
All sites	64
Kerbside	8
Roadside	21
Near road	19
Urban Background	16

Twenty-four sites recorded concentrations below 40 µg/m³, using the bias corrected period mean data (excluding sites <75% data capture). This is similar to the previous year and historical records.

It is not directly possible to compare diffusion tube data with hourly average objectives as the sampling period produces monthly concentrations. In previous reports, a scaling factor for the UK (2.2) allows the comparison with the 98th percentile Limit Value by producing a Surrogate Annual Mean with the following equation:

$$\text{Annual Mean}_{(\text{surrogate})} = \frac{\text{Limit Value}}{2.2}$$

The surrogate Annual Mean is 91 µg/m³. During 2009, there were no sites recording concentrations greater than the surrogate annual mean. In previous years 6 Western Avenue was consistently recorded one of the highest concentrations.

However, recent guidance form LAQM TG (09) utilises a mean annual concentration of 60µg/m³ to determine whether the short term objective would be met. Using this criterion; 10 sites would exceed the short term objective as shown in Table 13. The majority of these were roadside or kerbside locations. Several very high concentrations in March and September account for the inclusion of the two background sites.

Table 13 Sites with potential to exceed the Short Term Hourly Objective

Site	Location	Classification	Annual Mean (bias corrected)
7	45 Park Avenue	Background	73.0
12	18 Old Oak Common Lane, W3	Roadside	62.9
19	Lantry Court, Acton, W3	Background	67.0
25	17 Runnymede Gardens	Near Road	71.2
34	8 The Broadway, Ealing, W5	Kerbside	68.1
46	143 Church Road, Northolt, UB5	Roadside	61.1
50	11 Uxbridge Road, Southall, UB1	Roadside	71.4
56	Fernlea House, Hanger Lane	Roadside	79.1
80	6 Western Avenue	Roadside	72.1
85	Fernlea House, Hanger Lane	Roadside	73.1

The sites with the highest potential for exceedence are at Hangar Lane near the busy junction between the A40 and the A406 North Circular (Sites No 56 and 85).

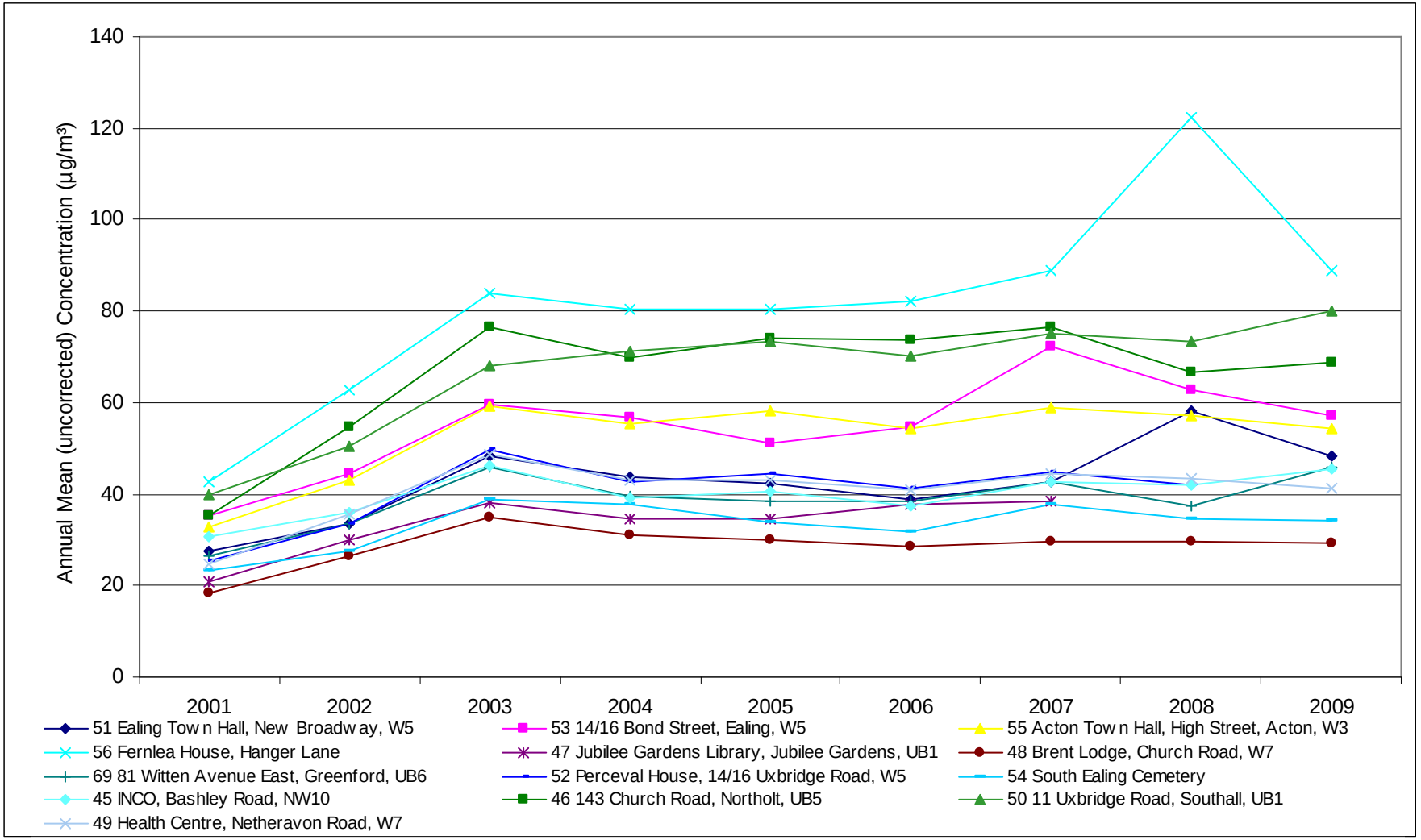

Figure 1 Historic NO_2 Diffusion Tube Concentrations (uncorrected) in London Borough of Ealing (annual average)

6 Recommendations

It is evident that a number of sampling sites do not provide useful data for monitoring NO_2 concentrations in Ealing. In particular, kerbside locations near bus stops do not provide a reasonable representation of concentrations at relevant local receptors, even when façade projections are calculated. It is unlikely that an individual would be located at a bus stop for more than one hour's duration. Therefore, it is recommended that a review of current kerbside sites be undertaken, with a view to re-locating to areas with relevant exposure.

Technical Guidance (TG (09)) and the Practical Guidance have provided a list of poor location characteristics. Sites with such characteristics should not be used for diffusion tube monitoring. These include avoiding the corners of buildings as turbulence could lead to the over estimation of concentrations, avoiding recesses, obstructions to air flow and overhanging vegetation. Therefore, it is recommended that as part of a general overview, the following diffusion tube sites in particular are re-located:

Site 17 (Maples Nursery) is currently non-vertical and located under the entrance roof.
Site 21 (Acton Health Centre); is currently too close to a vent.
Site 64 (St John Fisher Primary School), behind mirror with obstructed air flow. This is also applies to many sites located on road and street signs where the diffusion tube is behind the sign itself.
Site 83 (171 Old Oak Road) is not a secure site, located on the corner of the building and by the entrance of a garage.
Site 81 (Western Avenue) is located on the corner of a residential building.
Site 85 (Fernlea House) theoretically a co-location sites with the Hangar Lane automatic analyser. However, the triplicate tubes are more than 1 metre from the inlet. The triplicate set should be re-located to comply with the Practical Guidance and TG (09). The long-term "sister" site (No 56) is located around the corner on the same building.

7 Conclusions

The overall annual mean concentration across all sites was 46.2 µg/m³. The Kerbside average was 49.6 µg/m³, Roadside average was 50.7 µg/m³, Near Roadside average was 48.1 µg/m³ and the Urban Background average was 43.9 µg/m³.

Overall, concentrations at all 96 sites were 3.8% lower in 2009 than in 2008. Concentrations at the long term sites were lower than in 2009 and more closely aligned to results from previous years after the reclassification of 2008.

The majority of sites (64) recorded concentrations (bias-corrected) that would exceed the Air Quality Standard Objective of 40 µg/m³ (five more than in 2008).

Twenty-four sites recorded concentrations (bias-corrected) in compliance with the Air Quality Standard (one more than in 2008).

12 sites exceeded 60 µg/m³ as an annual mean, the level suggested by the LAQM Guidance 2009 that will lead to potential exceedences of the hourly mean limit value of the CAFÉ Directive. One site would exceed the hourly mean EC 85/203 Limit Value (91µg/m³).

It is recommended that a review of diffusion tube locations be undertaken to improve the relevance to sensitive receptors and to re-locate some diffusion tubes to sites which offer greater compliance with current guidance.

8 References

Defra, Air Quality Standards Regulations, 2007
Defa, Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for Laboratories and Users, 2008
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Appendices

Appendix 1 - Distribution of Diffusion Tubes within LB Ealing


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Image © 2010 Bluesky
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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Appendix 2 - Bias Correction Calculations for 2009

Table A14 Continuous Analyser Data 2009

Site	Classification	Annual Mean Concentration (µg/m³)	Data Capture (%)
Ealing TownHall	Near Roadside	40.4	77.7
Acton Town Hall	Roadside	63.7	70.6
Blair Peach School	Urban Background	30.8	89.5

Ealing Town data provisional after 7th October 2008, Acton Town Hall data provisional after 7th February 2008, Hanger Lane data ratified to 15th January, and Blair Peach data provisional after 14th January 2009.

Data capture for individual months for Acton Town Hall was less than 75% for July to October inclusive. Data Capture for Ealing Town Hall was less than 75% for the months April to July and October. Data Capture for Blair Peach School is also less than 90%. All three sites are considered to have poor data capture for the purposes of bias correction and have not been used.

Table A2 Bias Correction Factors

Site Name	Site Type	Bias Ratio
Ealing Town Hall, New Broadway	Near Roadside	**0.66**
Acton Town Hall, High Street, Acton	Roadside / Kerbside	1.13
Blair Peach School, Southall	Urban background	**0.95**

Therefore bias correction factors for 2009 were derived from the Review and Assessment spreadsheet. Results from single tube studies or with poor precision were not included in calculations. Bias correction factors for the three principle site classifications were used to derive bias adjustment figures for 2009. These are shown in Tables A3 to A5.

Table A3 National Bias Correction Factors 2009 – Roadside and Kerbside Sites

Supplier	Method	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Period Mean (Cm) (µg/m³)	Bias (B)	Tubes Precision Check	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in Water	R	Lancaster CC	12	37	31	19.0%	G	**0.84**
Gradko	20% TEA in Water	R	Cheshire East Council	12	34	21	62.1%	G	**0.62**
Gradko	20% TEA in Water	R	Dartford Council	12	60	58	4.6%	G	**0.96**
Gradko	20% TEA in Water	R	Fareham BC	11	44	36	21.1%	G	**0.83**
Gradko	20% TEA in Water	R	Gedling BC	12	45	36	25.1%	G	**0.80**
Gradko	20% TEA in Water	R	Exeter CC	12	38	39	-4.0%	G	**1.04**
Gradko	20% TEA in Water	K	New Forest DC	12	54	45	20.0%	G	**0.83**
Gradko	20% TEA in Water	R	New Forest DC	12	37	26	42.4%	G	**0.70**
Gradko	20% TEA in Water	R	Carlisle CC	9	38	31	21.5%	G	**0.82**
Gradko	20% TEA in Water	R	Newtownabbey BC	12	37	34	7.0%	G	**0.93**
Gradko	20% TEA in Water	R	Nottingham CC	12	45	41	11.8%	G	**0.89**
Gradko	20% TEA in Water	R	Nottingham CC	11	45	41	9.4%	G	**0.91**
Gradko	20% TEA in Water	R	Chelmsford BC	10	39	36	9.5%	G	**0.91**
Gradko	20% TEA in Water	R	Coventry CC	12	37	36	2.1%	G	**0.98**
Gradko	20% TEA in Water	R	Coventry CC	9	51	65	-22.0%	G	**1.28**
Gradko	20% TEA in Water	R	Dudley MBC	11	42	37	13.1%	G	**0.88**
Gradko	20% TEA in Water	R	Dudley MBC	12	44	40	11.3%	G	**0.90**
Gradko	20% TEA in Water	R	Rushmoor BC	10	35	33	6.2%	G	**0.94**
Gradko	20% TEA in Water	K	AEA Tech Intercomparison	12	121	107	12.6%	G	**0.89**
Gradko	20% TEA in Water	R	Cheshire West & Chester Council	11	41	37	10.0%	G	**0.91**
Gradko	20% TEA in Water							Overall (20 studies)	**0.89**

Table A4 National Bias Correction Factors 2009 – Near Roadside

Supplier	Method	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Period Mean (Cm) (µg/m³)	Bias (B)	Tubes Precision Check	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in Water	UC	Nottingham CC	12	36	34	8.2%	G	**0.92**
Gradko	20% TEA in Water	UC	Belfast CC	10	39	34	14.4%	G	**0.87**
Gradko	20% TEA in Water						Overall (2 studies)		**0.90**

Table A5 National Bias Correction Factors 2009 – Urban Background

Supplier	Method	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Period Mean (Cm) (µg/m³)	Bias (B)	Tubes Precision Check	Bias Adjustment Factor (A) (Cm/Dm)
Gradko	20% TEA in Water	UB	East Hertfordshire DC	9	29	33	-11.0%	G	**1.12**
Gradko	20% TEA in Water	B	Dudley MBC	12	30	27	9.4%	G	**0.91**
Gradko	20% TEA in Water						Overall (2 studies)		**1.02**

Appendix 3 - All Sites - Ambient NO_2 Concentrations for 2009

Table A6 Monitored NO_2 Concentrations 2009 (exceedences are in bold)

Site ID	Site Name	Site Type	Annual Mean (µg/m³)	Bias Corrected Annual Mean (µg/m³)	Data Capture (%)
1	39 Old Oak Lane	R	58.51	**52.07**	100.0
2	101 Wells House Road,	UB	42.16	**43.00**	100.0
3	Jenner Avenue	R	54.99	**48.94**	91.7
4	5 Leamington Park	N	49.64	**44.68**	100.0
5	John Perryn First and Middle School, Long Drive, W3	UB	51.54	**52.57**	83.3
6.1	Top. Wendover Court, Western Avenue, W3	N	61.90	**55.71**	83.3
6.2	2nd Floor	N	64.46	**58.01**	83.3
6.3	1st Floor	N	64.43	**57.99**	83.3
6.4	Ground Floor	N	65.05	**58.54**	83.3
7	45 Park Avenue	UB	64.47	**73.03**	83.3
8	6 Brentmead Gardens	UB	42.18	**43.02**	100.0
9	Iveagh Avenue	R	48.06	**42.78**	91.7
10	57-75 Old Oak Common Lane (PO)	N	59.40	**53.46**	100.0
11	2 St Andrews Road, W3	K	53.94	**48.01**	91.7
12.1	18 Old Oak Common Lane, W3	R	75.50	**67.20**	100.0
12.2	18 Old Oak Common Lane, W3	R	67.79	**60.33**	100.0
12.3	18 Old Oak Common Lane, W3	R	68.76	**61.20**	100.0
13	East Acton Primary School, East Acton Lane	UB	35.11	35.81	100.0
14	First Avenue	UB	53.59	**54.66**	91.7
15	177 The Vale, W3	N	54.95	**49.46**	100.0
17	Maples Nursery, East Churchfield Road, W3	N	38.04	34.24	100.0
19	Lantry Court, Acton, W3	UB	65.73	**67.04**	91.7
20	Age Concern, Social Centre, High Street, Acton, W	R	62.77	**55.86**	100.0
21	Acton Health Centre, Church Road, Acton, W3	N	37.16	33.44	91.7
22	Gunnersbury Unit, Acton Hospital, Gunnersbury Lane	K	57.11	**50.83**	91.7
23	156 Horn Lane, W3	N	50.65	**45.59**	91.7
24	Peal Gardens	R	41.88	37.28	100.0
25	17 Runnymede Gardens	N	79.10	**71.19**	100.0
26	13 Blenhelm Close (off Western Avenue)	R	42.63	37.94	83.3
27	203 Windmill Lane, Greenford	N	44.77	**40.29**	100.0
28	Social Services, Ruislip Road, Greenford, UB	UB	47.02	**47.96**	83.3
29	Shadwell Drive, Northolt, UB5	UB	47.45	**48.40**	75.0
30a	Bengarth Road, Northolt, UB5	R	50.82	**45.23**	83.3

Site ID	Site Name	Site Type	Annual Mean (µg/m³)	Bias Corrected Annual Mean (µg/m³)	Data Capture (%)
32	Lilliput Avenue	UB	41.28	**42.10**	100.0
33	Northolt Primary School, Compton Crescent, UB5	UB	51.52	**52.55**	100.0
34	8 The Broadway, Ealing, W5	K	76.53	**68.11**	100.0
35	Acton Town Medical Centre, 122 Gunnersbury Lane.	K	49.96	**44.46**	100.0
36	Hanwell Nursery, 25A Laurel Gardens, W7	UB	53.45	**54.52**	91.7
37	Ealing Hospital, St Bernards Wing, Uxbridge Road	UB	45.84	**46.76**	100.0
38	Hobbayne First School, Greenford Avenue, W7	UB	33.48	34.15	91.7
39	McDonalds Drive thru, Uxbridge Road, Southall	R	45.90	**40.85**	100.0
40.1	Hambrough Primary and Nursery School, South Road,	N	51.87	**46.68**	91.7
40.2	Hambrough Primary and Nursery School, South Road,	N	52.93	**47.64**	91.7
40.3	Hambrough Primary and Nursery School, South Road,	N	53.81	**48.43**	100.0
41	4 Merrick Road, Southall, UB2	N	45.43	**40.89**	91.7
44	Perivale Wood	UB	30.48	31.09	83.3
45	INCO, Bashley Road, NW10	R	45.41	**40.42**	100.0
46	143 Church Road, Northolt, UB5	R	68.59	**61.05**	100.0
47	Jubilee Gardens Library, Jubilee Gardens, UB1	UB	38.46	39.23	91.7
48	Brent Lodge, Church Road, W7	UB	29.28	29.86	100.0
49	Health Centre, Netheravon Road, W7	N	41.17	37.06	100.0
50	11 Uxbridge Road, Southall, UB1	R	80.17	**71.35**	91.7
51.1	Ealing Town Hall, New Broadway, W5	N	58.30	**52.47**	91.7
51.2	Ealing Town Hall, New Broadway, W5	N	65.65	**59.08**	91.7
51.3	Ealing Town Hall, New Broadway, W5	N	62.05	**55.85**	83.3
52	Perceval House, 14/16 Uxbridge Road, W5	N	40.01	36.01	100.0
53	14/16 Bond Street, Ealing, W5	R	57.24	**50.95**	100.0
54	South Ealing Cemetery	UB	34.10	34.79	100.0
55.1	Acton Town Hall, High Street, Acton, W3	R	54.22	**48.25**	100.0

Site ID	Site Name	Site Type	Annual Mean (µg/m³)	Bias Corrected Annual Mean (µg/m³)	Data Capture (%)
55.2	Acton Town Hall, High Street, Acton, W3	R	55.51	**49.40**	100.0
55.3	Acton Town Hall, High Street, Acton, W3	R	53.21	**47.36**	100.0
56	Fernlea House, Hanger Lane	R	88.88	**79.10**	91.7
57	106/116 St Pauls Close	UB	34.94	35.64	100.0
58	44 Acton Lane, W4	K	57.01	**50.74**	100.0
59	Clayponds Hospital and Day Treatment Centre, Sterling Place	UB	34.01	**34.69**	100.0
60	53 Old Oak Common Lane	N	64.36	**57.93**	100.0
61	15 Balfour Road, W13	UB	37.87	38.62	91.7
62	Kirn Road/Drayton Green Road, W13	R	56.22	**50.03**	91.7
63	St David's Home, 12 Castlebar Hill, W5	UB	34.36	35.05	100.0
64	St John Fisher Primary School, Thirlmere Avenue, G	UB	45.04	**45.94**	50.0
65	2 Horsenden Lane South, Greenford, UB6	R	65.13	**57.96**	91.7
66	57 Woodville Gardens, W5	N	53.26	**47.94**	100.0
67.1	Oldfield Primary School, Oldfield Lane North, Gree	UB	47.98	**48.94**	83.3
67.2	Oldfield Primary School, Oldfield Lane North, Gree	UB	47.39	**48.34**	83.3
67.3	Oldfield Primary School, Oldfield Lane North, Gree	UB	46.65	**47.58**	83.3
68	Gainsboro Gardens, UB6	N	50.34	**45.31**	100.0
69	81 Witten Avenue East, Greenford, UB6	R	45.89	**40.84**	100.0
70	126 Petts Hill, Northolt,	N	42.83	38.54	100.0
71	181 Castle Road, Northolt, UB5	R	40.10	35.69	100.0
72	2/4 Minterne Avenue	R	38.67	34.42	100.0
73.1	LP nr Glebe Nursery School, Western Road, Southall jn	K	56.38	**50.18**	91.7
73.2	LP nr Glebe Nursery School, Western Road, Southall jn	K	56.77	**50.53**	100.0
73.3	LP nr Glebe Nursery School, Western Road, Southall jn	K	57.04	**50.76**	100.0
74	132 Brent Road, Southall, UB2	K	54.91	**48.87**	100.0
75	6 Boston Gardens, W7	N	55.19	**49.67**	100.0
76	200 Boston Gardens, W7	K	53.96	**48.03**	75.0

Site ID	Site Name	Site Type	Annual Mean (µg/m³)	Bias Corrected Annual Mean (µg/m³)	Data Capture (%)
77	7 Greenford Avenue, Southall	N	39.80	35.82	100.0
78	119 Twyford Avenue, W3	R	44.54	39.64	75.0
79	Albert Dane Centre, 19-21 Western Road, Southall	UB	40.10	**40.90**	100.0
80	6 Western Avenue	R	81.04	**72.13**	100.0
81	54 Western Avenue	N	59.95	**53.96**	100.0
82	98 Western Avenue,	N	57.69	**51.92**	100.0
83	171 Old Oak Road	R	50.83	**45.24**	91.7
84	Southfields First and Middle School	UB	38.09	38.85	100.0
85.1	Fernlea House, Hanger Lane	R	80.49	**71.64**	100.0
85.2	Fernlea House, Hanger Lane	R	82.24	**73.19**	100.0
85.3	Fernlea House, Hanger Lane	R	83.71	**74.51**	100.0
86	27 Wells House Road	UB	40.12	**40.93**	100.0
87	94 North Acton Road	N	43.32	38.99	100.0
88	914 Greenford Road	R	45.87	**40.82**	100.0
89.1	Blair Peach School	UB	33.17	33.83	83.3
89.2	Blair Peach School	UB	32.73	31.15	83.3
89.3	Blair Peach School	UB	35.81	33.90	83.3
90.1	The Straight, opposite Randolph Road	UB	49.38	**50.37**	91.7
90.2	The Straight, opposite Randolph Road	UB	50.57	**51.58**	83.3
90.3	The Straight, opposite Randolph Road	UB	49.76	**50.75**	91.7
91.1	Opposite No.40 Manor Road	R	44.95	40.91	91.7
91.2	Opposite No.40 Manor Road	R	44.84	39.91	91.7
91.3	Opposite No.40 Manor Road	R	45.47	**40.47**	91.7
N1	326 Western Avenue	R	57.74	**51.39**	50.0
N2	21 Haven Lane	R	40.79	36.31	41.7
N3	Opposite 1a Haven Green	N	50.49	**44.94**	41.7
N4	Near CCTV post Haven Green	N	49.84	**44.86**	33.3
N5	Woodvale Road opposite 27 Haven Green	R	45.80	**40.77**	41.7
N6	6 Castlebar Road	R	53.47	**47.59**	41.7
N7	Rear of 6 Haven Green	R	44.61	39.70	41.7