Appendix 5 - Air Quality Monitoring Report

Alfriston Traffic Management Scheme

Air Quality Monitoring Report

1.0

January 2019

East Sussex Highways

Alfriston Traffic Management Scheme

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Executive Summary

A diffusion tube survey has been undertaken to assess whether the operation of the proposed traffic signalling scheme is likely to significantly alter local air quality. The scope of the assessment aims to highlight whether compliance issues may exist in Alfriston.

The 3-month diffusion tube survey was undertaken between the 14th of August 2018 and 16th of November 2018. During this period. The proposed traffic management system was tested between September and November 2018. Traffic lights were in operation between 17th September and 14th October, whereas a 20mph speed limit was also in place from 17th September to 11th November.

Owing to the nature of the survey, it is not possible to directly correlate changes in monthly mean NO_2 concentrations with specific aspects of the traffic light trials. The lack of a clear trend in measured values suggests that the impact of Scheme is not significant in air quality terms and is not perceptible against seasonal pollutant variation. In order to ascertain the impact of each iteration of the traffic lights, each trial period would have to be a minimum of 3 months, to allow for estimations over a full year.

The results from the monitoring survey indicated that NO_2 concentrations recorded at all monitored locations are comfortably within the related standard. The highest annual mean NO_2 concentrations were located along the main route through Alfriston (High Street and North Street). This is as a result of congestion (both within and without the proposed scheme), areas where vehicles are likely to accelerate, and street canyons effects. However, despite the busy-nature of these roads (both with and without the scheme), coupled with the street canyon effect, monitored annual mean NO_2 concentrations are all well below the objective.

Given the monitored annual mean NO_2 concentrations are well below 40 μg m^{-3}, the proposed scheme is unlikely to significantly worsen air quality within Alfriston and is compliant with local and national policy.

Contents

Acronyms and Abbreviations

AQMA	Air Quality Management Area
AURN	Automatic Urban and Rural Network
ASR	Annual Status Report
CAFÉ	Clean Air for Europe
Defra	Department of Environment, Food & Rural Affairs
DT	Diffusion Tube
ESCC	East Sussex County Council
EU	European Union
LAQM	Local Air Quality Management
LH	Lullington Heath
NO_2	Nitrogen Dioxide
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter smaller than 2.5 µm in diameter
RWP	Rainwater Pipe
TG	Technical Guidance
UK	United Kingdom
WDC	Wealden District Council

1. Introduction

Jacobs has been commissioned by East Sussex County Council (ESCC) to carry out a diffusion tube monitoring survey to determine the annual mean Nitrogen Dioxide (NO_2) concentrations on Alfriston High Street and nearby roads as a result of varying traffic flow measures.

1.1 Overview

Alfriston is a small, historic village, located within the administrative boundaries of Wealden District Council (WDC). The High Street (between Weavers Lane and Star Lane) is a narrow two-way road with residential or commercial properties on either side, in which instances of regular unorthodox driving measures have been reported where vehicles have been found to 'mount' the kerb to allow two-way flow. The threat this presents to pedestrians, coupled with the tourist appeal of the village and its connection to major road networks (A27 and A259), has raised the demand for a solution to such an unsuitable traffic system. One possible solution is a traffic light system to control flow through the narrow pass. However, this would result in vehicles queuing at either end of the main street and raises concerns of its implications to air quality.

The proposed traffic management system was tested between September and November 2018. Traffic lights were in operation between 17th September and 14th October and a 20 mph speed limit was also in place from 17th September to 11th November.

A 3-month diffusion tube monitoring survey (from August to November 2018) has been undertaken to ascertain and analyse the annual mean NO_2 concentrations and the likelihood of air quality issues arising as a result of altering traffic signalling methods. The scope of the assessment is to highlight whether compliance issues may exist in Alfriston and provide sufficient information to confirm that the scheme is not likely to significantly alter local air quality. This report does not seek to quantify the changes in NO_2 concentrations at each location with the scheme in place, owing to the short-term nature of the trials. It is recognised however, that the scheme may cause fluctuations in pollutant concentrations at different locations during its operation, due to the changing road and driving conditions.

As the survey is 3 months long, annualisation of the diffusion tube results has been carried out, in line with published guidance.

2. Legislation, Policy & Guidance

2.1 Legislation & Policy

EU Directive 2008/50/EC[1], also known as the Clean Air for Europe (CAFÉ) Directive, came into force in June 2008. This was transposed into national legislation in March 2010. The new directive consolidated previous air quality directives (apart from the Fourth Daughter Directive), setting Limit Values or Target Values for the concentrations of specific air pollutants and providing a new regulatory framework for PM smaller than 2.5 µm in diameter ($PM_{2.5}$). It also allowed Member States to apply to postpone attainment deadlines. The EU Limit Values applicable to this assessment are presented in Table 1.

Table 1. Air Quality Objectives for NO_2
In accordance to the Air Quality (England) Regulations 2000 (SI 928 as amended)

Pollutant	Concentration (µg/m^3)	Averaging Period	Compliance Date
Nitrogen Dioxide (NO_2)	200[a]	1-hour mean	1 January 2010
	40	Annual mean	1 January 2010

[a] Not to be exceeded more than 18 times a year.

In the UK, Part IV of the Environment Act 1995[2] sets out the Local Air Quality Management (LAQM) process, where local authorities report compliance to Department of Environment, Food & Rural Affairs (Defra). The Act places an obligation on all local authorities to regularly review and assess air quality in their administrative areas, and to determine whether air quality objectives are being achieved. As part of the management process, local authorities may require developers to assess the air quality effects of proposed developments, as in this case.

2.2 Guidance

Defra's Technical Guidance (LAQM.TG(16)[3]) sets the requirement and considerations to be taken when monitoring NO_2, as set out in sections 7.179 to 7.199, including Box 7.10. It provides recommendations for the selection of appropriate locations and the duration of the monitoring surveys, specifying minimum requirements for quality assurance and quality control, laboratory performance, precision, bias adjustment and annualisation.

[1] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.
[2] Part IV of the Environmental Act 1995 Local Air Quality Management Policy Guidance (PG09) February 2009.
[3] Part IV of the Environmental Act 1995 Environment (Northern Ireland) Order 2002 Part III Local Air Quality Management Technical Guidance (TG16) February 2018.

3. Methodology

3.1 Baseline Information

Baseline information relevant to the Air Quality of the surrounding area has been taken from the following sources:

- Results of the Jacobs diffusion tube survey;
- Review of WDC's latest Air Quality Annual Status Report (ASR) at the time of this report;
- Satellite imagery;
- Defra's websites.

3.2 Monitoring

The chosen method, diffusion tubes (provided by Gradko International Ltd), take samples over an approximate 1-month period and gives an average NO_2 concentration for this period. This makes the technique useful for assessing the annual objective of 40 µg/m^3 but cannot be used to assess compliance with the 1-hour average (i.e. the number of hours in a year with an hourly NO_2 concentration greater than 200 µg/m^3). They are a type of passive sampler, as they do not involve the pumping of any air; instead, the flow is controlled natural diffusion. According to LAQM.TG(16), this method requires a bias adjustment based upon local or national collocation studies from automatic monitoring stations.

Single diffusion tubes were placed at a total of 10 locations. Monitoring locations were designated dependant on the location of sensitive receptors which may be impacted by the proposed changes; this includes locations between or behind traffic lights, as displayed in Figure 1.

Site information for the diffusion tube survey and the monitoring period can be seen in Table 2. and Table 3. respectively.

Figure 1. Jacobs Alfriston Diffusion Tube Locations

Table 2. Jacobs Diffusion Tube Survey Site Information
Diffusion tube coordinates and site location descriptions

ID	X	Y	Description of Location
DT1	552036	102971	On High Street, located at the southernmost region of the new traffic signaling (Weavers Lane-High Street junction), mounted on a RWP on Wingrove House
DT2	552048	103003	On High Street, located in between new traffic signaling on Star Lane-High Street junction and Weavers Lane-High Street junction, mounted on a RWP situated on Coach House Gallery
DT3	552061	103041	On High Street, located centrally of the new traffic signaling (~41 m north of DT2), mounted on a RWP situated on Moonrakers Restaurant
DT4	551976	103076	Located on the junction of Star Lane-Weavers Lane, ~82.7 m east of the traffic signaling, mounted on a wooden telegraph pole
DT5	552024	103103	On Star Lane, located ~29.9 m north east from the northernmost region of the traffic signaling (at Star Lane-High Street junction), mounted on a RWP situated on The Star Inn
DT6	552045	103148	On High Street, located ~36.9 m north of the traffic signaling, mounted on a RWP situated on The House
DT7	552057	103206	Located on North Street, situated ~93.4 m north of the traffic signaling, mounted on a RWP on Holtye Cottage
DT8	552066	103236	Located on North Street, ~124.2 m north of the traffic signaling, mounted on a RWP situated on a residential property (No. 9)
DT9	552014	103218	Located on West Street, ~112.1 m north-north west of the traffic signaling, mounted on a RWP situated on residential property (No. 2)
DT10	552102	103322	Located between Sloe Lane-North Street junction, ~192.4 m north-north east of the traffic signaling, mounted on a drain pipe on Orchard Cottage

Table 3. Jacobs Diffusion Tube Survey Monitoring Period
3-month diffusion tube survey date on and off periods

	Month 1	Month 2	Month 3
Date On	14/08/2018	16/09/2018	14/10/2018
Date Off	16/09/2018	14/10/2018	12/11/2018

The diffusion tube site location photos are presented in Table A1 in Appendix A.

3.3 Annualisation

As stated in LAQM TG(16), it is necessary to perform annualisation for any monitoring survey with less than 9-months' worth of data over a year, with a minimum of 3-months monitoring required. Box 7.10 of LAQM TG(16) states that 2 to 4 nearby (ideally within 50 miles) Automatic Urban and Rural Network (AURN) monitoring sites are selected with a minimum data capture of 85 %. These sites should be background sites, including Urban Background, Suburban or Rural, to avoid air pollution interferences from urban settings. Where nearby background sites are not available, industrial and urban sites can be used, although traffic, roadside or kerbside sites should be avoided. For each automatic monitoring site's data, a ratio is produced from the annual mean and period mean (the period of interest, in this case 14th August to 12th November). An average is then produced from these

ratios, which forms the annualisation factor. The measured period mean concentrations are then multiplied by the annualisation factor to provide an initial estimate of the annual mean NO_2 concentration.

Table 4. displays information regarding the 3 Defra AURN sites that were used in the calculation of the annualisation factor.

Table 4. Defra AURN Monitoring Sites
AURN sites selected for the annualisation factor calculation, with relevant information regarding their proximity to Alfriston, background type and percentage data capture

AURN Site Name	Distance from Alfriston	Environment Type	Data Capture (%)	Annual Mean (µg/m^3)	Period Mean (µg/m^3)[a]	Annual/Period Mean Ratio
Lullington Heath	~1 mile to the south east	Rural Background	99.0	7.6	5.5	1.4
Brighton Preston Park	~13 miles to the west	Urban Background	99.1	16.4	14.7	1.1
Horley	~28 miles to the north west	Suburban Industrial	86.5	19.3	16.9	1.1
					Mean Ratio (Annualisation Factor):	**1.2**

[a] Period Mean calculated between 14/08/2018 and 12/11/2018.

Other AURN sites considered for the annualisation factor (within 50 miles) included Chatham Roadside (~42 miles north east), Eastbourne (~5 miles east), Storrington Roadside (~27 miles west) and Worthing A27 Roadside (~23.5 miles west). Eastbourne was discarded from the annualisation factor due to having a data capture less than 85% in 2018. Chatham, Storrington and Worthing A27 are Urban Traffic Sites, thus were excluded.

3.4 Bias Adjustment

After annualisation, a bias adjustment must be applied to the diffusion tube annualised mean NO_2 concentrations. The bias adjustment factor is calculated using Defra's National Diffusion Tube Bias Adjustment Factor Spreadsheet[4], which includes the results of a number of diffusion tube surveys undertaken at existing continuous monitoring sites. The results at these locations are compared to ascertain the bias (i.e. the percentage difference between the more reliable continuous monitors and the less reliable diffusion tubes). Specific information regarding the laboratory used, method used, and year of monitoring is available for each co-location study within the spreadsheet, allowing a bespoke bias adjustment factor to be calculated. For this survey, the diffusion tubes were analysed by Gradko International Ltd, using 20% TEA / water, in 2018, which produced an overall factor of 0.9. The initial estimate of the annual mean NO_2 concentrations are then multiplied by this bias adjustment factor.

The full annualisation and bias adjustment methodology is presented in Appendix B.

3.5 Limitations

Seasonal variations (in terms of both background and local sources of pollutant emissions) are not fully captured because of the survey duration. Background pollutant concentrations vary over a year based on a number of factors, including weather / climate, and external national / international sources of pollution. For the monitoring survey to establish the impact of the traffic measures on Air Quality and separate them out from changes associated with external sources, it would have to be undertaken over a longer period of time (i.e. minimum of 3 months per measure, as well as 3 months to establish a baseline to compare them to), which would provide a greater representability in the data. In other words, it is not possible to discern if the change from one diffusion tube period to the next is a result of external sources or the scheme, over these short timescales.

The understanding of accuracy and precision amongst the diffusion tubes affects the validity and confidence of the NO_2 concentrations acquired. The use of 1 diffusion tube per site does not allow the

[4] September 2018 Spreadsheet used, as available online at: https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

calculation of triplicate means, as well as an understanding of the standard deviation and coefficient of variance amongst the diffusion tubes.

With a lack of nearby local authority diffusion tubes and automatic monitoring stations, the knowledge of background air quality of Alfriston is limited. This increases the uncertainty associated with the annualisation process and could potentially affect the accuracy of the changes in air quality with and without the scheme.

4. Baseline Information

The vicinity of the scheme is predominantly rural, with a small concentration of residential and commercial properties located within Alfriston. The main sources of air pollution in the area are road traffic and agricultural-related activities. There are no significant industrial sources of air pollution in the vicinity of Alfriston.

4.1 Local Climate

The predominant prevailing wind direction at Alfriston, as displayed in Figure 2, is from the south west and north-north west.

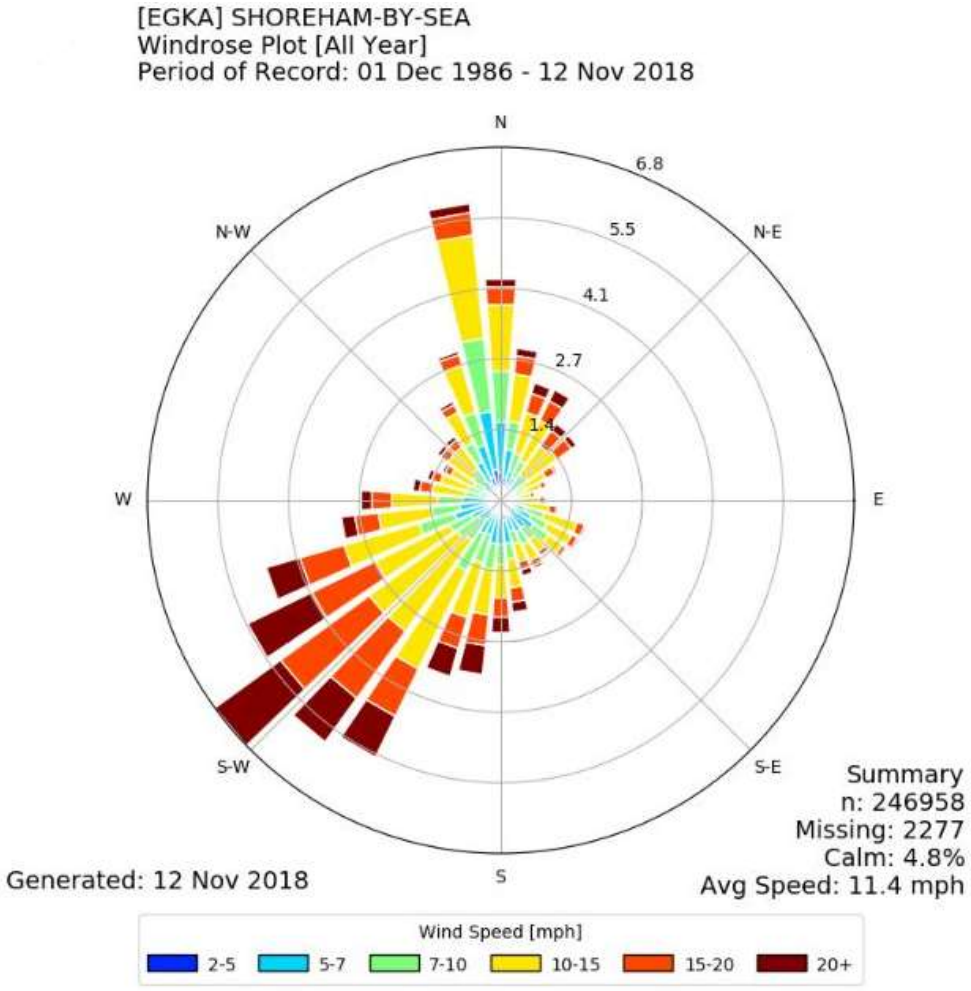


Figure 2. Windrose from the Closest Meteorological Station

Windspeed data obtained by Shoreham Airport (located ~31.3 km west of the site)

4.2 Air Quality Management Areas

The scheme is not located within an Air Quality Management Area (AQMA), the closest of which (Lewes Town Centre AQMA) is located approximately 7.5 km north west of Alfriston. This is not expected to be affected as a result of the Scheme.

4.3 Local Authority Monitoring

There are currently 10 automatic monitoring stations and 93 diffusion tube sites in operation across the five district councils of Lewes, Wealden, Eastbourne, Rother, and Hastings. However, none of these monitoring sites are located within or near Alfriston, as confirmed by review of the WDC's ASR.

4.4 Background Air Quality

Defra provides background mapping data for local authorities, which estimates annual mean background concentrations of NO_2. As seen in Table 5. , the maximum estimated annual mean background concentration for 2018 was 7.1 µg m^{-3}, which is well below the annual objective of 40 µg m^{-3}.

Table 5. Defra Background Mapping Data

Annual NO_2 concentrations (µg m^{-3}) at the closest grid locations to Alfriston

Local Authority	X	Y	Total NO_2 Concentration (µg m^{-3})	Grid Location in Relation to Alfriston
WDC	551500	103500	7.1	NW
WDC	552500	103500	7.1	NE
WDC	552500	102500	6.9	SE
WDC	551500	102500	7.0	SW

Estimated 2018 Background Air Pollution (estimated from a 2015 base year), downloaded from https://uk-air.defra.gov.uk/data/laqm-background-home. Total annual mean concentrations based on 1 km x 1 km grid squares. For further information please refer to the LAQM Support Helpdesk at http://laqm.defra.gov.uk/helpdesks.html.

5. Results of Monitoring Survey

The annual NO_2 mean concentrations of the diffusion tube survey are presented in Table 6. below.

Table 6. Alfriston Annual NO2 Concentrations of the Jacobs 3-Month Diffusion Tube Survey
Annual mean concentrations have undergone annualisation and bias adjustment

ID	Location	Annual Mean NO_2 Concentration ($\mu g/m^3$)[a]	Data Capture (%)
DT1	High Street RWP, Wingrove House	30.2	100
DT2	High Street RWP, Coach House Gallery	21.5	100
DT3	High Street RWP, Moonrakers	28.3	100
DT4	Telegraph pole on corner of Start Lane-Weavors Lane junction	11.8	100
DT5	Star Lane RWP, The Star Inn	17.1	100
DT6	High Street RWP, "The House"	28.3	100
DT7	North Street RWP, Holtye Cottage	31.7	100
DT8	North Street RWP, house No. 9	28.2	100
DT9	West Street RWP, house No. 2	14.0	100
DT10	Sloe Lane-North Street junction RWP, Orchard Cottage	13.3	100

[a] Annual mean NO_2 concentrations have undergone annualisation and bias adjustment

Diffusion tubes of particular interest to this monitoring report include those at potential locations where congestion is expected to increase as a result of the new traffic signalling, namely sites DT1 and DT6. These locations recorded annual mean NO_2 concentrations of 30.2 $\mu g\ m^{-3}$ and 28.3 $\mu g\ m^{-3}$ respectively.

Table 6. indicates that DT3, DT7 and DT8 (located along High Street through to North Street) recorded similar annual mean NO_2 concentrations. Of these, DT7 recorded the maximum annual mean NO_2 concentration across all ten monitoring locations (i.e. 31.7 $\mu g\ m^{-3}$). The monitored concentrations at these three sites are likely due to the busy nature of the roads, which act as a major access route between Alfriston, the A27 (to the north) and the A259 (to the south). Vehicle acceleration is also likely to be attributable to such concentrations, leading to increased NO_X emissions. These factors combined with the built environment (which does not allow for fresh air to dilute emissions, known as the street canyon effect[5]), are the most likely cause of the slightly higher annual mean NO_2 concentrations monitored along the High Street. The prevailing wind direction (presented in Figure 2) partially flows parallel to sections of High Street and North Street, suggesting that the severity of the canyon effect may be lessened during periods when there is a prevailing wind.

Diffusion tubes located in between the traffic signalling (DT2 and DT3) recorded concentrations of 21.5 and 28.3 $\mu g\ m^{-3}$. The lowest NO_2 concentrations across Alfriston were recorded at DT4, DT5, DT9 and DT10, which are not directly affected by the congestion of the traffic signalling but may be impacted by an altered traffic flow as a result of the scheme.

Overall, the monitored annual mean NO_2 concentrations were found to be well below the annual mean NO_2 objective of 40 $\mu g\ m^{-3}$.

Table 7. and Figure 3 displays the raw NO_2 concentrations recorded across Alfriston during the 3-month monitoring period. In comparison to the AURN monthly concentrations, as presented in Figure 4, a correlation can be seen in terms of seasonal variability. This is besides Horley monitor, at which concentrations tend to fluctuate throughout the year. The Brighton and Lullington Heath (LH) monitors, however, record their lowest NO_2 concentrations during June (Brighton) and August (LH), which then gradually increase to a peek at October (Brighton) and November (LH). This seasonal variance correlates to concentrations recorded at all diffusion tubes sites (with the exception of DT1), which provides further evidence that monthly mean changes in NO_2 concentrations shown by the monitoring cannot be solely attributed to the scheme.

[5] LAQM TG(16) defines a street canyon as "narrow streets where the height of buildings on both sides of the road is greater than the road width, leading to the formation of vortices and recirculation of air flow that can trap pollutants and restrict dispersion".

Table 7. Jacobs 3-Month Diffusion Tube Survey Raw Monitored NO2 Concentrations
Raw monthly data (without annualisation and bias adjustment)

ID	Date On	Date Off	Raw NO_2 Concentration ($\mu g\ m^{-3}$)
DT1	14/08/2018	16/09/2018	30.1
	16/09/2018	14/10/2018	26.5
	14/10/2018	12/11/2018	29.1
DT2	14/08/2018	16/09/2018	19.2
	16/09/2018	14/10/2018	20.4
	14/10/2018	12/11/2018	21.3
DT3	14/08/2018	16/09/2018	24.5
	16/09/2018	14/10/2018	26.5
	14/10/2018	12/11/2018	29.2
DT4	14/08/2018	16/09/2018	9.3
	16/09/2018	14/10/2018	12.0
	14/10/2018	12/11/2018	12.0
DT5	14/08/2018	16/09/2018	14.2
	16/09/2018	14/10/2018	16.7
	14/10/2018	12/11/2018	17.7
DT6	14/08/2018	16/09/2018	25.3
	16/09/2018	14/10/2018	28.8
	14/10/2018	12/11/2018	26.2
DT7	14/08/2018	16/09/2018	27.9
	16/09/2018	14/10/2018	31.5
	14/10/2018	12/11/2018	30.6
DT8	14/08/2018	16/09/2018	24.0
	16/09/2018	14/10/2018	28.3
	14/10/2018	12/11/2018	27.9
DT9	14/08/2018	16/09/2018	11.1
	16/09/2018	14/10/2018	14.2
	14/10/2018	12/11/2018	14.5
DT10	14/08/2018	16/09/2018	11.6
	16/09/2018	14/10/2018	13.5
	14/10/2018	12/11/2018	12.5

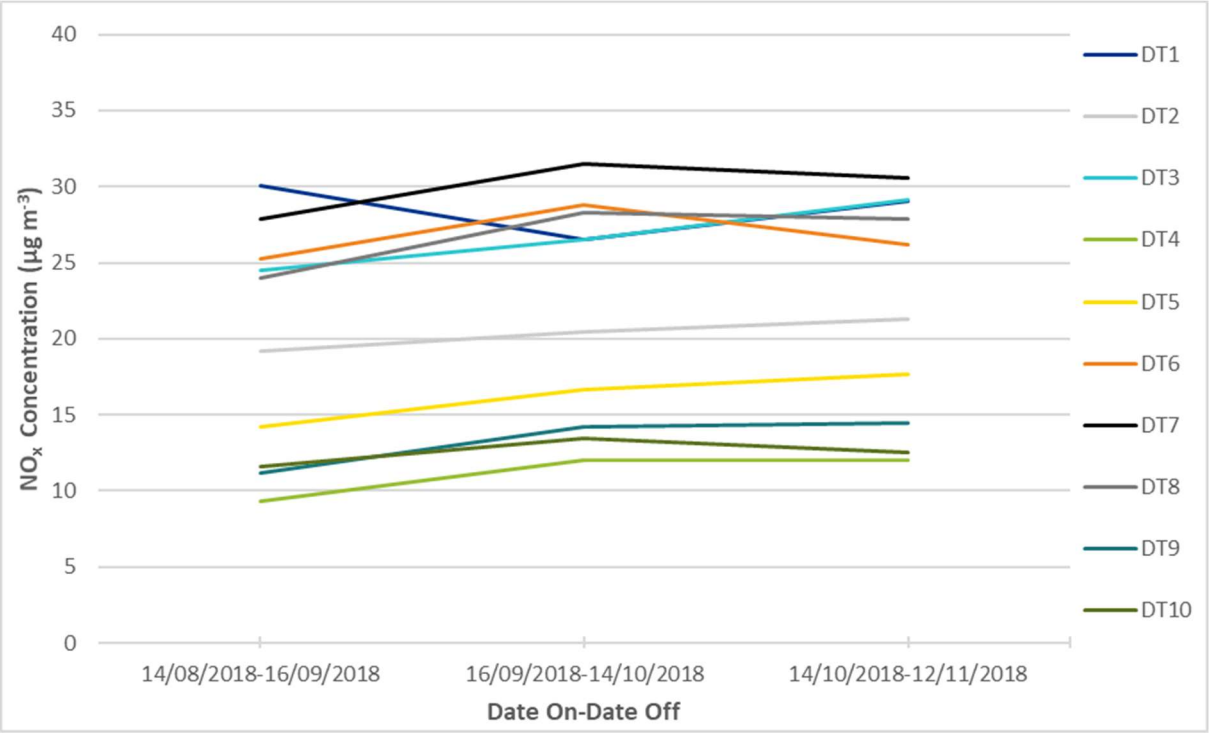


Figure 3. Jacob's 3-Month Diffusion Tube Raw Monitored NO_2 Concentrations

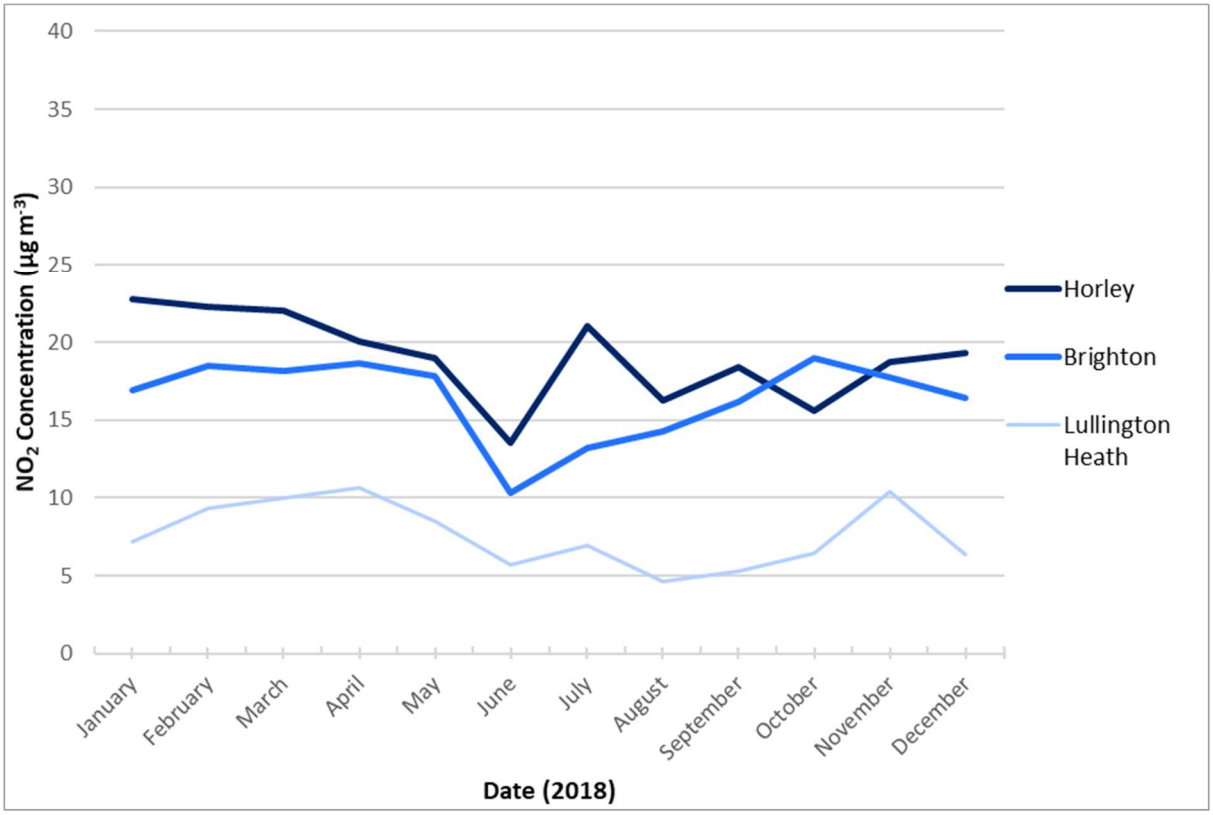


Figure 4. AURN Sites Monthly Average NO_2 Concentrations

The raw diffusion tube data and annualisation/bias adjustment calculations are presented in Table C1Table C1. in Appendix C.

6. Conclusion

A 3-month NO_2 diffusion tube survey has been undertaken at 10 locations within Alfriston, to ascertain whether the introduction of traffic management schemes could result in exceedances of the annual mean NO_2 objective at relevant sensitive receptors.

The findings from the monitoring survey indicates that the greatest annual mean NO_2 concentrations were found at locations along High Street and North Street, which are the roads most likely to be affected by congestion as a result of the scheme.

Owing to the nature of the survey, it is not possible to directly correlate changes in monthly mean NO_2 concentrations with specific aspects of the traffic light trials. The lack of a clear trend in measured values suggests that the impact of Scheme is not significant in air quality terms and is not perceptible against seasonal pollutant variation. In order to ascertain the impact of each iteration of the traffic lights, each trial period would have to be a minimum of 3 months, to allow for estimations over a full year.

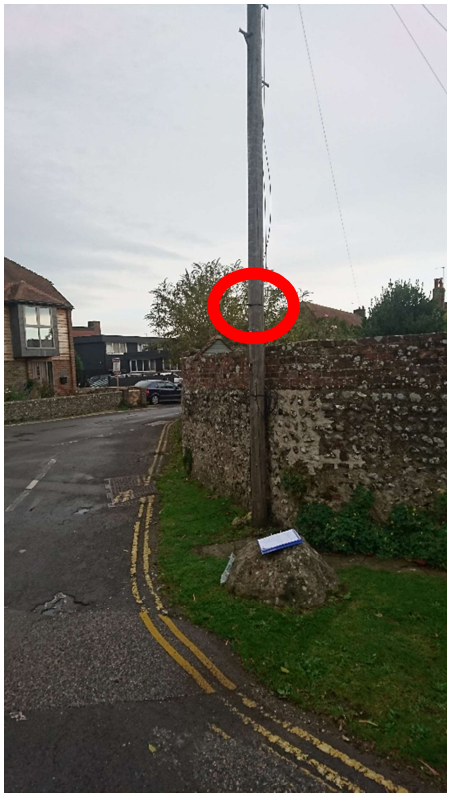
However, despite the busy-nature of these roads (both with and without the scheme), coupled with the street canyon effect, monitored annual mean NO_2 concentrations are all well below the objective.

Given the monitored annual mean NO_2 concentrations are well below 40 µg m^{-3}, the proposed scheme is unlikely to significantly worsen air quality within Alfriston and is compliant with local and national policy.

Appendix A. Diffusion Tube Survey Location Photos

Table A1. Jacob's Diffusion Tube Survey Site Locations
Photographic identification of each singular diffusion tubes (highlighted - red circle) per site

	
DT1: Wingrove House, High Street	DT2: Coach House Gallery, High Street

	
DT3: Moonrakers Restaurant, High Street	DT4: Telegraph Pole, Star Lane/Weavers Lane
	
DT5: The Star Inn, Star Lane	DT6: The House, High Street

	
DT7: Holtye Cottage, North Street	DT8: No. 9, North Street
	
DT9: No. 2, West Street	DT10: Orchard Cottage, North Street

Appendix B. Annualisation and Bias Adjustment Method (LAQM TG(16) guidance)

NO_2 by Diffusion Tubes

Diffusion tubes take samples over an approximately 1-month period. As such they are useful for assessing the annual objective of 40 µg m^{-3} but cannot be used to assess the number of hours greater than 200 µg m^{-3}. As they are not the reference method, and passive diffusion typically results in a low accuracy, it is necessary to bias correct the results based upon local or national collocation studies with chemiluminescent analysers. It is also necessary to calculate the data capture, and if this is less than 75%, the results should be annualised.

The low cost per tube permits sampling at a number of points in the area of interest; which is useful in highlighting “hotspots” of high concentrations, such as alongside major roads. They are less useful for monitoring around point sources or near to industrial locations where greater temporal resolution is required for particular objectives. They are useful both for annual monitoring as well as short term monitoring projects. They can be placed in many different locations, though are typically placed on building façades in heavily trafficked areas, and in urban background locations. If there are any continuous NO_2 chemiluminescent monitors within the local authority area, then three diffusion tubes should be collocated as close as possible to the chemiluminescent sampler’s inlet, but certainly within 1 m.

The site should be open to the sky, with no overhanging vegetation or buildings. It is important to place diffusion tubes where there is free circulation of air around the tube, but the opposite extreme should also be avoided, i.e. areas of higher than usual turbulence. For this reason, the tube should not be located on the corner of a building.

It is necessary to calculate the diffusion tubes’s annual average, annualised, and then bias corrected. In order to do this, firstly the annual average is calculated for all sites. So long as the diffusion tube calendar is adhered to, then even though the periods that the tubes are out varies, it is acceptable to do a simple average. If the periods that the tubes were out varied beyond the 4 to 5 week recommendation, then it may be necessary to do a time weighted average.

Annualisation

For any monitoring sites with fewer than 9 months’ worth of data, it is necessary to perform annualisation. A minimum of three months monitoring is required for annualisation to be completed. This can be undertaken using the technique discussed in Box B1.

Box B1. Example: Annualising NO2 Diffusion Tube Monitoring Data
As displayed in LAQM TG(16) guidance (Box 7.10)

A diffusion tube site (D1) has 8 months' worth of data and so it is necessary to annualise. A continuous background site (B1) has greater than 85% data capture for the year. For guidance on the choice of background sites, please refer to Box 7.9. The tubes were set out in accordance with the recommended calendar for 2015. If there are many locations to be annualised then it can be quicker to average the background site data to the same calendar as the diffusion tubes. The results are given in the below table. In addition, the results are given for the background site for those months that D1 data are available (Column B1 when D1 is Available).

Start Date	End Date	B1	D1	B1 when D1 is Available
7 January 2015	4 February 2015	15.6	38.4	15.6
4 February 2015	4 March 2015	38.3		
4 March 2015	1 April 2015	22.7	43.1	22.7
1 April 2015	29 April 2015	22.2		
29 April 2015	27 May 2015	24.9	51.3	24.9
27 May 2015	1 July 2015	20.8		
1 July 2015	29 July 2015	18.1	31.3	18.1
29 July 2015	26 August 2015	16.1	26.8	16.1
26 August 2015	30 September 2015	25.5	41.0	25.5
30 September 2015	28 October 2015	21.1		
28 October 2015	2 December 2015	28.1	29.8	28.1
2 December 2015	6 January 2016	32.0	39.8	32.0
Average		23.8	37.7	22.9

The annual mean ($\mathbf{A_m}$) of B1 is 23.8µg/m^3. The period mean ($\mathbf{P_m}$), of B1 is 22.9µg/m^3. The ratio **R** of the annual mean to the period mean ($\mathbf{A_m/P_m}$) is 1.04. This process should be repeated for all continuous background sites. If no continuous monitoring sites are available, then diffusion tube sites from background locations with 12 months' data may be used. In either case, the more background sites that can be identified the better. Calculate the average of these ratios $\mathbf{R_a}$. This is then the annualisation factor. For guidance on the calculation of $\mathbf{R_a}$, please refer to Box 7.9.

The measured period mean concentration **M** is 37.7µg/m^3. Multiply by this annualisation factor Ra to give the estimate of the annual mean for 2015. Assuming that all other background sites yielded an annualisation factor of 1.04, then R_a in this example is 1.04; and the annualised average of $\mathbf{D1 = M \times R_a = 37.7 \times 1.04 = 39.2 \mu g/m^3}$.

If the periods that the tubes were out varied beyond the 4 to 5 week recommendation, then it may be necessary to do a time weighted average rather than simple average in order to calculate M, A_m and P_m.

Where a short-term monitoring survey has been completed in the present year and an estimate of annual mean is required, please contact the LAQM Support Helpdesk for further information.

Bias Adjustment

After annualisation, the tubes should be corrected for bias. Bias represents the overall tendency of the diffusion tubes to under or over-read relative to the reference chemiluminescence analyser. This should not be confused with precision, which is an indication of how similar the results of duplicate or triplicate tubes are to each other. While it is possible to adjust diffusion tube results to account for bias, it is not possible to correct for poor precision.

Where local authorities have conducted a collocation study, then the results of the studies should be sent to the LAQM Support Helpdesk. This information is used to formulate a national bias adjustment factor for each type of tube. Figure B1 shows an example output from the National Diffusion Tube Bias Adjustment Factor Spreadsheet. In this example, there were five different studies throughout the UK, and the average bias factor was 0.79. Local authorities should compare the results of correcting data by the locally derived factor (in this example 0.80); to that of the nationally derived factor (in this example 0.79). It is important to stress that correction should not be done by both the local and national factors at the same time. If the factors are significantly different from each other, and/or if it makes a difference as to which sites are greater or less than 40 µg m^{-3}, then this should be clearly discussed in the LAQM report. The nationally derived factor will also include any locally derived factors based on collocation data sent to NPL. As such, the national factor is likely to be the more reliable.

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/15

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadsheet 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 September 2015

LAQM Helpdesk Website

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

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

Step 1: Select the Laboratory that Analyses Your Tubes from the Drop-Down List

If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List

If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List

If a year is not shown, we have no data[2]

Step 4:

Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.

If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@uk.bureauveritas.com or 0800 0327953

Analysed By[1]	Method (To undo your selection, choose (All) from the pop-up list)	Year[5] (To undo your selection, choose (All))	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m³)	Automatic Monitor Mean Conc. (Cm) (µg/m³)	Bias (B)	Tube Precision[6]	Bias Adjustment Factor (A) (Cm/Dm)
ESG Didcot	20% TEA in water	2014	KS	Marylebone Road Intercomparison	12	114	80	42.6%	G	0.70
ESG Didcot	20% TEA in water	2014	R	Rhondda Cynon Taf CBC	11	34	30	10.5%	G	0.90
ESG Didcot	20% TEA in water	2014	KS	South Lakeland District Council	9	41	32	29.2%	G	0.77
ESG Didcot	20% TEA in water	2014	UB	Wigan Council	13	28	22	27.5%	P	0.78
ESG Didcot	20% TEA in water	2014		Overall Factor[3] (4 studies)				Use		0.79

Figure B1. National Bias Adjustment Factor Spreadsheet

As displayed in LAQM TG(16) guidance (Figure 7.2)

Appendix C. Monitoring Survey Raw Data and Calculation Findings

The Gradko provided (raw) data for monthly NO_2 concentrations over the 3-month survey can be seen in the pages below. In addition to this, the process of averaging, annualisation and bias adjustment of the 3-month survey can be seen in Table C1.

gradko environmental
(A division of Gradko International Ltd.)
St. Martins House, 77 Wales Street Winchester, Hampshire SO23 0RH
tel.: 01962 860331 fax: 01962 841339 e-mail:diffusion@gradko.co.uk

ilac-MRA UKAS TESTING 2187

LABORATORY ANALYSIS REPORT

NITROGEN DIOXIDE IN DIFFUSION TUBES BY U.V.SPECTROPHOTOMETRY

REPORT NUMBER M06637R
BOOKING IN REFERENCE M06637
DESPATCH NOTE 46090
CUSTOMER Jacobs Engineering UK Ltd Attn: David Wright
1st Floor Jacobs
Friars House
Manor House Drive
Coventry
CV1 2TE
DATE SAMPLES RECEIVED 18/09/2018

Location	Sample Number	Exposure Data Date On	Date Off	Time (hr.)	µg/m^3 *	ppb *	TOTAL µg NO_2
1 HIGH STREET RWP ON WINGROVE HOUSE	1201688	14/08/2018	16/09/2018	790.37	30.08	15.70	1.73
2 HIGH STREET RWP ON THE COACHOUSE GALLERY	1201689	14/08/2018	16/09/2018	790.58	19.20	10.02	1.10
3 HIGH STREET POST OUTSIDE MOONROAKERS	1201690	14/08/2018	16/09/2018	790.70	24.50	12.79	1.41
4 TELEGRAPH POLE @ CORNER OF START LANE/WEAVORS LANE	1201691	14/08/2018	16/09/2018	790.17	9.33	4.87	0.54
5 STAR LANE RWP ON THE STAR INN	1201692	14/08/2018	16/09/2018	789.95	14.23	7.43	0.82
6 HIGH STREET RWP ON "THE HOUSE"	1201693	14/08/2018	16/09/2018	790.55	25.25	13.18	1.45
7 NORTH STREET RWP ON HOLME COTTAGE	1201694	14/08/2018	16/09/2018	791.00	27.88	14.55	1.60
8 NORTH STREET RWP	1231671	14/08/2018	16/09/2018	790.07	23.98	12.52	1.38
9 WEST STREET RWP ORCHARD COTTAGE	1231672	14/08/2018	16/09/2018	791.17	11.15	5.82	0.64
10 NORTH STREET RWP ORCHARD COTTAGE	1201678	14/08/2018	16/09/2018	791.67	11.63	6.07	0.67
BLANK TUBE	1231673	14/08/2018	16/09/2018	792.00	0.05	0.03	0.00
BLANK TUBE	1231674	14/08/2018	16/09/2018	792.00	0.09	0.05	0.01
BLANK TUBE	1231675	14/08/2018	16/09/2018	792.00	0.05	0.03	0.00

REPORT OFFICIALLY CHECKED

Gradko International Ltd
This signature confirms the authenticity of these results
Signed.....
L. Gates, Laboratory Manager

gradko environmental
(A division of Gradko International Ltd.)
St. Martins House, 77 Wales Street Winchester, Hampshire SO23 0RH
tel.: 01962 860331 fax: 01962 841339 e-mail:diffusion@gradko.co.uk

2187

LABORATORY ANALYSIS REPORT

NITROGEN DIOXIDE IN DIFFUSION TUBES BY U.V.SPECTROPHOTOMETRY

REPORT NUMBER M07384R
BOOKING IN REFERENCE M07384
DESPATCH NOTE 46392
CUSTOMER Jacobs Engineering UK Ltd Attn: David Wright
1st Floor Jacobs
Friars House
Manor House Drive
Coventry
CV1 2TE
DATE SAMPLES RECEIVED 16/10/2018

Location	Sample Number	Exposure Data Date On	Date Off	Time (hr.)	µg/m³ *	ppb *	TOTAL µg NO_2
1 High Street RWP on Wingrove House	1231676	16/09/2018	14/10/2018	667.92	26.49	13.83	1.29
2 High Street RWP on the Coach House Gallery	1231670	16/09/2018	14/10/2018	668.17	20.45	10.67	0.99
3 High Street Post Outside Moonrakers	1231661	16/09/2018	14/10/2018	668.17	26.54	13.85	1.29
4 Telegraph Pole @ Corner of Star Lane Weavers Lane	1231662	16/09/2018	14/10/2018	668.00	12.03	6.28	0.58
5 Star Lane RWP on The Star Inn	1231663	16/09/2018	14/10/2018	668.08	16.66	8.70	0.81
6 High Street RWP on "The House"	1231664	16/09/2018	14/10/2018	668.25	28.76	15.01	1.40
7 North Street RWP on Holtye Cottage	1231665	16/09/2018	14/10/2018	668.33	31.52	16.45	1.53
8 North Street RWP	1231666	16/09/2018	14/10/2018	668.58	28.32	14.78	1.38
9 West Street RWP NO2 Property	1231667	16/09/2018	14/10/2018	668.58	14.22	7.42	0.69
10 North Street RWP Orchard Cottage	1231668	16/09/2018	14/10/2018	668.67	13.46	7.02	0.65
Blank Tube #1	1231669			668.67	0.10	0.05	0.01
Blank Tube #2	1240318			668.67	0.10	0.05	0.01
Balnk Tube #3	1240319			668.67	0.08	0.04	0.00
Laboratory Blank				668.67	0.02	0.01	0.001

Comment: Results are not blank subtracted
Results have been corrected to a temperature of 293 K (20°)

Overall M.U. ±9.7% **Limit of Detection** 0.030µgNO_2
Tube Preparation : 20% TEA / Water Analysed on UV CARY3
Analyst Name Agata Szymonik **Report Checked By** Adam Robinson

Date of Analysis 23/10/2018 **Date of Report** 23/10/2018

Analysis carried out in accordance with documented in-house Laboratory Method GLM7

REPORT OFFICIALLY CHECKED

Gradko International Ltd
This signature confirms the authenticity of these results
Signed.....
L. Gates, Laboratory Manager

gradko environmental
(A division of Gradko International Ltd.)
St. Martins House, 77 Wales Street Winchester, Hampshire SO23 0RH
tel.: 01962 860331 fax: 01962 841339 e-mail:diffusion@gradko.co.uk

ilac-MRA UKAS TESTING 2187

LABORATORY ANALYSIS REPORT

NITROGEN DIOXIDE IN DIFFUSION TUBES BY U.V.SPECTROPHOTOMETRY

REPORT NUMBER M08026R
BOOKING IN REFERENCE M08026
DESPATCH NOTE 46393
CUSTOMER Jacobs Engineering UK Ltd Attn: David Wright
1st Floor Jacobs
Friars House
Manor House Drive
Coventry
CV1 2TE
DATE SAMPLES RECEIVED 13/11/2018

Location	Sample Number	Exposure Data: Date On	Date Off	Time (hr.)	µg/m^3 *	ppb *	TOTAL µg NO_2
1 HIGH STREET RWP ON WINGROVE HOUSE	1240303	14/10/2018	12/11/2018	701.58	29.08	15.18	1.48
2 HIGH STREET RWP ON THE COACH HOUSE GALLERY	1240304	14/10/2018	12/11/2018	701.50	21.28	11.11	1.09
3 HIGH STREET POST OUTSIDE MOONRAKERS	1240305	14/10/2018	12/11/2018	701.58	29.16	15.22	1.49
4 TELEGRAPH POLE @ CORNER OF START LANE/WEAVORS LANE	1240306	14/10/2018	12/11/2018	701.83	12.02	6.27	0.61
5 STAR LANE RWP ON THE STAR INN	1240307	14/10/2018	12/11/2018	701.83	17.66	9.22	0.90
6 HIGH STREET RWP ON "THE HOUSE"	1240308	14/10/2018	12/11/2018	701.92	26.19	13.67	1.34
7 NORTH STREET RWP ON HOLME COTTAGE	1240309	14/10/2018	12/11/2018	702.25	30.60	15.97	1.56
8 NORTH STREET RWP (END PROPERTY)	1240310	14/10/2018	12/11/2018	702.25	27.86	14.54	1.42
9 WEST STREET RWP No2 PROPERTY	1240311	14/10/2018	12/11/2018	702.17	14.50	7.57	0.74
10 NORTH STREET RWP ORCHARD COTTAGE	1240312	14/10/2018	12/11/2018	702.33	12.54	6.54	0.64
BLANK TUBE #1	1240313			702.33	0.08	0.04	0.00
BLANK TUBE #2	1240314			702.33	0.10	0.05	0.01
BLANK TUBE #3	1240315			702.33	0.12	0.06	0.01
Laboratory Blank				702.33	0.25	0.13	0.013

Comment: Results are not blank subtracted

REPORT OFFICIALLY CHECKED

Gradko International Ltd
This signature confirms the authenticity of these results
Signed.....
L. Gates, Laboratory Manager

Table C1. Calculation Process of the Jacob's 3-Month Diffusion Tube Survey

Statistical manipulation of raw data (as presented previously) and production of final annual mean ('Bias Adjusted')

ID	Date On	Date Off	Raw Monitored Concentration (µg/m^3)	Period Mean (µg/m^3)	Annualisation Factor (µg/m^3)	Annual Mean (µg/m^3)	Bias Adjustment Factor (µg/m^3)	Bias Adjusted (µg/m^3)
DT1	14/08/2018	16/09/2018	30.1	28.6	1.21	34.7	0.87	30.2
	16/09/2018	14/10/2018	26.5					
	14/10/2018	12/11/2018	29.1					
DT2	14/08/2018	16/09/2018	19.2	20.3	1.21	24.7	0.87	21.5
	16/09/2018	14/10/2018	20.4					
	14/10/2018	12/11/2018	21.3					
DT3	14/08/2018	16/09/2018	24.5	26.7	1.21	32.5	0.87	28.3
	16/09/2018	14/10/2018	26.5					
	14/10/2018	12/11/2018	29.2					
DT4	14/08/2018	16/09/2018	9.33	11.1	1.21	13.5	0.87	11.8
	16/09/2018	14/10/2018	12.0					
	14/10/2018	12/11/2018	12.0					
DT5	14/08/2018	16/09/2018	14.2	16.2	1.21	19.7	0.87	17.1
	16/09/2018	14/10/2018	16.7					
	14/10/2018	12/11/2018	17.7					
DT6	14/08/2018	16/09/2018	25.3	26.7	1.21	32.5	0.87	28.3
	16/09/2018	14/10/2018	28.8					
	14/10/2018	12/11/2018	26.2					
DT7	14/08/2018	16/09/2018	27.9	30.0	1.21	36.5	0.87	31.7
	16/09/2018	14/10/2018	31.5					
	14/10/2018	12/11/2018	30.6					
DT8	14/08/2018	16/09/2018	24.0	26.7	1.21	32.5	0.87	28.2
	16/09/2018	14/10/2018	28.3					
	14/10/2018	12/11/2018	27.9					

Table C1. Calculation Process of the Jacob's 3-Month Diffusion Tube Survey

Statistical manipulation of raw data (as presented previously) and production of final annual mean ('Bias Adjusted')

ID	Date On	Date Off	Raw Monitored Concentration (µg/m^3)	Period Mean (µg/m^3)	Annualisation Factor (µg/m^3)	Annual Mean (µg/m^3)	Bias Adjustment Factor (µg/m^3)	Bias Adjusted (µg/m^3)
DT9	14/08/2018	16/09/2018	11.1	13.3	1.21	16.1	0.87	14.0
	16/09/2018	14/10/2018	14.2					
	14/10/2018	12/11/2018	14.5					
DT10	14/08/2018	16/09/2018	11.6	12.5	1.21	15.2	0.87	13.3
	16/09/2018	14/10/2018	13.5					
	14/10/2018	12/11/2018	12.5					