Air Quality Monitoring at Edinburgh Airport 2017/2018

Nitrogen Dioxide

Report for Edinburgh Airport Ltd

Ricardo Energy & Environment

ED 11003 | Final | Date 07/08/2018

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Executive Summary

Ricardo Energy & Environment was commissioned by Edinburgh Airport Ltd to undertake a six-month air quality monitoring survey investigating whether the Air Quality Strategy (AQS) objectives of nitrogen dioxide (NO_2) concentrations at Edinburgh Airport are being met during 2017/2018. This survey follows on from similar studies carried out during 1999, 2003/2004, 2006/2007, 2010/2011 and 2013/2014.

Estimated annual mean NO_2 concentrations above the objective of 40 µg m^{-3} were measured at two sites; EDI 02 and EDI 03, with annual NO_2 concentrations of 48.5 µg m^{-3} and 44.2 µg m^{-3}, respectively. These sites are not considered relevant exposure when comparing to the annual mean objective and therefore, this objective is not likely to have been breached at any location during 2017/2018.

The hourly NO_2 objective of no more than 18 exceedances of 200 µg m^{-3} in a year is not likely to have been exceeded at any location.

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1 Introduction

Ricardo Energy & Environment was commissioned by Edinburgh Airport Ltd to undertake a six-month air quality monitoring survey investigating whether the Air Quality Strategy (AQS) objectives of nitrogen dioxide (NO_2) concentrations at Edinburgh Airport are being met during 2017/2018. This survey follows on from similar studies carried out during 1999, 2003/2004, 2006/2007, 2010/2011 and 2013/2014.

1.1 Purpose of Study

The objective of this study is to describe and assess the impacts on air quality due to emissions from activity in and around Edinburgh Airport, such as road traffic and aircraft. The study seeks to provide Edinburgh Airport Ltd with a quantitative estimate of the air quality in the context of the current United Kingdom (UK) and Scottish air quality standards.

1.2 Units of Concentration

The units throughout this report are presented in micrograms per cubic metre ($\mu g\ m^{-3}$), which is consistent with the presentation of AQS objectives, unless otherwise noted.

1.3 Structure of report

This document is an air quality survey for Edinburgh Airport Ltd:

- Chapter 1 summarises the need for the work and the approach to completing the study.
- Chapter 2 introduces the latest Scottish and UK legislative standards and objectives for nitrogen dioxide (NO_2) also where these objectives are relevant.
- Chapter 3 contains details of the methodology used to conduct the air quality survey and details the survey area.
- Chapter 4 describes the results of the survey and discusses whether the UK objectives and EU limit values for nitrogen dioxide (NO_2) are considered likely to have been exceeded within the study area. The results of the analysis are discussed and shown in tabular and graph form.
- Chapter 5 details the conclusions.

2 Air Quality Standards and Guidelines

2.1 Air Quality Strategy and Objectives

The latest Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland was published on 17th July 2007. The objectives mirror limit values required by EU Framework and Daughter Directives on Air Quality. The limit values were transposed into UK law through the Air Quality Standards Regulations 2007 which came into force on 15th February 2007. The most recent EU Air Quality Directives were published on 21st May 2008 and were transposed into UK regulations on 11th June 2010. Table 2.1 shows an outline of the current UK Air Quality Objectives that are relevant to this study. Nitrogen dioxide (NO_2) is considered in this report in relation to the annual average and short-term objectives for each pollutant. The table shows the standards in micrograms per meter cubed (µg m^{-3}) with the number of exceedances that are permitted. Experience from monitoring shows that if the 40 µg m^{-3} annual mean value is achieved for NO_2, there is normally no risk of the hourly-mean objective being breached.

Table 2. 1 Objectives included in the Air Quality Regulations and subsequent amendments, for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective		Date to Be Achieved by
	Concentration	Measured as	
Nitrogen dioxide (NO_2)	*200 µg m^{-3} not to be exceeded more than 18 times a year*	*1- hour mean*	-
	40 µg m^{-3}	*annual mean*	-

2.2 Sensitive Locations

The locations where objectives apply are defined in the AQS as locations outside buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed over the relevant averaging period of the objectives. Typically, these include residential properties, hospitals and schools for the longer averaging periods (i.e. annual mean) pollutant objectives and the above locations plus workplaces, shopping areas etc. for short-term (i.e. 1-hour and 24-hour) pollutant objectives. Table 2.2 lists examples of where the AQS objectives should and should not apply.

Table 2. 2 Objectives Examples of where the Air Quality Objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
1-hour mean	NO_2	All locations where the annual mean and 24-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks and railway stations etc. which are not fully enclosed. Any outdoor locations to which the public might reasonably be expected to have access.	Kerbside sites where the public would not be expected to have regular access.

3 Methodology

3.1 Method for Monitoring NO_2

As was the case during the earlier studies, oxides of nitrogen (NO_x) remain amongst the principal pollutants near Edinburgh Airport. The main NO_x species considered are nitric oxide (NO) and nitrogen dioxide (NO_2). The chief sources of these pollutants are combustion of fuel from motor vehicles, heating and power-generation plant and other industrial processes. However, local ground level concentrations of these pollutants can also be significantly affected by airport activities such as movements of aircraft and associated motor vehicles, both airside activity and passenger-traffic travelling to and from the airport.

The main pollutant of concern is NO_2, both a primary and secondary pollutant. Primary NO_2 is that which is emitted directly, usually from combustion sources e.g. traffic exhausts and power-generation. However, the vast majority of NO_2 in ambient air is secondary and derives from the reaction of NO and Ozone (O_3). Whilst NO is not considered a health concern at ambient levels, NO_2 is a known respiratory irritant.

The purpose of this study was to reassess the likely NO_2 concentrations around certain areas of Edinburgh Airport regarding the current air quality objectives. It should be noted that the objectives are used in this case as general indicators of air quality. The annual mean objective only applies at areas where there is a relevant public exposure e.g. residential property.

Diffusion tubes are cost-effective 'passive' sampling devices, which require no mains or battery power and hence, are ideal for this type of survey, at several locations, over a relatively small area. Details of the chemistry of diffusion tube samplers for NO_2 are provided in Appendix 1.

Single diffusion tube samplers for NO_2 were exposed at approximately monthly intervals for six-months at selected airside and non-airside locations. These were chosen to reflect a variety of potential NO_2 concentration-situations, including local sources and more general background areas around Edinburgh Airport.

3.1.1 Estimated Accuracy of the NO_2 Results

Diffusion tube samplers are generally referred to as an indicative method of measurement. In terms of the EC Directive for NO_2 concentrations, indicative methods of measurement should be accurate to within $\pm$25%. The automatic monitoring of NO_2 at Scottish Air Quality Database (SAQD) sites is undertaken with a chemiluminescence analyser, which is defined as the EU reference method of monitoring. Under the directive, this reference method is required to have accuracy in the range $\pm$15%.

3.1.2 Survey Timetable

The survey commenced in December 2017 and ended in June 2018. The monitoring was undertaken for six successive periods of approximately one month each time. Table 3.1 gives the dates of the six rounds of monitoring at each airport site.

Table 3. 1 Summary of Diffusion Tube Exposure Periods

Period	Exposure Dates
1	05/12/2017 – 09/01/2018
1*	18/12/2017 – 09/01/2018
2	09/01/2018 – 31/01/2018
3	31/01/2018 – 08/03/2018
4	08/03/2018 – 28/03/2018
5	28/03/2018 – 02/05/2018
6**	02/05/2018 – 15/06/2018

* – Period 1 has two exposure dates as there were airside access issues, unable to deploy diffusion tubes until later in month
** – Missing diffusion tube caps, unable to remove/transport tubes, therefore sample period extended

The Local Air Quality Management Technical Guidance[1] (LAQM.TG(16)) states that if the diffusion tube sampling periods vary beyond the four to five week recommendation, then it may be necessary to do a time weighted average. Sampling period six of this study extended beyond the recommended five week exposure period due to transportation and equipment issues, therefore the results underwent a time weighted average calculation as per LAQM TG(16) (Box 7.10 & Section 7.189).

3.2 Monitoring Locations

3.2.1 Diffusion Tube Monitoring

In general, monitoring was undertaken at the same locations as the 2013 study. Locations were chosen to reflect a variety of sources and likely concentrations. For the 2017 study, eight new sites have replaced eight of 2013 sites – this was due to a change in airport design/layout and traffic flow. Figures 3.1 and 3.2 and Table 3.2 show the locations of the monitoring sites with photographs provided in Appendix 2.

Table 3. 2 Edinburgh Airport Diffusion Tube Monitoring Locations

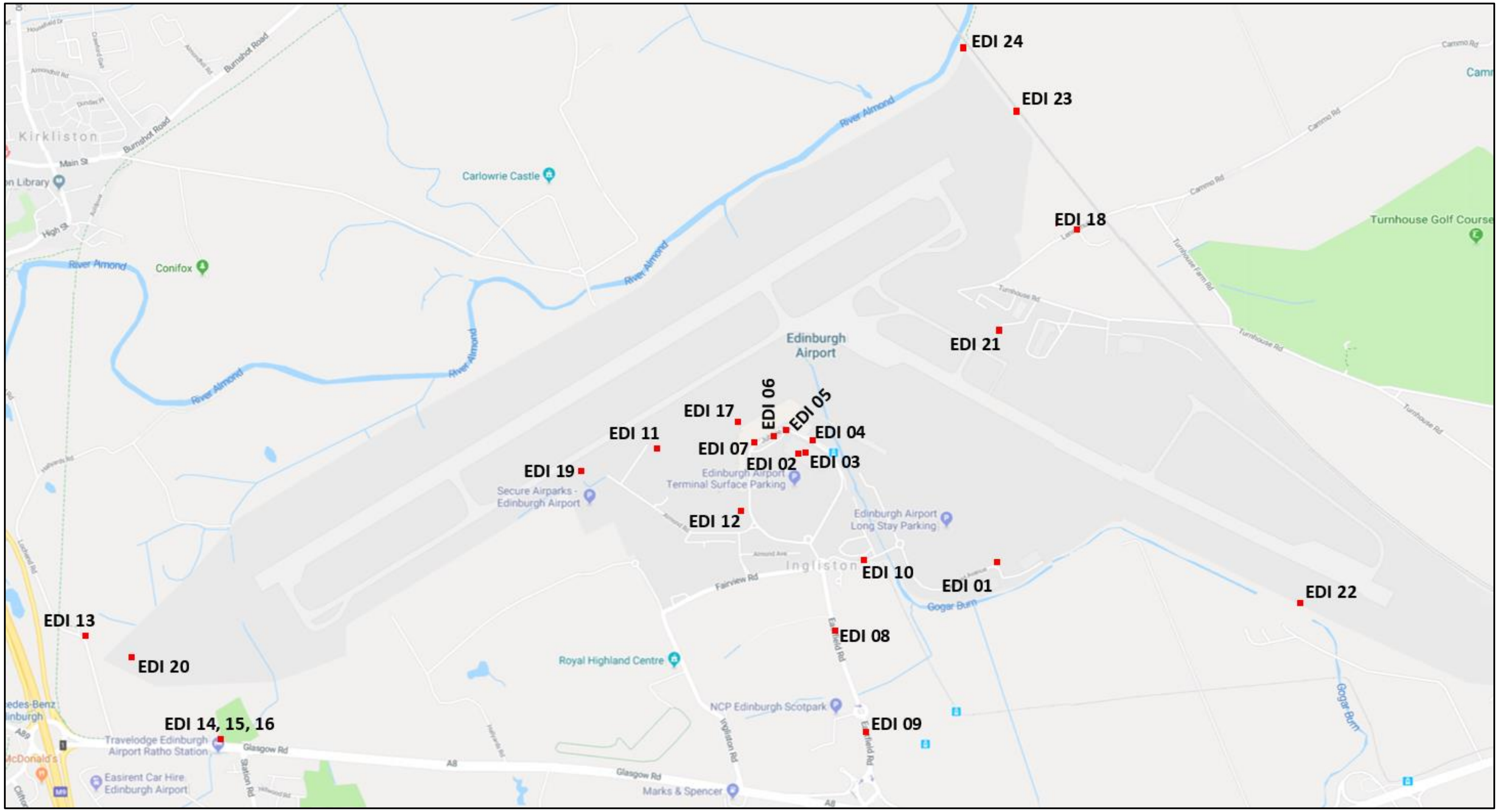
Site ID	Location Name	Site Coordinates		Site Description and Activity
EDI 01	Signature (Previously IGAT Term)	55.9443	-3.3519	Outside ID centre, on transporter area gate
EDI 02	Multi story car park taxi rank	55.9476	-3.3623	Ticket machine at taxi rank within multi story
EDI 03	Multi story drop off	55.9476	-3.36229	On help point of multi-storey car park drop off area
EDI 04	Plaza Zebra Crossing	55.9476	-3.36162	Zebra crossing near bus stops/plaza complex
EDI 05	Airlink Kiosk	55.9483	-3.363	Outside Airlink kiosk (start of queue area for passengers)
EDI 06	Multi story car park covered walkway	55.9482	-3.3635	Near fire assembly point at Summer terminal
EDI 07	International arrivals 1	55.948	-3.3648	Outside international arrival 1 entrance
EDI 08	Eastfield Road at MWH (Previously	55.9422	-3.3604	Across from MWH on Eastfield Road South

[1] Local Air Quality Management Technical Guidance, LAQM.TG(16), Defra and the Devolved Administrations, April 2016 (Online) Available at http://www.scottishairquality.co.uk/assets/documents/technical%20guidance/LAQM-TG16-April-16-v1.pdf (Accessed on 15/07/2018)

Site ID	Location Name	Site Coordinates		Site Description and Activity
	Eastfield Road East)			
EDI 09	Eastfield Road roundabout	55.9394	-3.35884	Previously Eastfield Road West
EDI 10	Eastfield avenue	55.9444	-3.35877	Outside Hilton Double Tree Hotel / Transporter area
EDI 11	Control post 3 entrance	55.9476	-3.36968	At entrance to control post 3, above fence
EDI 12	Stand 1B (outside capital house)	55.9459	-3.36511	Beside runway and arrivals from plane (other side of fence)
EDI 13	Lochend Road	55.9421	-3.40001	End of runway (west of airport), on fence beside quiet road, that can be quite busy at rush hour (approx. 90m away from residential property)
EDI 14	Glasgow Road AQ Monitoring Station	55.9391	-3.39296	Tri location to air quality monitoring sites
EDI 15	Glasgow Road AQ Monitoring Station	55.9391	-3.39296	Tri location to air quality monitoring sites
EDI 16	Glasgow Road AQ Monitoring Station	55.9391	-3.39296	Tri-location to air quality monitoring sites
EDI 17	Head of Stand 9	55.94429	-3.35103	On assembly point 4 post at head of STAND 9. Next to access road and aircraft taxing area. The terminal building itself has been extended, since 2010, up to the stand creating a roof over the nearby access road. The only open side being that were the tube is located.
EDI 18	Lenniemuir	55.954197	-3.347750	On telegraph pole on corner of Lenniemuir Road outside number 10.
EDI 19	AFS Fencelink Airside	55.947	-3.37368	On fence next to fire training rig.
EDI 20	Runway 06 end of runway lights (airside)	55.9414	-3.3979	On yellow lighting gantry, approx. 2m high, directly below flight path of 06 approach.
EDI 21	Cargo - CP1 Airside	55.9513	-3.35196	Control Post 1 Cabin on post between entrances

Site ID	Location Name	Site Coordinates		Site Description and Activity
EDI 22	Gogar Castle (airside)	55.943	-3.33718	On 2nd perimeter fence post to the left of Gate N. Close to Gogar Castle. Disused runway approx. 75m away. NB the secondary runway was closed during the sampling period meaning the site could not be accessed to collect for the last month.
EDI 23	Runway 24 approach lights (airside)	55.95947	-3.35394	On perimeter fence, opposite first set of yellow lights, railway approx. 15m away up an embankment.
EDI 24	Crash gate 8 (airside)	55.9595	-3.35394	On perimeter fence by Gate 8 (Emergency access Gate) Railway line approx. 40m. The tube is located on a fence post to the right of the gate.
EDI 25	Control	-	-	Blank, travel tube

Figure 3. 1 All Edinburgh Airport Diffusion Tube Monitoring Locations



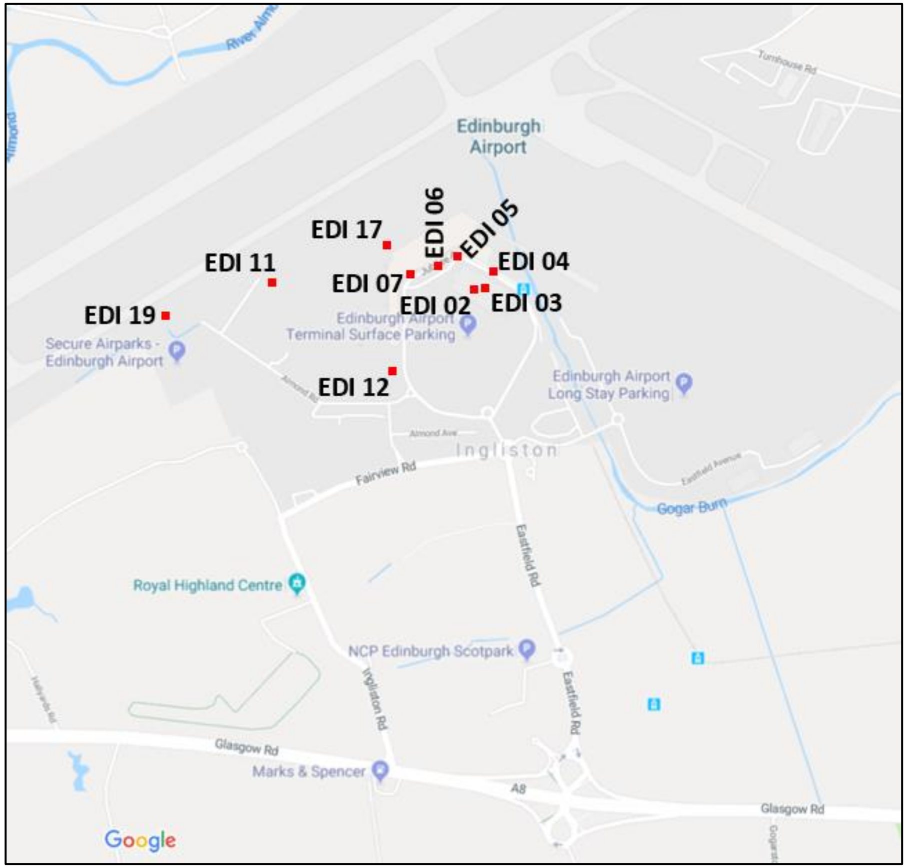
Key:
■ – Diffusion tube site
EDI 01 – Site ID

N

Scale 1:200m

Source: Google Maps, Contains Ordnance Survey data © Crown copyright and database right 2018

Figure 3. 2 Edinburgh Airport Diffusion Tube Monitoring Locations – Terminal



Key:
■ – Diffusion tube site
EDI 01 – Site ID

Scale
1:200m

N

Source: Google Maps, Contains Ordnance Survey data © Crown copyright and database right 2018

3.3 QA/QC

This section outlines the QA/QC procedures applied for the purposes of this study. To ensure the monitoring data were of a high quality the following QA/QC procedure were put in place:

- daily checks of the monitoring data
- audits of the automatic monitoring site
- analysis of NO_2 diffusion tubes using UKAS-accredited laboratory
- data ratification of resulting dataset

NO_2 Diffusion Tubes

Analysis of the diffusion tube samples was carried out using UV spectrophotometry by SOCOTEC (formerly known as Environmental Scientifics Group (ESG)). SOCOTEC holds current UKAS accreditation (Testing Laboratory No 1015, ISO 17025) for this type of analysis. The NO_2 tubes were prepared by spiking a 50:50 triethanolamine (TEA) in acetone solution onto grids, which are located in the black end cap of the diffusion tube. During exposure NO_2 passively diffuses up the tube towards the spiked grid where it is absorbed by the TEA. Following exposure, the tubes are desorbed with distilled water and the extract analysed using UV spectrophotometry to estimate the concentration of nitrate ions.

SOCOTEC participate in the AIR-PT scheme, operated by LGC Standards and supported by the Health and Safety Laboratory, with yearly assessment against agreed performance criteria. AIR-PT combines two long running PT schemes: LGC Standards STACKS PT scheme and HSL Workplace Analysis Scheme for Proficiency (WASP) PT scheme. SOCOTEC currently hold the highest rank of a **Satisfactory** laboratory for the analysis of NO_2 diffusion tubes. A copy of the latest round of results can be found on the Defra LAQM website (https://laqm.defra.gov.uk/assets/AIR-PT-Rounds-13-to-24-Apr-2016-Feb-2018.pdf).

The diffusion tube sampling method is only indicative and can give results which under read or over read the true NO_2 concentration. Hence, in line with LAQM.TG(16), recommendations on the use of diffusion tubes, triplicate tubes were co-located with a suitable chemiluminescent NO_x analyser. For this study the Edinburgh Glasgow Road automatic air quality monitoring station was selected as the most suitable for the co-location exercise.

A further check of the diffusion tube sampling regime was carried out with the use of a travel blank. The travel blank is a capped diffusion tube that is store on-site and travels with the exposed diffusion tubes. The travel blank is then used to identify contamination of the samples that could occur during transportation and storage. The travel blanks used within this study showed no significant contamination of tubes during transportation and storage (see Table A4.1). For this reason, no data have been rejected due to contamination.

Automatic NOx Analyser

The Edinburgh Glasgow Road automatic monitoring is part of the Scottish Air Quality Database (SAQD) network. As part of the SAQD, a full QA/QC regime is applied to the monitoring equipment and data. This includes:

- hourly download of data
- daily checks of data
- on-site calibrations
- 6-monthly site audits
- 3-monthly data ratification

Data are downloaded on an hourly basis from the monitoring site and checked by Ricardo-AEA's data checkers to ensure that any faults are quickly identified and thus minimising data loss. Manual calibrations of the NO_x analyser are carried out by Edinburgh City Council, in addition to the calibrations carried out during the site audit visits.

To confirm that the monitoring equipment is working correctly, six-monthly audits of the monitoring site using UKAS-accredited (Laboratory No: 0401, ISO 17025) tests were carried out in July 2017 and February 2018; and consisted of the following performance checks:

- site cylinder concentration test
- site calibration system check
- automatic analysers flow and leak check
- NO_x analyser converter test
- NO_x analyser linearity test

All results were within specified tolerances confirming that there were no faults with the equipment.

The data from the automatic monitoring was ratified in three-monthly blocks; January to March, April to June, July to September and October to December. Ratification consists of scaling the data using the results of the audit and all on-site calibrations. Any unreliable data are removed, and the final ratified dataset produced. These procedures are consistent with those used for UK national automatic urban and rural network (AURN) air quality monitoring stations.

4 Results and Discussion

4.1 Bias Adjustment Calculations

Diffusion tubes are an indicative method of measuring nitrogen dioxide (NO_2). To improve the accuracy of diffusion tube data, all results should be bias adjusted using triplicate diffusion tubes collocated with an automatic chemiluminescent NO_x analyser or the national calculated bias factor. For this study, the SAQD site Edinburgh Glasgow Road was used for the triplicate diffusion tubes. Using the results from the collocation study and the LAQM Review and Assessment bias adjustment spreadsheet[2], a local bias adjustment factor was calculated. Table 4.1 shows the bias adjustment factor and monitoring data from the collocation study.

Table 4. 1 Bias Adjustment Factors and Co-Located Automatic Monitoring Data

Automatic Monitoring Site	Calculated Automatic NO_2 Mean ($\mu g\ m^{-3}$)	Automatic Monitor Data Capture (%)	Calculated Diffusion Tube NO_2 Mean ($\mu g\ m^{-3}$)	Data Capture for Period 05/12/2017 – 15/06/2017 (%)	Bias Adjustment Factor
Edinburgh Glasgow Road	26	98.7	24.9	99.7	0.68

#Please note that at the time of writing this report, the 2017/2018 automatic monitoring data has been ratified until March 2018, therefore the April 2018 onwards results are still provisional.

In addition to the locally derived bias adjustment factor, the LAQM helpdesk collates NO_2 diffusion tube bias adjustment factors derived from collocation studies carried out throughout the UK. From the most up-to-date diffusion tube national bias adjustment spreadsheet[3], published in June 2018 (Version 06/18), the national bias factor for ESG Didcot's (SOCOTEC) 50:50 TEA in Acetone diffusion tubes was found to be 0.77.

For this study, in order to take the worst-case approach, the national bias adjustment factor of **0.77** was used to correct all diffusion tube data. Details of the bias adjustment calculation are shown in Appendix 3.

4.2 Estimation of NO_2 Annual Mean

To assess against the annual mean objective for NO_2, data from short term monitoring programs, such as this study, need to be adjusted to estimate the annual mean. The methodology for estimating the annual mean can be found in LAQM.TG (16) (Box 7.9). The monitoring locations and adjustment factors used for estimating the annual mean concentrations for the diffusion tubes are detailed in Table 4.2 and Table 4.3. Using period mean (05/12/2017 – 15/06/2018) and annual mean (16/06/2017 – 15/06/2018) NO_2 concentrations from one SAQD and two AURN monitoring sites, an annualisation factor of **0.874** was derived for the non-airside diffusion tubes (Table 4.2). Using period mean (18/12/2017 – 15/06/2018) and annual mean (16/06/2017 – 15/06/2018) NO_2 concentrations from one SAQD and two AURN monitoring site, an annualisation factor of **0.896** was derived for the airside diffusion tubes (Table 4.3).

For sites with less than 100% data capture, it is possible to carry out a similar analysis for the remaining period of data. During this study, four sites; EDI 01, EDI 15, EDI 21 and EDI 22 had data capture rates

[2] Bias adjustment Calculation Spreadsheet, AEA Energy & Environment, February 2011 (Online)
Available at https://laqm.defra.gov.uk/bias-adjustment-factors/local-bias.html (Accessed July 2018)
[3] National Diffusion Tube Bias Adjustment Spreadsheet, Version 06/18, June 2018
Available at https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html (Accessed July 2018)

of 83% respectively. It was possible to derive separate annualisation factors for these diffusion tube sites based on their individual exposure dates. For these sites, a factor of **0.821**, **0.872**, **0.843** and **0.843** were used for correcting the data, respectively. Table 4.4 shows a summary of the periods in question and the resulting correction factors for these sites.

Table 4. 2 Annualisation of Diffusion Tube Data from Sites with 100% Data Capture for non-airside

Long Term Site	Annual Mean (A_m - µg m^{-3}) (16/06/2017 – 15/06/2018)	Period Mean (P_m - µg m^{-3}) (05/12/2017 – 15/06/2018)	Ratio (A_m/P_m)
Edinburgh St Leonards	18.7	19.8	0.944
Bush Estate	5	6	0.833
Edinburgh Currie	6.5	7.7	0.844
		Average	0.874

#Please note that at the time of writing this report, the 2017/2018 automatic monitoring data has been ratified until March 2018, therefore the April 2018 onwards results are still provisional.

Table 4. 3 Annualisation of Diffusion Tube Data from Sites with 100% Data Capture for airside

Long Term Site	Annual Mean (A_m - µg m^{-3}) (16/06/2017 – 15/06/2018)	Period Mean (P_m - µg m^{-3}) (18/12/2017 – 15/06/2018)	Ratio (A_m/P_m)
Edinburgh St Leonards	18.7	18.5	1.011
Bush Estate	5	6	0.833
Edinburgh Currie	6.5	7.7	0.844
		Average	0.896

#Please note that at the time of writing this report, the 2017/2018 automatic monitoring data has been ratified until March 2018, therefore the April 2018 onwards results are still provisional.

Table 4. 4 Annualisation of Diffusion Tube Data from Sites with <100% Data Capture

Monitoring Site	Site Code	Period	Average Ratio
Signature	EDI 01	05/12/2017 – 02/05/2018	0.821
Glasgow Road (2)	EDI 15	05/12/2017 – 08/03/2018, 28/03/2018 – 15/06/2018	0.872
Cargo – CP1 Airside	EDI 21	18/12/2017 – 02/05/2018	0.843
Gogar Castle (airside)	EDI 22	18/12/2017 – 02/05/2018	0.843

4.3 NO_2 Concentrations – 2017/2018

Table 4.5 summarises the calculated annual mean NO_2 concentrations and data capture rates for the period 05/12/2017 to 15/06/2018, with the results shown in graph form in Figure 4.1. Estimated annual mean NO_2 concentrations above the objective level of 40 µg m^{-3} were measured at two sites; EDI 02 and EDI 03, with measured annual mean NO_2 concentrations of 48.5 µg m^{-3} and 44.2 µg m^{-3}.

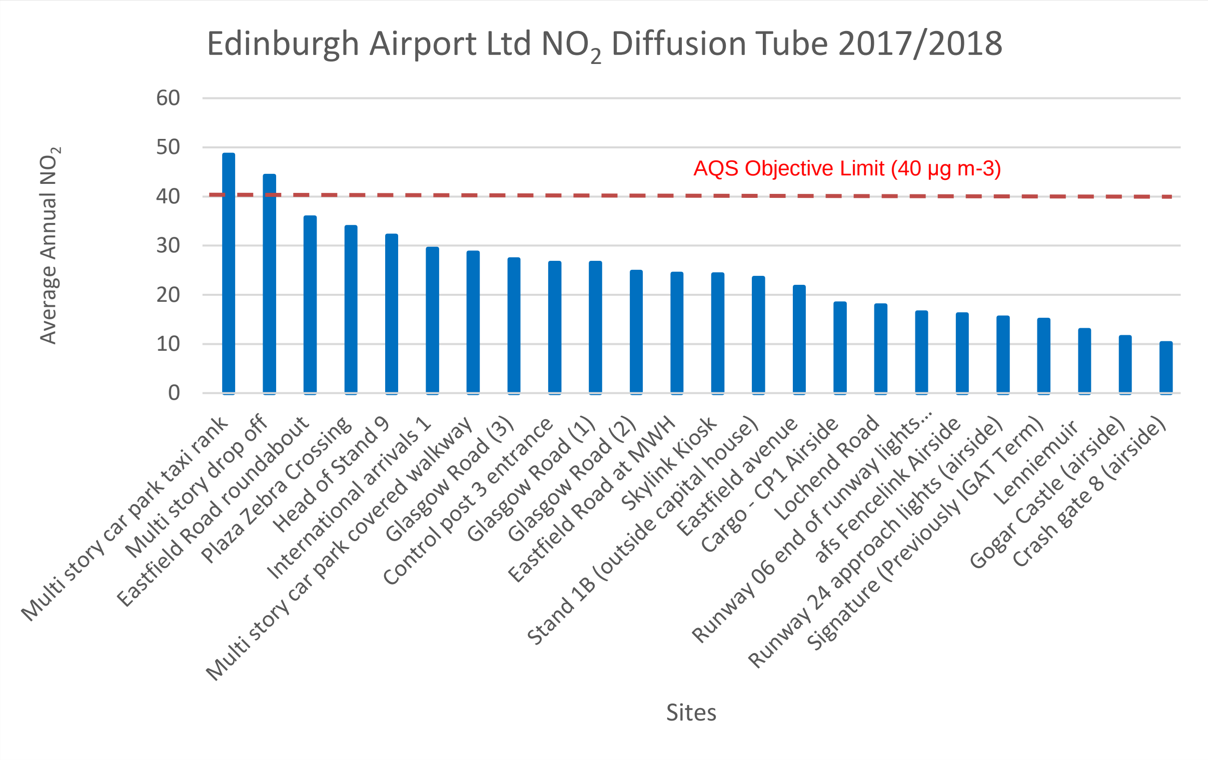
A further comparison can be made to the hourly NO_2 objective of no more than 18 exceedances in a year of 200 µg m^{-3}. This objective is relevant at locations where you would expect people to be exposed for one hour or greater. As stated in technical guidance LAQM.TG (16) (Page 7, Paragraphs 7.90 to 7.91), the hourly mean objective is likely to have been breached if the annual mean NO_2 concentration is 60 µg m^{-3} or greater. Therefore, it can be concluded that it is not likely that the hourly mean objective has been exceeded at any location in this study.

Table 4. 5 Annual Mean NO_2 Concentrations 2017/2018

Site Name	Site Code	Annual Average NO_2 2017/2018 (μg m^{-3})	Data Capture (%)
Signature (Previously IGAT Term)	EDI 01	15.0	83.3*
Multi storey car park taxi rank	EDI 02	48.5	100
Multi storey drop off	EDI 03	44.2	100
Plaza Zebra Crossing	EDI 04	33.8	100
Airlink Kiosk	EDI 05	24.2	100
Multi story car park covered walkway	EDI 06	28.6	100
International arrivals 1	EDI 07	29.4	100
Eastfield Road at MWH	EDI 08	24.3	100
Eastfield Road roundabout	EDI 09	35.8	100
Eastfield avenue	EDI 10	21.6	100
Control post 3 entrance	EDI 11	26.5	100
Stand 1B (outside capital house)	EDI 12	23.4	100
Lochend Road	EDI 13	17.9	100
Glasgow Road (1)	EDI 14	26.5	100
Glasgow Road (2)	EDI 15	24.7	83.3**
Glasgow Road (3)	EDI 16	27.2	100
Head of Stand 9	EDI 17	32.0	100
Lenniemuir	EDI 18	12.8	100
AFS Fencelink Airside	EDI 19	16.1	100
Runway 06 end of runway lights (airside)	EDI 20	16.4	100
Cargo - CP1 Airside	EDI 21	18.3	83.3*
Gogar Castle (airside)	EDI 22	11.4	83.3*
Runway 24 approach lights (airside)	EDI 23	15.4	100
Crash gate 8 (airside)	EDI 24	10.2	100

* - data capture below 100% due to decommissioning of Edinburgh Airport's secondary runway which meant that the airside/landside fence, on which the diffusion tubes were located, were altered/removed.
** - data capture below 100% as one of the triplicate diffusion tubes gained an erroneous result and was disregarded as per LAQM.TG (16), page 7-55, section 7.188.

Figure 4. 1 Annual Mean NO_2 Concentrations, 2017



4.4 Comparison with Previous Years NO_2 Concentrations

Table 4.6 shows the annual mean concentrations for Edinburgh Airport at five surveys carried out between 2003 and 2018. Figure 4.2 shows a histogram of the results in relation to AQS 40 µg m^{-3} annual mean objective for NO_2.

In 2017, there is a general trend of decreasing NO_2 concentrations at most sites when compared to concentrations throughout 2003 – 2013, excluding 2013's "New Site Multi Storey Car Park 2" (renamed in 2017 to "Multi Storey Drop Off"), which exhibits an estimated 25.2 µg m^{-3} increase in NO_2 between studies. This is likely to have been influenced by the reconfiguration in the passenger drop off area in Edinburgh Airport. However, the highest peak concentrations for most sites can still be seen in 2010, which is likely to have been influenced by meteorological conditions that year.

Figure 4.3 shows a de-seasonalised trend plot of data from the Edinburgh St Leonards AURN site between 2008 and 2018. Edinburgh St Leonards was chosen as it has been in operation since November 2003 whilst Edinburgh Glasgow Road has only been in operation since September 2012. With more than five years of monitoring, any trends will be more visible in Edinburgh St Leonards data. A slight downward trend in NO_2 concentrations has been seen at this location with elevated NO_2 concentrations also seen during 2010.

Table 4. 6 Annual Mean NO_2 Concentrations at Edinburgh Airport Between 2003 - 2018

	Average NO_2 (µg m^{-3}) 2003/2004	Average NO_2 (µg m^{-3}) 2007/2008	Average NO_2 (µg m^{-3}) 2010/2011	Average NO_2 (µg m^{-3}) 2013/2014	Average NO_2 (µg m^{-3}) 2017/2018
GAT Terminal / Signature	19	18	29	16	15
Head of Stand 9	n/a	36	61	54	32
Fuel Farm new CP3	27	30	42	33	n/a
Fire Training Area (2013) / AFS Fencelink Airside (2017)	21	17	26	19	16.1
Runaway 06 Approach Lights	21	18	26	22	16.4
Crash Gate 8	n/a	12	17	12	10.2
Runaway 24 Approach Lights	28	20	23	20	15.4
CP1 (Cargo Airside)	35	22	32	29	18.3
Farm East Gogar Castle	21	14	22	n/a	n/a
Gogar Castle	14	16	19	14	11.4
International Arrivals	43	44	55	39	29.4
Main Stay Car Park	29	34	42	34	n/a
Coach Park Entrance	47	46	52	49	n/a
Taxi Area	n/a	49	50	46	n/a
Eastfield Road EAST (2013) / Eastfield Road Roundabout (2017)	n/a	36	50	44	35.8
Lochend Road West of Airport	25	22	30	27	n/a
Eastfield Road WEST (2013) / Eastfield Road at MWH (2017)	n/a	32	37	35	24.3
Eastfield Avenue	n/a	n/a	n/a	24	n/a
Edinburgh Glasgow Road (Average)	n/a	n/a	n/a	35	26.1
Lenniemuir 2	n/a	14	23	18	n/a
New Site - Multi Storey Car Park 1	n/a	n/a	n/a	33	n/a
New Site - Multi Storey Car Park 2 / Multi Story Drop Off	n/a	n/a	n/a	19	44.2
Lenniemuir	n/a	14	23	n/a	12.8
Multi Storey car park taxi rank	n/a	n/a	n/a	n/a	48.5
Plaza Zebra Crossing	n/a	n/a	n/a	n/a	33.8
Airlink Kiosk	n/a	n/a	n/a	n/a	24.2
Multi Storey Car Park Covered Walkway	n/a	n/a	n/a	n/a	28.6
Eastfield Avenue	n/a	n/a	n/a	n/a	21.6
Control Post 3 Entrance	n/a	n/a	n/a	n/a	26.5
Stand 1B (outside Capital House)	n/a	n/a	n/a	n/a	23.4
Lochend Road	n/a	n/a	n/a	n/a	17.9
Average across all sites	**28**	**26**	**35**	**30**	**24**

Figure 4. 2 Annual Mean NO_2 Concentrations at Edinburgh Airport Between 2003 – 2018

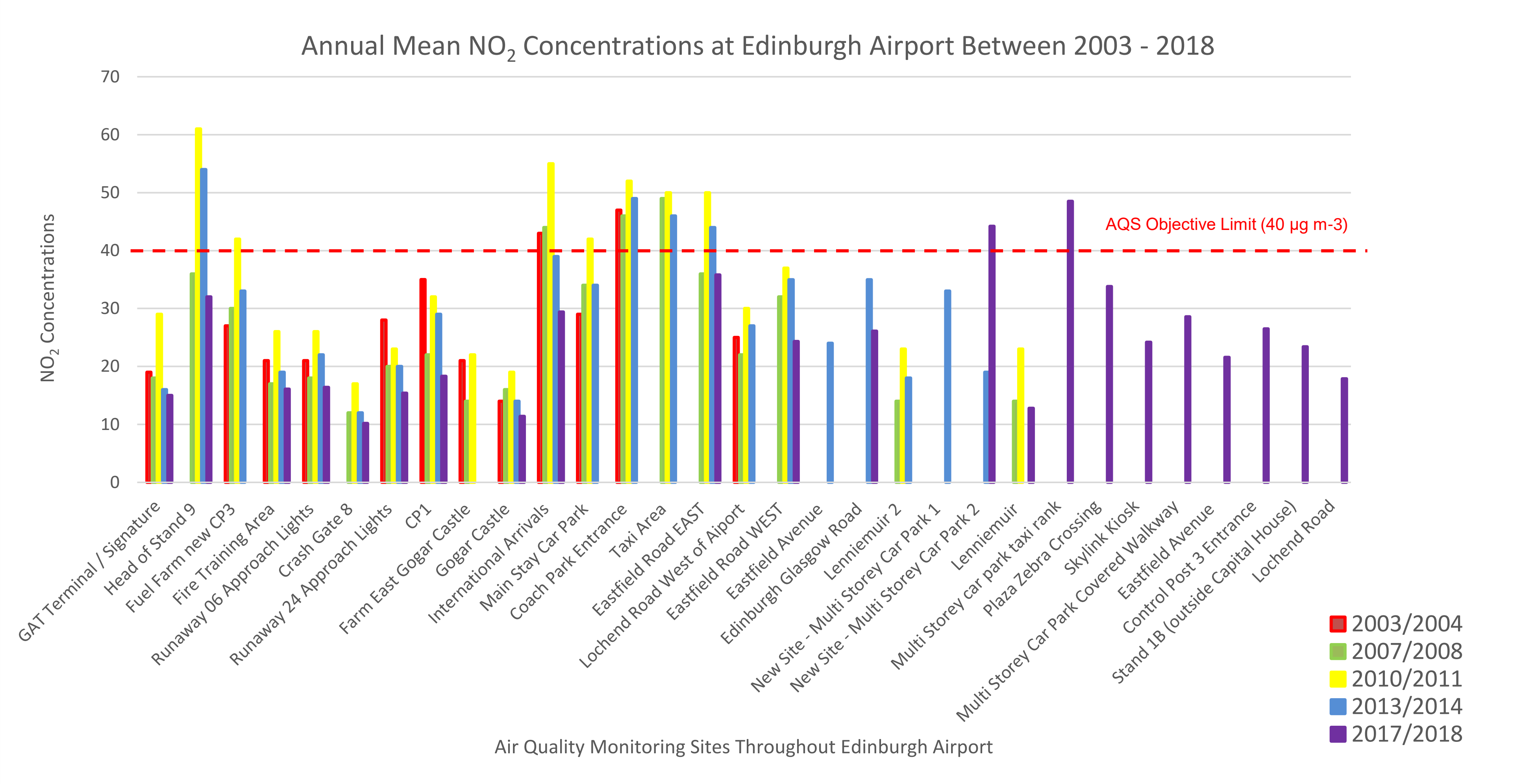
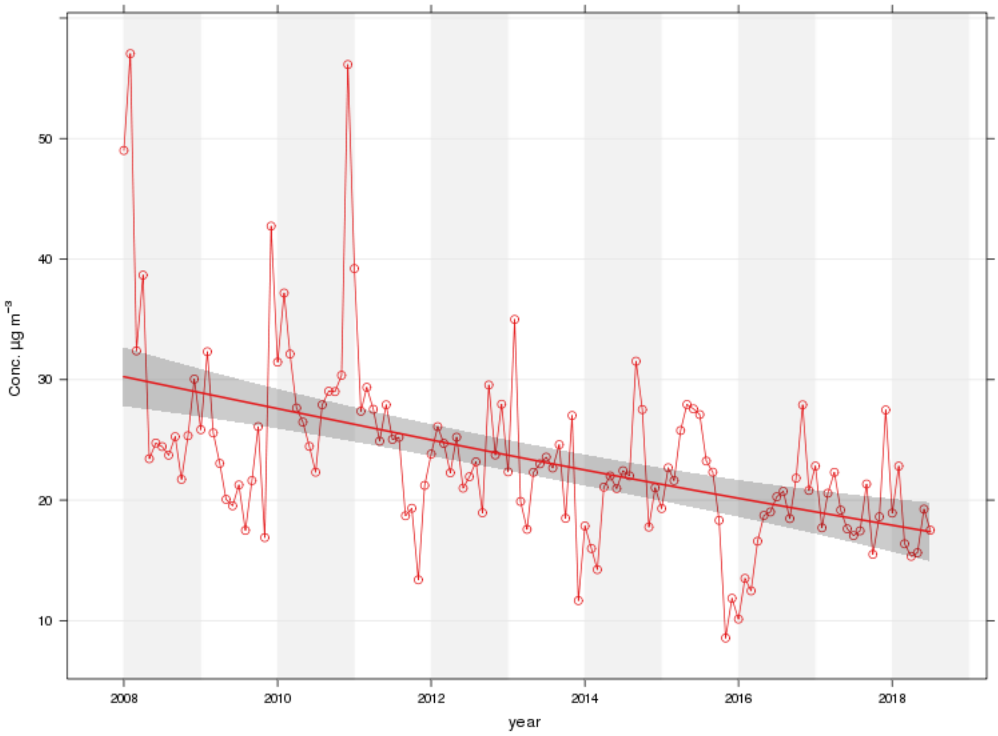


Figure 4. 3 Monthly Mean NO_2 Concentrations at Edinburgh St Leonards AURN Monitoring Site Between 2008 – 2018

De-seasonalised NO_2 for Edinburgh St Leonards Automatic Monitoring Site



Source: Scottish Air Quality, Openair data analysis tools, Trend Level, available at: http://www.scottishairquality.co.uk/data/openair?build=trendlevel Accessed 17/072018

5 Conclusions

Ricardo Energy & Environment was commissioned by Edinburgh Airport Ltd to undertake a six-month air quality monitoring survey investigating nitrogen dioxide (NO_2) concentrations at Edinburgh Airport during 2017/2018.

Estimated annual mean NO_2 concentrations above the objective of 40 µg m^{-3} were measured at two sites; EDI 02 and EDI 03, respectively. These sites are not considered relevant exposure when comparing to the annual mean objective and therefore, this objective is not likely to have been breached at any location during 2017.

The hourly NO_2 objective of no more than 18 exceedances of 200 µg m^{-3} in a year is not likely to have been exceeded at any location. In 2017, there is a general trend of decreasing NO_2 concentrations at all sites relative to what was measured in 2013. A slight downward trend in NO_2 concentrations has been seen at the automatic Edinburgh St Leonards monitoring site from 2008 to 2018.

For future air quality monitoring studies in Edinburgh Airport, it is recommended that diffusion tubes are deployed for 12 months to increase reliability of data and to better understand the nitrogen dioxide concentrations at the airport throughout off peak and peak travel times. It would also be interesting to monitor the airport's particulate matter 10 (PM_{10}) concentrations alongside the diffusion tubes.

Appendices

Appendix 1 – NO_2 Diffusion Tubes

Passive sampling involves the collection of air pollutants using an absorbing material without the use of pumps; hence, no power supply is required. This makes these samplers very easy to deploy and flexible in terms of siting.

A passive sampler for gaseous species is defined as a device which is capable of sampling gas or vapour pollutants from the atmosphere, at a rate controlled by a physical process such as diffusion through a static layer or permeation through a membrane, but which does not involve the active movement of air through the sampler

Samplers are available for a wide range of pollutant species. The NO_2, SO_2, NH_3 and O_3 diffusion tubes supplied by Ricardo-AEA are based on the work of Palmes, and consist of a cylindrical plastic tube, approximately 71 mm long and 11 mm in diameter. During sampling, one end is open and the other end holds an absorbent for the gaseous species to be monitored.

The basic principle on which diffusion tube samplers operate is that of molecular diffusion, with molecules of a gas diffusing from a region of high concentration (open end of the sampler) to a region of low concentration (absorber end of the sampler). The movement of molecules of gas (1) through gas (2) is governed by Fick's law, which states that the flux is proportional to the concentration gradient:

$$J = -D_{12}\frac{dc}{dz} \qquad (1)$$

Where:

J	=	the flux of gas (1) through gas (2) across unit area in the Z direction ($\mu g/m^2/s$)
c	=	the concentration of gas (1) in gas (2) ($\mu g\ m^{-3}$)
z	=	the length of the diffusion path (m)
D_{12}	=	the molecular diffusion coefficient of gas (1) in gas (2) (m^2/s)

For a cylinder of cross-sectional area **a** (m^2) and length **l** (m), then **Q** (μg) the quantity of gas transferred along the tube in **t** seconds (taken as the quantity of gas absorbed during **t**) is given by

$$Q = \frac{D_{12}(C_1 - C_o)at}{l} \qquad (2)$$

Where C_o and C_1 are the gas concentrations at either end of the tube.

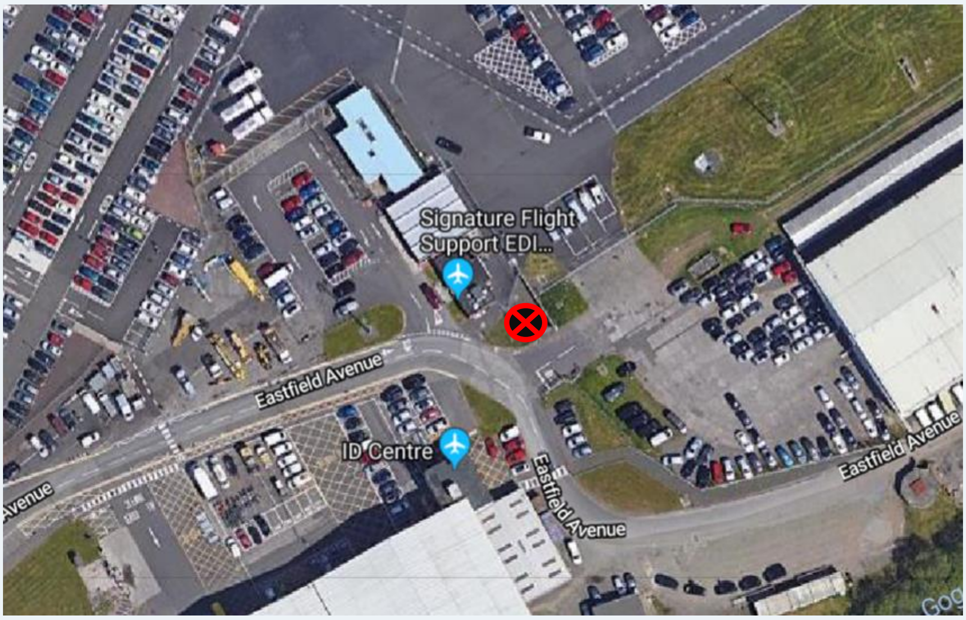
In a diffusion tube, the concentration of gas (1) is maintained at zero by an efficient absorber at one end of the tube (i.e. C_o = zero) and the concentration C_1 is the average concentration of the gas (1) at the open end of the tube over the period of exposure.

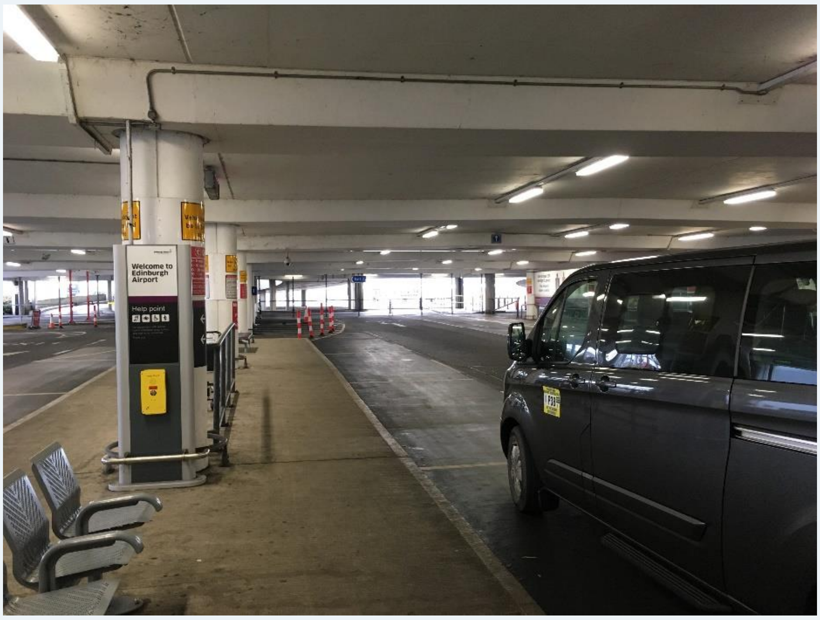
Hence:

$$C = \frac{Ql}{D_{12}at} \qquad (3)$$

The diffusion coefficient for the gas to be monitored must be determined, or obtained from the literature. A best estimate of the area and length of a typical tube must be determined by measurement using Vernier callipers. Nominal tube dimensions are set at 11mm (diameter) and 71mm (length). The gas concentration C, can be readily derived from the quantity of gas absorbed Q, (assessed by desorption & chemical analysis of the tube), and the exposure time t.

Appendix 2 – Site Photographs

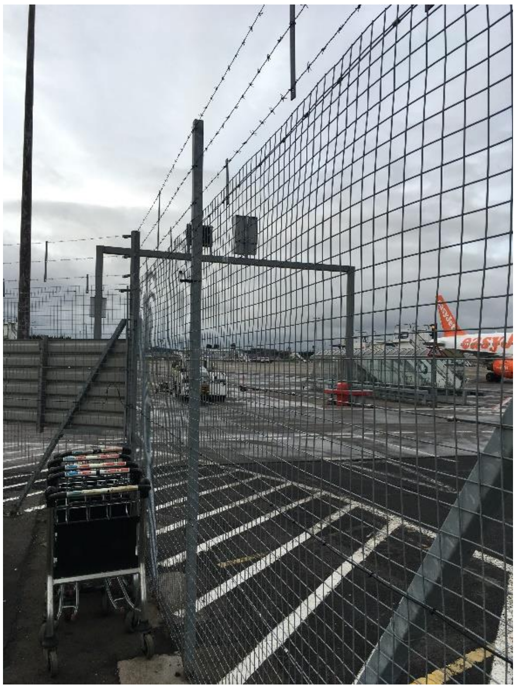
Site Code	Location Image
EDI 01	 Source: Google Maps, Contains Ordnance Survey data © Crown copyright and database right 2018
EDI 02	

EDI 03	
EDI 04	

EDI 05	
EDI 06	

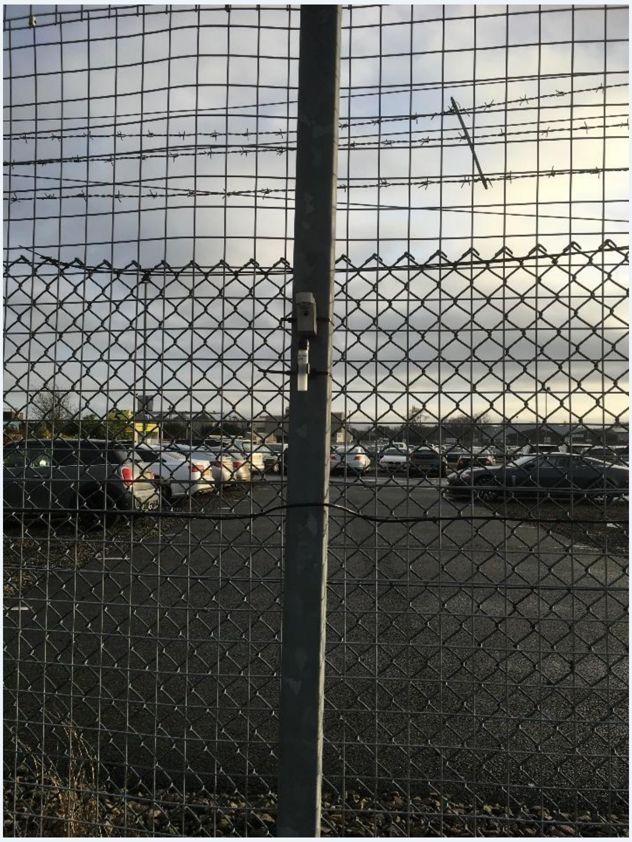
EDI 07	 Smoking shelter Crossing closed. Please follow diversion. BUS STAND
EDI 08	 40 bam

EDI 09	
EDI 10	 

EDI 11	
EDI 12	 

EDI 13	
EDI 14 EDI 15 EDI 16	

EDI 17	
EDI 18	

EDI 19	
EDI 20	

EDI 21	
EDI 22	

EDI 23	
EDI 24	
EDI 25	Control tube – N/A

Appendix 3 – Adjustment Factor

Figure A3.1 shows the local bias adjustment factor calculation spreadsheet. As can be seen, the locally derived bias adjustment factor was calculated to be 0.68 when using all available diffusion tube data. However, it was found, the results from the triplicate tubes sampled in period 4 showed poor precision. As a result, and in line with the guidance detailed in LAQM.TG (16), the poor result was rejected from the triplicate tube.

In line with the guidance detailed in LAQM.TG (16), the national bias adjustment factor spreadsheet, shown in Figure A3.2 was utilised. In this case, diffusion tube data and automatic monitoring data and resulting bias adjustment factors from collocations studies throughout the UK are collated. In this case, looking at 29 collocation studies using diffusion tube results as provided by SOCOTEC (formerly known as ESG Didcot) (using 50:50 TEA in Acetone) gave an overall factor of 0.77.

For this study the national derived factor of **0.77** was used.

Figure A3. 1 Bias Adjustment Factor Calculation Spreadsheet

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

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	05/12/2017	09/01/2018	45.0	49.1	55.2	50	5.1	10	12.8	39.3	100	Good	Good
2	09/01/2018	31/01/2018	50.9	57.7	54.5	54	3.4	6	8.5	34.6	100	Good	Good
3	31/01/2018	08/03/2018	44.1	46.0	45.3	45	1.0	2	2.4	34.8	99	Good	Good
4	08/03/2018	28/03/2018	42.0		42.4	42	0.3	1	2.5	25.5	100	Good	Good
5	28/03/2018	02/05/2018	34.1	33.8	31.1	33	1.7	5	4.1	20.7	100	Good	Good
6	02/05/2018	15/06/2018	28.3	28.2	24.3	27	2.3	8	5.7	16.9	99	Good	Good
7													
8													
9													
10													
11													
12													
13													

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

Overall survey --> Good precision | Good Overall DC

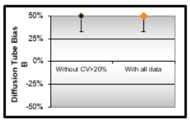
Site Name/ ID: Edinburgh Glasgow Road

Precision 6 out of 6 periods have a CV smaller than 20%

(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 6 periods of data
Bias factor A 0.68 (0.61 - 0.77)
Bias B 46% (29% - 63%)
Diffusion Tubes Mean: 42 μgm⁻³
Mean CV (Precision): 5
Automatic Mean: 29 μgm⁻³
Data Capture for periods used: 100%
Adjusted Tubes Mean: 28 (26 - 32) μgm⁻³

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 6 periods of data
Bias factor A 0.68 (0.61 - 0.77)
Bias B 46% (29% - 63%)
Diffusion Tubes Mean: 42 μgm⁻³
Mean CV (Precision): 5
Automatic Mean: 29 μgm⁻³
Data Capture for periods used: 100%
Adjusted Tubes Mean: 28 (26 - 32) μgm⁻³



Jaume Targa, for AEA
Version 04 - February 2011

If you have any enquiries about this spreadsheet please contact the LAQM Helpdesk at: LAQMHelpdesk@uk.bureauveritas.com

Figure A3. 2 National Diffusion Tube Bias Adjustment Factor Spreadsheet (Version 06/18)

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/18

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 September 2018
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	50% TEA in acetone	2017	R	Cambridge City Council	12	45	33	37.7%	G	0.73
ESG Didcot	50% TEA in acetone	2017	R	Wrexham County Borough Council	12	20	17	14.5%	G	0.87
ESG Didcot	50% TEA in acetone	2017	UI	North Lincolnshire Council	12	22	16	40.7%	G	0.71
ESG Didcot	50% TEA in acetone	2017	KS	Caerphilly CBC	12	37	32	15.8%	G	0.86
ESG Didcot	50% TEA in acetone	2017	R	Caerphilly CBC	11	44	29	51.2%	G	0.66
ESG Didcot	50% TEA in acetone	2017	UB	City of York Council	12	23	15	53.4%	G	0.65
ESG Didcot	50% TEA in acetone	2017	R	City of York Council	10	37	28	30.8%	G	0.76
ESG Didcot	50% TEA in acetone	2017	R	City of York Council	11	32	23	41.0%	G	0.71
ESG Didcot	50% TEA in acetone	2017	R	City of York Council	12	40	25	58.6%	G	0.63
ESG Didcot	50% TEA in acetone	2017	R	Hambleton District Council	10	21	20	4.0%	G	0.96
ESG Didcot	50% TEA in acetone	2017	R	Horsham District Council	11	35	29	18.1%	G	0.85
ESG Didcot	50% TEA in acetone	2017	R	Horsham District Council	12	31	26	21.3%	G	0.82
ESG Didcot	50% TEA in acetone	2017	R	Horsham District Council	11	33	23	41.1%	G	0.71
ESG Didcot	50% TEA in acetone	2017	R	Slough Borough Council	12	45	35	26.4%	G	0.79
ESG Didcot	50% TEA in acetone	2017	UB	Slough Borough Council	12	32	25	28.6%	G	0.78
ESG Didcot	50% TEA in acetone	2017	UB	Slough Borough Council	11	39	33	19.2%	G	0.84
ESG Didcot	50% TEA in acetone	2017	R	Tunbridge Wells	12	56	40	38.2%	G	0.72
ESG Didcot	50% TEA in acetone	2017	UB	Kingston upon Hull City Council	12	32	23	38.2%	G	0.72
ESG Didcot	50% TEA in acetone	2017	UB	Kingston upon Hull City Council	12	32	23	38.2%	G	0.72
ESG Didcot	50% TEA in acetone	2017	R	Suffolk Coastal DC	12	45	37	23.8%	G	0.81
ESG Didcot	50% TEA in acetone	2017	R	Dacorum Borough Council	9	31	27	14.7%	G	0.87
ESG Didcot	50% TEA in acetone	2017	R	North East Lincolnshire Council	11	37	24	53.5%	G	0.65
ESG Didcot	50% TEA in acetone	2017	UB	Swansea Council	10	17	14	23.4%	G	0.81
ESG Didcot	50% TEA in acetone	2017	R	Swansea Council	12	33	24	34.5%	G	0.74
ESG Didcot	50% TEA in acetone	2017		Overall Factor[3] (29 studies)				Use		0.77

Appendix 4 – NO_2 Diffusion Tube Results

Table A4. 1 Unadjusted NO_2 Diffusion Tube Results

Site Name	Site Code	NO_2 Concentration (µg m^{-3})						
		P1	P1[2]	P2	P3	P4	P5	P6
Signature (Previously IGAT Term)	EDI 01	31		26.8	20.4	22.9	17.2	Missing
Multi story car park taxi rank	EDI 02	77.4		75.7	80.3	51.9	70.9	69.3
Multi story drop off	EDI 03	71.4		64.6	59.7	64.6	58.1	73.1
Plaza Zebra Crossing	EDI 04	63.9		60.2	59	50.9	38	36.6
Airlink Kiosk	EDI 05	48.1		47.7	24.3	40.5	32.2	30.7
Multi story car park covered walkway	EDI 06	50.9		53.3	47.3	43.2	36.9	30.7
International arrivals 1	EDI 07	57.7		55.5	44.3	42.5	39.2	30.1
Eastfield Road at MWH	EDI 08	44.4		47.2	40.5	33.7	31.4	25.1
Eastfield Road roundabout	EDI 09	67		64.5	45.5	47.9	45.6	51
Eastfield avenue	EDI 10	41.1		19.5	34.9	33.6	33.7	27.3
Control post 3 entrance	EDI 11	42.3		47.6	42.6	29.5	40.7	33.8
Stand 1B (outside capital house)	EDI 12	37.9		38.9	37.6	34.2	34.9	28.3
Lochend Road	EDI 13	30		39.9	26.7	29.9	20.2	20.6
Glasgow Road (1)	EDI 14	45		50.9	44.1	42	34.1	28.3
Glasgow Road (2)	EDI 15	49.1		57.7	46	29.9	33.8	28.2
Glasgow Road (3)	EDI 16	55.2		54.5	45.3	42.4	31.1	24.3
Head of Stand 9	EDI 17		52.5	51.5	50	49.3	39.2	42.4
Lenniemuir	EDI 18		27.8	29.8	15.6	19.4	14.4	13.8
AFS Fencelink Airside	EDI 19		28.9	28.1	25.5	27.6	19.4	17.3
Runway 06 end of runway lights (airside)	EDI 20		30.5	35.5	23.2	21.1	22.6	17.2
Cargo - CP1 Airside	EDI 21		35.7	37.5	23.2	23.3	20.9	Missing
Gogar Castle (airside)	EDI 22		20.6	20.8	15.7	18.3	12.6	Missing
Runway 24 approach lights (airside)	EDI 23		31.8	33.3	22	22.9	16.5	16.6
Crash gate 8 (airside)	EDI 24		20.9	22.2	13.9	17.1	11.3	10.3
Blank	EDI 25	0.09		<0.03	0.07	0.07	0.06	0.05

P1[2] - Access issues to airside, deployment of airside diffusion tubes delayed until 18/12/2017

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