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AURN Annual Technical Report 2018

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Executive summary

Ricardo Energy & Environment carries out the quality assurance and quality control (QA/QC) activities for the Automatic Urban and Rural Monitoring Network (AURN) on behalf of the Environment Agency, the UK Department for Environment, Food and Rural Affairs (Defra), the Scottish Government, Welsh Government and Department of Agriculture, Environment and Rural Affairs (DAERA) in Northern Ireland.

This annual report summarises the QA/QC activities carried out over the period 1st January to 31st December 2018. It summarises the key data capture and data quality statistics and highlights any issues that have been identified relating to the QA/QC activities associated with the AURN during this period

The number of AURN monitoring stations in operation during part or all of this period was 169. In addition, there were two co-located Partisol gravimetric particulate samplers, located at Port Talbot Margam (measuring PM_{10}) and London Marylebone Road (measuring $PM_{2.5}$ and PM_{10}).

During this year, two full intercalibration exercises (winter and summer) were carried out, involving comprehensive performance tests on every analyser in the network. In addition, two ozone-only intercalibration exercises (spring and autumn) were carried out. This allows the accuracy of the measured results to be determined, and a measurement uncertainty for each analyser to be calculated, as required by the Data Quality Objectives of the European Union's Air Quality Directive (2008/50/EC).

The mean data capture for ratified hourly average data was 92.49% (averaged over all pollutants O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$), for the 12-month reporting period January to December 2018.

The data capture target of the Air Quality Directive is 90% (excluding periods of planned maintenance e.g. calibrations, audits and servicing). An allowance of 5% is made for this, hence a target of 85%. Mean data captures for individual pollutants were as follows: CO 96.90%, NO_2 94.22%, O_3 95.82%, SO_2 87.88%, PM_{10} 89.80%, and $PM_{2.5}$ 91.41%. Hence, the mean data captures for all pollutants met this target in calendar year 2018.

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1 Introduction

1.1 Background

The UK Automatic Urban and Rural Network (AURN) was established to provide information on air quality throughout the UK for a range of pollutants. The primary function of the AURN is to provide data in compliance with EU Directives on Air Quality. However, in addition, the data and information from the AURN are required by scientists, policy makers and planners to enable them to make informed decisions on managing and improving air quality for the benefit of health and the natural environment.

A number of organisations are involved in the day-to-day running of the network. Currently, the role of Central Management and Co-ordination Unit (CMCU) for the AURN is contracted to Bureau Veritas, whilst the Environmental Research Group (ERG) of King's College London (KCL) has been appointed as Management Unit for the AURN monitoring stations that are also part of the London Air Quality Network (LAQN), together with a small number of others in the south of England. Ricardo Energy & Environment undertakes the role of Quality Assurance and Quality Control Unit (QA/QC Unit) for all stations within the AURN. The responsibility for day-to-day operation of individual monitoring stations is assigned to Local Site Operators (LSOs): local organisations with relevant experience in the field under the direct management of (and contract to) CMCU. Calibration gases for the network were supplied by Air Liquide UK Ltd during 2018 and were provided with an ISO17025 certificate of calibration by Ricardo Energy & Environment. The monitoring equipment was serviced and maintained by a number of Equipment Support Units, under contract to the CMCU in the case of fully EA funded stations. This report includes information on performance of the AURN site at London Harlington where the QA/QC work is not conducted on behalf of the Environment Agency and Defra.

Data from the AURN are disseminated to the public, the scientific community and other users via UK-AIR (the online UK Air Information Resource, http://uk-air.defra.gov.uk/) and other media such as social media and freephone services. This is the responsibility of the Data Dissemination Unit (DDU) under a separate contract. The DDU is also responsible for producing a summary report of the data from this and other UK air quality monitoring networks. This is published annually as the "Air Pollution in the UK" series of reports, available on UK-AIR.

Approximately half of the stations in the AURN are fully funded by the Environment Agency, and the management of all aspects of these stations is carried out by the CMCU. The remainder are owned by third parties (mostly local authorities, LA's) but affiliated to the AURN; the stations and monitoring equipment remain the responsibility of local authorities or other organisations. This includes servicing and maintenance, and LSO activities. The distinction between fully-funded and affiliate monitoring stations is no longer clear-cut, as a number of otherwise LA-owned affiliate stations have one or more fully-funded analysers installed. However, all AURN stations benefit from centralised data ratification by the CMCU, six-monthly QA/QC audits, certified gas mixtures for analyser calibrations, and centralised data collection and dissemination. A total of 169 monitoring stations in the AURN operated during the year 2018. This does not include the two stations where Partisol gravimetric particulate samplers were co-located with automatic particulate analysers. (The gravimetric data have historically been used in validating the performance of the automatic analysers). For data processing purposes, in these cases the gravimetric sampler is treated as a separate station; and they are shown, and counted, separately in the data capture tables in section 4. Hence, in these tables the total number of stations appears as 171.

This report excludes information on performance of the AURN site at London Harlington where the QA/QC work is not conducted on behalf of the Environment Agency and Defra.

Mace Head is a remote monitoring station on the western coast of the Republic of Ireland: it is included in the UK AURN to provide information on background ozone levels unaffected by local pollution sources.

The main reasons for data loss at the monitoring stations were predominantly due to instrument or air conditioning faults, response instability or problems associated with the replacement of analysers and infrastructure.

1.2 What the AURN Data are Used For

The AURN and its fore-runners has been in operation since 1992, although some automatic air quality monitoring has been undertaken in the UK since 1973. The network has expanded and developed over many years. Provisional data are disseminated hourly (i.e. in near real time) by the Data Dissemination Unit (DDU) via UK-Air. The QA/QC Unit carries out data ratification quarterly in arrears, and reports the ratified dataset quarterly, also via UK-Air.

The major objectives of the network are as follows:

- Monitoring compliance with relevant statutory air quality standards, objectives, limit values and target values are met (e.g. the UK's own Air Quality Strategy, and the EC Air Quality Directive (2008/50/EC);
- Informing the public about air quality;
- Providing information for local air quality review and assessments within the UK Air Quality Strategy;
- Identifying long-term trends in air pollution concentrations; and
- Assessing the effectiveness of policies to control pollution.

The data from the AURN are used for:

- Reporting to the EU Commission against Air Quality Directives.
- Comparison with air quality objectives as laid out in the Air Quality Strategy.
- Providing the public with information through air quality bulletins.
- Forecasting future air quality levels.
- Policy development for human health and ecosystem protection.
- The European Monitoring & Evaluation Programme (EMEP).
- The UK Local Air Quality Management regime under Part IV of the Environment Act 1995.
- National Indicators on environmental quality.

1.3 What this Report Covers

This report explains and reports the main QA/QC activities carried out over the twelve-month period 1st January to 31st December 2018, including a summary of QA/QC methodology applied, and an overview of data capture.

1.4 Where to Find More Information

Further information on the AURN can be found in the following:

- UK-AIR at https://uk-air.defra.gov.uk/, which contains information on individual stations along with real-time hourly data, graphs and statistics.

- A summary report of the data is also published annually in the “Air Pollution in the UK” series of reports, available on UK-Air.

A glossary of commonly used terms is given in Appendix 1.

1.5 Changes to the Network During 2018

Table 1-1 shows the changes to the AURN, i.e. monitoring stations started up or closed down, during 2018:

Table 1-1 Changes to AURN Stations During 2018

Station	Start date	Pollutants measured
Swindon Walcot	01/01/2018	NO_2
Burton-on-Trent Horninglow	01/02/2018	NO_2
Cardiff Newport Road	01/04/2018	NO_2 PM_{10}
Dewsbury Ashworth Grove	01/04/2018	NO_2
Birmingham Ladywood	23/08/2018	PM_{10} $PM_{2.5}$

Birmingham Ladywood is a replacement station for Birmingham Tyburn, which closed in June 2017 due to redevelopment of the area. It is planned that Birmingham Ladywood will also measure NO_2, SO_2 and ozone, however technical issues prevented these data being reported in 2018.

1.6 Changes to Instrumentation

A programme of upgrade and renewal of particulate analysers was started in 2018. This ongoing programme aims to remove obsolete FDMS analysers from the network and replace them with new instruments. The new instruments are a mixture of Beta Attenuation Monitors (BAMs) and Fidas 200 instruments. There have been BAMs in the AURN for many years, but the Fidas is a relatively new addition. The Fidas is an aerosol spectrometer that uses a light scattering method to detect airborne particles in a range of size fractions. The sample inlet system is heated to prevent interference by water vapour. Data are reported as hourly averages.

As Fidas analysers are capable of measuring several size fractions at the same time, where a single FDMS analyser (measuring either PM_{10} or $PM_{2.5}$) is replaced by a Fidas (which measures both fractions), both $PM_{2.5}$ and PM_{10} will be reported from the date of installation of the Fidas.

2 Methodology

2.1 Overview of QA/QC Activities

The QA/QC activities consist of the following key parts:

- QA/QC audits of all analysers in the network every six months (three months for ozone)
- Ratification of the data on a three-monthly basis, and upload of ratified data to the Data Dissemination Unit.
- Assessment of new station locations in conjunction with the CMCU, and assessment of compliance with the siting criteria in the Air Quality Directive.
- Investigation of instances of suspected poor-quality data.

2.2 QA/QC Audits

2.2.1 Purpose of Intercalibration

The QA/QC intercalibration audits fulfil a number of important functions:

- Validation of the production of provisionally scaled data, which is rapidly disseminated to the public soon after collection.
- Identification of poorly-performing analysers and infrastructure (for example housings and air conditioning units), together with recommendations for corrective action.
- A measure of network performance, by examining for example, how different NOx analysers around the network respond to a common gas standard. This test checks how “harmonised” UK measurements are; i.e. that a 200ppb NO_2 pollution episode at any given monitoring station would be reported in exactly the same way at every other station in the UK, regardless of the location or the analyser used to record the event.
- Assessment of the area around the monitoring station: has the environment changed in the last six months? Is the location still representative of the station classification?

The QA/QC audits test the following aspects of analyser performance:

1. Analyser accuracy and precision. These are basic checks to ensure analysers respond to known concentrations of gases in a reliable manner.
2. Instrument linearity. This test refines the response checks on analysers, by assessing whether doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser’s response characteristics are not linear, data cannot be reliably scaled into concentrations.
3. Instrument signal noise. This test checks that an analyser responds to calibration gases in a stable manner with time. A “noisy” analyser may not provide high quality data which may be difficult to process at lower concentrations.
4. Analyser response time. This test checks that the analyser responds quickly to a change in gas concentrations. If analyser response is too slow, data may not accurately reflect ambient concentrations.
5. Leak and flow checks. These tests ensure that ambient air reaches the analysers, without being compromised in any way. Leaks in the sampling system can affect the ability of the analyser to sample ambient air reliably.
6. NOx analyser converter efficiency. This test evaluates the ability of the analyser to measure NO_2. An inefficient converter severely compromises the data from the analyser.
7. FDMS k_0 evaluation. The analyser uses this factor to calculate mass concentrations, so the value is calculated to determine its accuracy compared to the stated value. This is only

required for FDMS particulate monitoring instruments: it is not relevant to the BAM or Fidas as these operate in a different way.

8. Particulate analyser flow rate checks. These tests ensure that the flow rates through critical parts of the analyser are within specified limits. There are specific analyser flow rates that are set to make sure particle size fractions and mass concentration calculations are performed correctly.
9. Evaluation of station cylinder concentrations. These tests use a set of certified cylinders that are taken to all the stations. The concentrations of the station cylinders are used to scale pollution datasets, so it is important to ensure that the concentrations of gases in the cylinders do not change.
10. Competence of Local Station Operators (LSOs) in undertaking calibrations. As it is the calibrations by the LSOs that are used to scale pollution datasets, it is important to check that these are undertaken competently.
11. Zero "calibration" of all automatic PM analysers. This test allows the baseline performance of PM analysers to be evaluated, to determine whether any remedial action is required to the analyser or baseline to be corrected during ratification.

Once all data have been collected, a "Network Intercalibration" is conducted. This utilises the audit gas cylinders transported to each station in the Network. These cylinders will have been recently calibrated by the Calibration Laboratory at Ricardo Energy & Environment. This exercise allows us to examine how different station analysers respond when they are supplied with the same gas used at other stations. For ozone analysers, the calibration is undertaken with recently calibrated ozone photometers.

The technique used to process the intercalibration results is broadly as follows:

- The analyser responses to audit gas are converted into concentrations, using provisional calibration factors obtained from the Management Units on the day of the intercalibration. These factors are also used for the provisional data supplied to UK-AIR.
- These individual results are tabulated, and statistical analyses undertaken (e.g. network average result, network standard deviation, deviation of individual stations from the network mean etc.).

These results are then used to pick out problem stations, or "outliers", which are investigated further to determine reasons and investigate possible remedies for the outliers. The definition of an outlier is an analyser result that falls outside the following limits:

- ±10% of the network average for NOx, CO and SO_2 analysers,
- ±5% of the reference standard photometer for ozone analysers,
- ±2.5 % of the stated k_0 value for FDMS analysers,
- ±10% for particulate analyser flow rates,
- Particulate analyser average zero response within ±3.0 µg m^{-3}.
- ±10% for the recalculation of station cylinder concentrations.

Thus, the intercalibration investigates the quality of provisional data output by the Management Units for use in forecasting, interactive television services and the web. It also provides input into the ratification process by highlighting stations where close scrutiny of datasets is likely to be required. Any outliers that are identified are rigorously checked to determine the cause, and any required corrective action to be taken, if necessary. There are a number of likely main causes for outlier results, as discussed below:

- Drift of an analyser between scheduled LSO calibrations. This is by far the most common cause of an outlier result, and one that is simply corrected for during ratification of data.

- Drift of station cylinder concentrations between intercalibrations. Station cylinders can sometimes become unstable, especially at low pressures. All station cylinder concentrations are checked every six months and are replaced as necessary.
- Erroneous calibration factors. It can occasionally happen that an analyser calibration is unsuccessful, and results in unsuitable scaling factors being used to produce pollution datasets. These are identified and corrected during ratification.
- Pressurisation of the sampling system at the audit. Occasionally, an analyser can be very sensitive to small changes in applied flow rates of calibration gas. This is more difficult to identify and correct and may have consequences for data quality.
- Leaks, sample switching valves, etc. Outliers can be generated if an analyser is not sampling ambient air properly. It is likely that if a leaking analyser is identified, data losses will result.

Full audits of all analysers are carried out at six-monthly intervals in the winter (January-March) and summer (July-September). In addition, audits of ozone analysers are also carried out in spring (April) and autumn (October).

2.2.2 Baseline Checks for FDMS and BAM Particulate Analysers

As part of the routine QA/QC audits, particulate analysers (FDMS and BAM) have zero checks carried out every six months using filters on the inlets for a few days. This allows identification of analysers which have high baseline responses to air containing no particulate matter, often due to inefficient driers (for FDMS). The CEN standard method for ambient particulate matter EN16450 states that action must be taken when baseline response is higher than 3 µg m^{-3} but does not state what the action should be. Originally, the only agreed action was to delete the data. However, as part of ongoing improvement activities a protocol has been agreed to enable baselines to be corrected where baseline responses exceed 3 µg m^{-3}. (The zero baseline check for the Fidas instrument is carried out using a different testing procedure).

2.2.3 Uncertainties of Measurement

The measured uncertainties of measurement are determined at each QA/QC audit, and the results for the winter and summer 2018 audits are given in Appendix 2.

The European Committee for Normalisation (CEN) have prepared a series of documents prescribing how analysers must be operated, to produce datasets that conform to the Data Quality Objectives of the EC Directives. The CEN documents for operation of air pollution analysers; BS EN14211:2012 (NOx), BS EN14212:2012 (SO_2), BS EN14626:2012 (CO) and BS EN14625:2012 (O_3) set out a series of performance criteria for analysers which must be achieved, both in the field and under laboratory conditions. The test requirements have been extensively reported in previous intercalibration summaries and should be referenced for further information. The CEN operating methodologies are incorporated into the requirements of the air quality Directive 2008/50/EC. Member States had until June 2010 to ensure their monitoring networks were compliant. Older, non-compliant equipment still on site after this date needed to be replaced before June 2013. Ricardo Energy & Environment took steps to ensure the procedures used in the UK complied with the requirements ahead of any imposed deadlines. To this end, the procedures used for the intercalibrations have been fully compliant with the CEN protocols since January 2006.
To comply with the Directive, the uncertainty for gaseous analyser measurements must be less than ±15%. For PM analysers, the required measurement uncertainty is less than ±25%. For stations that have CEN-compliant instrumentation, it is possible to calculate the overall uncertainty of measuring air quality.

There were a small number of analysers where the calculated uncertainty was higher than the Directive compliance limit. The most common cause of this is noisy response as measured during the audit. This is generally an indication of poor instrument performance, and these are reviewed at the Quality Circle to assess the impact on reported data. High noise levels on particulate analysers are reported to CMCU and ESUs prior to each service to ensure the necessary repair procedures are carried out by the engineer.

It should be noted that these uncertainties are applicable ***only on the day of test***. They are therefore a snapshot only, and it should not necessarily be inferred that these values apply to the entire year's dataset. In particular, a high uncertainty measured at audit may be as a result of a fault, and this results in an ESU visit to repair the instrument. The QA/QC Unit then decides whether to report the data for the affected period or delete them, as appropriate.

The following analysers were outside the maximum uncertainties during 2018:

Winter:
- Leamington Spa $PM_{2.5}$
- Wicken Fen NO_2

Summer:
- Derry Rosemount NO_2
- Haringey Roadside NO_2
- London Haringey Priory Park South NO_2
- Peebles NO_2

In these cases, analyser faults were identified, and some data deleted during ratification.

2.2.4 Certification and Accreditation

The QA/QC Unit holds ISO/IEC17025 accreditation for the field calibration of gaseous analysers, performance tests of particulate analysers and calibration of the gas mixtures used for regular LSO calibrations. Ozone analysers receive quarterly multipoint calibrations from a certified photometer, as required by the Directive.

Certified calibrations of ozone photometers used by the ESUs are provided by the QA/QC Unit prior to six-monthly service schedules.

2.3 Overview of Data Ratification

Data for each station are supplied monthly by the CMCUs. Once initial monthly data files have been received, checked and loaded into Ricardo Energy & Environment's data handling system, the process of data ratification begins. This process is required to refine data scaling based on all the calibration and audit data available, and to identify, withdraw or flag anomalous data due to instrument or sampling faults or where data fall outside the Uncertainties or Limits of Detection defined by the Data Quality Objectives (DQOs) of Directive 2008/50/EC (the Air Quality Objective) and the European Union's Implementing Provisions for Reporting.

3 Data Capture

3.1 Overview

The overall data capture for the period January-December 2018 is given in Table 3.1. Ratified hourly average (daily average for Partisols) data capture for the network averaged 92.49% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the twelve-month reporting period January-December 2018. Data capture statistics are calculated using the actual data capture as hourly averages (daily for Partisol) against the total number of hours (or days) in the relevant period; service and maintenance are counted as lost data. It is permissible to discount routine service and calibration from achievable data capture targets, but this is not calculated. All pollutants achieved 85% or higher data capture on average. The data capture target for the purposes of monitoring compliance with the EU Air Quality Directive (Directive 2008/50/EC) is 90% excluding planned servicing and maintenance. For practical purposes in the AURN, planned maintenance is assumed to be 5% so a target of 85% data capture is used. Data capture is calculated from the number of valid hourly averages recorded in the year, or from the date of commissioning if the station or analyser is introduced during the year.

3.2 Overall Data Capture

The overall data capture for all stations for 2018 is given in Table 3.1.

Table 3.1 Summary of Data Capture for the AURN, January-December 2018

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	
Number of Stations	7	157	75	77	81	27	171
Number of stations < 85 %	0	12	4	15	10	7	20
Number of stations < 90%	0	19	6	23	20	7	30
Average	96.90	94.22	95.82	89.80	91.41	87.88	92.49

3.3 Generic Data Issues

The following generic data quality issues have been identified in 2018:

- The use of obsolete mass transducer filters on FDMS analysers, resulting in high analyser noise. These are being removed from stations during QA/QC audits.

- The use of mass transducer filters of a certain mass, which give erroneous k_0 values at QA/QC audits and may well have affected measured concentrations over some years. This matter has been taken up with the UK distributer and the manufacturer in the US.

- Poor performance of some analysers, particularly older SO_2 analysers. A number of the SO_2 analysers reached the end of their useful lives during the latter part of 2018, impacting upon data capture. The Environment Agency has since purchased seven replacement SO_2 analysers which were installed in 2019.

In some cases, the ESU may choose to avoid significant data loss by removing an instrument for workshop repair and install a temporary loan instrument in station. This is termed a “hotspare” analyser. This may not be of the same type of analyser, which has implications for LSO calibration procedures, and also for the reporting of instrument types in the annual data submission.

The QA/QC audits continued to identify high zero baselines responses for some particle analysers in the network; some data were deleted as a result. These zero tests, along with regional volatile comparisons, continue to provide evidence for poor FDMS drier performance at some stations. However, the results of zero baseline tests are now being used to apply correction to data where high baselines have been identified.

3.4 Data Capture - England (excluding London)

The data capture statistics for stations within England (excluding London) are given in Table 3.2.

Table 3.2 Data Capture for Stations in England, January-December 2018

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Barnsley Gawber		99.02	99.10			98.94	99.02
Barnstaple A39				62.34	90.92		**76.63**
Bath Roadside		99.16					99.16
Billingham		96.94					96.94
Birkenhead Borough Road		99.54					99.54
Birmingham A4540 Roadside		98.78	97.10	92.81	94.33		95.75
Birmingham Acocks Green		97.36	99.27		97.72		98.12
Birmingham Ladywood				69.85	99.40		**84.62**
Blackburn Accrington Road		97.10					97.10
Blackpool Marton		93.00	95.08		84.13		90.74
Borehamwood Meadow Park		97.98					97.98
Bournemouth		96.08	97.52		95.95		96.52
Bradford Mayo Avenue		97.33					97.33
Brighton Preston Park		99.08	98.79		97.81		98.56
Bristol St Paul's		83.87	83.56	79.68	79.87		**81.75**
Bristol Temple Way		98.11		94.11			96.11
Burton-on-Trent Horninglow		99.51					99.51
Bury Whitefield Roadside		99.43		94.16			96.79
Cambridge Roadside		98.16					98.16

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Cannock A5190 Roadside		74.09					**74.09**
Canterbury		97.13	93.74				95.44
Carlisle Roadside		95.16		90.63	91.22		92.34
Charlton Mackrell		99.41	0.00				**49.70**
Chatham Roadside		98.89		96.45	96.08		97.14
Chesterfield Loundsley Green		91.67		95.25	95.09		94.00
Chesterfield Roadside		91.82		82.39	95.58		89.93
Chilbolton Observatory		98.58	98.87	93.00	90.00	97.61	95.61
Christchurch Barrack Road		88.49			97.09		92.79
Coventry Allesley		97.16	99.32		94.25		96.91
Coventry Binley Road		99.10		94.49			96.79
Derby St Alkmund's Way		99.68					99.68
Dewsbury Ashworth Grove		41.64					**41.64**
Doncaster A630 Cleveland Street		99.27					99.27
Eastbourne		55.02			97.84		**76.43**
Exeter Roadside		96.56	97.07				96.82
Glazebury		78.12	79.01				**78.56**
Hartlepool St Abbs Walk		99.19					99.19
High Muffles		94.82	96.24				95.53
Honiton		98.42					98.42
Horley		87.03					87.03
Hull Freetown		99.03	99.12		97.84	74.77	92.69
Hull Holderness Road		99.04		94.70			96.87
Immingham Woodlands Avenue		65.80					**65.80**
Ladybower		91.88	78.56			90.89	87.11
Leamington Spa		91.87	99.57	94.87	94.36		95.17
Leamington Spa Rugby Road		98.77		64.22	74.21		**79.07**
Leeds Centre	98.45	98.37	97.69	96.89	93.82	98.17	97.23
Leeds Headingley Kerbside		99.02		95.78	96.55		97.12
Leicester A594 Roadside		99.17		93.60			96.38
Leicester University		99.21	99.33		97.92		98.82
Leominster		98.88	99.43				99.16
Lincoln Canwick Road		99.52					99.52

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Liverpool Speke		99.17	99.14	93.42	97.07	76.48	93.06
Lullington Heath		98.96	99.27			99.08	99.10
Luton A505 Roadside		99.18					99.18
Manchester Piccadilly		99.11	98.80		94.77	97.29	97.49
Manchester Sharston		98.26	97.99				98.13
Market Harborough		95.34	98.93				97.13
Middlesbrough		97.53	97.34	93.94	92.93	98.09	95.97
Newcastle Centre		88.08	96.43	93.42	91.53		92.37
Newcastle Cradlewell Roadside		99.18		93.70			96.44
Northampton Spring Park		99.34	99.25		96.60		98.39
Norwich Lakenfields		99.24	99.04	86.43	89.39		93.52
Nottingham Centre		97.29	97.75	95.16	95.18	94.89	96.05
Nottingham Western Boulevard		93.60		92.65			93.12
Oldbury Birmingham Road		34.65					**34.65**
Oxford Centre Roadside		94.94					94.94
Oxford St Ebbes		98.44		96.96	96.18		97.19
Plymouth Centre		98.96	97.67	95.82	92.45		96.23
Plymouth Tavistock Road		84.94					**84.94**
Portsmouth		99.50	98.96	63.97	55.74		**79.54**
Portsmouth Anglesea Road		96.66		97.45			97.05
Preston		99.08	98.61		95.63		97.77
Reading London Road		97.36		92.77			95.07
Reading New Town		99.22	99.32	77.79	93.38		92.43
Rochester Stoke		94.69	99.18	98.00	97.00	95.34	96.84
Salford Eccles		98.69		86.00	84.00		89.56
Saltash Callington Road				87.76	95.50		91.63
Sandy Roadside		98.30		63.69	62.20		**74.73**
Scunthorpe Town		97.59		95.64		98.73	97.32
Shaw Crompton Way		94.84					94.84
Sheffield Barnsley Road		97.49			93.98		95.74
Sheffield Devonshire Green		98.76	99.22	96.75	91.44		96.54
Sheffield Tinsley		97.15					97.15

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Sibton			98.80				98.80
Southampton A33		98.97		72.19			85.58
Southampton Centre		94.54	94.99	72.50	86.82	90.11	87.79
Southend-on-Sea		75.51	98.16		72.45		**82.04**
St Helens Linkway		97.74		92.33			95.03
St Osyth		98.25	99.02				98.64
Stanford-le-Hope Roadside		99.03		81.03	97.93		92.66
Stockton-on-Tees A1305 Roadside		99.02			95.68		97.35
Stockton-on-Tees Eaglescliffe		97.97		88.95	95.99		94.30
Stoke-on-Trent A50 Roadside		97.55		94.98			96.26
Stoke-on-Trent Centre		98.20	98.25		92.34		96.26
Storrington Roadside		98.85					98.85
Sunderland Silksworth		94.79	86.04		90.15		90.33
Sunderland Wessington Way		85.29					85.29
Swindon Walcot		97.19					97.19
Telford Hollinswood		94.97					94.97
Thurrock		96.94	96.02	93.73		95.89	95.64
Walsall Woodlands		99.74	99.57				99.65
Warrington		92.24		69.79	89.89		**83.97**
Weybourne			99.86				99.86
Wicken Fen		98.34	99.32			91.64	96.43
Widnes Milton Road		17.23					**17.23**
Wigan Centre		97.71	98.89		77.71		91.43
Wirral Tranmere		99.10	94.22		93.88		95.73
Worthing A27 Roadside		95.16			89.54		92.35
Yarner Wood		97.74	97.40				97.57
York Bootham		98.26		96.07	95.54		96.62
York Fishergate		95.71		91.83	93.30		93.61
Number of Stations	**1**	**107**	**49**	**47**	**53**	**15**	**112**
Number of stations < 85 %	**0**	**10**	**4**	**12**	**8**	**2**	**17**
Number of stations < 90%	**0**	**14**	**5**	**16**	**12**	**2**	**24**
Average	**98.45**	**92.91**	**92.92**	**88.08**	**91.29**	**87.37**	**91.14**

3.5 Data Capture - London

The data capture statistics for stations within London are given in Table 3.3

Table 3.3 Data Capture for Stations in London, January-December 2018

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Camden Kerbside		95.91		96.72	88.26		93.63
Ealing Horn Lane				98.78			98.78
Haringey Roadside		99.79					99.79
London Bexley		99.29			98.81		99.05
London Bloomsbury		98.77	98.47	88.06	92.49	78.42	91.24
London Eltham		95.75	99.61		82.89		92.75
London Haringey Priory Park South		98.90	95.13				97.01
London Harlington*		92.39	96.91	96.72	96.72		95.68
London Hillingdon		92.60	98.09				95.35
London Marylebone Road	97.63	98.40	98.53	96.58	89.58	91.79	94.97
London Marylebone Road				94.25	90.96		92.60
London N. Kensington	98.04	99.21	98.12	99.97	99.97	95.79	98.61
London Teddington Bushy Park					96.19		96.19
London Westminster		97.13			89.00		93.07
Southwark A2 Old Kent Road		85.29		80.61			**82.95**
Tower Hamlets Roadside		96.11					96.11
Number of Stations	**2**	**13**	**7**	**8**	**10**	**3**	**16**
Number of stations < 85 %	**0**	**0**	**0**	**1**	**1**	**1**	**1**
Number of stations < 90%	**0**	**1**	**0**	**2**	**4**	**1**	**1**
Average	**97.83**	**96.12**	**97.84**	**93.96**	**92.49**	**88.67**	**94.86**

*London Harlington is not part of the EA QA/QC contract

3.6 Data Capture - Scotland

The data capture statistics for stations within Scotland are given in Table 3.4

Table 3.4 Data Capture for Stations in Scotland, January-December 2018

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Aberdeen		99.00	99.24	96.50	97.52		98.06
Aberdeen Union Street Roadside		99.04					99.04
Aberdeen Wellington Road		99.33					99.33
Auchencorth Moss			99.22	95.00	92.00		95.41
Bush Estate		99.06	99.13				99.10
Dumbarton Roadside		96.30					96.30
Dumfries		99.43					99.43
Dundee Mains Loan		90.99					90.99
Edinburgh Nicolson Street		99.75					99.75
Edinburgh St Leonards	90.18	96.77	98.37	93.12	93.46	93.26	94.19
Eskdalemuir		97.36	95.31				96.34
Fort William		99.29	98.78				99.04
Glasgow Great Western Road		99.34					99.34
Glasgow High Street		98.20		98.00	98.00		98.07
Glasgow Kerbside		99.19					99.19
Glasgow Townhead		99.11	99.26	96.00	94.00		97.09
Grangemouth		93.62		90.05	92.27	95.64	92.89
Grangemouth Moray		94.18					94.18
Greenock A8 Roadside		99.61		98.68	98.69		98.99
Inverness		98.78		89.00	94.00		93.93
Lerwick			85.32				85.32
Peebles		87.49	94.42				90.95
Strathvaich			99.53				99.53
Number of Stations	**1**	**20**	**10**	**8**	**8**	**2**	**23**
Number of stations < 85 %	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Number of stations < 90%	**0**	**1**	**1**	**1**	**0**	**0**	**1**
Average	**90.18**	**97.29**	**96.86**	**94.54**	**94.99**	**94.45**	**96.37**

3.7 Data Capture - Wales

The data capture statistics for stations within Wales are given in Table 3.5

Table 3.5 Data Capture for Stations in Wales, January-December 2018

.

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Aston Hill		97.07	96.69				96.88
Cardiff Centre	99.22	71.08	99.14	88.58	88.11	70.96	86.18
Cardiff Newport Road		97.58		88.23			92.90
Chepstow A48		95.31		92.85	92.79		93.65
Cwmbran		99.33	99.38				99.36
Hafod-yr-ynys Roadside		98.47					98.47
Narberth		98.57	99.05	98.00	97.00	83.74	95.27
Newport		43.46		57.00	57.00		**52.49**
Port Talbot Margam (Partisol)				94.52			94.52
Port Talbot Margam	98.14	97.52	98.60	96.39	93.25	98.98	97.15
Swansea Roadside		98.72		96.30	92.07		95.70
Wrexham		88.55		91.00	85.00	0.00	**66.14**
Number of Stations	**2**	**11**	**5**	**9**	**7**	**4**	**12**
Number of stations < 85 %	**0**	**2**	**0**	**1**	**1**	**3**	**2**
Number of stations < 90%	**0**	**3**	**0**	**3**	**3**	**3**	**3**
Average	**98.68**	**89.61**	**98.57**	**89.21**	**86.46**	**63.42**	**89.06**

3.8 Data Capture - Northern Ireland and Mace Head

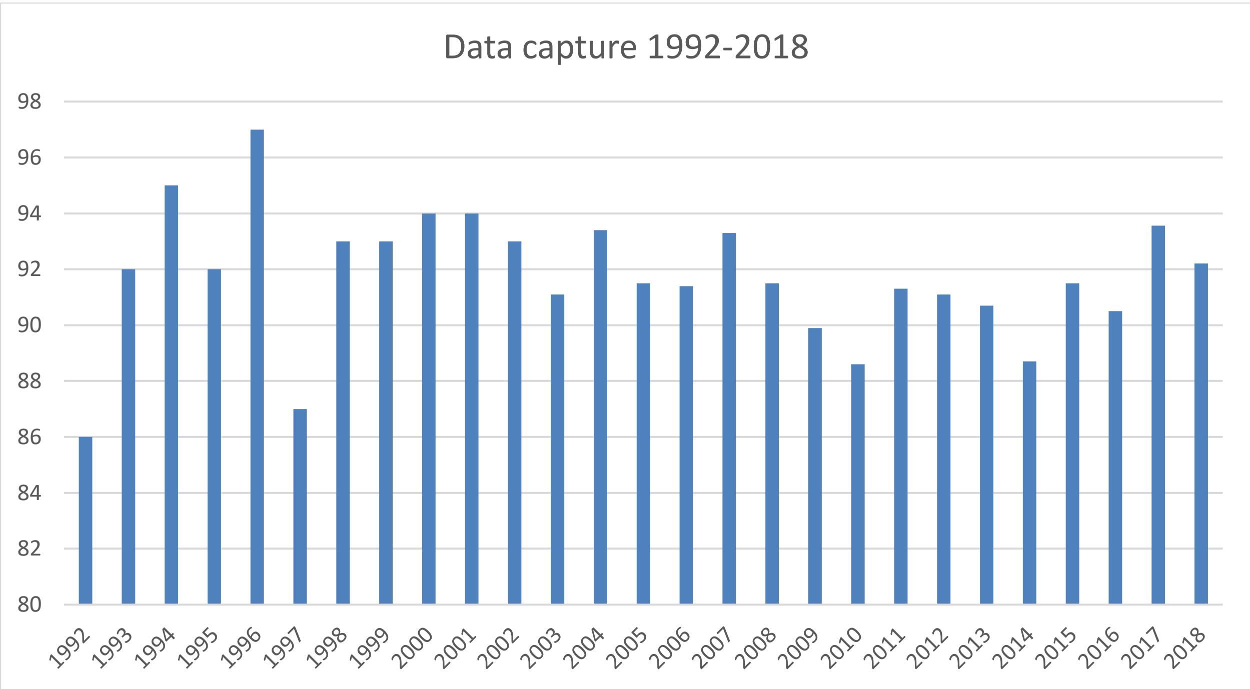
The data capture statistics for stations within Northern Ireland, plus Mace Head (Republic of Ireland), are given in Table 3.6.

Table 3.6 Data Capture for Stations in Northern Ireland, plus Mace Head, January-December 2018

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Mace Head			98.86				98.86
Armagh Roadside		93.94		95.25			94.59
Ballymena Antrim Road		95.97					95.97
Ballymena Ballykeel		97.65				72.45	85.05
Belfast Centre	96.68	94.82	99.11	84.92	94.38	96.97	94.48
Belfast Stockman's Lane		97.21		94.86			96.04
Derry Rosemount		98.38	97.08	95.37	95.54	96.75	96.62
Lough Navar			99.22	93.00	86.00		92.74
Number of Stations	**1**	**6**	**4**	**5**	**3**	**3**	**8**
Number of stations < 85 %	**0**	**0**	**0**	**1**	**0**	**1**	**0**
Number of stations < 90%	**0**	**0**	**0**	**1**	**1**	**1**	**1**
Average	**96.68**	**96.33**	**98.57**	**92.68**	**91.97**	**88.73**	**94.29**

3.9 Trends in Data Capture

The annual AURN data captures from 1992-2018 are shown in Figure 3.1.



The annual data capture has remained relatively constant over the last 20 or so years, despite a massive increase in the number of stations, analysers and measurements made in the network. New technologies have been incorporated over this time, which have provided challenges in data capture terms.

4 Summary and Conclusions

The number of AURN monitoring stations in operation during part or all of this period was 169. In addition, there were two co-located Partisol stations, at Port Talbot Margam (PM_{10}) and London Marylebone Road ($PM_{2.5}$ and PM_{10}) which are counted separately for data processing purposes.

Full audits of all analysers were carried out at six-monthly intervals in the winter (January-March) and summer (July-September). In addition, audits of ozone analysers were also carried out in spring (April) and autumn (October).

The mean data capture for ratified hourly average data was 92.49% (averaged over all pollutants O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$), for the 12-month reporting period January to December 2018. Mean data captures for individual pollutants were as follows: CO 96.90%, NO_2 94.22%, O_3 95.82%, SO_2 87.88%, PM_{10} 89.80%, and $PM_{2.5}$ 91.41%. Hence, the mean data captures for all pollutants met this target in calendar year 2018. There were 20 stations with data capture below 85%.

There were six analysers whose measured uncertainty at the summer and winter QA/QC audits was outside the requirement of the Air Quality Directive.

Appendices

Appendix 1: Glossary of Terms
Appendix 2: Uncertainty of Measurement
Appendix 3: List of Stations with Data Capture Below 85%

Appendix 1 – Glossary of terms

- Air Quality Directive

The European Union's Directive 2008/50/EC of 21st May 2008, on Ambient Air Quality and Cleaner Air for Europe, often referred to as 'the Air Quality Directive'.

- Air Quality Standards

Standards are the concentrations of pollutants in the atmosphere which can broadly be taken to indicate a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive sub-groups.

- Air Quality Strategy

The United Kingdom's own National Air Quality Strategy, containing policies for assessment and management of air quality in the UK. This was first published in 1997, as a requirement of The Environment Act 1995. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland describes the plans drawn up by the Government and the devolved administrations to improve and protect ambient air quality in the UK in the medium-term. The Strategy sets objectives for the main air pollutants to protect health. Performance against these objectives will be monitored where people are regularly present and might be exposed to air pollution.

- Air Quality Strategy Objective

The Air Quality Strategy sets objectives for the maximum concentrations of eight pollutants. These are at least as stringent as the limit values of the Air Quality Directive.

- Beta Attenuation Monitor (BAM)

A type of instrument used for monitoring concentrations of particulate matter. Particulate matter is deposited on a filter paper, and the attenuation of beta rays by the deposited matter is measured to determine the amount of material present.

- Carbon Monoxide (CO)

A colourless, odourless gas resulting from the incomplete combustion of hydrocarbon fuels. CO interferes with the blood's ability to carry oxygen to the body's tissues and results in adverse health effects.

- Equipment Support Unit (ESU)

Commercial organisation contracted by the EA or affiliated station owners to carry out specialist service and repair to the air quality monitoring equipment.

- FDMS

This stands for 'Filter Dynamic Measurement System' and refers to a type of instrument for monitoring concentrations of particulate matter. The FDMS is a modified form of TEOM. This technique uses a vibrating filter, the vibration frequency changing as mass builds up. This method can measure the concentration of volatile and non-volatile particles.

- Fidas™

A type of instrument which uses an optical technique for monitoring concentrations of particulate matter. This instrument can measure several size fractions simultaneously.

- ISO/IEC17025

General requirements for the competence of testing and calibration laboratories. This is the international reference for testing and calibration laboratories wanting to demonstrate their capacity to deliver reliable results. It enables laboratories to demonstrate that they operate competently and generate valid results, thereby promoting confidence in their work both nationally and around the world.

- LSO-Local Site Operator

A nominated individual or organisation who carry out regular instrument calibrations, filter changes and other routine station tasks.

- Oxides of Nitrogen (NOx)

Combustion processes emit a mixture of oxides of nitrogen, primarily nitric oxide (NO) and nitrogen dioxide (NO_2), collectively termed NOx. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. Nitrogen dioxide emissions can also be further oxidised in air to acid gases, which contribute to the production of acid rain.

- Ozone (O_3)

A pollutant gas which is not emitted directly from any source in significant quantities but is produced by reactions between other pollutants in the presence of sunlight. (This is what is known as a 'secondary pollutant'.) Ozone concentrations are greatest in the summer. O_3 can travel long distances and reach high concentrations far away from the original pollutant sources.

- Particulate Matter (PM)

Small airborne particles. PM may contain many different materials such as soot, wind-blown dust or secondary components, which are formed within the atmosphere as a result of chemical reactions. Some PM is natural and some is man-made.

- Partisol™

A particulate sampler which collects aerosol onto pre-weighed filters. The filter changes automatically at midnight, and thus gives daily average concentrations.

- PM_{10}

Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter, as defined in ISO 7708:1995, Clause 6. This size fraction is important in the context of human health, as these particles are small enough to be inhaled into the airways of the lung – described as the 'thoracic convention' in the above ISO standard. PM_{10} is often described as 'particles of less than 10 micrometres in diameter' though this is not strictly correct.

- $PM_{2.5}$

Particles which pass through a size-selective inlet with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter, as defined in ISO 7708:1995, Clause 7.1. This size fraction is important in the context of human health, as these particles are small enough to be inhaled very deep into the lung – described as the 'high risk respirable convention' in the above ISO standard. $PM_{2.5}$ is often described as 'particles of less than 2.5 micrometres in diameter' though this is not strictly correct.

- Sulphur dioxide (SO_2)

An acid gas formed when fuels containing sulphur impurities are burned.

Appendix 2 – Uncertainty of measurement

This table shows the actual uncertainty of measurement in % as determined by the QA/QC audits in winter and summer 2018.

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Aberdeen	11.2	11.3					11.1	11.2	8.7	8.8	16.4	16.5
Aberdeen Union Street Roadside							12.2	12.2				
Aberdeen Wellington Road							12.3	12.2				
Armagh Roadside							12.8	12.2	9.7	8.9		
Aston Hill	11.2	8.3					12.2	12.2				
Auchencorth Moss	11.2	11.2							10.1	9.4	16.8	17.2
Ballymena Antrim Road							13.4	12.9				
Ballymena Ballykeel						11.2	13.5	13.8				
Barnsley Gawber	8.3	8.3			11.7	12.9	9.8	11.8				
Barnstaple A39									8.7	9.3	16.9	16.4
Bath Roadside							12.3	12.2				
Belfast Centre	8.4	8.3	7.6	8.1	11.1	10.5	11.7	11.5	9.7		17	
Belfast Stockman's Lane							13.9	13.4	9.3	10.4		
Billingham							12.2	12.2				
Birkenhead Borough Road							12.3	12.2				
Birmingham Acocks Green	11.2	11.2					13	12.2			17.1	16.4
Birmingham A4540 Roadside	11.2	11.2					12.6	12.3	8.8	8.7	16.4	16.4

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Birmingham Tyburn												
Blackburn Accrington Road							11.9	11.7				
Blackpool Marton	8.3	8.3					10.1	9.8			16.6	16.6
Borehamwood Meadow Park							9.8	9.8				
Bournemouth	11.2	11.2					12.2	12.3			12.6	12.8
Bradford Mayo Avenue							11.1	12.9				
Brighton Preston Park	11.2	11.2					12.2	12.5			11	
Bristol St Paul's	11.2	11.2					12.4	12.2	8.7	8.7	16.8	16.4
Bristol Temple Way							12.2	12.8	10.1	9.4		
Burton-on-Trent Horninglow							12.2	13.5				
Bury Whitefield Roadside							12.3	12.2	8.7	9.7		
Bush Estate		11.2					12.2	12.3				
Cambridge Roadside							11.8	11.7				
Camden Kerbside							12.1	11.8	9.1	8.7	16.5	16.4
Cannock A5190 Roadside							12.3	12.2				
Canterbury	11.6	11.2					12.6	12.6				
Cardiff Centre	11.2	11.2			9.9	9.8	13.5	12.5	8.7	10	16.4	16.9
Cardiff Newport Road								12.3		9.3		
Carlisle Roadside							12.2	12	8.7	8.7	16.4	16.4
Charlton Mackrell	11	10.5					12.3	12.3				

Site	**O_3**		**CO**		**SO_2**		**NO_2**		**PM_{10}**		**$PM_{2.5}$**	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Chatham Centre Roadside							12.6	12.2		9.3		12.6
Chepstow A48							14.1	12.1	11.8	8.7	16.4	16.4
Chesterfield Loundsley Green							11.4	11.3	8.7	8.7	16.4	16.4
Chesterfield Roadside							12.2	11.7	10.1	16.7	16.7	16.5
Chilbolton	11.2	11.2			10.7	10	13.4	13.8	8.7	8.7	16.4	16.4
Christchurch Barrack Road							12.6	13.3			12.8	12.6
Coventry Allesley	8.3	8.3					9.8	10.1	9.6			16.4
Coventry Binley Road							12.2	12.4	8.7	8.7		
Cwmbran	8.3	8.3					13.1	13.1				
Derby St Alkmunds Way							12.2	12.2				
Derry Rosemount	11.2	11.2			11.3	12	13.8	**15.4**	8.7	9.2	16.4	16.4
Dewsbury Ashworth Grove							12.2	13.6				
Doncaster A630 Cleveland Street							12.3	12.3				
Dundee Mains Loan							9.8	9.8				
Dumbarton Roadside							11.1	11.3				
Dumfries							12.3	12.3				
Ealing Horn Lane									8.7	8.7		
Eastbourne							12.2	13.4			17	16.4
Edinburgh Nicolson Street							12.2	12.2				

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Edinburgh St Leonards	11.5	11.2	7.6	8.2	10.2	11.3	13.8	12.3	8.7	8.7	16.5	16.4
Eskdalemuir	11.2	11.9					12.4	12.2				
Exeter Roadside	7.2	7.3					13.2	13.2				
Fort William	11.2	11.3					12.2	12.2				
Glasgow Great Western Road							12.7	12.2				
Glasgow High Street							13.5	12.2	8.7	8.7	16.4	16.4
Glasgow Kerbside							10.9	9.8				
Glasgow Townhead	9	8.3					13.4	12.2	8.7	8.7	16.4	16.5
Glazebury	11.2	11.5					12.2	12.2				
Grangemouth					9.9	9.9	13.1	11.3	8.7	9.6	17.4	12.6
Grangemouth Moray					13.2	12.4	11.3	11.1				
Greenock A8 Roadside							9.8	9.8				
Hafod-yr-ynys Roadside							12.2	12.2				
Haringey Roadside							13	**15.2**				
Hartlepool St Abbs Walk							12.3	12.2				
High Muffles	11.2	11.2					13.3	12.2				
Honiton							12.2	12.2				
Horley							12.4	13.9				
Hull Freetown	8.3	8.3			10	10	9.8	9.8			16.5	16.8
Hull Holderness Road							12.3	12.4	9.3	9.4		
Immingham Woodlands Avenue							12.3	12.2				
Inverness							12.2	12.2	9.6		15.4	
Ladybower	11.2	11.2			10	10	12.2	12.4				

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Leamington Spa	10.5	10.4					11.1	14.2	8.7	10.2	**101.3**[$]	16.7
Leamington Spa Rugby Road							12.2	12.4	9.5	8.7	16.4	16.4
Leeds Centre	8.3	9.2	8.8	7.5	11.6	12.4	10.4	11	8.7	9.4	16.4	16.4
Leeds Headingley Kerbside							13.1	12.8	8.7	9.5	16.4	16.9
Leicester A594 Roadside							12.4	12.2	8.7	9.7		
Leicester University	8.3	8.3					9.8	9.8			16.8	16.4
Leominster	11.5	11.2					12.2	12.3				
Lerwick	11.2	11.2			10	10	12.2	14				
Lincoln Canwick Road							12.6	12.2				
Liverpool Speke	8.3	8.3			10	10	11.7	9.8	8.7		16.4	
London Bexley							12.2	12.2			16.6	16.4
London Bloomsbury	11.2	11.2			10	10	12.3	12.3	8.7	8.7	16.4	16.4
London Eltham	10.4	10.5					12.3	14.6			16.4	16.7
London Haringey Priory Park South	10.5	10.5					12.3	**17.4**				
London Hillingdon	8.3	8.3					12.2	9.9				
London Marylebone Road	11.2	11.2	7.5	7.9	11.4	10.7	12.4	12.3	9.2	8.7	16.4	19.6
London N. Kensington	11.2	11.2	7.5	7.8	10.1	10.9	12.9	13.9	8.7	8.7	16.4	9.3
London Teddington Bushy Park									8.9	8.7	16.5	16.5

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
London Westminster							11.3	11.6			11.3	12.6
Lough Navar	11.2	11.2							8.7			
Lullington Heath	11.2	11.2			10.8	10	12.2	12.4				
Luton A505 Roadside							12.2	12.5				
Mace Head	8.3	8.3										
Manchester Piccadilly	8.3	8.3			11.6	11.6	9.8	10.4		10.6	16.5	17.5
Manchester Sharston	11.2	11.2			10	10	12.2	12.2				
Market Harborough	8.3	8.3					10.4	11				
Middlesbroug h	11.2	11.2			10	11.8	12.2	12.2	8.7	8.7	17.1	16.4
Narberth	11.2	11.2			10	10	12.2	12.8	8.7	7.9		
Newcastle Centre	8.3	8.3					9.8	9.9	8.7	8.7	16.4	16.4
Newcastle Cradlewell Roadside							13	12.2	9.5	12.8		
Newport								12.3		8.5		
Northampton Spring Park	7.3	7.5					13.2	13.1		9.3	12.6	
Norwich Lakenfields	8.3	8.3					9.8	12.3	13.4	8.7	16.4	16.4
Nottingham Centre	8.3	8.3			10	10.2	9.8	9.8	9.1	8.9	16.4	16.4
Nottingham Western Boulevard							12.2	12.2	8.7			
Oldbury Birmingham Road							13.5	13				
Oxford Centre Roadside							11.7	13.3				
Oxford St Ebbes	10.7	10.4					12.1	12.5	9.1	9.4	16.4	16.4

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Peebles	11.2	11.2					13.6	**83.1** #				
Plymouth Tavistock Road							12.2	12.2				
Plymouth Centre	8.3	8.3					9.8	10.1	8.7	8.7	16.4	17.2
Port Talbot Margam	8.3	8.3	11.6	11.6	11.6	11.6	9.8	10.7	8.7	8.7	16.4	16.4
Portsmouth	8.3	8.3					13.2	13.1	10.6	8.7	16.4	17
Portsmouth Anglesea Road							12.2	12.2		9.3		
Preston	8.3	8.3					9.8	9.8			16.4	16.4
Reading London Road							11.3	11.7	9.9	9.3		
Reading New Town	8.3	8.3					9.8	10.5	8.7	8.7	16.4	16.4
Rochester Stoke	11.2	11.5			10	10	13.4	14.6	8.7		16.4	
Salford Eccles							13.2	11.1	8.7	8.7	16.4	16.5
Saltash Callington Road									9.8	10.8	16.4	16.4
Sandy Roadside							12.3	12.7	8.7	8.7	16.4	18.1
Scunthorpe Town					10	10	11.1	11.2	8.7	8.7		
Shaw Crompton Way							12.2	12.2	12.6	10.4		
Sheffield Barnsley Road							12.8	12.2			12.7	12.6
Sheffield Devonshire Green	8.3	8.3					9.8	9.8	8.7	8.7	16.4	16.8
Sheffield Tinsley							12.9	11.2				
Sibton	11.3	11.2										

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Southampton Centre	8.3	8.3			10	10	10.9	9.8	8.7	8.7	16.6	16.6
Southampton A33 Roadside							12.2	12.8	8.7	8.7		
Southend-on-Sea	8.3						9.8					
Southwark A2 Old Kent Road							12.3	12.7	8.7	8.7		
St Helens Linkway							12.2	12.2	8.7	8.8		
St Osyth	8.3	8.3					9.8	9.8				
Stanford-le-Hope Roadside							12.5	12.9	8.7	9.8	16.4	16.8
Stockton on Tees A1035 Roadside							12.2	12.2			16.9	16.4
Stockton-on-Tees Eaglescliffe							12.4	12.3	10	9.5	12.6	12.7
Stoke-on-Trent Centre	8.3	8.3					9.8	9.8		8.7	16.5	
Stoke on Trent A50 Roadside							12.2	12.2	8.8	8.7		
Storrington Roadside							9.8	9.8				
Strath Vaich	11.2	11.2										
Sunderland Silksworth	11.2	11.2					11.2	13.9			16.4	16.5
Sunderland Wessington Way							12.2	12.2				
Swansea Roadside							12.2	12.4	11.2	9.3	15.8	12.6
Swindon Walcot							12.2	12.2				
Telford Hollinswood							12.3	13.2				
Thurrock	11.3	11.2			10.3	10	12.5	12.3	8.7	8.7		

Site	O_3		CO		SO_2		NO_2		PM_{10}		$PM_{2.5}$	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Tower Hamlets Roadside							13.3	12.4				
Walsall Woodlands	11.2	11.2					13.7	12.2				
Warrington							12	11.4	8.7	9	16.4	17.9
Weybourne	8.3	8.3										
Wicken Fen	11.2	11.2			10.2	10	**15.5**	12.2				
Widnes Milton Road							12.2			19.5		
Wigan Centre	8.3	9.7					13.3	11.6			16.4	17.3
Wirral Tranmere	8.3	8.3					9.8	9.8			16.4	16.4
Worthing A27 Roadside								12.3		9.3	13.6	
Wrexham					9.8	9.8	12.2	12.3	22.5		11	
Yarner Wood	11.2	11.2					12.3	12.2				
York Bootham							12.3	11.2	8.7	9.8	16.4	16.5
York Fishergate							12.2	11.2	8.7	10.1	16.4	17
Total > 15 (gaseous) or > 25 (PM)	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**4**	**0**	**0**	**1**	**0**

$ The spurious high result for Leamington Spa $PM_{2.5}$ was due to a flow fault discovered at the audit. Some data around this period have been deleted.

The uncertainty for the Peebles NOx analyser at the summer 2018 was recorded during a period when there was an analyser fault. The data for this period have been deleted.

Appendix 3 – List of Stations with Data Capture below 85%

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Widnes Milton Road		17.23					17.23
Oldbury Birmingham Road		34.65					34.65
Dewsbury Ashworth Grove		41.64					41.64
Charlton Mackrell		99.41	0.00				49.70
Newport		43.46		57.00	57.00		52.49
Immingham Woodlands Avenue		65.80					65.80
Wrexham		88.55		91.00	85.00	0.00	66.14
Cannock A5190 Roadside		74.09					74.09
Sandy Roadside		98.30		63.69	62.20		74.73
Eastbourne		55.02			97.84		76.43
Barnstaple A39				62.34	90.92		76.63
Glazebury		78.12	79.01				78.56
Leamington Spa Rugby Road		98.77		64.22	74.21		79.07
Portsmouth		99.50	98.96	63.97	55.74		79.54
Bristol St Paul's		83.87	83.56	79.68	79.87		81.75
Southend-on-Sea		75.51	98.16		72.45		82.04
Southwark A2 Old Kent Road		85.29		80.61			82.95
Warrington		92.24		69.79	89.89		83.97
Birmingham Ladywood				69.85	99.40		84.62
Plymouth Tavistock Road		84.94					84.94

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