AURN Annual Technical Report 2019

Report for the Environment Agency
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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 2019. 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 175 at 173 separate locations. There are 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}). These are counted as separate stations for the purpose of this report.

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 93.75% (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 2019.

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 86.20%, NO_2 94.77%, O_3 94.32%, SO_2 84.51%, PM_{10} 93.55%, and $PM_{2.5}$ 92.97%. Hence, the mean data captures for all pollutants except SO_2 met this target in calendar year 2019. Average data capture for SO_2 was below the target of 85%: this was affected by problems with new analysers introduced to the network.

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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 the Air Quality Directive 2008/50/EC[1].. 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. In 2019, the Environmental Research Group (ERG) of King's College London (KCL) was Management Unit for the AURN monitoring stations that are also part of the London Air Quality Network (LAQN). (The ERG has since become part of Imperial College London). 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 BOC during 2019 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) but affiliated to the AURN; and 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 173 monitoring stations in the AURN operated during part or all of the year 2019. 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 3. Hence, in these tables the total number of stations appears as 175.

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

This report includes information on performance of the AURN site at London Harlington although 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 forerunners 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 2019, 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 2019

Table 1-1 shows the changes to the AURN, i.e. monitoring stations started up or closed down, during 2019:

Table 1-1 AURN Stations that Started Up or Closed Down During 2019

Station	Start date	Close date	Pollutants measured
London Honor Oak Park	1st January 2019	-	PM_{10}, $PM_{2.5}$
Market Harborough	-	27th March 2019	NO_2, O_3
West Bromwich Kenrick Park	10th April 2019	-	NO_2
Bath Roadside	-	11th June 2019	NO_2
Crewe Coppenhall	15th Oct 2019	-	NO_2
Bath A4 Roadside	24th Oct 2019	-	NO_2

1.6 Changes to Instrumentation

A programme of upgrade and renewal of particulate analysers was started in 2018 and continued through 2019. The FDMS instruments, which used to be widely used in the AURN for monitoring PM, were approaching the end of their useful lives, and nearing the point at which they would no longer be supported by the manufacturer. The ongoing upgrade 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, where applicable. 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 2019 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-all NOx- were outside the maximum uncertainties during 2019:

- Winter:
  - Haringey Roadside,
  - Leominster,
  - Oxford St Ebbes.

- Summer:
  - Horley,
  - Narberth,
  - Newport,
  - Oxford St Ebbes,
  - Worthing A27 Roadside.

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

Ricardo have undertaken an investigation to quantify the impact on performance of PM analysers in use in the Automatic Urban and Rural Monitoring Network (AURN), following a series of undocumented design changes on a critical consumable component.

These changes to the replaceable measurement filter on Tapered Element Oscillating Microbalance (TEOM) Filter Dynamics Measurement System (FDMS) analysers, caused a significant increase in the number of poor performance tests identified during routine quality control audits undertaken by Ricardo. The worsening of performance was first observed in January 2017. It is not possible to determine which sites used these filters, nor over which time periods.

Lengthy investigations and testing by Ricardo identified clear differences in manufacturing of the filters, which were seen to have a direct effect on performance. However, the manufacturer, despite clear evidence to the contrary, continues to claim that the manufacturing process has not changed at all. Eventually, following exhaustive discussions and provision of evidence, the manufacturer issued updated acceptance criteria for performing tests using these filters, relaxing the pass criteria for the test from ±2.5% to ±4.0%

The scaling of FDMS measurement data remains unaffected, but this relaxing of pass criteria will lead to an increase in the measurement uncertainty of the FDMS analysers. The data quality objectives are still fulfilled for an analyser measuring PM_{10} and $PM_{2.5}$. Following consultation and the agreement of Defra and the Environment Agency, the updated uncertainty will be applied to all FDMS analyser data reported from January 2019 onwards.

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 2019 is given in Table 3.1. Ratified hourly average (daily average for Partisols) data capture for the network averaged 93.55% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the 12-month reporting period January-December 2019. 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 except SO_2 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 2019 is given in Table 3.1.Note that where an instrument starts or stops measuring during the year, the quoted data capture is that for the part of the year in which the instrument was operating: for example, an instrument commissioned on 30th June which then operated for the rest of the year without interruption would have a data capture of 100% for the year.

Table 3.1 Summary of Data Capture for the AURN, January-December 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Number of Stations	7	158	76	89	82	27	175
Number of stations < 85 %	4	13	8	9	7	11	16
Number of stations < 90%	4	22	12	14	14	14	30
Average	**86.20**	**94.77**	**94.32**	**93.55**	**92.97**	**84.51**	**93.75**

3.3 Generic Data Issues

The following generic data quality issues have been identified in 2019:

- 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 since 2017. This matter has been taken up with the UK distributer and the manufacturer in the US. Whilst not having any effect on the accuracy of the data, this does result in an increase in the measurement uncertainty for FDMS data in 2019. Unfortunately, it is not possible to identify which analysers are affected; however, the data still meet the data quality objective of ±25%.

- 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 2019, impacting upon data capture. The Environment Agency has purchased replacement SO_2 analysers which were being installed as of mid-2019. However, technical problems with these new instruments resulted in a significant loss at many stations.

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 Greater London) are given in Table 3.2.

Table 3.2 Data Capture for Stations in England excluding Greater London, January-December 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Barnsley Gawber		86.23	99.22			86.51	90.65
Barnstaple A39				95.39	95.33		95.36
Bath A4 Roadside		98.85					98.85
Bath Roadside		97.87					97.87
Billingham		99.73					99.73
Birkenhead Borough Road		99.73					99.73
Birmingham A4540 Roadside		86.63	96.38	99.20	99.20		95.35
Birmingham Acocks Green		99.04	97.90	99.38	97.20		98.38
Birmingham Ladywood			84.02	92.49	92.76		89.76
Blackburn Accrington Road		91.84					91.84
Blackpool Marton		92.77	95.45	99.86	85.39		93.37
Borehamwood Meadow Park		96.62					96.62
Bournemouth		99.30	99.43		96.28		98.34
Bradford Mayo Avenue		95.95					95.95
Brighton Preston Park		96.64	99.04		97.30		97.66
Bristol St Paul's		85.17	90.38	85.58	85.70		86.71
Bristol Temple Way		99.61		93.79			96.70
Burton-on-Trent Horninglow		98.39					98.39
Bury Whitefield Roadside		96.31		96.23			96.27
Cambridge Roadside		86.89					86.89
Cannock A5190 Roadside		99.13					99.13
Canterbury		99.00	99.30				99.15
Carlisle Roadside		96.35		94.76	94.10		95.07
Charlton Mackrell		98.12	37.41				67.76
Chatham Roadside		98.88		96.87	90.01		95.25
Chesterfield Loundsley Green		94.27		96.84	88.14		93.08
Chesterfield Roadside		98.56		94.20	98.28		97.01
Chilbolton Observatory		87.49	96.91	99.67	99.67	96.39	96.03
Christchurch Barrack Road		97.87			94.52		96.19
Coventry Allesley		99.39	98.81	99.37	94.20		97.94
Coventry Binley Road		99.49		97.77			98.63
Crewe Coppenhall		96.69					96.69

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Derby St Alkmund's Way		97.88					97.88
Dewsbury Ashworth Grove		18.74					18.74
Doncaster A630 Cleveland Street		97.97					97.97
Eastbourne				99.04	99.04		99.04
Exeter Roadside		91.10	98.66				94.88
Glazebury		96.94	95.90				96.42
Hartlepool St Abbs Walk		99.20					99.20
High Muffles		99.09	98.28				98.68
Honiton		99.53					99.53
Horley		98.98					98.98
Hull Freetown				99.58	99.58		99.58
Hull Freetown		98.82	99.21	99.58	95.24	95.02	97.58
Hull Holderness Road		99.52		94.21			96.87
Immingham Woodlands Avenue		95.27					95.27
Ladybower		93.72	95.96			58.37	82.68
Leamington Spa		96.40	86.93	97.00	97.12		94.36
Leamington Spa Rugby Road		96.78		94.25	92.23		94.42
Leeds Centre	99.17	99.01	98.56	89.37	94.74	98.52	96.56
Leeds Headingley Kerbside		98.92		95.38	92.47		95.59
Leicester A594 Roadside		98.39		97.92			98.16
Leicester University		99.08	99.17		96.53		98.26
Leominster		98.89	99.02				98.96
Lincoln Canwick Road		99.55					99.55
Liverpool Speke		98.78	98.76	93.94	95.38	87.35	94.84
Lullington Heath		97.55	98.11			81.05	92.23
Luton A505 Roadside		97.11					97.11
Manchester Piccadilly		98.85	98.76		92.15	89.49	94.81
Manchester Sharston		99.06	99.11				99.09
Market Harborough		98.54	98.54				98.54
Middlesbrough		98.49	98.58	97.16	95.95	93.95	96.83
Newcastle Centre		98.17	98.28	95.37	94.01		96.46
Newcastle Cradlewell Roadside		96.23		77.34			86.79
Northampton Spring Park		74.68	99.59		97.92		90.73
Norwich Lakenfields		99.29	99.39	90.02	97.19		96.47
Nottingham Centre		98.31	98.65	96.95	97.18	77.40	93.70
Nottingham Western Boulevard		99.53		97.77			98.65
Oldbury Birmingham Road		85.76					85.76

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Oxford Centre Roadside		97.18					97.18
Oxford St Ebbes		97.45		97.48	95.71		96.88
Plymouth Centre		99.05	98.50	96.39	94.76		97.18
Plymouth Tavistock Road		82.79					82.79
Portsmouth		99.61	96.63	95.23	92.56		96.01
Portsmouth Anglesea Road		99.27		95.23			97.25
Preston		98.96	99.20	99.87	97.33		98.84
Reading London Road		95.98		92.74			94.36
Reading New Town		57.96	62.04	52.79	38.08		52.72
Rochester Stoke		94.65	98.87	99.58	99.58	94.61	97.46
Salford Eccles		97.15		99.93	99.93		99.00
Saltash Callington Road				94.99	96.32		95.66
Sandy Roadside		97.15		90.86	87.87		91.96
Scunthorpe Town		97.49		90.09		97.63	95.07
Shaw Crompton Way		94.14					94.14
Sheffield Barnsley Road		81.76			92.12		86.94
Sheffield Devonshire Green		80.11	81.06	97.26	97.32		88.94
Sheffield Tinsley		95.80					95.80
Sibton			99.66				99.66
Southampton A33		96.74		90.08			93.41
Southampton Centre		99.08	98.74	97.01	97.17	98.61	98.12
Southend-on-Sea		98.97	99.26	99.29	97.72		98.81
St Helens Linkway		83.85		79.25			81.55
St Osyth		97.04	99.27				98.16
Stanford-le-Hope Roadside		98.92		95.79	90.88		95.19
Stockton-on-Tees A1305 Roadside		98.18			94.99		96.59
Stockton-on-Tees Eaglescliffe		99.04		95.19	94.12		96.12
Stoke-on-Trent A50 Roadside		99.29		95.57			97.43
Stoke-on-Trent Centre		98.53	98.65	98.92	97.47		98.39
Storrington Roadside		96.50					96.50
Sunderland Silksworth		97.76	97.34	99.83	85.11		95.01
Sunderland Wessington Way		88.64					88.64
Swindon Walcot		99.19					99.19
Telford Hollinswood		98.82					98.82
Thurrock		98.82	42.77	97.50		96.68	83.94
Walsall Woodlands		99.33	97.32				98.32
Warrington		87.66		94.06	68.37		83.36

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
West Bromwich Kenrick Park		99.18					99.18
Weybourne			94.95				94.95
Wicken Fen		94.13	96.59			75.92	88.88
Widnes Milton Road		82.92					82.92
Wigan Centre		96.91	99.44	99.85	96.07		98.07
Wirral Tranmere		99.17	99.30	99.85	96.77		98.77
Worthing A27 Roadside		96.99			97.42		97.20
Yarner Wood		98.38	95.67				97.03
York Bootham		98.81		94.75	94.95		96.17
York Fishergate		98.14		96.26	67.80		87.40
Number of Stations	**1**	**110**	**50**	**59**	**54**	**16**	**116**
Number of stations < 85 %	**0**	**9**	**5**	**3**	**3**	**5**	**9**
Number of stations < 90%	**0**	**17**	**6**	**5**	**8**	**8**	**19**
Average	**99.17**	**94.13**	**94.18**	**94.78**	**92.87**	**82.97**	**94.00**

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 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Camden Kerbside		98.92		96.14	97.53		97.53
Ealing Horn Lane				81.72			81.72
Haringey Roadside		94.74					94.74
London Bexley		99.19			82.03		90.61
London Bloomsbury		97.72	97.59	91.63	97.69	78.86	92.70
London Eltham		97.45	99.65		97.21		98.11
London Haringey Priory Park South		99.13	94.63				96.88
London Harlington		99.02	97.72	97.15	97.15		97.76
London Hillingdon		91.10	99.27				95.18
London Honor Oak Park				99.94	99.94		99.94
London Marylebone Road	96.74	94.59	97.88	96.42	90.73	98.28	95.77
London Marylebone Road Partisol				78.08	95.34		86.71
London N. Kensington	84.50	99.00	95.97	99.97	99.58	93.29	95.38
London Teddington Bushy Park					93.17		93.17
London Westminster		77.08			91.70		84.39
Southwark A2 Old Kent Road		97.93		90.10			94.02
Tower Hamlets Roadside		99.52					99.52
Number of Stations	**2**	**13**	**7**	**9**	**11**	**3**	**17**
Number of stations < 85 %	**1**	**1**	**0**	**2**	**1**	**1**	**2**
Number of stations < 90%	**1**	**1**	**0**	**2**	**1**	**1**	**3**
Average	**90.62**	**95.80**	**97.53**	**92.35**	**94.74**	**90.14**	**93.77**

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 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Aberdeen		96.78	88.42	92.93	93.50		92.91
Aberdeen Union Street Roadside		99.21					99.21
Aberdeen Wellington Road		99.16					99.16
Auchencorth Moss			99.68	99.91	99.91		99.83
Bush Estate		94.52	79.10				86.81
Dumbarton Roadside		97.28					97.28
Dumfries		99.26					99.26
Dundee Mains Loan		95.90					95.90
Edinburgh Nicolson Street		99.42					99.42
Edinburgh St Leonards	69.70	95.14	97.90	90.88	93.41	80.35	87.90
Eskdalemuir		96.53	85.18				90.86
Fort William		99.06	99.30				99.18
Glasgow Great Western Road		91.40					91.40
Glasgow High Street		97.44		99.89	99.89		99.07
Glasgow Kerbside		98.39					98.39
Glasgow Townhead		99.09	99.01	99.25	99.25		99.15
Grangemouth		88.48		93.95	97.16	91.82	92.85
Grangemouth Moray		91.35					91.35
Greenock A8 Roadside		99.46		99.75	99.75		99.65
Inverness		99.08		88.52	88.46		92.02
Lerwick			99.16				99.16
Peebles		99.02	99.18				99.10
Strathvaich			95.63				95.63
Number of Stations	**1**	**20**	**10**	**8**	**8**	**2**	**23**
Number of stations < 85 %	**1**	**0**	**1**	**0**	**0**	**1**	**0**
Number of stations < 90%	**1**	**1**	**3**	**1**	**1**	**1**	**2**
Average	**69.70**	**96.80**	**94.26**	**95.63**	**96.41**	**86.08**	**95.89**

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 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Aston Hill		78.82	87.47				83.14
Cardiff Centre	71.91	62.53	71.89	67.68	64.00	65.47	67.25
Cardiff Newport Road		98.79		95.83			97.31
Chepstow A48		95.06		94.84	96.87		95.59
Cwmbran		99.43	99.77				99.60
Hafod-yr-Ynys Roadside		98.80					98.80
Narberth		96.79	98.88	75.47	97.35	79.86	89.67
Port Talbot Margam				90.41			90.41
Port Talbot Margam	98.56	94.82	99.30	95.01	92.32	99.12	96.52
Swansea Roadside		98.72		93.92	94.47		95.70
Wrexham		80.21		80.35	80.35	59.32	75.06
Number of Stations	**2**	**10**	**5**	**8**	**6**	**4**	**11**
Number of stations < 85 %	**1**	**3**	**1**	**3**	**2**	**3**	**3**
Number of stations < 90%	**1**	**3**	**2**	**3**	**2**	**3**	**4**
Average	**85.23**	**90.40**	**91.46**	**86.69**	**87.56**	**75.94**	**89.91**

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.

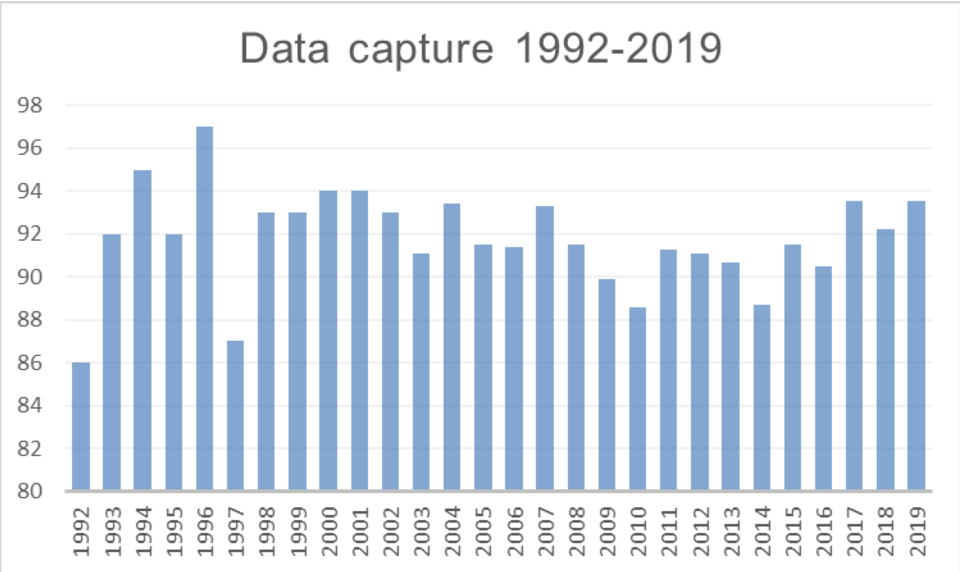
Table 3.6 Data Capture for Stations in Northern Ireland, plus Mace Head, January-December 2019

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Mace Head			99.22				99.22
Armagh Roadside		95.72		87.29			91.51
Ballymena Antrim Road		94.27					94.27
Ballymena Ballykeel		95.96				38.66	67.31
Belfast Centre	82.83	51.39	82.58	88.34	88.16	73.29	77.77
Belfast Stockman's Lane		98.65		93.96			96.31
Derry Rosemount		98.24	97.48	77.33	83.49	95.91	90.49
Lough Navar			97.84	97.61	97.60		97.69
Number of Stations	**1**	**6**	**4**	**5**	**3**	**3**	**8**
Number of stations < 85 %	**1**	**1**	**1**	**1**	**1**	**2**	**2**
Number of stations < 90%	**1**	**1**	**1**	**3**	**2**	**2**	**2**
Average	**82.83**	**89.04**	**94.28**	**88.91**	**89.75**	**69.29**	**89.32**

3.9 Trends in Data Capture

The overall annual AURN data captures from 1992-2019 are shown in Figure 3.1.

Figure 3-1 AURN Overall Annual Data Captures



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 Data Reporting

The ratified dataset has been uploaded to the Data Dissemination Unit on a quarterly basis during the year. These may be viewed on UK-AIR https://uk-air.defra.gov.uk/

The dataset was used in the 2019 compliance reporting which was submitted by the due date of 30 Sep 2020.

5 Summary and Conclusions

The number of AURN monitoring stations in operation during part or all of this period was 173. 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}).

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 were also carried out in spring (April) and autumn (October).

The mean data capture for ratified hourly average data was 93.75% (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 2019. Mean data captures for individual pollutants were as follows: CO 86.20%, NO_2 94.77%, O_3 94.32%, SO_2 84.51%, PM_{10} 93.55%, and $PM_{2.5}$ 92.97%. Hence, the mean data captures for all pollutants met this target in calendar year 2019. There were 16 stations out of 175 with mean data capture below 85%. There were only eight analysers out of 614 in the network, whose measured uncertainty at the summer or winter QA/QC audits was outside the requirement of the Air Quality Directive.

The data were reported to UK-AIR on a quarterly basis, and supplied for compliance reporting by 30^{th} September 2020.

Appendices

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 is 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 achieve 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.

- ESU-Equipment Support Unit

Commercial organisations 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 can measure several size fractions simultaneously.

- ISO/IEC17025

General requirements for the competence of testing and calibration laboratories, 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^{TM}

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 2019.

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	11.5	11.2					11.2	11.3	8.7	9.5	16.4	16.4
Aberdeen Union Street Roadside							12.2	12.2				
Aberdeen Wellington Road							12.3	12.2				
Armagh Roadside							11.1	11.2	8.7	9.6		
Aston Hill	8.3	8.3					13.9	12.2				
Auchencorth Moss	11.2	11.2										
Ballymena Antrim Road							13.1	12.3				
Ballymena Ballykeel					10.2	10.4	12.2	12.3				
Barnsley Gawber	10.6	8.4			11.6	12.6	10.2	9.8				
Barnstaple A39									10.1	9.6	12.6	12.6
Bath Roadside							12.2					
Belfast Centre	8.3	8.3	8.6	10.0	10.1	11.4	10.2	9.8	9.0	8.7	16.7	16.4
Belfast Stockman's Lane							12.2	12.2	10.1	9.3		
Billingham							12.2	12.2				
Birkenhead Borough Road							12.2	12.2				
Birmingham Acocks Green	11.2	11.2					12.2	12.2			16.7	
Birmingham A4540 Roadside	11.3	11.2					12.2	12.3	8.7		16.6	

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 Ladywood		7.3				12.5	13.1	13.0	10.0			
Blackburn Accrington Road							12.0	11.8				
Blackpool Marton		8.3						10.0				16.7
Borehamwood Meadow Park							9.8	9.8				
Bournemouth	11.2	11.2					12.2	12.4			12.6	12.6
Bradford Mayo Avenue							12.5	11.7				
Brighton Preston Park	11.2	11.2					12.2	12.2			11.0	
Bristol St Paul's	11.2	11.2					12.2	12.2	8.7	9.3	16.4	12.6
Bristol Temple Way							12.3	12.3	9.3	9.3		
Burton-on-Trent Horninglow							12.2	12.2				
Bury Whitefield Roadside							12.2	12.2	9.3	10.2		
Bush Estate	11.2	11.2					12.3	12.2				
Cambridge Roadside							12.4	12.7				
Camden Kerbside							12.1	13.8	8.7	9.3	17.1	16.4
Cannock A5190 Roadside							12.2	12.5				
Canterbury	11.2	11.2					12.2	12.2				
Cardiff Centre	11.2	11.2			10.1	10.1	12.2	12.4		8.7		16.4
Cardiff Newport Road							12.2	12.2	9.3	9.3		
Carlisle Roadside							11.4	12.5	9.3	9.3	12.6	12.6
Charlton Mackrell	10.4	12.1					12.4	14.7				

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
Chatham Centre Roadside							12.5	13.2	9.3	9.3	12.6	12.6
Chepstow A48							14.2	11.7	9.3	9.3	12.6	12.6
Chesterfield Loundsley Green							12.6	11.2	8.9		16.6	
Chesterfield Roadside							12.6	12.8	9.1		16.4	
Chilbolton	11.2	11.2			10.0	10.0	12.3	12.2				
Christchurch Barrack Road							12.2	12.4			12.6	12.6
Coventry Allesley	8.4	8.3					9.8	9.8	8.7		16.9	
Coventry Binley Road							12.2	12.2	9.3	9.3		
Crewe												
Cwmbran	8.3	8.3					13.1	13.2				
Derby St Alkmunds Way							12.2	12.5				
Derry Rosemount	11.2	11.6			10.7	11.4	12.2	14.3	9.0	8.7	16.4	16.4
Dewsbury Ashworth Grove							12.2	12.2				
Doncaster A630 Cleveland Street							12.2	12.2				
Dundee Mains Loan							9.8	9.8				
Dumbarton Roadside							11.1	11.6				
Dumfries							12.6	12.4				
Ealing Horn Lane									9.3	9.3		
Eastbourne							12.3	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 Nicolson Street							13.4					
Edinburgh St Leonards	11.2	11.2	7.9	7.5	11.5	10.0	12.5	12.7	8.7	8.7	16.4	16.4
Eskdalemuir	11.2	11.2					12.5	12.4				
Exeter Roadside	8.3	7.2					13.2	13.9				
Fort William	11.2	12.0					12.8	12.4				
Glasgow Great Western Road							12.4	12.2				
Glasgow High Street							12.2	12.3				
Glasgow Kerbside							9.8	9.8				
Glasgow Townhead	8.3	8.5					12.2	12.2				
Glazebury	14.0	11.2					12.7	12.2				
Grangemouth						12.4	11.8	12.8	15.6	9.3	18.7	12.7
Grangemouth Moray					13.1	13.2	11.3	11.2				
Greenock A8 Roadside							10.4	12.5				
Hafod-yr-Ynys Roadside							12.2	12.2				
Haringey Roadside							20.7	14.1				
Hartlepool St Abbs Walk							12.2	12.3				
High Muffles	11.5	11.2					12.2	12.2				
Honiton							12.4	12.3				
Horley							12.1	16.3				
Hull Freetown	8.3	8.3			10.0	10.0	9.8	9.8			16.4	17.7
Hull Holderness Road							12.2	12.2	10.4	9.6		
Immingham Woodlands Avenue							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
Inverness							12.2	12.5				
Ladybower	11.3	11.2			11.9	10.0	14.0	12.2				
Leamington Spa	11.7	10.4					11.7	11.7	8.7		16.6	
Leamington Spa Rugby Road							12.5	12.8			16.6	
Leeds Centre	8.3	8.6	7.5	8.0	11.6	11.7	9.8	9.8	8.7	8.7	16.4	16.8
Leeds Headingley Kerbside							12.2	12.3	8.7	8.8	16.4	16.6
Leicester A594 Roadside							14.1	12.2	9.3	9.3		
Leicester University	8.3	8.3					9.8	10.0			16.4	16.4
Leominster	11.2	11.2					**23.2**	12.5				
Lerwick	11.2	11.2			10.0	10.0	12.6	12.2				
Lincoln Canwick Road							13.4	12.3				
Liverpool Speke	8.3	8.5			10.0	10.1	9.8	9.8		9.3	12.6	12.6
London Bexley							12.3	12.2			16.4	16.6
London Bloomsbury	11.2	11.2			10.9	10.0	12.2	12.2	8.7	15.8	16.5	16.4
London Eltham	10.5	10.4					11.1	13.2			16.4	16.7
London Haringey Priory Park South	10.4	10.4					13.6	12.3				
London Honor Oak Park												
London Hillingdon	8.3	8.3					9.8	9.8				
London Marylebone Road	11.2	11.2	7.6	7.5	10.5	10.7	12.2	12.2	8.8	8.7	16.4	16.4
London N. Kensington	11.2	11.2	7.5	7.7	10.0	10.0	13.4	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
London Teddington Bushy Park									8.7	8.7	16.6	16.4
London Westminster							11.8	11.2			13.0	12.6
Lough Navar	11.2	11.4										
Lullington Heath	11.2	11.2			10.0	10.0	12.2	13.4				
Luton A505 Roadside							12.4	12.3				
Mace Head	8.3	8.3										
Manchester Piccadilly	8.3	8.3			11.6	11.6	9.8	11.3	8.9	8.7	16.4	16.4
Manchester Sharston	11.2	11.2			10.0	10.0	12.2	12.2				
Market Harborough	8.3						9.8					
Middles-brough	11.2	11.2			10.5	10.5	12.2	12.2	8.7	9.5	16.4	16.5
Narberth	11.2	11.2			10.6	10.1	12.2	**162.6**	7.5			
Newcastle Centre	8.3	8.3					9.8	9.8	8.9	8.7	16.6	16.4
Newcastle Cradlewell Roadside							12.2	12.2	9.5	9.4		
Newport							11.7	**17.4**				
Northampton Spring Park	7.2	7.2					13.2	13.1			12.6	13.1
Norwich Lakenfields	8.3	8.3					9.8	9.9	13.0	7.5	16.4	
Nottingham Centre	8.3	8.3			10.1	10.4	9.8	9.8	9.9		16.4	
Nottingham Western Boulevard							12.4	12.5	9.4	9.3		
Oldbury Birmingham Road							13.2	13.0				

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
Oxford Centre Roadside							12.6	11.9				
Oxford St Ebbes	11.0	10.4					**19.1**	**15.4**	8.7		16.8	
Peebles	11.2	11.2					12.8	12.2				
Plymouth Tavistock Road							12.3	12.3				
Plymouth Centre	8.3	8.3					10.2	12.0	8.7	8.7	16.4	16.4
Port Talbot Margam	8.3	8.3	11.6	11.5	11.6	11.6	11.6	11.6	8.7	8.7	16.4	16.4
Portsmouth	8.5	8.3					13.2	13.2	9.1		16.4	
Portsmouth Anglesea Road							12.3	12.3	9.3	9.3		
Preston	8.3	8.4					10.8	9.8			16.4	
Reading London Road							13.5	12.5	11.6	9.3		
Reading New Town	8.3	8.3					9.8	9.8	8.7	9.3	16.8	12.6
Rochester Stoke	11.2	11.2			10.1	10.0	12.2	13.9	7.6			
Salford Eccles							11.8	11.3				
Saltash Callington Road									9.3	9.3	12.6	12.6
Sandy Roadside							12.2	12.2	8.7	9.3	16.4	12.6
Scunthorpe Town					10.0	10.0	11.1	11.8	9.3	9.4		
Shaw Crompton Way							12.4	12.2	9.7	9.3		
Sheffield Barnsley Road							12.2	12.2			13.0	12.6

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
Sheffield Devonshire Green	9.1	8.4					11.2	9.8	8.8		16.4	
Sheffield Tinsley							11.1	11.6				
Sibton	11.2	11.2										
Southampton Centre	8.3	8.3			11.7	10.0	9.9	12.2	8.7	8.7	16.4	16.4
Southampton A33 Roadside							12.3	12.9	8.7	8.7		
Southend-on-Sea	8.4	8.3					9.8	9.8			16.5	18.1
Southwark A2 Old Kent Road							12.2	12.2	9.5	9.3		
St Helens Linkway							12.3	12.2	9.3	21.3		
St Osyth	8.3	8.3					9.9	9.8				
Stanford-le-Hope Roadside							12.2	12.2	9.5	9.3	12.6	12.6
Stockton on Tees A1035 Roadside							12.2	12.2			12.6	12.8
Stockton-on-Tees Eaglescliffe							12.4	12.2	13.8	9.9	12.8	12.8
Stoke-on-Trent Centre	8.3	8.3					9.8	9.8			16.4	
Stoke on Trent A50 Roadside							12.2	12.2	9.3	9.3		
Storrington Roadside							10.2	9.8				
Strath Vaich	11.9	11.2										
Sunderland Silksworth	11.2	11.2					11.6	11.2			17.0	16.9
Sunderland Wessington Way							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
Swansea Roadside							12.2	12.3	9.9	9.4	12.6	12.8
Swindon Walcot							12.2	12.2				
Telford Hollinswood							12.2	12.2				
Thurrock	11.2	11.2			10.0	10.0	12.2	12.2	9.3	9.3		
Tower Hamlets Roadside							12.2	12.2				12.6
Walsall Woodlands	11.2	11.2					12.5	12.5				
Warrington							12.5	11.9	9.3	9.3	12.6	12.6
Weybourne		8.4										
Wicken Fen	11.2	11.2			10.4	10.0	12.5	12.2				
Widnes Milton Road							12.2	12.2	9.3	9.3		
Wigan Centre	8.3	8.3					11.5	12.2			16.4	
Wirral Tranmere	8.3	8.6					9.8	9.8			16.4	16.4
Worthing A27 Roadside							12.3	**17.5**			13.0	12.6
Wrexham						9.8		12.2				
Yarner Wood	11.6	11.2					12.2	12.3				
York Bootham							11.2	11.1	8.7	8.7	16.7	16.4
York Fishergate							11.5	11.1	9.3	9.3	12.6	12.6
Total > 15% (gaseous) or > 25% (PM)	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**5**	**0**	**0**	**0**	**0**

Two stations (Crewe Coppenhall and Bath A4 Roadside) commenced operation after the summer 2019 intercalibration exercise and therefore do not appear in the above statistics.

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

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
London Westminster		77.08			91.70		84.39
Thurrock		98.82	42.77	97.50		96.68	83.94
Warrington		87.66		94.06	68.37		83.36
Aston Hill		78.82	87.47				83.14
Widnes Milton Road		82.92					82.92
Plymouth Tavistock Road		82.79					82.79
Ladybower		93.72	95.96			58.37	82.68
Ealing Horn Lane				81.72			81.72
St Helens Linkway		83.85		79.25			81.55
Belfast Centre	82.83	51.39	82.58	88.34	88.16	73.29	77.77
Wrexham		80.21		80.35	80.35	59.32	75.06
Charlton Mackrell		98.12	37.41				67.76
Ballymena Ballykeel		95.96				38.66	67.31
Cardiff Centre	71.91	62.53	71.89	67.68	64.00	65.47	67.25
Birmingham Ladywood		0.00	84.02	92.49	92.76	0.00	53.85
Reading New Town		57.96	62.04	52.79	38.08		52.72

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