QAQC Report for the Automatic Urban and Rural Network, July-September 2018

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 quarterly report summarises the QAQC activities carried out over the period 1st July 2018 to 30th September 2018. It presents the key data capture and data quality statistics and highlights any issues that have been identified relating to the monitoring stations and their apparatus. The number of AURN monitoring stations in operation during part or all of this period was 171 at 169 separate locations.

During this quarter, the summer 2018 intercalibration exercise was carried out, involving comprehensive performance tests on every analyser in the network. 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 data from each analyser in the network have been ratified by the QA/QC Unit using documented and validated methods. This process takes into account input from Local Site Operator (LSO) calibrations, the QA/QC audits and records from Equipment Support Unit (ESU) activity.

The routine QA/QC procedures have included checking of particulate analyser baselines for some time now. 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. Up to the 2015 dataset 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}. Accordingly, baseline correction – where it is deemed appropriate – has now been incorporated into the data ratification protocols.

Data ratification for the quarter was completed by the deadline of 30th June 2018. The mean data capture for ratified hourly average data was 89.78% (averaged over all pollutants O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$), for the three-month reporting period July to September 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 94.49%, NO_2 92.17%, O_3 94.32%, SO_2 85.91%, PM_{10} 82.18%, and $PM_{2.5}$ 85.05%. Hence, the mean data captures for all pollutants except $PM_{2.5}$ and PM_{10} met this target in Quarter 3 (Q3) of 2018. Principal reasons for data loss are given here for pollutants and stations which fail to make the 85% data capture target for the quarter.

The uncertainty of measurement for each analyser has been determined to ensure compliance with the Data Quality Objective. Four analysers out of the total of 427 tested were found to be outside the uncertainty limits.

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1 Introduction

1.1 Background

The UK Automatic Urban and Rural Network (AURN) has been established to provide information on air quality concentrations 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]. 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 (MU) 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 Control Unit (QA/QC Unit) for all stations within the AURN. The responsibility for operating individual monitoring stations is assigned to local organisations with relevant experience in the field under the direct management (and contract to) CMCU. The people within these organisations who carry out the operation of the monitoring stations are referred to as Local Site Operators (LSOs). Calibration gases for the network are supplied by Air Liquide Ltd and are provided with an ISO17025 certificate of calibration by Ricardo Energy & Environment. The monitoring equipment is serviced and maintained by a number of Equipment Support Units, under contract to the CMCU or the station owner in the case of Local Authority-owned affiliated stations.

Dissemination of the data from the AURN via UK-AIR (the UK online Air Information Resource, http://uk-air.defra.gov.uk) and other media such as social media and freephone services, is undertaken by the Data Dissemination Unit (DDU). A summary report of the data is also published annually in the "*Air Pollution in the UK*" series of reports, which can be found at https://uk-air.defra.gov.uk/library/annualreport/index .

A total of 171 monitoring stations at 169 locations in the AURN operated during this quarter. The total of 171 includes two stations where Partisol gravimetric particulate samplers are co-located with automatic particulate analysers. For data processing purposes the gravimetric sampler is treated as a separate station; and they are shown, and counted, separately in the data capture tables in section 4.

1.2 What this Report Covers

This report covers the three-month period July-September 2018, or "Quarter 3" (Q3) of the year. This report covers the main QA/QC activities and a summary of the significant station operational issues.

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

1.3 Where to Find More Information

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

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

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

1.4 Changes to the Network during this Quarter

One station, Birmingham Ladywood, commenced operation during this quarter. This is a replacement for Birmingham Tyburn, which closed in 2017. Problems with communications meant that only data from the FDMS analysers could be downloaded initially. Delays in receiving the data from this station mean the data are not included for comment in this report.

In addition, several particulate analysers were replaced as part of an ongoing upgrade programme. The replacement Fidas instrument at Lough Navar replaces a single FDMS which measured PM_{10} only; as the Fidas measures both PM_{10} and $PM_{2.5}$ it was decided to disseminate both metrics to the data dissemination unit for visibility in UK-AIR.

Table 1-1 shows the changes that were made to the network during the period July – September 2018:

Table 1-1 Network Changes Jul - Sep 2018

Station	Pollutants	Replacement analyser type	Effective date
Lough Navar	PM_{10} and $PM_{2.5}$	Fidas	8th Aug 2018
Inverness	PM_{10} and $PM_{2.5}$	Fidas	13th Aug 2018
Chilbolton Observatory	PM_{10} and $PM_{2.5}$	BAM	15th Aug 2018
Rochester Stoke	PM_{10} and $PM_{2.5}$	BAM	13th Aug 2018
Barnstaple A39	PM_{10} and $PM_{2.5}$	BAM	13th Aug 2018
Auchencorth Moss	PM_{10} and $PM_{2.5}$	Fidas	14th Aug 2018
Chepstow A48	PM_{10} and $PM_{2.5}$	BAM	15th Aug 2018
Leicester A594 Roadside	PM_{10}	BAM	10th Sep 2018
Birmingham Ladywood (New station)	PM_{10} and $PM_{2.5}$	FDMS	23rd Aug 2018
Salford Eccles	PM_{10} and $PM_{2.5}$	BAM	10th Sep 2018
Coventry Binley Road	PM_{10}	BAM	13th Sep 2018
Liverpool Speke	PM_{10} and $PM_{2.5}$	BAM	21st Sep 2018
St Helens Linkway	PM_{10}	BAM	21st Sep 2018

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 delivery of ratified data to the Data Dissemination Unit for dissemination via UK-AIR and other routes.
- Assessment of new station locations in conjunction with the CMCU, and assessment of compliance with the siting criteria in the Directive.
- Investigation of instances of suspected poor-quality data.

2.2 Summer 2018 QA/QC Audits

The intercalibration requires the coordination and close cooperation of QA/QC Unit, Management Units, Equipment Support Units (ESUs) and LSOs in making sure the entire operation runs smoothly and is the result of many months of planning. Leading up to the intercalibration, a draft schedule of visits is prepared and circulated to MU's and ESU's for approval. ESU ozone photometers are calibrated at Ricardo Energy & Environment and all QA/QC equipment and cylinders are tested, calibrated and verified before use.

QA/QC visits are always undertaken before any ESU service visits, to allow the performance of the sites to be quantified for the six-month period prior to the visit. During the QA/QC visit, the LSO usually attends to demonstrate their competence in performing routine calibrations. The audits are used to transport independent calibration standard gases and test apparatus to all of the sites, to quantify the performance of the entire measurement process at the monitoring stations. The results obtained from these tests are fed into the ratification process, where any correction of datasets can be applied to account for any performance anomalies.

ESU service visits are normally undertaken within a three-week period following the QA/QC visit. At this time, the analysers and sampling systems are all cleaned and serviced in accordance with manufacturer's specifications. The analysers are then set up ready for the following six-month period, until the next round of intercalibrations and servicing.

This scheduling has proven to be very successful in delivering reliable operation of monitoring stations and high-quality data. The programme is iterative: improvements and enhancements are continually added to further improve performance and analyse results.

The QA/QC visits fulfil a number of important functions:

- A "health check" on the production of provisionally scaled data, which is rapidly disseminated to the public soon after collection.
- Identification of poorly performing analysers and infrastructure, 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 in (for example) Belfast would be reported in exactly the same way at every other site 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 site 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 provide poor 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.
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. SO_2 analyser hydrocarbon interference. This test evaluates the analyser's ability to remove interfering hydrocarbon gases from the sample gas. A failed test could have significant implications for analyser data.
10. Evaluation of site cylinder concentrations. These tests use a set of Ricardo Energy & Environment certified cylinders that are taken to all the sites. The concentrations of the site cylinders are used to scale pollution datasets, so it is important to ensure that the concentrations of gases in the cylinders do not change.
11. Competence of Local Site Operators (LSO) 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.
12. 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.

2.3 Network Intercalibration

Once all data have been collected, a "Network Intercalibration" is conducted. This utilises the audit gas cylinders transported to each site in the Network. These cylinders are recently calibrated by the Calibration Laboratory at Ricardo Energy & Environment and allows QA/QC Unit to examine how different site analysers respond when they are supplied with the same gas used at other sites. 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 disseminated via UK-AIR and other routes.
- These individual results are tabulated, and statistical analyses undertaken (e.g. network average result, network standard deviation, deviation of individual sites from the network mean etc.).

These results are then used to pick out problem sites, 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 site 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 sites 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 site cylinder concentrations between intercalibrations. Site cylinders can sometimes become unstable, especially at low pressures. All site cylinder concentrations are checked every six months and cylinders 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.

2.4 Methodology for FDMS Baseline Checks

As part of the QA/QC remit for continuous improvement, an ad hoc study of particulate matter (PM) analyser baseline response was undertaken in 2015. This study was coordinated following investigations of issues identified both by CMCU during routine operation and by QA/QC unit during the ratification process.

The study initially concentrated on FDMS analysers, examining the baseline profile of the reference channels and the relationship with other neighbouring monitoring stations. It had become clear that, on a daily mean basis, regional reference PM concentrations regularly reach a minimum value that approaches 0 µg m^{-3}. A mean zero average concentration of 3 µg m^{-3} provides a trigger for further investigation, and possible drier replacement if deemed necessary. The test is equally valid for BAM instruments, and thus the tests are also carried out on these.

The routine QA/QC procedures have included checking of particulate analyser baselines for some time now. 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. Until 2016 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}.

Fidas instruments are also subject to zero checks, but by their nature of operation, this can be completed during the normal site audit activity, and so no LSO visit is required to remove the filter. Data losses are therefore minimised.

2.5 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 the QA/QC Unit's data processing 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 Directive) and the European Union's Implementing Provisions for Reporting.

3 Intercalibration Results

3.1 Summer Intercalibration, July-August 2018

During the summer 2018 intercalibration, audits were carried out on 170 monitoring stations out of 171 (including Partisols) in operation at the time.

The results of the intercalibration are summarised in Table 3-1 below:

Table 3-1 Summary of audited analyser performance – 171 UK stations

Parameter	Number of outliers	Number in network	% outliers in total
NOx analyser	16	158	10.1
CO analyser	1	7	14.3
SO_2 analyser	8	27	29.6
Ozone analyser	11 (4 more than 10% from standard)	75	14.7
FDMS, Fidas and BAM analysers	5 x K_0, 5 x flows	76 PM_{10} 71 $PM_{2.5}$	6.8
Gravimetric PM analysers	0	8	0
Cylinders	9	192	4.7
Total	46 analysers	422 analysers	10.9% of analysers

The number of analyser outliers identified (10.9%) is lower than at the summer 2017 intercalibration (13.2%).

3.2 Network Intercalibrations

The concentration of the audit cylinders was calculated averaged across all monitoring stations using the zero and scaling factors provided by the CMCU on the day of audit. How close the result is to the stated cylinder concentration is a good indication of the accuracy of the provisional results across the entire network. The results are given in Table 3-2 below.

Table 3-2 Audit Cylinder Results

Parameter	Network Mean, ppb (ppm for CO)	Audit reference concentration ppb (ppm for CO)	Network Accuracy %	%Std Dev
NO	465	459	1.3%	4.6%
NO_2	402	408	-1.4%	4.6%
CO	20.2	20.1	0.5%	2.7%
SO_2	465	456	2.0%	4.8%

- **Oxides of Nitrogen**

  A total of 16 outliers were identified during this intercalibration. Of these outliers, three can be attributed to analyser drift, five to changes in site cylinder concentration, one to differences between the BV and Ricardo cylinder databases, three due to converter faults and four to issues experienced during the audit which compromised the results.

  There were three converters which fell outside the ±5% acceptance limits. There were two converter tests between 95% and 98%. There were a further ten converters identified where the initial result was outside the ±2% trigger for NO_2 rescaling.

- **Carbon Monoxide**

  There was a single CO outlier identified at this intercalibration, caused by an air conditioner failure at the audit.

- **Sulphur Dioxide**

  A total of eight outliers were identified at this intercalibration. Five of the outliers can be attributed to drifting cylinders, one was caused by an apparent difference between audit and LSO calibrations and two were caused by differences between CMCU and QA/QC cylinder database concentrations. All m-xylene interference tests were less than 30 ppb.

- **Ozone**

  A total of 11 outliers were identified at this intercalibration. Four of the outliers had a calibration response more than 10% from the reference photometer.

- **Particulate Matter**

  There were five calculated k_0 values outside the required ±2.5% of the stated values. All of the outlier results were within 3.2% of the stated values.

  Following comprehensive investigation, QA/QC unit has confirmed that testing the k_0 with the current batches of 92mg filters is the root cause of the increase in outliers identified and is no longer using these filters for k_0 determination. It appears that these suspect filters, which are widely used throughout the network, may also be causing the analysers to overestimate measured concentrations, by up to 4%. The supplier of the filters has confirmed that the newest filter batches cause a change in the response of the FDMS and will be issuing formal notification of this in due course. We will circulate this information in due course.

  Three FDMS main flows were found to be outside the ±10% acceptance limits. Two BAM total flows were found to be outside this limit. All Partisol total flows were found to be within the ±10% acceptance limits.

London Sites

The results of the intercalibration for the 16 London sites (including the co-located Partisols) in operation at the time of the intercalibration are summarised in **Error! Reference source not found.** below:

Table 3-3 Summary of audited analyser performance – London Sites

Parameter	Number of outliers	Number in region
NOx analyser	2	13
NOx converter	1	
CO analyser	0	2
SO_2 analyser	1	3
Ozone analyser	1	8
FDMS, Fidas and BAM analysers	1 k0, 1 flow	17
Gravimetric PM analysers	0	3

English Sites (Excluding London)

The results of the intercalibration for the 110 sites in England outside of London are summarised in **Error! Reference source not found.** below:

Table 3-4 Summary of audited analyser performance – Sites in England

Parameter	Number of outliers	Number in region
NOx analyser	12	106
NOx converter	4	
CO analyser	0	1
SO_2 analyser	4	16
Ozone analyser	7	53
FDMS, Fidas and BAM analysers	4 k_0, 3 flow	94
Gravimetric PM analysers	0	3

Scottish Sites

The results of the intercalibration for the 23 Scottish sites are summarised in **Error! Reference source not found.** below:

Table 3-5 Summary of audited analyser performance – Scottish Sites

Parameter	Number of outliers	Number in region
NOx analyser	2	19
NOx converter	0	
CO analyser	0	1
SO_2 analyser	2	2
Ozone analyser	0	9
FDMS, Fidas and BAM analysers	1	14
Gravimetric PM analysers	0	1

Welsh Sites

The results of the intercalibration for the 11 Welsh sites are summarised in **Error! Reference source not found.** below:

Table 3-6 Summary of audited analyser performance – Welsh Sites

Parameter	Number of outliers	Number in region
NOx analyser	0	11
NOx converter	0	
CO analyser	0	2
SO_2 analyser	0	4
Ozone analyser	1	5
FDMS, Fidas and BAM analysers	0	10
Gravimetric PM analysers	0	1

Northern Ireland Sites

The results of the intercalibration for the eight sites in Northern Ireland, plus Mace Head in the Republic of Ireland, are summarised in **Error! Reference source not found.** below:

Table 3-7 Summary of audited analyser performance – Northern Ireland Sites plus Mace Head

Parameter	Number of outliers	Number in region
NOx analyser	1	6
NOx converter	0	
CO analyser	1	1
SO_2 analyser	1	3
Ozone analyser	1	4
FDMS, Fidas and BAM analysers	0	7
Gravimetric PM Analysers	0	0

3.3 Certification

The Network Certificate of Calibration is available on the AURN Hub (login page at https://aurnhub.defra.gov.uk/login.php). This certificate presents the results of the individual analyser scaling factors on the day of the audit, as calculated by Ricardo Energy & Environment using the audit cylinder standards, in accordance with our ISO17025 accreditation.

3.4 Calculation of Measurement of Uncertainty

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 has taken steps to ensure the procedures used in the UK comply 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 sites that have CEN-compliant instrumentation, it is possible to calculate the overall uncertainty of measuring air quality. This information is station and analyser specific and presented in **Error! Reference source not found.** below:

Table 3-8 Analyser measurement uncertainties (%)

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Aberdeen	06-Aug	11.3			11.2	8.8	16.5		
Aberdeen Union Street Roadside	07-Aug				12.2				
Aberdeen Wellington Road	06-Aug				12.2				
Armagh Roadside	09-Aug				12.2	8.9			
Aston Hill	18-Jul	8.3			12.2				
Auchencorth Moss	11-Jul	11.2				9.4	17.2		
Ballymena Antrim Road	08-Aug				12.9				
Ballymena Ballykeel	09-Aug			11.2	13.8				
Barnsley Gawber	25-Jul	8.3		12.9	11.8				
Barnstaple A39	03-Jul					9.3	16.4		
Bath Roadside	16-Jul				12.2				
Belfast Centre	14-Aug	8.3	8.1	10.5	11.5				
Belfast Stockman's Lane	13-Aug				13.4	10.4			
Billingham	14-Aug				12.2				

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Birkenhead Borough Road	24-Jul				12.2				
Birmingham Acocks Green	30-Jul	11.2			12.2		16.4		
Birmingham A4540 Roadside	31-Jul	11.2			12.3	8.7	16.4		
Birmingham Tyburn									
Blackburn Accrington Road	12-Jul				11.7				
Blackpool Marton	11-Jul	8.3			9.8		16.6		
Borehamwood Meadow Park	13-Aug				9.8				
Bournemouth	07-Aug	11.2			12.3		12.8		
Bradford Mayo Avenue	23-Jul				12.9				
Brighton Preston Park	11-Jul	11.2			12.5				11.0
Bristol St Paul's	17-Jul	11.2			12.2	8.7	16.4		
Bristol Temple Way	17-Jul				12.8	9.4			
Burton-on-Trent Horninglow	06-Aug				13.5				
Bury Whitefield Roadside	12-Jul				12.2	9.7			
Bush Estate	11-Jul	11.2			12.3				
Cambridge Roadside	13-Aug				11.7				
Camden Kerbside	23-Jul				11.8	8.7	16.4		
Cannock A5190 Roadside	01-Aug				12.2				
Canterbury	06-Sep	11.2			12.6				
Cardiff Centre	25-Jul	11.2		9.8	12.5	10.0	16.9		
Cardiff Newport Road	25-Jul				12.3	9.3			
Carlisle Roadside	11-Jul				12.0	8.7	16.4		
Charlton Mackrell	04-Jul	10.5			12.3				
Chatham Centre Roadside	23-Aug				12.2	9.3	12.6		
Chepstow A48	23-Jul				12.1	8.7	16.4		
Chesterfield Loundsley Green	17-Jul				11.3	8.7	16.4		
Chesterfield Roadside	17-Jul				11.7	16.7	16.5		
Chilbolton	03-Jul	11.2		10.0	13.8	8.7	16.4		
Christchurch Barrack Road	07-Aug				13.3		12.6		
Coventry Allesley	23-Jul	8.3			10.1		16.4		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Coventry Binley Road	23-Jul				12.4	8.7			
Crewe Coppenhall									
Cwmbran	26-Jul	8.3			13.1				
Derby St Alkmunds Way	19-Jul				12.2				
Derry Rosemount	08-Aug	11.2		12.0	**15.4**	9.2	16.4		
Dewsbury Ashworth Grove	25-Jul				13.6				
Doncaster A630 Cleveland Street	02-Aug				12.3				
Dundee Mains Loan	12-Jul				9.8				
Dumbarton Roadside	02-Jul				11.3				
Dumfries	10-Jul				12.3				
Ealing Horn Lane	18-Jul					8.7			
Eastbourne	11-Jul				13.4		16.4		
Edinburgh Nicolson Street	10-Jul				12.2				
Edinburgh St Leonards	10-Jul	11.2	8.2	11.3	12.3	8.7	16.4		
Eskdalemuir	10-Jul	11.9			12.2				
Exeter Roadside	04-Jul	7.3			13.2				
Fort William	18-Jul	11.3			12.2				
Glasgow Great Western Road	25-Jul				12.2				
Glasgow High Street	25-Jul				12.2	8.7	16.4		
Glasgow Kerbside	25-Jul				9.8				
Glasgow Townhead	26-Jul	8.3			12.2	8.7	16.5		
Glazebury	11-Jul	11.5			12.2				
Grangemouth	09-Jul			9.9	11.3	9.6	12.6		
Grangemouth Moray	09-Jul			12.4	11.1				
Greenock A8 Roadside	03-Jul				9.8				
Hafod-yr-Ynys Roadside	26-Jul				12.2				
Haringey Roadside	12-Jul				**15.2**				
Hartlepool St Abbs Walk	15-Aug				12.2				
High Muffles	02-Aug	11.2			12.2				
Honiton	03-Jul				12.2				
Horley	09-Jul				13.9				
Hull Freetown	31-Jul	8.3		10.0	9.8		16.8		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	$*GR_{10}$	$*GR_{2.5}$
Hull Holderness Road	31-Jul				12.4	9.4			
Immingham Woodlands Avenue	01-Aug				12.2				
Inverness	24-Jul				12.2				11.5
Ladybower	16-Jul	11.2		10.0	12.4				
Leamington Spa	24-Jul	10.4			14.2	10.2	16.7		
Leamington Spa Rugby Road	24-Jul				12.4	8.7	16.4		
Leeds Centre	24-Jul	9.2	7.5	12.4	11.0	9.4	16.4		
Leeds Headingley Kerbside	24-Jul				12.8	9.5	16.9		
Leicester A594 Roadside	17-Jul				12.2	9.7			
Leicester University	17-Jul	8.3			9.8		16.4		
Leominster	18-Jul	11.2			12.3				
Lerwick	08-Aug	11.2		10.0	14.0				
Lincoln Canwick Road	19-Jul				12.2				
Liverpool Speke	24-Jul	8.3		10.0	9.8				
London Bexley	16-Jul				12.2		16.4		
London Bloomsbury	17-Jul	11.2		10.0	12.3	8.7	16.4		
London Eltham	13-Jul	10.5			14.6		16.7		
London Haringey Priory Park South	12-Jul	10.5			**17.4**				
London Harlington	15-Aug	11.2			12.2				
London Hillingdon	15-Aug	8.3			9.9				
London Marylebone Road	11-Jul	11.2	7.9	10.7	12.3	8.7	19.6	8.0	11.0
London North Kensington	10-Jul	11.2	7.8	10.9	13.9	8.7	9.3		
London Teddington Bushy Park	09-Jul					8.7	16.5		
London Westminster	14-Aug				11.6		12.6		
Lough Navar	06-Aug	11.2							
Lullington Heath	10-Jul	11.2		10.0	12.4				
Luton A505 Roadside	25-Jul				12.5				
Mace Head	07-Aug	8.3							
Manchester Piccadilly	13-Jul	8.3		11.6	10.4	10.6	17.5		
Manchester Sharston	11-Jul	11.2		10.0	12.2			8.0	11.9
Market Harborough	19-Jul	8.3			11.0				
Middlesbrough	14-Aug	11.2		11.8	12.2	8.7	16.4		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Narberth	30-Jul	11.2		10.0	12.8	7.9			
Newcastle Centre	16-Aug	8.3			9.9	8.7	16.4		
Newcastle Cradlewell Roadside	16-Aug				12.2	12.8			
Newport	23-Jul				12.3	8.5			
Northampton Spring Park	26-Jul	7.5			13.1	9.3			
Norwich Lakenfields	15-Aug	8.3			12.3	8.7	16.4		
Nottingham Centre	16-Jul	8.3		10.2	9.8	8.9	16.4		
Nottingham Western Boulevard	16-Jul				12.2				
Oldbury Birmingham Road	31-Jul				13.0				
Oxford Centre Roadside	05-Jul				13.3				
Oxford St Ebbes	05-Jul	10.4			12.5	9.4	16.4		
Peebles	13-Jul	11.2			**83.1#**				
Plymouth Tavistock Road	05-Jul				12.2				
Plymouth Centre	05-Jul	8.3			10.1	8.7	17.2		
Port Talbot Margam	24-Jul	8.3	11.6	11.6	10.7	8.7	16.4	8.0	
Portsmouth	09-Aug	8.3			13.1	8.7	17.0		
Portsmouth Anglesea Road	09-Aug				12.2	9.3			
Preston	12-Jul	8.3			9.8		16.4		
Reading London Road	06-Jul				11.7	9.3			
Reading New Town	06-Jul	8.3			10.5	8.7	16.4		
Rochester Stoke	23-Aug	11.5		10.0	14.6				
Salford Eccles	06-Jul				11.1	8.7	16.5		
Saltash Callington Road	05-Jul					10.8	16.4		
Sandy Roadside	24-Jul				12.7	8.7	18.1		
Scunthorpe Town	01-Aug			10.0	11.2	8.7			
Shaw Crompton Way	04-Jul				12.2	10.4			
Sheffield Barnsley Road	18-Jul				12.2		12.6		
Sheffield Devonshire Green	18-Jul	8.3			9.8	8.7	16.8		
Sheffield Tinsley	18-Jul				11.2				
Sibton	15-Aug	11.2							
Southampton Centre	08-Aug	8.3		10.0	9.8	8.7	16.6		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Southampton A33 Roadside	08-Aug				12.8	8.7			
Southend-on-Sea									
Southwark A2 Old Kent Road	03-Sep				12.7	8.7			
St Helens Linkway	26-Jul				12.2	8.8			
St Osyth	20-Aug	8.3			9.8				
Stanford-le-Hope Roadside	21-Aug				12.9	9.8	16.8		
Stockton on Tees A1035 Roadside	13-Aug				12.2		16.4		
Stockton-on-Tees Eaglescliffe	13-Aug				12.3	9.5	12.7		
Stoke-on-Trent Centre	03-Jul	8.3			9.8	8.7			
Stoke on Trent A50 Roadside	03-Jul				12.2	8.7			
Storrington Roadside	10-Jul				9.8				
Strath Vaich	23-Jul	11.2							
Sunderland Silksworth	15-Aug	11.2			13.9		16.5		
Sunderland Wessington Way	15-Aug				12.2				
Swansea Roadside	31-Jul				12.4	9.3	12.6		
Swindon Walcot	04-Jul				12.2				
Telford Hollinswood	06-Aug				13.2				
Thurrock	21-Aug	11.2		10.0	12.3	8.7			
Tower Hamlets Roadside	18-Jul				12.4				
Walsall Woodlands	01-Aug	11.2			12.2				
Warrington	23-Jul				11.4	9.0	17.9		
Weybourne	14-Aug	8.3							
Wicken Fen	16-Aug	11.2		10.0	12.2				
Widnes Milton Road	02-Aug					19.5			
Wigan Centre	26-Jul	9.7			11.6		17.3		
Wirral Tranmere	27-Jul	8.3			9.8		16.4		
Worthing A27 Roadside	29-Aug				12.3	9.3			
Wrexham	23-Jul			9.8	12.3				
Yarner Wood	06-Jul	11.2			12.2				
York Bootham	26-Jul				11.2	9.8	16.5		
York Fishergate	26-Jul				11.2	10.1	17.0		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$	*GR_{10}	*$GR_{2.5}$
Total > 15 (gaseous) or > 25 (PM)	**-**	**0**	**0**	**0**	**4**	**0**	**0**		

*GR_{10} and $GR_{2.5}$-Gravimetric PM, specifically Partisol measurements

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

No audit was carried out at Southend-on-Sea during this exercise as the audit was delayed until November 2018.

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, and do not necessarily infer 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 (e.g. Peebles, above), and this results in an ESU visit to effect a repair. The QA/QC Unit then decides whether to report the data or delete them as appropriate.

4 Data Ratification Results

4.1 Data Capture – Network Overview

4.1.1 Overall Data Capture

The overall data capture for the period July-September 2018 is given in Table 4-1. 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 the target of 85% also shown in the table. Note that data capture figures are correct at time of writing (January 2019) and are subject to change.

Table 4-1 Data Capture Summary, July-September 2018 (Quarter 3)

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Number of Stations	7	158	76	77	81	28	171
Number of stations < 85 %	1	17	6	23	20	6	30
Number of stations < 90%	1	23	7	30	31	7	39
Average	94.49	92.17	94.32	82.18	85.05	85.91	89.78

Average data capture was at least 85% for all pollutants – CO, NO_2, O_3 and SO_2. However, it is important to note that most PM analysers in the Network underwent a zero test during quarter 3 (Q3) of 2018, which inevitably results in the loss of a few days' data. In some cases, the filter was left on for excessive periods (intentionally or otherwise), resulting in unnecessary data loss.

4.1.2 Generic Data Quality Issues

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

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.

4.2 Data Capture and Station-Specific Issues - England (Excluding Greater London)

A summary of data capture for England for July-September 2018 is given in Table 4-2:

Table 4-2 Data Capture for England, July-September 2018

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Barnsley Gawber		98.10	98.46			98.41	98.32
Barnstaple A39				60.10	88.59		74.34
Bath Roadside		98.51					98.51

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Billingham		99.64					99.64
Birkenhead Borough Road		99.14					99.14
Birmingham A4540 Roadside		98.46	98.69	86.78	92.53		94.11
Birmingham Acocks Green		98.28	98.46		96.24		97.66
Birmingham Ladywood		0.00	0.00	0.00	0.00	0.00	0.00
Blackburn Accrington Road		95.29					95.29
Blackpool Marton		98.82	98.96		79.12		92.30
Borehamwood Meadow Park		98.73					98.73
Bournemouth		90.85	96.11		95.38		94.11
Bradford Mayo Avenue		99.55					99.55
Brighton Preston Park		98.41	98.10		98.91		98.48
Bristol St Paul's		37.73	38.50	27.94	28.08		33.06
Bristol Temple Way		94.16		91.44			92.80
Burton-on-Trent Horninglow		98.64					98.64
Bury Whitefield Roadside		99.28		88.22			93.75
Cambridge Roadside		72.96					72.96
Cannock A5190 Roadside		35.19					35.19
Canterbury		97.60	98.64				98.12
Carlisle Roadside		96.42		86.10	92.84		91.79
Charlton Mackrell		98.73	98.87				98.80
Chatham Roadside		98.46		92.07	91.08		93.87
Chesterfield Loundsley Green		88.18		91.30	85.19		88.22
Chesterfield Roadside		85.69		73.41	92.84		83.98
Chilbolton Observatory		98.19	98.73	88.18	73.87	98.28	91.45

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Christchurch Barrack Road		62.41			96.01		79.21
Coventry Allesley		98.55	98.69		95.47		97.57
Coventry Binley Road		98.51		83.83			91.17
Derby St Alkmund's Way		99.50					99.50
Dewsbury Ashworth Grove		25.45					25.45
Doncaster A630 Cleveland Street		98.96					98.96
Eastbourne		91.44			93.89		92.66
Exeter Roadside		90.44	90.85				90.65
Glazebury		22.74	28.13				25.43
Hartlepool St Abbs Walk		98.51					98.51
High Muffles		93.16	93.25				93.21
Honiton		95.34					95.34
Horley		73.28					73.28
Hull Freetown		98.64	98.82		95.88	98.41	97.94
Hull Holderness Road		98.69		92.26			95.47
Immingham Woodlands Avenue		95.11					95.11
Ladybower		98.32	98.14			72.83	89.76
Leamington Spa		99.14	99.41	94.75	96.29		97.40
Leamington Spa Rugby Road		98.60		33.51	67.07		66.39
Leeds Centre	98.37	98.32	98.55	95.06	95.06	98.28	97.06
Leeds Headingley Kerbside		97.74		95.29	94.43		95.82
Leicester A594 Roadside		98.37		79.12			88.75
Leicester University		98.51	98.73		95.43		97.55
Leominster		98.69	99.05				98.87
Lincoln Canwick Road		99.41					99.41
Liverpool Speke		98.69	98.64	97.74	98.64	57.79	90.30

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Lullington Heath		98.32	98.73			98.55	98.54
Luton A505 Roadside		97.87					97.87
Manchester Piccadilly		98.46	98.55		88.50	98.37	95.97
Manchester Sharston		98.55	98.55				98.55
Market Harborough		94.75	98.91				96.83
Middlesbrough		93.84	97.92	93.39	93.80	97.37	95.26
Newcastle Centre		98.64	98.69	93.07	85.64		94.01
Newcastle Cradlewell Roadside		98.51		92.84			95.67
Northampton Spring Park		99.64	99.77		92.26		97.22
Norwich Lakenfields		98.51	97.46	64.99	65.04		81.50
Nottingham Centre		98.55	98.78	95.70	95.74	97.55	97.26
Nottingham Western Boulevard		80.34		94.88			87.61
Oldbury Birmingham Road		99.59					99.59
Oxford Centre Roadside		94.16					94.16
Oxford St Ebbes		99.32		94.47	94.43		96.07
Plymouth Centre		98.46	92.39	87.27	86.73		91.21
Plymouth Tavistock Road		57.88					57.88
Portsmouth		99.64	99.64	0.00	0.00		49.82
Portsmouth Anglesea Road		99.91		95.11			97.51
Preston		98.46	96.51		92.62		95.86
Reading London Road		99.37		92.80			96.08
Reading New Town		98.64	98.73	30.30	94.52		80.55
Rochester Stoke		82.74	98.51	99.64	99.05	98.46	95.68
Salford Eccles		98.82		50.45	50.59		66.62
Saltash Callington Road				95.38	95.29		95.34
Sandy Roadside		95.06		26.68	34.19		51.98
Scunthorpe Town		94.93		94.25		99.41	96.20

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Shaw Crompton Way		95.11					95.11
Sheffield Barnsley Road		98.64			93.66		96.15
Sheffield Devonshire Green		98.05	98.78	93.30	87.59		94.43
Sheffield Tinsley		98.01					98.01
Sibton			97.33				97.33
Southampton A33		99.73		44.97			72.35
Southampton Centre		82.97	83.24	71.24	71.29	69.88	75.72
Southend-on-Sea		47.46	99.86		53.53		66.95
St Helens Linkway		99.18		90.85			95.02
St Osyth		97.92	98.69				98.30
Stanford-le-Hope Roadside		99.55		40.63	97.06		79.08
Stockton-on-Tees A1305 Roadside		98.96			96.33		97.64
Stockton-on-Tees Eaglescliffe		96.01		91.30	91.80		93.04
Stoke-on-Trent A50 Roadside		98.41		95.47			96.94
Stoke-on-Trent Centre		98.23	98.37		88.63		95.08
Storrington Roadside		97.64					97.64
Sunderland Silksworth		91.53	95.79		92.39		93.24
Sunderland Wessington Way		98.28					98.28
Swindon Walcot		98.51					98.51
Telford Hollinswood		99.41					99.41
Thurrock		93.98	94.25	89.36		93.66	92.81
Walsall Woodlands		99.86	99.82				99.84
Warrington		99.64		83.92	95.70		93.09
Weybourne			99.91				99.91
Wicken Fen		98.46	98.55			98.05	98.35
Widnes Milton Road		0.00					0.00
Wigan Centre		92.66	98.23		44.97		78.62

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Wirral Tranmere		98.37	98.60		80.21		92.39
Worthing A27 Roadside		88.22			75.14		81.68
Yarner Wood		98.05	98.41				98.23
York Bootham		97.19		92.84	92.57		94.20
York Fishergate		96.83		93.39	95.20		95.14
Number of Stations	**1**	**108**	**50**	**47**	**53**	**16**	**112**
Number of stations < 85 %	**0**	**14**	**4**	**16**	**14**	**4**	**24**
Number of stations < 90%	**0**	**17**	**4**	**22**	**21**	**4**	**28**
Average	**98.37**	**91.03**	**93.17**	**77.57**	**82.40**	**85.96**	**87.92**

The following station-specific issues were identified:

Barnstaple A39

The FDMS analysers continued to perform poorly due to the temperature cycling inside the cabin causing instrument response to drift. The PM_{10} was affected most, and data have been deleted from 1st July to 3rd August. BAMs have been installed on 13th August.

Birmingham A4540 Roadside

The main valve was found to be stuck on the PM_{10} FDMS on 6th July. The engineer was unable to repair it on site, and a hotspare was installed on 9th July. Some data were also lost due to poor dewpoints prior to a drier change.

Blackpool Marton

The $PM_{2.5}$ FDMS had problems with high dewpoints during the quarter, ultimately leading to removal for workshop repair in October. The data were deleted by the CMCU from 21st to 30th September.

Bristol St Pauls

The station was offline from 25th July to 13th September due to an electrical fault.

Bury Whitefield Roadside

Data were lost from 12th to 20th July due to the zero test. The ESU found the main valve was stuck on 19th September, A further callout on 26th September found the chiller unit full of water.

Cannock A5190 Roadside

The station was switched off on 2nd August due to aircon failure. Monitoring recommenced in October.

Carlisle Roadside

The PM_{10} FDMS suffered multiple faults during the quarter, including flow and cooler issues.

Chesterfield Loundsley Green

The NOx analyser had a persistent autocal run-on during this quarter, with the loss of at least one hour per day. The $PM_{2.5}$ data were lost between 17th to 23rd July due to the zero test, then again 20th to 26th September due to a broken cable inside the instrument.

Chesterfield Roadside

The NOx analyser had a persistent autocal run-on during the quarter. At service on 7th August, the pump tubing was found to have worn through due to contact with the vibrating pump. Following on from a fault in Q2, a period of poor quality PM_{10} data was deleted from 1st July to the audit on 17th July; with the subsequent zero test, data were lost to 23rd July

Chilbolton Observatory

The FDMS analysers were replaced by a Fidas on 24th July. Following installation, the Fidas was found to be incorrectly configured, and data up to 30th July were deleted.

Christchurch Barrack Road

A suspected sampling fault resulted in the deletion of data from 1st to 3rd August.

Coventry Binley Road

The FDMS analyser lost its firmware resulting in a loss of data from 11th to 17th July. The FDMS was replaced by a BAM on 17th September. Zero tests on both analysers resulted in further data loss.

Dewsbury Ashworth Grove

The sample line was found to have worn through on the pump at the service on 7th September. All data up to the service have been deleted.

Glazebury

The power cable to the station was severed by agricultural activity on 11th July. Power was restored on 14th September, but the NOx analyser would not restart, and was repaired on 20th September.

Horley

A leak in the converter found at the summer QA/QC audit resulted in the loss of data from 10th June to 25th July.

Ladybower

The SO_2 analyser was removed for workshop repair on 15th August due to a suspected detector fault. Upon reinstallation on 5th September, lamp and detector temperature faults soon reappeared. Investigation by the ESU found the site power supply voltage to be low. Problems continued into Q4.

Leamington Spa Rugby Road

The quality of PM_{10} data has been poor for some time, with low levels measured compared to the $PM_{2.5}$ here and at nearby sites. Data have been deleted from 5th May to 26th July (very noisy data) and the PM_{10} from 27th August to 30th September (leaks). $PM_{2.5}$ has also been deleted from 5th May to 26th July.

Leicester A594 Roadside

A period of exceptionally noisy PM_{10} data from 17th to 31st July have been deleted. The fault was cured by adjusting the amplifier board.

Liverpool Speke

The SO_2 analyser suffered persistent severe drift throughout the quarter, with the lamp adjusted 10th July and a possible lamp problem identified on 17th August. The lamp was replaced on 13th September, but no improvement was noted; a hotspare was installed in Q4.

Manchester Piccadilly

Some spurious $PM_{2.5}$ data were deleted from 19th September up to the service on 24th September; no information on the nature of the fault is available.

Newcastle Centre

The $PM_{2.5}$ FDMS suffered a fault prior to the service on 11th September, no record of the fault is available. The fault persisted after the service.

Norwich Lakenfields

Both $PM_{2.5}$ and PM_{10} FDMS analysers suffered noisy, spiked volatiles during the quarter. Data from both have been deleted from 12th July to 9th August.

Nottingham Western Boulevard

The NOx sample filter glass was found to have snapped at some point prior to the LSO calibration on 4th September, and the analyser was turned off at CMCU request. The permeation tube was still inside, and resulted in some residual contamination of the sample stream; data from 20th August to 6th September have been lost.

Plymouth Centre

Valve failure in the PM_{10} FDMS resulted in the loss of data from 24th to 30th August. Condensation was found in the $PM_{2.5}$ tubing, resulting in the loss of data from 11th to 16th July.

Plymouth Tavistock Road

Problems were encountered with the air conditioning, resulting in the station overheating. Data have been deleted between 27th June to 7th August, when the air conditioning was replaced.

Portsmouth

Due to poor air conditioning performance, both $PM_{2.5}$ and PM_{10} data were unstable and of very poor quality. Data from both analysers have been deleted from 20th June to 30th September.

Reading New Town

The PM_{10} data were found to be low compared to other sites between 3rd August and 30th September and have been deleted during ratification. ESU investigations have not identified a specific fault.

Rochester Stoke

The NOx analyser suffered a failure of the motherboard on 5th September; replacement parts were fitted at the service on 19th September.

Salford Eccles

The FDMS analysers were replaced by a Fidas on 11th July. However, there were a number of faults experienced, and a hotspare Fidas was installed on 16th August; however this analyser did not respond to calibration dust. A replacement new analyser was installed on 22nd August, and data collection finally commenced.

Sandy Roadside

The FDMS analysers were switched off on 13th June to prevent damage as a result of the failure of the station air conditioning. Monitoring restarted on 28th August, although a fault with the PM_{10} FDMS resulted in further data loss into September.

Sheffield Devonshire Green

The zero test on the $PM_{2.5}$ resulted in the loss of data from 18th to 26th July; further data loss occurred due to instability following service on 31st July.

Southampton A33

As a result of air conditioning failure, the PM_{10} FDMS was unstable and data were deleted from 18th June to 13th August.

Southampton Centre

On 12th July CMCU prompted LSO investigation into a rise in site operating temperature. On arrival the LSO found that someone had jammed a stick inside the air conditioning fan grill and as a result the air conditioning unit had failed. The LSO was not able to restart the unit and powered off all the instruments to prevent heat damage. A call out was issued and the air conditioning engineer repaired the unit on 24th July. Once the site temperature was stable the LSO restarted all the instruments on 26th July. Some further data were deleted either side of the issue due to response instability caused by the temperature change. A further issue with the SO_2 analyser removed for workshop repair from 12th to 25th September.

Southend-on-Sea

The air conditioning unit was found to have failed on 18th August and resulting elevated temperatures affected the stability of the $PM_{2.5}$ data. The data have been deleted from 18th August to 5th September, when the analyser was switched off. The air conditioning was replaced and monitoring restated on 8th

October. The elevated temperatures also caused the NOx analyser to drift, and these data have also been deleted.

Stanford-le-Hope Roadside

The PM_{10} data were unstable with spuriously high volatile concentrations. Data from 1st July to 23rd August have been deleted.

Stoke-on-Trent Centre

A period of excessively noisy data observed from 12th to 19th July was caused by a leak and a pump fault; these data have been deleted.

Thurrock

The LSO was called out on 2nd August to change the FDMS filters to correct spurious data. The PM_{10} data from 27th July to 2nd August.

Warrington

The PM_{10} FDMS lost its firmware twice during the quarter; data have been lost 23rd to 27th July and 8th to 14th August.

Widnes Milton Road

The NOx analyser has had a fault for many months, and data collection had been discontinued; no data exist for this quarter.

Wigan Centre

The $PM_{2.5}$ FDMS performed poorly during the quarter, following a number of faults in previous quarter. Data between 10th August and 21st September were noisy and with spurious volatile concentrations and have been deleted.

Worthing A27 Roadside

The switching valve in the NOx analyser became blocked on 11th July; data have been lost up to repair on 17th July.

4.3 Data Capture and Station-Specific Issues - Greater London

A summary of data capture for Greater London for July-September 2018 is given in Table 4-3:

Table 4-3 Data Capture for Greater London, July-September 2018

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Camden Kerbside		99.09		90.53	70.83		86.82
Ealing Horn Lane				97.37			97.37
Haringey Roadside		99.73					99.73
London Bexley		98.55			97.19		97.87
London Bloomsbury		97.83	98.60	93.89	95.47	90.44	95.24
London Eltham		95.15	99.55		96.38		97.03
London Haringey Priory Park South		99.64	81.75				90.69
London Harlington		88.68	88.63	90.90	90.90		89.78
London Hillingdon		94.52	94.75				94.63
London Marylebone Road	96.65	96.78	97.10	95.65	85.82	86.19	92.31

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
London Marylebone Road (Partisol)				96.74	84.78		90.76
London N. Kensington	96.78	99.18	97.55	99.91	99.91	99.00	99.11
London Teddington Bushy Park					96.42		96.42
London Westminster		96.24			96.01		96.13
Southwark A2 Old Kent Road		47.06		46.33			46.69
Tower Hamlets Roadside		99.50					99.50
Number of Stations	**2**	**13**	**7**	**8**	**10**	**3**	**16**
Number of stations < 85 %	**0**	**1**	**1**	**1**	**2**	**0**	**1**
Number of stations < 90%	**0**	**2**	**2**	**1**	**3**	**1**	**3**
Average	**96.72**	**93.23**	**93.99**	**88.92**	**91.37**	**91.88**	**91.88**

The following station-specific issues were identified:

Camden Kerbside

The CMCU noticed a sudden step change in measured $PM_{2.5}$ concentrations on 10th August; the filters were changed, and subsequently the ESU made several visits to affect a repair. Eventually the drier was changed on 31st August, and data returned to acceptable quality. All $PM_{2.5}$ data have been deleted for this period.

London Haringey Priory Park South

The ozone analyser flagged a flow fault on 24 July. The ESU attended on 6th August and removed it for workshop repair. Data have been deleted from 5th to 9th August. The fault reappeared, and further data were lost from 30th August to 4th September.

London Marylebone Road

The $PM_{2.5}$ FDMS suffered a mass transducer fault on 17th July, and was removed for workshop repair, being returned to site on 25th July. In addition, the $PM_{2.5}$ Partisol suffered multiple filter exchange faults during the quarter. A power failure caused loss of all data from 23rd to 24th September.

Southwark A2 Old Kent Road

The station overheated during July and August, resulting from a failed air conditioning unit, and the cabin being painted black. Data have been lost from 1st July to 17th August.

4.4 Data Capture and Station-Specific Issues - Wales

A summary of data capture for Wales for July-September 2018 is given in Table 4-4.

Table 4-4 Data Capture for Wales, July-September 2018

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aston Hill		98.69	98.91				98.80
Cardiff Centre	98.60	85.42	98.55	81.39	65.63	73.73	80.94

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Cardiff Newport Road		98.55		69.79			84.17
Chepstow A48		94.93		93.84	93.80		94.19
Cwmbran		99.55	99.64				99.59
Hafod-yr-Ynys Roadside		98.32					98.32
Narberth		98.23	98.78	98.78	98.78	97.37	98.39
Newport		72.78		99.91	99.91		90.87
Port Talbot Margam (Partisol)				98.91			98.91
Port Talbot Margam	96.42	97.10	98.64	95.79	87.73	98.32	95.52
Swansea Roadside		98.41		94.11	89.95		94.16
Wrexham		98.37		100.00	97.83	0.00	74.05
Number of Stations	**2**	**11**	**5**	**9**	**7**	**4**	**12**
Number of stations < 85 %	**0**	**1**	**0**	**2**	**1**	**2**	**3**
Number of stations < 90%	**0**	**2**	**0**	**2**	**3**	**2**	**3**
Average	**97.51**	**94.58**	**98.90**	**92.50**	**90.52**	**67.36**	**92.33**

The following station-specific issues were identified:

Cardiff Centre

The ESU was called out to the NOx analyser on 24th August to address a problem with spurious data following the nightly IZS operation. The engineer was unable to fix it onsite, and it was removed for overhaul In the workshop. A hotspare was installed on 30th August. Following reinstallation of the original site analyser on 21st September, and another fault was detected, and the hotspare reinstalled on 24th September to 3rd October.

The SO_2 analyser failed to restart due to a lamp fault following service on 5th August and was removed for workshop repair. The analyser was reinstalled on 20th August; however, the lamp fault returned and the analyser was taken back to the workshop from 15th to 20th September.

Poor quality $PM_{2.5}$ data had been observed at the end of Q2 and this continues up to 31st July; data for this period have been deleted.

An engineer callout was issued on 24th September for unstable PM_{10} data; no fault was found but the engineer suspected that the vibration from nearby building works was affecting the mass transducer. ESU visits were also delayed due to the contamination of the station floor by excrement which required specialist cleaning.

Cardiff Newport Road

The PM_{10} BAM analyser suffered repeated tape breaks this quarter, resulting in it being removed for workshop repair. Some data also appeared to be too low. Data have been lost or deleted from 26th July to 22nd August.

Port Talbot Margam

The $PM_{2.5}$ FDMS produced very noisy and often negative data for the period 22nd August to an ESU callout on 30th August. These have been deleted.

Swansea Roadside

There were two unspecified data gaps in the $PM_{2.5}$ data from 1st to 4th August and 11th to 15th August.

Wrexham

The SO_2 analyser continued to perform badly during the quarter; all SO_2 data have been deleted.

4.5 Data Capture and Station-Specific Issues - Scotland

A summary of data capture for Scotland for July-September 2018 is given in Table 4-5:

Table 4-5 Data Capture for Scotland, July-September 2018

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aberdeen		98.01	98.64	94.97	94.88		96.63
Aberdeen Union Street Roadside		99.14					99.14
Aberdeen Wellington Road		98.82					98.82
Auchencorth Moss			98.82	94.34	76.9		90.02
Bush Estate		98.14	98.32				98.23
Dumbarton Roadside		95.24					95.24
Dumfries		99.14					99.14
Dundee Mains Loan		95.29					95.29
Edinburgh Nicolson Street		99.68					99.68
Edinburgh St Leonards	78.53	96.11	96.11	82.56	84.96	98.01	91.55
Eskdalemuir		95.47	95.61				95.54
Fort William		98.73	99.00				98.87
Glasgow Great Western Road		99.64					99.64
Glasgow High Street		98.55		96.42	96.47		97.15
Glasgow Kerbside		98.05					98.05
Glasgow Townhead		98.64	98.64	95.11	93.98		96.59
Grangemouth		93.75		98.23	98.51	97.42	96.98
Grangemouth Moray		95.20					95.20

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Greenock A8 Roadside		99.59		99.64	99.68		99.64
Inverness		96.78		70.65	90.22		85.88
Lerwick			95.79				95.79
Peebles		52.13	79.53				65.83
Strathvaich			99.05				99.05
Number of Stations	**1**	**20**	**10**	**8**	**8**	**2**	**23**
Number of stations < 85 %	**1**	**1**	**1**	**2**	**2**	**0**	**1**
Number of stations < 90%	**1**	**1**	**1**	**2**	**2**	**0**	**2**
Average	**78.53**	**95.31**	**95.95**	**91.49**	**91.95**	**97.71**	**95.13**

The following station-specific issues were identified:

Auchencorth Moss

No data have been supplied for the period 16th to 31st July, following the zero test. The FDMS analysers were replaced by a Fidas on 8th August.

Edinburgh St Leonards

A hotspare CO analyser was installed on 2nd July due to the site analyser developing a fault. The hotspare was incorrectly configured (data to only one decimal place) so the data from this have been deleted to a further hotspare was installed on 17th July.

Following data quality concerns, the PM zero tests were repeated after the service on 17th July. The zero tests then lasted from 10th to 24th July.

Inverness

The PM_{10} Partisol suffered frequent filter exchange faults late in Q2 and into Q3; this was found to be irreparable and the decision was made to accelerate the replacement of the Partisols with a Fidas. This was carried out on 23rd July.

Peebles

On completion of the service, on 17th July, the engineer noted that the cabin temperature had risen due to a failing air conditioning unit. The high temperature was responsible for moisture forming inside the NOx analyser's photomultiplier tube; this was cleaned out and required time to settle down before analyser calibration. However, on 19th July the LSO was advised to switch off the analysers to safeguard them against the excessive enclosure temperature resulting from the a/c unit failure. A replacement a/c unit was installed on 31st July and the LSO powered up both instruments on 2nd August, however, an ESU call out was issued the following day for faults on both analysers. Engineer investigation on 6th August reported a NOx photomultiplier tube failure and sample pump failure in the ozone analyser. The pump was rebuilt and ozone monitoring was restored, however, the NOx fault condition remained pending component replacement.

4.6 Data Capture and Station-Specific Issues - Northern Ireland & Mace Head

A summary of data capture for Northern Ireland, and Mace Head in the Republic of Ireland, for July-September 2018, is given in Table 4-6:

Table 4-6 Data Capture for Northern Ireland (plus Mace Head), July-September 2018

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Mace Head			99.23				99.23
Armagh Roadside		89.72		86.73			88.22
Ballymena Antrim Road		98.73					98.73
Ballymena Ballykeel		98.91				99.59	99.25
Belfast Centre	96.06	96.01	99.77	55.62	87.68	96.15	87.05
Belfast Stockman's Lane		91.44		96.47			93.95
Derry Rosemount		98.46	98.69	93.34	93.39	93.80	95.53
Lough Navar			99.59	74.64	57.43		77.22
Number of Stations	1	6	4	5	3	3	8
Number of stations < 85 %	0	0	0	2	1	0	1
Number of stations < 90%	0	1	0	3	2	0	3
Average	96.06	95.55	99.32	81.36	79.50	96.51	92.40

The following station-specific issues were identified:

Armagh Roadside

The NOx analyser had a persistent autocal run-on during the quarter; one hour of data per day has been lost.

The period 12th to 14th July was deleted due to the volatile concentrations being a regional outlier. The PM_{10} FDMS developed a sample dew point fault; data have been lost from 27th July to 6th August.

Belfast Centre

Poor air conditioning performance affected all analysers, particularly the FDMS. PM_{10} data have been deleted 26th June to 31st July and 11th to 21st August. $PM_{2.5}$ has been lost from 10th to 22nd August.

Lough Navar

As part of the PM replacement program the FDMS PM_{10} analyser was removed on 17th July and the Fidas installation commenced. The sample tube installation through the slate, gabled roof required special attention and the complete replacement was finalised the following day.

The QA/QC audit was scheduled for 6th August and prior to this there was a discussion over the diagnostic channel recording 4 upon installation completion, rather than the expected 1 recorded at all other Fidas instruments available in the network at the time. Supplier and manufacturer assured CMCU that this did not constitute an instrument performance fault, but it was agreed with QA/QC that it would be adjusted at audit to the established reading of 1. This was duly achieved at audit. However, it was then observed that this appeared to prompt an instrument response change that could not be reconciled and further debate ensued. CMCU then observed that since the audit completion all the measured metrics of PM_1, $PM_{2.5}$, PM_4, PM_{10} and TSP (total suspended particulate) were similar and with certainly insufficient distinction between them and this information was fed back. It was acknowledged that an analyser performance issue existed and on 28th August. ESU investigation reported that a small clump of dried moss was discovered in the extension pipe connection to the IADS (Intelligent Aerosol Drying System) that formed part of the sample system. The blockage was cleared, all subsequent PM metrics could be reconciled, and perceived satisfactory monitoring was restored. All data over this period were deleted.

A further potential fault was observed between 19th and 27th September, when the IADS temperature was far higher than expected. Careful examination of the data could see no effect, and the data for this period are reported as ratified.

4.7 Zero Baseline Correction

A protocol was agreed in 2016 to enable PM baselines to be corrected where baseline responses exceed 3 µg m^{-3}. Baseline correction has been incorporated into the data ratification protocols as of 2016 data onwards.

It is possible that the zero tests carried out at the winter 2019 audits will reveal additional cases where zero baseline correction would be advisable. If this happens, any changes to previously ratified data will be dealt with according to the agreed protocols.

4.8 Ongoing Investigations

As reported in previous QA/QC reports, QA/QC Unit has confirmed that testing the k_0 with the current batches of 92 mg filters is the root cause of the increase in outliers identified at previous intercomparisons. It appears that these suspect filters, which are widely used throughout the network, may also be causing the analysers to overestimate measured concentrations, by up to 4%. A reply has been received from the manufacturer and discussions continue.

5 Changes to Previously Ratified Data

Occasionally there are circumstances where it is necessary to make changes to data which have previously been flagged as “Ratified”. This may be for example where:

- A QAQC audit or other investigation has detected a problem which affects data back into an earlier ratification period.
- Long-term analysis has detected an anomaly between expected and measured trends which requires further investigation and possible data correction.
- Further research comes to light which indicates that new or tighter QAQC criteria are required to meet the data quality objectives. This may require review and revision of historic calibration data by applying the new criteria.

During ratification of the 2018 Q3 data, some changes were also made to data from previous quarters that had previously been flagged as ratified. These changes, and the reasons, are shown in Table 5-1.

Table 5-1 Changes to Data Previously Marked as Ratified

Monitoring Station	Pollutant(s)	Dates	Nature of Change
Camden Kerbside	$PM_{2.5}$	1st Jan 2018 – 2nd Aug 2018	Zero baseline adjustment
Cardiff Centre	$PM_{2.5}$	26th Jun – 25th Jul	Data deletion
Chesterfield Roadside	PM_{10}	11th Jun – 17th Jul	Very spiky and noisy, TEOM heads need cleaning.
Christchurch Barrack Road	NO_X	27th Jun – 2nd Aug	Data deletion.
Dundee Mains Loan	NO_X	End of March	Removed negative spike in March.
Edinburgh St Leonards	NO_X	All Q2	Reprocess sensitivity.
Glasgow Townhead	$PM_{2.5}$	From winter service on 14th Feb to end of Q3	Zero baseline correction (3 $\mu g\ m^{-3}$).
Leamington Spa Rugby Road	PM_{10} & $PM_{2.5}$	14th May – 24th Jul	Deleted all PM – very noisy.
Leominster	NO_X	All Q1 & Q2	Reprocessed zero baseline.
London Westminster	NO_X	Q1 & Q2 from winter service	Reprocessed zero baseline.
Nottingham Centre	PM_{10}	Between 6th Mar and 19th Jul.	Zero baseline correction between winter 2018 and summer 2018 zero tests.
Portsmouth	PM_{10} & $PM_{2.5}$	20th Jun (Q2) – 10th Oct (Q4)	Deletion of poor quality data
Sandy Roadside	PM_{10} & $PM_{2.5}$	All Q2	Minor revisions
Southwark A2 Old Kent Road	NO_X	All Q2	Reprocessed sensitivity and deleted 28th Jun to end of quarter & into Q3.

Walsall Woodlands	O_3	May onwards	Inconsistency in zero processing. Reprocessed baseline to remove step change.
York Bootham	NOx	All Q2	Processing improved.

6 Health and Safety Report

There were no incidents in the AURN where station status went to “High” during this quarter.

7 Equipment Upgrade Requirements

A programme of upgrades of FDMS to BAM and Fidas instruments is underway during 2018. Progress during this quarter is given in section 1.4.

8 Station Infrastructure Issues

No station infrastructure issues have been identified by the QA/QC Unit this quarter.

9 Conclusions and Recommendations

1. During Quarter 3 of 2018 a total of 171 monitoring stations at 169 locations were in operation. The total of 171 includes two stations where Partisol gravimetric particulate samplers are co-located with automatic particulate analysers.
2. During this quarter, the summer 2018 intercalibration exercise was carried out, involving comprehensive performance tests on every analyser in the network. This allows the accuracy of the measured results to be determined, and a measurement uncertainty for each analyser to be determined, as required by the Data Quality Objective.
3. 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 94.49%, NO_2 92.17%, O_3 94.32%, SO_2 85.91%, PM_{10} 82.18%, and $PM_{2.5}$ 85.05%. Hence, the mean data captures for all pollutants except PM_{10} met this target in Quarter 3 of 2018. Principal reasons for data loss have been discussed in previous sections, for pollutants and stations which fail to make the 85% data capture target for the quarter.
4. Data ratification for the quarter was completed by the deadline of 31st December 2018.
5. The uncertainty of measurement for each analyser has been determined to ensure compliance with the Data Quality Objective. Four analysers were found to be outside the required uncertainty.
6. Several SO_2 analysers have shown significant drift and/or spurious response in this and previous quarters, and the least satisfactory analysers should be considered for replacement. Wrexham is a good example of this, as data have been deleted for nearly twelve months.

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