QA/QC Data Ratification Report for the Automatic Urban and Rural Network, January-March 2014, and Intercalibration Report, Winter 2014

Report for Department for Environment, Food and Rural Affairs, the Scottish Government, the Welsh Government, the Northern Ireland Department of Environment

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Executive summary

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

Ratified hourly average data capture for the network averaged 89.72% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the 3-month reporting period January-March 2014. Average data capture for all pollutants except $PM_{2.5}$ were above 85%. There were 24 stations with data capture less than 85% for the period (34 below 90%).

A total of 135 monitoring stations in the AURN operated during this quarter, of which 74 were Local Authority owned stations affiliated to the national network. Some are co-located and separately named gravimetric particulate analysers at stations with automatic analysers. Many affiliated stations have additional Defra-funded analysers installed on site.

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

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Section A Data Ratification Report, January-March 2014

1 Introduction Data Ratification Report

This quarterly report covers the Quality Assurance and Quality Control (QA/QC) activities undertaken by Ricardo-AEA to ratify automatic monitoring data from Defra and the Devolved Administrations' Automatic Urban and Rural air quality monitoring Network (AURN) for the period 1 January – 31 March 2014. During this quarter there was a total of 135 operational monitoring stations in the network, at which 381 automatic analysers were in use. Eleven stations have non-automatic gravimetric particulate samplers (Partisols); at four stations (Auchencorth Moss, Harwell, London North Kensington and Marylebone Road) these are co-located with FDMS analysers for both PM_{10} and $PM_{2.5}$.

1.1 Overview of Network Performance

Ratified hourly average (daily average for Partisols) data capture for the network averaged 89.72% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the three-month reporting period January-March 2014 (see Table 1.1). All species except $PM_{2.5}$ achieved 85 % or higher data capture on average. 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 yet calculated. For stations starting or closing during the period, the data capture is based on the actual date starting or closing.

Table 1.1: AURN Ratified Data Capture (%) by Quarter, January-March 2014

	CO	PM_{10}	$PM_{2.5}$	NO_2	O_3	SO_2	Mean
Q1 2014	95.35	85.45	83.51	94.31	95.01	90.02	89.72

Overall, 301 out of the 381 analysers (79%) achieved data capture levels above the required 85% target during this reporting period. Table 1.2 shows the number of analysers which did not meet the target.

Table 1.2: Number of Analysers with Data Capture below 85%

Total Number Of Analysers		Q1 Jan-Mar 2014 (No. below 85%)
CO	7	1
NO_2	116	8
O_3	79	6
PM_{10}[1]	70	24
$PM_{2.5}$[1]	80	35
SO_2	29	6
Total <85%		80

[1] Includes FDMS, BAM and Partisol analysers.

In total, 30 out of the 136 operational network stations in the quarter (18%) had an average data capture rate below the required 90% level for the January-March 2014 period.

1.2 Changes to Ratified Data

The following data from previous quarters have been changed as a result of the ratification process for this quarter:

- Middlesbrough PM_{10}, deleted 1 November-31 December 2013; high volatiles.
- Oxford St Ebbes PM_{10}, deleted 6 Oct-31 December 2013, low volatiles possibly due to drier fault.
- Rochester Stoke $PM_{2.5}$, deleted 5-31 December 2013, $PM_{2.5}$ higher than PM_{10}.
- Swansea Roadside, PM_{10} and $PM_{2.5}$, rescaled 1 August-31 December 2013, low flowrates.

A list of changes to ratified data is given at http://uk-air.defra.gov.uk/data/changes-to-ratified-data .

1.1 Changes to the Network for Directive Compliance

An ongoing programme of changes to the AURN is under way, to ensure it continues to be compliant with the requirements of the European Union's Air Quality Directive (EU Directive 3008/50/EC). However, no new stations were commissioned during the period covered by this report.

2 Background Information

2.1 AURN Hub and LSO Manual

The AURN Hub is a password protected website for the use of AURN contractors including Local Site Operators (LSOs) and Equipment Support units.

The LSO manual is available via the AURN Hub at http://uk-air.defra.gov.uk/reports/empire/lsoman/lsoman.html. Current versions of the LSO calibrations spreadsheet are also available to download from the LSO manual page of the Hub.

2.2 Monitoring Station Information

All information on monitoring stations is now uploaded to Central Management and Control Unit (CMCU)'s database and Defra's online air quality archive UK-AIR for dissemination using Google Earth. Ricardo-AEA makes considerable effort in ensuring that site locations are accurate on the new Google Earth site information and UK-Air archive pages. All future additions to the AURN will include accurate positioning using Google Earth.

3 Generic Data Quality Issues

3.1 FDMS Performance Issues

Several FDMS analysers continued to give problems during the quarter. Out of 150 operational analysers, 59 had data capture less than 90% (39 less than 85%). However, *average* data capture for both $PM_{2.5}$ and PM_{10} were above 90% for this quarter.

3.2 Precision of Gaseous Data

During 2013, the data logging systems of sites in the AURN were updated (where necessary) to provide raw data to one decimal place (two for carbon monoxide), rather than as integers (one decimal place for CO) as had previously been the case. As of 1 January, raw data from the following sites were still being supplied as integer values to the QA/QC Unit:

1. Carlisle Roadside
2. Chesterfield (though this is currently closed)
3. Horley
4. Newcastle Cradlewell Roadside
5. Newport
6. Rochester Stoke (currently to 0.5 ppb)
7. Scunthorpe (0.5 ppb)
8. Sunderland Silksworth
9. Warrington
10. Salford Eccles
11. York Fishergate

It is anticipated that, where necessary, these sites will be upgraded during the summer 2014 service round.

4 Station Specific Issues

In this section, we discuss in turn specific station issues for the following geographic groupings – London, England (excluding London), Scotland, Northern Ireland and Wales. Where analysers were commissioned during the period, the stated data capture for these instruments is calculated from the date of commissioning. In the following tables, analysers with data capture less than 90% are highlighted in yellow and those with data capture less than 85% are highlighted in orange.

4.1 London

4.1.1 Data Capture

The data capture for stations in London (within the M25) for the period January-March 2014 is given in Table 4.1:

Table 4.1 Data Capture for London, January-March 2014 (%)

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Camden Kerbside		96.85	97.59	99.63			98.02
Haringey Roadside		81.25	81.94	99.44			87.55
London Bexley			74.12	99.58		86.02	86.57
London Bloomsbury		90.97	91.06	98.29	98.38	97.92	95.32
London Eltham			83.98	98.75	99.77		94.17
London Haringey Priory Park South				99.40	99.49		99.44
London Harlington		91.67	94.44	94.26	95.28		93.91
London Harrow Stanmore			55.23				55.23
London Hillingdon				94.40	98.47		96.44
London Marylebone Road	97.31	91.11	95.83	96.57	91.76	93.70	94.38
London Marylebone Road Partisols		94.44	97.78				96.11
London N. Kensington	98.24	87.64	92.22	92.08	98.29	97.50	94.33
London N. Kensington Partisols		100.00	100.00				100.00
London Teddington				98.56	42.13		70.35
London Teddington Bushy Park			12.41				12.41
London Westminster			100.00	98.33			98.40
Southwark A2 Old Kent Road		86.81		59.40			73.10
Tower Hamlets Roadside				99.68			99.68
Number of Sites	**2**	**9**	**13**	**14**	**8**	**4**	**18**
Number of sites < 85 %	**0**	**1**	**5**	**1**	**1**	**0**	**4**
Number of sites < 90%	**0**	**3**	**5**	**1**	**1**	**1**	**6**
Network mean	**97.78**	**91.19**	**82.82**	**94.88**	**90.45**	**93.78**	**85.86**

4.1.2 Station Specific Issues

Haringey Roadside

The PM_{10} FDMS suffered several flow or leak-related faults during the quarter Both FDMS instruments also had an extended zero check from 18 February to 6 March while checks on instrument performance were made post-repair.

London Bexley

The analyser was found to have a valve position fault on 9 February, once repaired a zero check was carried out until 25 February.

London Harrow Stanmore

A zero filter was installed at the audit on 19 February. The LSO was unable to access the site until 31 March to remove it.

London Teddington

At the winter QA/QC audit on 20 February 2014, the ozone sample inlet was found to be connected to the wrong port on the analyser. Data have been deleted back to the autumn 2014 audit on 2 October 2014.

London Teddington Bushy Park

The FDMS $PM_{2.5}$ data have been very noisy since installation of other equipment in the cabin. This is believed to be due to inadequate air conditioning in the cabin.

Southwark A2 Old Kent Road

The NOx converter was found to have failed at the audit on 5 February. The ESU did not effect repairs at the subsequent service, and it was not until 11 March that a new converter was fitted.

4.2 England (excluding London)

4.2.1 Data Capture

The data capture for stations in England for the period January-March 2014 is given in Table 4.2:

Table 4.2 Data Capture for England, January-March 2014

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Barnsley Gawber				98.06	98.10	46.94	81.03
Barnstaple A39		93.10	98.61				95.86
Bath Roadside				98.29			98.29
Billingham				77.92			77.92
Birmingham Acocks Green			97.13	97.92	97.69		97.58
Birmingham Tyburn		95.69	94.40	98.70	89.81	98.89	95.50
Birmingham Tyburn Roadside		84.58	60.14	97.82	96.44		84.75
Blackburn Darwen Roadside				99.44			99.44
Blackpool Marton			41.71	94.12	95.32		77.05
Bottesford					99.07		99.07

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Bournemouth			96.67	98.43	98.52		98.44
Brighton Preston Park			97.78	98.43	98.33		98.37
Bristol St Paul's		85.09	86.30	98.10	98.38		91.97
Cambridge Roadside				98.61			98.61
Canterbury				98.47	99.81		99.14
Carlisle Roadside		70.19	70.37	72.27			70.94
Charlton Mackrell				98.52	99.31		98.91
Chatham Centre Roadside		99.17	99.26	95.51			97.98
Chesterfield		85.56	89.49	99.68			91.57
Chesterfield Roadside		97.45	97.18	93.80			96.14
Coventry Memorial Park			87.64	95.42	96.16		93.07
Eastbourne		92.96	90.60	98.84			94.14
Exeter Roadside				98.70	99.77		99.24
Glazebury				94.17	98.56		96.37
Great Dun Fell					93.70		93.70
Harwell		90.23	92.87	97.31	97.50	97.36	95.06
Harwell		96.67	94.44				95.56
High Muffles				98.52	98.52		98.52
Honiton				98.66			98.66
Horley				98.75			98.75
Hull Freetown		90.05	90.19	97.08	90.60	58.33	85.25
Ladybower				98.38	98.66	98.47	98.50
Leamington Spa		93.66	93.56	83.24	95.79		91.56
Leamington Spa Rugby Road		88.38	88.66	94.03			90.35
Leeds Centre	97.31	94.03	94.12	92.87	97.50	97.31	95.52
Leeds Headingley Kerbside		96.34	96.57	99.63			97.52
Leicester University			89.31	98.24	98.33		95.29
Leominster				96.34	98.52		97.43
Lincoln Canwick Road				96.99			96.99
Liverpool Queen's Drive Roadside				98.06			98.06
Liverpool Speke		92.18	92.18	97.13	97.08	96.34	94.98
Lullington Heath				93.75	98.66	94.54	95.65
Manchester Piccadilly			91.71	92.73	96.90	97.31	94.66
Manchester South				98.38	82.18		90.28
Market Harborough				98.10	97.78		97.94
Middlesbrough		13.01	80.37	91.48	91.20	96.94	74.60
Newcastle Centre		92.87	92.59	97.08	96.81		94.84
Newcastle Cradlewell Roadside				91.90			91.90
Northampton Kingsthorpe			92.22	99.40	99.54		99.32
Norwich Lakenfields		71.11	67.13	98.47	98.66		83.84
Nottingham Centre		94.95	91.53	97.22	97.13	43.15	84.80
Oxford Centre Roadside				92.04			92.04
Oxford St Ebbes		0.00	61.39	98.43			53.27

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Plymouth Centre		64.35	45.83	98.19	98.33		76.68
Portsmouth		83.80	81.67	33.19	98.75		74.35
Preston			89.40	98.15	98.52		95.35
Reading New Town		95.88	84.21	98.33	98.47		94.22
Rochester Stoke		99.40	46.76	93.56	98.15	97.78	87.13
Salford Eccles		95.93	95.88	98.15			96.65
Saltash Callington Road		95.93	81.71				88.82
Sandy Roadside		82.59	95.14	98.80			92.18
Scunthorpe Town		95.42		96.99		59.44	83.95
Sheffield Devonshire Green		70.23	85.60	97.13	97.13		87.52
Sheffield Tinsley				98.15			98.15
Sibton					99.86		99.86
Southampton Centre		95.19	91.02	92.59	96.85	97.22	94.57
Southend-on-Sea			97.55	96.39	97.31		97.08
St Osyth				97.96	97.78		97.87
Stanford-le-Hope Roadside		97.04	96.25	98.15			97.15
Stockton-on-Tees Eaglescliffe		95.37	95.42	98.47			96.42
Stoke-on-Trent Centre		97.04	75.74	97.31	97.55		91.91
Storrington Roadside		96.25	94.07	59.68			83.33
Sunderland Silksworth			92.64	99.58	91.11		94.44
Thurrock		99.63		95.32	98.47	98.24	97.92
Walsall Woodlands				99.68	99.68		99.68
Warrington		93.80	94.07	99.44			95.77
Weybourne					99.95		99.95
Wicken Fen				82.82	97.36	82.73	87.64
Wigan Centre			92.69	97.36	98.75		96.27
Wirral Tranmere			6.16	98.33	98.47		67.65
Yarner Wood				96.16	98.61		97.38
York Bootham		90.60	96.90				93.75
York Fishergate		97.31	97.36	90.65			95.11
Number of Sites	**1**	**40**	**50**	**75**	**51**	**15**	**82**
Number of sites < 85 %	0	10	13	7	1	4	14
Number of sites < 90%	0	13	20	7	2	4	19
Network mean	**97.31**	**84.25**	**85.07**	**93.44**	**97.12**	**87.60**	**91.32**

4.2.2 Station Specific Issues

Barnsley Gawber

The SO_2 data for much of the quarter was noisy and erratic; data from 1 January to 15 February have been deleted.

Billingham

A leak was found in the analyser, which required workshop repair, Data have been lost from 12 February to 3 March, where a “hot spare” analyser was installed.

Birmingham Tyburn Roadside

Both $PM_{2.5}$ and PM_{10} analysers were identified as regional outliers for much of this quarter; data have been deleted.

Blackpool Marton

Following an extended period of poor performance, the FDMS was removed for workshop repair on 8 January, and returned to site on 20 February.

Carlisle Roadside

The power supply to the site was disconnected on 9 February and reconnected again on 3 March.

Hull Freetown

SO_2 data between 12 February and 19 March were lost due to a backing paper being installed in the analyser along with the particulate filter.

Middlesbrough

The sample inlet was changed on 30 January resulting in a strep change in the NOx data; investigations are ongoing. During ratification the PM_{10} volatile concentrations were found to be excessively high compared to the $PM_{2.5}$ volatiles; PM_{10} data have been deleted from 1 January to 14 March, where concentrations returned to more acceptable levels.

Norwich Lakenfields

The $PM_{2.5}$ FDMS analyser suffered from loss of firmware on 24 February and ultimately had to be removed for workshop repair, returning to site on 3 April. The PM_{10} data became unstable on start of the zero check on 7 February; the subsequent service failed to improve the data and problems continued up to 3 March when a leak was found in the flow controller.

Nottingham Centre

The site SO_2 analyser performed very poorly during the quarter due to failure of the main control board, which caused multiple temperature faults.

Oxford St Ebbes

Both $PM_{2.5}$ and PM_{10} volatile data appeared low up to the drier replacement in May 2014. The air conditioning fault may be a contributory factor in this quarter. PM_{10} data have been deleted for the entire quarter (as well as back into 2013, and into the second quarter of 2014), and $PM_{2.5}$ from 25 February to the end of the quarter.

Plymouth Centre

Both FDMS analysers, particularly the $PM_{2.5}$, have suffered from poor performance during this quarter, and ongoing into subsequent months. Despite several visits from the ESU, data remained noisy with frequent spikes in the volatile fraction or negative volatile concentrations.

Rochester Stoke

A step change in the $PM_{2.5}$ data occurred at the LSO visit on 5 December, which was rectified at the service on 17 February. Data between these dates have been deleted.

Saltash Callington Road

Following the zero check on 17 January, the $PM_{2.5}$ analyser became unstable and noisy, and data have been deleted up to 31 January.

Scunthorpe Town

The SO_2 analyser suffered a lamp failure on 26 February, which was not resolved until mid-May.

Sheffield Devonshire Green

Flow sensor and pump faults with the $PM_{2.5}$ FDMS, and a drier replacement in the PM_{10} FDMS resulted in the loss of some data this quarter.

Storrington Roadside

The NOx analyser experienced a blocked capillary on 26 February, then a leaking converter and a processor fault was diagnosed. The analyser was eventually removed for workshop repair resulting in considerable data loss in this and the subsequent quarter.

Wicken Fen

The NOx analyser suffered a photomultiplier failure in January, along with a faulty auto calibration valve. Although a replacement SO_2 analyser was installed in December to rectify very poor data, this analyser also proved unreliable in this quarter and further data was lost due to unspecified failures.

Wirral Tranmere

The zero filter was installed onto the sample head on 6 January at the audit, but when the filter was removed and head replaced, the sharp cut cyclone was not reattached to the inlet, meaning the analyser was measuring PM_{10} instead of $PM_{2.5}$. This was discovered by the QA/QC unit at the subsequent on 8 April, data between the audits have been deleted.

4.3 Scotland

4.3.1 Data Capture

The data capture for stations in Scotland for the period January-March 2014 is given in Table 4.3.

Table 4.3 Data Capture for Scotland, January-March 2014

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Aberdeen		72.64	75.51	97.87	88.94		83.74
Aberdeen Union Street Roadside				97.82			97.82
Auchencorth Moss		98.89	98.89		98.33		98.38
Auchencorth Moss (FDMS)		90.65	77.27				83.96
Bush Estate				95.60	98.70		97.15
Dumbarton Roadside				94.49			94.49
Dumfries				98.19			98.19
Edinburgh St Leonards	97.22	88.10	83.24	91.53	97.04	97.96	92.52
Eskdalemuir				96.90	98.66		97.78
Fort William				98.56	98.70		98.63
Glasgow Kerbside		85.88	74.63	97.27			85.93
Glasgow Townhead		58.80	88.38	97.31	97.31		85.45
Grangemouth		94.68	87.31	93.33		96.76	93.02
Grangemouth Moray				97.59			97.59
Inverness		97.78	80.00	99.40			98.59
Lerwick					0.00		0.00
Peebles				98.56	98.61		98.59
Strath Vaich					74.40		74.40
Number of Sites	**1**	**8**	**8**	**14**	**10**	**2**	**18**

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Number of sites < 85 %	0	2	5	0	2	0	4
Number of sites < 90%	**0**	**4**	**7**	**0**	**3**	**0**	**6**
Network mean	97.22	85.93	83.15	96.75	85.07	97.36	87.57

4.3.2 Station Specific Issues

Aberdeen

The PM_{10} data was noisy for some of the period and has been deleted during ratification. In addition the ozone analyser had a lamp failure, and the $PM_{2.5}$ FDMS a failed valve motor during March.

Auchencorth Moss

Problems with the air conditioning continued during the quarter. The $PM_{2.5}$ volatile concentrations were significantly higher than the PM_{10} volatiles; $PM_{2.5}$ data for the period 25 January-6 February were deleted during ratification.

Glasgow Kerbside

Continuing problems with the air conditioning unit resulted in the loss of data from both FDMS units.

Glasgow Townhead

The $PM_{2.5}$ analyser became very noisy following the zero checks on 23 January; this was cured on 26 February following replacement of the mass transducer. The PM_{10} analyser had periods of instability following the service in January.

Lerwick

The station is temporarily closed due to building works at the Observatory.

Strath Vaich

The ozone analyser and ancillary equipment were damaged by a lightning strike in December. The repaired analyser was reinstalled on 22 January.

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4.4 Wales

4.4.1 Data Capture

The data capture for stations in Wales for January-March 2014 is given in Table 4.4.

Table 4.4 Data Capture for Wales, January-March 2014

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Aston Hill				90.60	98.38		94.49
Cardiff Centre	96.99	92.27	92.69	97.36	95.37	96.02	95.12
Chepstow A48		88.47	85.46	99.40			91.11
Cwmbran				98.43	99.81		99.12
Narberth		96.16		95.69	98.47	97.87	97.05
Newport		86.53	86.34	97.87			90.25
Port Talbot Margam (PM_{10} Partisol)		94.44					94.44
Port Talbot Margam	83.06	98.43	30.05	94.54	98.24	98.33	83.77
Swansea Roadside		96.44	96.11	98.33			96.96
Wrexham		97.78	91.11	95.23		96.90	96.00
Number of Sites	**2**	**8**	**6**	**9**	**5**	**4**	**10**
Number of sites < 85 %	**1**	**0**	**1**	**0**	**0**	**0**	**1**
Number of sites < 90%	**1**	**2**	**3**	**0**	**0**	**0**	**1**
Network mean	**90.02**	**93.81**	**80.29**	**96.38**	**98.06**	**97.28**	**93.76**

4.4.2 Station Specific Issues

Port Talbot Margam

The CO analyser was removed from site for a workshop repair to the infrared source from 17 to 26 March. The $PM_{2.5}$ data was send to be higher than the PM_{10} during this quarter; $PM_{2.5}$ data have been deleted from the audit on 22 January up to the new drier being fitted on 26 March.

4.5 Northern Ireland (including Mace Head)

4.5.1 Data Capture

The data capture for stations in Northern Ireland (including Mace Head in the Republic of Ireland) for the period October to December 2014 is given in Table 4.5.

Table 4.5 Data Capture for Ireland, January-March 2014

Name	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Armagh Roadside		80.74		95.56			88.15
Ballymena Ballykeel						99.77	99.77
Belfast Centre	97.31	95.42	96.34	88.98	96.62	97.27	95.32
Derry		78.06	91.99	98.80	99.54	93.52	92.38
Lough Navar		90.60			97.13		93.87
Mace Head					97.61		
Number of Sites	**1**	**4**	**2**	**3**	**4**	**3**	**5**
Number of sites < 85 %	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Number of sites < 90%	**0**	**2**	**0**	**1**	**0**	**0**	**1**
Network mean	**97.31**	**86.20**	**94.17**	**94.44**	**97.76**	**96.85**	**93.90**

4.5.2 Station Specific Issues

Armagh Roadside

The zero check was carried out for 12 days which is longer than usual; in addition, some noisy data were deleted during ratification.

4.6 Overall Data Capture

Overall data capture for each pollutant across the network for the quarter is given in Table 4.6.

Table 4.6 Overall Data Capture, January-March 2014

	CO	PM_{10}	PM_{25}	NO_2	O_3	SO_2	Average
Number of Stations	7	70	80	116	79	29	135
Number of stations < 85 %	1	14	24	7	4	5	23
Number of stations < 90%	1	23	35	8	6	6	33
Network mean	95.35	85.45	83.51	94.31	95.01	90.02	89.72

Section B – Winter 2014 Intercalibration Report

5 Introduction to Intercalibration Exercise

During January to March 2014, Ricardo-AEA undertook an intercalibration of 135 monitoring stations in operation in the Defra and the Devolved Administrations Automatic Urban and Rural Monitoring Network (AURN). The intercalibration exercise is a vital step in the process of data ratification. The monitoring station audits are used to undertake a number of analyser and infrastructure performance checks that cannot be performed by Local Site Operators, with a view to ensuring confidence in the accuracy, consistency and traceability of air pollution measurements made at all the monitoring stations.

The intercalibration requires the coordination and close cooperation of QA/QC unit, both Central Management and Control Units, ESU's and LSO's in making sure the entire operation runs smoothly. This is the result of many months of planning. Leading up to the intercalibration, a draft schedule of visits is prepared and circulated to Management Units (MU')s and ESU's for approval. All QA/QC equipment and cylinders to be used in the intercalibration are first tested, calibrated and verified before use. The QA/QC unit's ozone photometers (used in checking and calibration of ozone analysers) are tested independently against national standards, by the National Physical Laboratory. ESU ozone photometers are calibrated at Ricardo-AEA using Ricardo-AEA's photometers as a transfer standard.

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 may attend, 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 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.

There is some ongoing restructuring of the network, but none since the summer intercalibration.

6 Scope of Intercalibration Exercise

6.1 QA/QC Site Visits

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 200 ppb 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 not provide high quality data which may be difficult to process at lower concentrations.
4. Analyser response time. This test checks that the analyser responds quickly to a change in gas concentrations. If analyser response is too slow, data may not accurately reflect ambient concentrations.
5. Leak and flow checks. These tests ensure that ambient air reaches the analysers, without being compromised in any way. Leaks in the sampling system can affect the ability of the analyser to sample ambient air reliably.
6. NOx analyser converter efficiency. This test evaluates the ability of the analyser to measure NO_2. An inefficient converter severely compromises the data from the analyser.
7. FDMS k_0 evaluation. The analyser uses this factor to calculate mass concentrations, so the value is calculated to determine its accuracy compared to the stated value.
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-AEA 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 LSO's 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.

6.2 Network Intercomparison Exercise

Once all data have been collected, a "Network Intercomparison" 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-AEA, and allow us 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 intercomparison 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 the web/interactive TV services.
- 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 ko 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 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.

6.3 FDMS Baseline Checks

As part of the QA/QC remit for continuous improvement, an *ad hoc* study of PM analyser baseline response has been undertaken for the past 2 years. This study has been 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 has become clear that, on a daily mean basis, regional reference PM concentrations regularly reach a minimum value that approaches 0 µg m^{-3}.

With this information, stations where this observation was not true were "zero calibrated" using high efficiency scrubbers installed on the sample inlets. The results of these calibrations have been used to compare against the analyser baseline responses and, in all comparisons, calibration and baseline show excellent agreement.

The detection limit is calculated by multiplying the standard deviation of the zero calibration by 3.3. Typical results show that a 'healthy' FDMS should have a detection limit of less than 5 µg m^{-3}.Recent European guidance (CEN TS16450) provides a recommendation that zero tests on PM analysers should yield a result no higher than 3 µg m^{-3}, which provides the AURN with a robust performance limit for data ratification.

A list of stations where the analysers gave an average zero response of more than 3 µg m^{-3} is given in the subsequent section.

7 Results

The results section has been restructured to allow easier regional analysis. As well as a detailed national summary, a regional summary and breakdown outlier analysis is provided.

7.1 National Network Overview

7.1.1 Summary

The results of the intercalibration are summarised in Table 7.1 below:

Table 7.1 - Summary of audited analyser performance – 135 UK stations

Parameter	Number of outliers	Number in network	% outliers in total
NOx analyser	18	117	15 (31)%
CO analyser	0	9	0%
SO_2 analyser	6	30	20 (27)%
Ozone analyser	23	82	28 (17)%
FDMS and BAM analysers	3 k_0, 6 flow, (12 zero)	58 FDMS PM_{10} 2 BAM PM_{10} 69 FDMS $PM_{2.5}$ 2 BAM $PM_{2.5}$	7 (3)%
Gravimetric PM analysers	0 flow	9 PM_{10} 9 $PM_{2.5}$	0%
Total	56	387	14.5%

Two of the 135 sites were not in operation at the time of the intercalibration. Replacement locations are currently being sought for the sites at Bury Roadside and Glasgow Centre.

There are currently no gravimetric measurements of PM_{10} or $PM_{2.5}$ at either of the Glasgow monitoring stations.

The number of analyser outliers identified is better than the previous exercise. At the Summer 2013 intercalibration 16.0% of the analysers in use were identified as outliers.

The procedures used to determine network performance are documented in Ricardo-AEA Work Instructions. These methods are regularly updated and improved and are evaluated by the United Kingdom Accreditation Service (UKAS). Ricardo-AEA holds ISO17025 accreditation for the on-site calibration of all the analyser types (NOx, CO, SO_2, O_3) and for the determination of the FDMS k_0 factor and particulate analyser flow rates used in the network. An ISO17025 certificate of calibration (Calibration Laboratory number 0401) for the analysers in the AURN is appended to this report.

7.1.2 Network Intercomparisons

The concentration of the audit cylinders was calculated averaged across all monitoring sites 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 7.2. Certified cylinder concentrations are normalised for this purpose as several cylinders are used.

Table 7.2 Audit Cylinder Results

Parameter	Network Mean	Audit reference concentration	Network Accuracy %	%Std Dev
NO	469 ppb	462 ppb	1.6	4.3
NO_2	402 ppb	411 ppb	-2.3	4.9
CO	21.6 ppm	21.3 ppm	1.4	4.2
SO_2	467 ppb	448 ppb	4.2	4.8

- Oxides of Nitrogen.

  A total of 18 outliers (15%) were identified during this intercalibration. This is significantly better than the previous exercise - 31% of the analysers were identified as outliers in the summer exercise. Of these outliers, 9 can be attributed to analyser drift, 6 to changes in site cylinder concentration and 3 to issues experienced during the audit which compromised the results.

  There were 2 converters which fell outside the ±5% acceptance limits. There were 3 further converters identified where the initial result was outside the ±2% trigger for NO_2 rescaling. Additional analysis showed that a total of two outlier converters required rescaling or data deletion to be undertaken.

- Carbon Monoxide

  There were no outliers identified at this intercalibration. No outliers were identified at the previous exercise.

- Sulphur Dioxide

  A total of 6 outliers (20%) were identified at this intercalibration. This is slightly worse than the winter exercise, when 8 analysers were found to be outside the acceptance limits. All m-xylene interference tests were less than 20ppb, compared to 18ppb in summer 2013.

- Ozone

  A total of 23 outliers (28%) were identified during the winter exercise. This is worse than the previous intercalibration, where 14 analysers were found to be outside the ±5% acceptance criterion.

- Particulate Analysers

  There were three calculated k_0 determinations outside the required ±2.5% of the stated values. No outliers were identified at the previous exercise.

Three FDMS main flows were found to be outside the ±10% acceptance limits. Three BAM total flows were found to be outside this limit. This total is worse than the previous exercise; four analyser flow outliers were identified in the summer.

All Partisol analyser total flows were within the acceptance limits.

- PM analyser zero tests

A total of 21 analysers gave average responses to particle-free air that were higher than ±3 µg m^{-3}. This is much better than the previous exercise, where 33 responses were higher than 3 µg m^{-3}. These results will be fed into the ratification process to determine appropriate action. A list of analysers failing this test is given in Table 7.3

Table 7.3 Particle Analysers with Zero Above 3 µg m^{-3}, Winter 2014

Site		Zero average µg m^{-3}
Birmingham Tyburn Roadside 21-23 Jan 14	$PM_{2.5}$	4.4
Derry 20-24 Feb 14	$PM_{2.5}$	4.2
Edinburgh St Leonards 4-7 Feb 14	PM_{10}	3.7
Glasgow Townhead 21-23 Jan 14	PM_{10}	3.4
Leeds Headingley Kerbside 14-16 Jan 14	PM_{10}	3.1
Liverpool Speke 9-13 Jan 14	PM_{10}	4
London Bexley 14-25 Feb 14	$PM_{2.5}$	3
London N Kensington 31 Jan-3 Feb 14	PM_{10}	8.9
London Teddington Bushy Park 24-28 Feb 14	$PM_{2.5}$	3.1
Lough Navar 19-24 Feb 14	PM_{10}	5
Middlesbrough 29-31 Jan 14	PM_{10}	3.8
Newport St Julians 23-27 Jan 14	PM_{10}	3.3
Newport St Julians 23-27 Jan 14	$PM_{2.5}$	4.7
Norwich Lakenfields 5-7 Feb 14	PM_{10}	3.1
Oxford St Ebbes 25 Feb - 4 Mar 14	PM_{10}	4.8
Oxford St Ebbes 25 Feb - 4 Mar 14	$PM_{2.5}$	5.4
Portsmouth 25-28 Feb 14	PM_{10}	6
Salford Eccles 14-17 Jan 14	$PM_{2.5}$	3
Southampton Centre 26-28 Feb 14	PM_{10}	3.1
Storrington Roadside 28-31 Jan 14	PM_{10}	6.2
Warrington 9-13 Jan 14	$PM_{2.5}$	3.2

- Site Cylinder Concentrations

17 of the 273 site cylinders (6.2%) used to scale ambient pollution data were found to be outside the ±10% acceptance limit, worse than the 4.3% identified in the summer.

7.2 London Sites

The results of the intercomparison for the 16 London sites in operation at the time of the intercalibration are summarised below:

Table 97.4 - Summary of audited analyser performance – London Sites

Parameter	Number of outliers	Number in region
NOx analyser	4	13
NOx converter	1	
CO analyser	0	3
SO_2 analyser	2	4
Ozone analyser	1	9
FDMS and BAM analysers	0 k_0, 0 flow (1 zero)	6 FDMS PM_{10} 10 FDMS $PM_{2.5}$
Gravimetric PM analysers	0	2 PM_{10} 3 $PM_{2.5}$
Cylinders	4	37

7.3 Scottish Sites

The results of the intercomparison for the 18 Scottish sites are summarised below:

Table 7.5 - Summary of audited analyser performance – Scottish Sites

Parameter	Number of outliers	Number in region
NOx analyser	3	14
NOx converter	0	
CO analyser	0	2
SO_2 analyser	0	3
Ozone analyser	3	10
FDMS and BAM analysers	1 k_0, 0 flow (1 zero)	6 FDMS PM_{10} 6 FDMS $PM_{2.5}$
Gravimetric PM analysers	0	4 PM_{10} 4 $PM_{2.5}$
Cylinders	1	33

7.4 Welsh Sites

The results of the intercomparison for the 10 Welsh sites are summarised below:

Table 7.6 - Summary of audited analyser performance – Welsh Sites

Parameter	Number of outliers	Number in region
NOx analyser	1	10
NOx converter	0	
CO analyser	0	2
SO_2 analyser	1	4
Ozone analyser	0	6
FDMS and BAM analysers	0 k_0, 3 flow (1 zero)	5 FDMS PM_{10} 1 BAM PM_{10} 3 FDMS $PM_{2.5}$ 1 BAM $PM_{2.5}$
Gravimetric PM analysers	0	2 PM_{10} 1 $PM_{2.5}$
Cylinders	1	26

7.5 Northern Ireland Sites (incl. Mace Head)

The results of the intercomparison for the 5 Northern Irish sites and Mace Head are summarised below:

Table 7.7 - Summary of audited analyser performance – Northern Irish Sites

Parameter	Number of outliers	Number in region
NOx analyser	0	3
NOx converter	0	
CO analyser	0	1
SO_2 analyser	0	3
Ozone analyser	0	4
FDMS and BAM analysers	0 k_0, 0 flow (2 zero)	4 FDMS PM_{10} 1 FDMS $PM_{2.5}$
Gravimetric PM analysers	0	0 PM_{10} 0 $PM_{2.5}$
Cylinders	0	9

7.6 English Sites

The results of the intercomparison for the 86 English sites are summarised below:

Table 7.8 - Summary of audited analyser performance – English Sites

Parameter	Number of outliers	Number in region
NOx analyser	10	76
NOx converter	1	
CO analyser	0	1
SO_2 analyser	3	16
Ozone analyser	19	53
FDMS and BAM analysers	2 k_0, 3 flow (7 zero)	37 FDMS PM_{10} 1 BAM PM_{10} 46 FDMS $PM_{2.5}$ 1 BAM $PM_{2.5}$
Gravimetric PM analysers	0	1 PM_{10} 4 $PM_{2.5}$
Cylinders	11	191

As noted earlier, the results from the intercalibration exercises are used to inform the entire data ratification process. Any actions required as a result of the intercalibration findings are discussed in the ratification section of this report.

8 Site Cylinder Concentrations

During the intercalibration, the concentrations of the on-site cylinders were evaluated using the audit cylinder standards. The calculated results showed that 17 of the 273 cylinders (6.2%) used to scale analyser data into concentrations (NO, CO and SO_2) were outside the ±10% acceptance criterion. This is worse than the winter exercise, where 4.3% (12) of the scaling cylinders were outside the acceptance limits. There were 9 NO cylinders identified as outliers.

In addition, the concentrations of 28 NO_2 cylinders appeared to have drifted by more than 10%. NO_2 cylinders are not used for the scaling of data and so will not be replaced at this time. Hence, a total of 45 of the 273 cylinders (16.5%) were outside the acceptance limits. This is worse than the previous intercalibration, when 13.5% of cylinders were found to be outside the 10% acceptance.

Of the 9 NO cylinders, two appeared to have been contaminated (Birmingham Tyburn and Edinburgh St Leonards); significant oxidation of the NO into NO_2 has occurred since the last intercalibration. The cylinders have been replaced and the performance of the new cylinders will be closely monitored at subsequent audits.

Three cylinders showed significant drift and have been replaced.

The remaining four NO cylinders and the 8 SO_2 cylinders will be checked at the next audits and appropriate action taken if necessary.

9 Measurement Uncertainties

The European Committee for Normalisation (CEN) has 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 EN14211:2005 (NOx), BS EN14212:2005 (SO_2), BS EN14626:2005 (CO) and BS EN14625:2005 (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 referred to 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 are compliant. Older, non-compliant equipment still on site after this date needed to be replaced before June 2013. Ricardo-AEA 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 intercomparisons 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 sites that have CEN-compliant gaseous instrumentation, it is possible to calculate the overall uncertainty of measuring air quality. This information is site- and analyser-specific and presented in the table below:

Table 9.1 – Analyser measurement uncertainties

Date	Site	O_3	CO	SO_2	NO_2 annual	NO_2 hour	PM_{10}	$PM_{2.5}$
20-Jan	Barnsley Gawber	10.7		13.4	10	10		
16-Jan	Bath Roadside				13.5	14		
28-Jan	Billingham				13.5	14		
20-Jan	Birmingham Acocks Green	12.4			13.5	14		16.4
21-Jan	Birmingham Tyburn	8.7		12.3	11.8	11.8	8.7	16.4
21-Jan	Birmingham Tyburn Roadside	12.4			13.5	14	8.7	16.4
15-Jan	Blackburn Darwen Roadside				10.5	10.5		
14-Jan	Blackpool Marton	10.7			10	10		No test
25-Feb	Bottesford	10.7						
27-Feb	Bournemouth	12.4			13.5	14		11
28-Jan	Brighton Preston Park	12.4			13.5	14		11
16-Jan	Bristol St Paul's	12.4			13.5	14	8.7	No test
04-Feb	Cambridge Roadside				10.5	10.5		
19-Feb	Camden Kerbside				10.5	10.5	8.7	16.4
10-Feb	Canterbury	12.4			13.5	14		
13-Jan	Carlisle Roadside				10.5	10.5	8.7	16.4
11-Feb	Charlton Mackrell	11.8			13.5	14		
11-Feb	Chatham Centre Roadside				13.5	14	8.7	16.4
21-Jan	Chesterfield				10.5	10.5	8.7	16.4
21-Jan	Chesterfield Roadside				10.5	10.5	8.7	16.4

Date	Site	O_3	CO	SO_2	NO_2 annual	NO_2 hour	PM_{10}	$PM_{2.5}$
18-Feb	Coventry Memorial Park	10.7			10	10		No test
29-Jan	Eastbourne				13.5	14	8.7	16.4
15-Jan	Exeter Roadside	8.7			11.8	11.8		
16-Jan	Glazebury	12.4			failed	test		
02-Jul	Great Dun Fell	12.4						
18-Feb	Haringey Roadside				10.5	10.5	8.7	16.4
12-Aug	Harwell	12.4		13.4	13.5	14	8.7	16.4
28-Jan	Harwell PARTISOL						8	11
29-Jan	High Muffles	12.4			13.5	14		
15-Jan	Honiton				13.5	14		
27-Jan	Horley				10.5	10.5		
14-Jan	Hull Freetown	10.7		13.4	10	10	8.7	16.4
22-Jan	Ladybower	12.4		13.4	13.5	14		
26-Feb	Leamington Spa	11.8			10.5	10.5	8.7	16.4
27-Feb	Leamington Spa Rugby Road				13.5	14	8.7	16.4
13-Jan	Leeds Centre	10.7	9.5	13.4	10	10	8.7	16.4
13-Jan	Leeds Headingley Kerbside				13.5	14	8.7	16.4
19-Feb	Leicester University	10.7			10	10		16.4
10-Feb	Leominster	12.4			13.5	14		
25-Feb	Lincoln Canwick Road				13.5	14		
09-Jan	Liverpool Queen's Drive Roadside				13.5	14		
09-Jan	Liverpool Speke	10.7		13.4	10	10	8.7	16.4
14-Feb	London Bexley			13.4	13.5	14		16.4
12-Feb	London Bloomsbury	12.4		13.4	13.5	14	10.38	26.38
27-Jan	London Eltham	11			10.5	10.5		16.4
18-Feb	London Haringey Priory Park South	11.8			13.5	14		
03-Jan	London Harlington	12.4			13.5	14	8.7	16.4
19-Feb	London Harrow Stanmore							16.4
06-Feb	London Hillingdon	33.72			10	10		
29-Jan	London Marylebone Road	12.4	9.5	13.4	13.5	14	8.7	16.4
29-Jan	London Marylebone Road PARTISOL						8	11
31-Jan	London N. Kensington	12.4	9.5	13.4	13.5	14	8.7	16.4
31-Jan	London N. Kensington PARTISOL						8	11
20-Feb	London Teddington	12.4			13.5	14		
20-Feb	London Teddington Bushy Park							16.4
04-Feb	London Westminster	No test			13.5	14		11
13-Feb	Lullington Heath	12.4		13.4	13.5	14		
15-Jan	Manchester Piccadilly	12.4		13.4	13.5	14		16.4
15-Jan	Manchester South	12.4			13.5	14		
20-Feb	Market Harborough	10.7			10	10		
29-Jan	Middlesbrough	12.4		13.4	13.5	14	8.7	16.4
27-Jan	Newcastle Centre	10.7			9.99	9.99	8.7	16.4
27-Jan	Newcastle Cradlewell Roadside				10.5	10.5		
17-Feb	Northampton Kingsthorpe	8.7			11.8	11.8		11

Date	Site	O_3	CO	SO_2	NO_2 annual	NO_2 hour	PM_{10}	$PM_{2.5}$
05-Feb	Norwich Lakenfields	10.7			10	10	8.7	16.4
24-Feb	Nottingham Centre	10.7		13.4	10	10	8.7	16.4
28-Feb	Oxford Centre Roadside				10.5	10.5		
25-Feb	Oxford St Ebbes				10.5	10.5	8.7	16.4
14-Jan	Plymouth Centre	10.7			10	10	8.7	16.4
25-Feb	Portsmouth	10.7			11.8	11.8	8.7	16.4
15-Jan	Preston	10.7			10	10		16.4
24-Feb	Reading New Town	10.7			10	10	8.7	16.4
11-Feb	Rochester Stoke			13.4	13.5	14	8.7	16.4
14-Jan	Salford Eccles	11.8			10.5	10.5	8.7	20.56
14-Jan	Saltash Callington Road						8.7	16.4
03-Feb	Sandy Roadside				13.5	14	11.48	16.4
13-Jan	Scunthorpe Town			11	10.5	10.5	8.7	
20-Jan	Sheffield Devonshire Green	10.7			10	10	8.7	16.4
21-Jan	Sheffield Tinsley				13.5	14		
05-Feb	Sibton	12.4						
26-Feb	Southampton Centre	10.7		13.4	10	10	8.7	16.4
13-Feb	Southend-on-Sea	10.7			10	10		16.4
05-Feb	Southwark A2 Old Kent Road				13.5	14	8.7	
13-Feb	St Osyth	10.7			10	10		
12-Feb	Stanford-le-Hope Roadside				13.5	14	36.48	16.4
28-Jan	Stockton-on-Tees Eaglescliffe				13.5	14	9.3	12.6
23-Jan	Stoke-on-Trent Centre	10.7			10	10	8.7	16.4
28-Jan	Storrington Roadside				10	10	8.7	16.4
28-Jan	Sunderland Silksworth	12.4			10.5	10.5		16.4
12-Feb	Thurrock	12.4		13.4	13.5	14	8.7	
13-Feb	Tower Hamlets Roadside				10.5	10.5		
22-Jan	Walsall Woodlands	12.4			13.5	14		
08-Jan	Warrington				10.5	10.5	8.7	16.4
06-Feb	Weybourne	10.7						
04-Feb	Wicken Fen	12.4		13.4	13.5	14		
14-Jan	Wigan Centre	12.4			10.5	10.5		16.4
06-Jan	Wirral Tranmere	10.7			10	10		31.6
12-Feb	Yarner Wood	12.4			13.5	14		
14-Jan	York Bootham						8.7	16.4
14-Jan	York Fishergate				10.5	10.5	8.7	16.4
26-Feb	Mace Head	Not approved						
19-Feb	Armagh Roadside				10.5	10.5	8.7	
18-Feb	Ballymena Ballykeel			11				
24-Feb	Belfast Centre	10.7	9.5	13.4	10	10	8.7	16.4
20-Feb	Derry	12.4		13.4	13.5	14	8.7	16.4
19-Feb	Lough Navar	12.4					8.7	
11-Feb	Aberdeen	12.4			13.5	14	8.7	16.4
11-Feb	Aberdeen Union Street Roadside				13.5	14		
05-Feb	Auchencorth Moss	12.4					8.7	16.4
05-Feb	Auchencorth Moss Partisol						8	11
05-Feb	Bush Estate	12.4			13.5	14		
20-Jan	Dumbarton Roadside				10.5	10.5		

Date	Site	O_3	CO	SO_2	NO_2 annual	NO_2 hour	PM_{10}	$PM_{2.5}$
13-Jan	Dumfries				13.5	14		
04-Feb	Edinburgh St Leonards	12.4	9.5	13.4	13.5	14	8.7	16.4
16-Jan	Eskdalemuir	12.4			13.5	14		
22-Jan	Fort William	12.4			13.5	14		
21-Jan	Glasgow Kerbside				15.3	15.3	8.7	16.4
21-Jan	Glasgow Townhead	10.7			13.76	14.24	8.7	16.4
03-Feb	Grangemouth			11	10.5	10.5	8.7	16.4
03-Feb	Grangemouth Moray				10.5	10.5		
12-Feb	Inverness				13.5	14	8	11
	Lerwick	No test						
04-Feb	Peebles	12.4			13.5	14		
05-Mar	Strath Vaich	12.4						
10-Feb	Aston Hill	12.4			13.5	14		
23-Jan	Cardiff Centre	12.4	9.5	13.4	13.5	14	8.7	16.4
24-Jan	Chepstow A48				10.5	10.5	8.7	16.4
23-Jan	Cwmbran	10.7			11.8	11.8		
07-Jan	Mold	12.4			13.5	14		
21-Jan	Narberth	12.4		13.4	13.5	14	10.02	
23-Jan	Newport				10.5	10.5	16.43	16.4
	Port Talbot Margam	10.7	9.5	13.4	13.5	14	8.7	16.4
22-Jan	Port Talbot Margam Partisol						8	
22-Jan	Swansea Roadside				13.5	14	36.44	13.33
07-Jan	Wrexham			13.4	13.5	14	8	11

This table is updated and extended after every intercalibration to include upgraded sites and replacement analysers.

The poor measurement uncertainty reported for the PM analysers at London Bloomsbury, Salford Eccles, Stanford-le-Hope Roadside, Wirral Tranmere and Swansea Roadside arose as a result of the very low measured flow rates at the audit. The significance of this will be examined fully during ratification.

The ozone analyser at Mace Head is not a CEN compliant model and therefore no generic performance data have been calculated.

10 Certification

The Network Certificate of Calibration is presented in Appendix 1. This certificate presents the results of the individual analyser scaling factors on the day of the audit, as calculated by Ricardo-AEA using the audit cylinder standards, in accordance with our ISO17025 accreditation.

Appendix 1 Certificate of Calibration

0401

Authorised Signatories: S Eaton

B Stacey

Signed:

Date of Issue: 04 August 2014

Customer Name and Address: John Newington

Atmosphere and Noise
Resource, Atmosphere and Sustainability
Department for Environment, Food and Rural Affairs
Area 2C Nobel House, 17 Smith Square, London, SW1P 3JR

Date of Calibration: January to March 2014

Description: Calibration factors for monitoring stations in the UK Automatic Urban and Rural Monitoring Network

The reported expanded uncertainties are based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95% The uncertainty evaluation has been carried out in accordance with UKAS requirements.

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory

1. Carbon Monoxide

Site	Date Year = 2014	Analyser number	[1]Zero output	Uncertainty (ppm)	[2]Calibration Factor	Uncertainty (%)	*Maximum Residual (%)
English Sites							
Leeds Centre	13-Jan	458	-0.4	0.2	0.937	2.9	3.3
London Sites							
London Marylebone Road	29-Jan	10073	1.0	0.2	1.009	2.2	1.8
London N. Kensington	31-Jan	2313	0.1	0.2	1.024	2.1	1.3
Northern Irish Sites							
Belfast Centre	24-Feb	462	-0.4	0.2	1.062	2.1	2.0
Scottish Sites							
Edinburgh St Leonards	04-Feb	159	0.1	0.2	1.040	2.5	1.7
Welsh Sites							
Cardiff Centre	23-Jan	1502	0.9	0.2	0.990	2.3	1.9
Port Talbot Margam	22-Jan	605214618	0.6	0.2	1.032	2.3	1.1

2. Sulphur Dioxide

Site	Date Year =2014	Analyser number	[1]Zero output	Uncertainty (ppb)	[2]Calibration Factor	Uncertainty (%)	*Max Residual (%)	*m-xylene interference (ppb)
English Sites								
Barnsley Gawber	20-Jan	8050082	0.4	2.5	0.990	4.4	3.1	3.6
Birmingham Tyburn	21-Jan	EH937000	2.3	2.5	0.881	3.4	1.2	0.5
Harwell	28-Jan	83	3.6	2.5	0.833	3.3	1.1	4.3
Hull Freetown	14-Jan	342	1.2	2.4	0.702	3.3	3.1	0.6
Ladybower	22-Jan	1176	-0.7	2.4	0.544	3.3	3.6	3.1
Leamington Spa	26-Feb	Analyser	not	present				
Leeds Centre	13-Jan	8050084	0.2	2.5	0.989	3.7	3.6	1.8
Liverpool Speke	09-Jan	1765	7.2	2.6	0.996	3.4	1.3	14.3
Lullington Heath	13-Feb	1179	0.2	2.5	0.952	3.2	1.6	9.6
Manchester Piccadilly	15-Jan	19216	-1.2	2.5	0.946	3.4	1.4	6.7
Middlesbrough	29-Jan	1660	5.4	2.5	0.935	3.2	2.7	7.2
Nottingham Centre	24-Feb	1629	-1.5	2.5	0.931	3.2	0.8	9.1
Rochester Stoke	11-Feb	2800	14	2.6	0.770	3.2	1.1	10.2
Scunthorpe Town	13-Jan	110870	32	2.5	0.725	4.2	2.5	-13.1
Southampton Centre	26-Feb	343	17.2	2.5	0.990	3.5	1.8	9.0
Thurrock	12-Feb	189	1.3	2.6	0.833	3.2	0.5	6.1
Wicken Fen	04-Feb	73	0.3	2.5	0.914	3.2	0.5	14.8
London Sites								
London Bexley	14-Feb	318	7.8	2.5	0.817	3.3	0.9	-0.7
London Bloomsbury	12-Feb	74	3.1	2.5	0.861	3.4	2.1	9.3
London Marylebone Road	29-Jan	19220	0.8	2.5	0.996	3.3	1.0	10.8

London N. Kensington	31-Jan	2576	9.5	2.7	0.877	3.4	0.9	10.1
Northern Irish Sites								
Ballymena Ballykeel	18-Feb	4901234	-1.9	2.7	1.007	3.3	1.4	9.1
Belfast Centre	24-Feb	1766	13.3	2.5	0.940	3.3	1.2	-6.9
Derry	20-Feb	1697	0.8	2.6	1.100	3.7	2.2	4.8
Scottish Sites								
Edinburgh St Leonards	04-Feb	84	6	2.5	0.983	3.9	3.2	7.7
Grangemouth	03-Feb		1	2.5	0.836	3.1	1.3	19.2
Welsh Sites								
Cardiff Centre	23-Jan	#070	4.2	2.5	0.954	3.5	2.5	8.3
Narberth	21-Jan	344	7.3	2.5	0.832	3.4	1.1	12.3
Port Talbot Margam	22-Jan	605214617	2.0	2.5	0.937	3.3	1.3	6.1
Wrexham	07-Jan		14.9	2.5	1.000	3.6	2.2	10.4

3. Ozone

English Sites

Site	Date Year =2014	Analyser number	[1]Zero output	Uncertainty (ppb)	[2]Calibration Factor	Uncertainty (%)	*Max Residual (%)
Barnsley Gawber	20-Jan	8060030	0.4	3	1.022	3.1	1.2
Birmingham Acocks Green	20-Jan	2435	-1.3	3	1.046	3.1	0.5
Birmingham Tyburn	21-Jan	WB6AG7TM	0.3	3	0.977	3.2	1.3
Birmingham Tyburn Roadside	21-Jan	2434	0.8	3	1.041	3.1	1.1
Blackpool Marton	14-Jan	cm08060037	0.2	3	0.998	3.1	0.5
Bottesford	25-Feb	CM08060022	-0.1	3	0.943	3.2	1.0
Bournemouth	27-Feb	17503	0.0	3	0.987	3.1	1.2
Brighton Preston Park	28-Jan	542	3.4	3	0.947	3.1	0.5
Bristol St Paul's	16-Jan	155	-1.2	3	1.008	3.3	0.2
Canterbury	10-Feb	2448	0.0	3	0.950	3.1	0.5
Charlton Mackrell	11-Feb	1111957	0.0	3	0.972	3.1	0.8
Coventry Memorial Park	18-Feb	CM08060044	0.1	3	1.030	3.2	1.7
Exeter Roadside	15-Jan	F0100E0S	3.2	3	0.983	3.2	0.8
Glazebury	16-Jan	19751	0.8	3	0.994	3.1	0.3
Great Dun Fell	02-Jul	1647	0.3	3	1.104	3.1	0.9
Harwell	28-Jan	1648	-1.5	3	1.019	3.1	0.1
High Muffles	29-Jan	1641	-0.1	3	1.064	3.1	0.2
Hull Freetown	14-Jan	8060045	0.8	3	0.954	3.1	1.6
Ladybower	22-Jan	1651	0.3	3	1.024	3.1	2.3
Leamington Spa	26-Feb	411770	0.3	3	0.936	3.3	0.8
Leeds Centre	13-Jan	8060036	0.6	3	0.966	3.1	1.0
Leicester University	19-Feb	CM08060020	-0.1	3	1.110	3.2	0.3
Leominster	10-Feb	170	1.9	3	1.043	3.1	0.5
Liverpool Speke	09-Jan	CM0806004	0.0	3	1.142	3.2	0.6

Lullington Heath	13-Feb	1644	-0.7	3	1.002	3.1	0.6
Manchester Piccadilly	15-Jan	0	0.3	3	1.068	3.1	0.3
Manchester South	15-Jan	16954	0.3	3	1.031	3.1	0.5
Market Harborough	20-Feb	CM08060031	0.5	3	1.116	3.3	0.6
Middlesbrough	29-Jan	944	0.4	3	0.986	3.1	0.5
Newcastle Centre	27-Jan	CM08060033	-0.3	3	0.984	3.3	1.3
Northampton Kingsthorpe	17-Feb	47R76STR	0.6	3	0.925	3.1	0.4
Norwich Lakenfields	05-Feb	CM08060028	0.4	3	1.078	3.1	0.2
Nottingham Centre	24-Feb	CM08060032	0.3	3	1.195	3.2	0.5
Plymouth Centre	14-Jan	CM08060027	0.0	3	1.009	3.2	0.5
Portsmouth	25-Feb	CM08060023	-0.7	3	0.992	3.0	0.3
Preston	15-Jan	cm08060042	0.6	3	1.028	3.1	0.9
Reading New Town	24-Feb	CM08060025	0.0	3	1.011	3.1	0.4
Rochester Stoke	11-Feb	378	-0.8	3	0.970	3.2	0.8
Salford Eccles	14-Jan	4117771	2.3	3	0.964	3.3	5.3
Sheffield Devonshire Green	20-Jan	8060024	0.6	3	1.019	3.1	0.8
Sibton	05-Feb	146	-0.8	3	1.021	3.2	0.4
Southampton Centre	26-Feb	CM08060021	0.2	3	1.157	3.1	0.7
Southend-on-Sea	13-Feb	CM08060017	0.1	3	1.027	3.1	1.1
St Osyth	13-Feb	CM08060035	0.5	3	0.992	3.2	0.3
Stoke-on-Trent Centre	23-Jan	CM08060026	1.0	3	1.022	3.3	1.5
Sunderland Silksworth	28-Jan	436	1.5	3	0.964	3.1	1.2
Thurrock	12-Feb	221	0.3	3	1.104	3.2	1.2
Walsall Woodlands	22-Jan	2431	2.8	3	0.941	3.1	0.6
Weybourne	06-Feb	CM10180038	-0.8	3	1.026	3.1	0.5
Wicken Fen	04-Feb	165	-1.0	3	1.057	3.1	0.5
Wigan Centre	14-Jan	0	-1.5	3	1.030	3.1	0.8
Wirral Tranmere	06-Jan	CM08060040	0.2	3	1.016	3.2	0.4
Yarner Wood	12-Feb	2437	-1.2	3	1.017	3.1	0.7
London Sites							
London Bloomsbury	12-Feb	435	-0.9	3	1.012	3.1	0.4
London Eltham	27-Jan	1111958	0.0	3	0.967	3.1	0.8
London Haringey????	18-Feb	1111953	0.0	3	1.174	3.2	1.5
London Harlington	03-Jan	107	0.8	3	1.105	3.1	0.1
London Hillingdon	06-Feb	8060034	-0.1	3	1.066	3.1	1.5
London Marylebone Road	29-Jan	19223	6.2	3	1.162	3.2	2.8
London N. Kensington	31-Jan	2372	2.8	3	1.026	3.2	0.4
London Teddington	20-Feb	2447	0.5	3	1.052	3.2	1.2
London Westminster							
Northern Ireland Sites (plus Mace Head)							
Belfast Centre	24-Feb	cm08060038	0.1	3	1.068	3.2	2.9
Derry	20-Feb	1586	1.6	3	1.011	3.1	0.4
Lough Navar	19-Feb	1640	0.2	3	1.010	3.1	0.2
Mace Head	26-Feb	77086-385	0.4	3	1.037	3.1	3.0

Scottish Sites							
Aberdeen	11-Feb	800	0.7	3	1.024	3.1	0.1
Auchencorth Moss	05-Feb	1646	-0.2	3	1.062	3.2	1.0
Bush Estate	05-Feb	1645	-0.3	3	1.021	3.1	0.3
Edinburgh St Leonards	04-Feb	136	0.2	3	1.013	3.1	0.6
Eskdalemuir	16-Jan	158	-1.0	3	1.367	3.1	1.9
Fort William	22-Jan	1023	0.5	3	0.999	3.1	2.1
Glasgow Townhead	21-Jan	CM08060029	-0.2	3	1.025	3.1	0.5
Lerwick							
Peebles	04-Feb	2449	-2.3	3	1.031	3.1	0.8
Strath Vaich	05-Mar	170	0.7	3	1.068	3.1	1.2
Welsh Sites							
Aston Hill	10-Feb	144	-0.7	3	1.019	3.1	1.0
Cardiff Centre	23-Jan	168	-1.3	3	1.022	3.1	0.7
Cwmbran	23-Jan	CM0860043	0.7	3	0.981	3.1	0.4
Mold	07-Jan	1642	-0.1	3	0.996	3.2	0.1
Narberth	21-Jan	824	1.2	3	0.999	3.1	0.6
Port Talbot Margam	22-Jan	CM10140049	0.1	3	0.982	3.2	1.0

4. Oxides of Nitrogen

English Sites

Site	Date Year =2014	Analyser number		[1]Zero output	Uncertainty (ppb)	[2]Calibration Factor	Uncertainty (%)	*Max residual (%)	*Converter efficiency (%)
Barnsley Gawber	20-Jan	8050057	NOx	1.2	2.5	0.910	3.5	2.1	98.5
			NO	1.4	2.5	0.914	3.5	1.7	
Bath Roadside	16-Jan	12758	NOx	1.7	2.6	1.202	3.5	1.1	96.5
			NO	1.8	2.6	1.208	3.5	0.7	
Billingham	28-Jan	574	NOx	-1.0	3.8	1.383	3.7	4.8	101.0
			NO	0.5	2.7	1.384	3.5	3.4	
Birmingham Acocks Green	20-Jan	3364	NOx	0.9	2.6	1.132	3.5	1.3	98.4
			NO	-0.1	2.6	1.132	3.5	1.0	
Birmingham Tyburn	21-Jan	Y7ACC7MC	NOx	0.6	2.6	0.985	3.5	0.9	99.2
			NO	-0.3	2.6	0.999	3.5	0.8	
Birmingham Tyburn Roadside	21-Jan	68	NOx	0.8	2.9	1.713	3.5	0.9	98.1
			NO	0.0	2.9	1.700	3.5	1.4	
Blackburn Darwen Roadside	15-Jan	1011851	NOx	2.0	2.5	1.013	3.7	2.4	100.8
			NO	-1.0	2.5	1.004	3.5	1.0	
Blackpool Marton	14-Jan	08050075	NOx	0.6	2.5	0.913	3.5	1.3	100.3
			NO	0.0	2.5	0.948	3.5	0.8	
Bournemouth	27-Feb	17507	NOx	2.0	2.6	1.164	3.5	2.6	99.1
			NO	0.1	2.6	1.203	3.5	1.9	
Brighton Preston Park	28-Jan	2222	NOx	1.8	2.7	1.150	3.5	0.4	98.2
			NO	2.0	2.8	1.162	3.5	0.2	
Bristol St Paul's	16-Jan	77	NOx	0.0	2.7	1.293	3.5	0.7	92.9
			NO	0.1	2.7	1.286	3.5	0.4	

Cambridge Roadside	04-Feb	1011843	NOx	3.0	2.7	1.387	3.5	1.5	101.4
			NO	0.0	2.8	1.375	3.5	0.8	
Canterbury	10-Feb	11666	NOx	-2.4	3.0	1.289	3.5	1.6	97.9
			NO	-1.9	2.8	1.311	3.5	1.4	
Carlisle Roadside	13-Jan	1011849	NOx	0.0	3.0	1.417	3.5	2.0	98.7
			NO	-2.0	2.7	1.406	3.5	1.2	
Charlton Mackrell	11-Feb	2120	NOx	0.8	2.5	1.048	3.5	1.5	98.4
			NO	0.5	2.5	1.061	3.5	1.4	
Chatham Centre Roadside	11-Feb	3393	NOx	1.8	2.6	1.105	3.5	0.4	100.1
			NO	-0.1	2.6	1.106	3.5	0.3	
Chesterfield	21-Jan	1011837	NOx	0.6	2.6	1.080	3.5	4.3	100.8
			NO	0.8	2.6	1.080	3.5	4.1	
Chesterfield Roadside	21-Jan	1011835	NOx	0.2	2.6	1.069	3.5	1.4	100.4
			NO	0.2	2.5	1.064	3.5	2.1	
Coventry Memorial Park	18-Feb	08030109	NOx	-0.5	2.5	0.792	3.5	0.9	98.2
			NO	0.2	2.4	0.783	3.5	0.9	
Eastbourne	29-Jan	3363	NOx	0.0	2.6	1.129	3.5	1.2	99.8
			NO	0.7	2.6	1.139	3.5	2.0	
Exeter Roadside	15-Jan	G0000D1S	NOx	0.6	2.6	1.023	3.5	0.9	98.0
			NO	0.4	2.6	1.029	3.5	0.7	
Glazebury	16-Jan	14354	NOx		analyser	failed	during	audit	
			NO						
Harwell	28-Jan	79	NOx	4.3	2.6	1.259	3.5	0.7	93.0
			NO	5.7	2.6	1.261	3.5	0.1	
High Muffles	29-Jan	1783	NOx	1.6	2.6	1.237	3.5	3.8	99.2
			NO	1.7	2.6	1.244	3.5	4.8	
Honiton	15-Jan	3392	NOx	0.6	2.7	1.230	3.5	0.5	99.6
			NO	1.4	2.7	1.209	3.5	1.4	
Horley	27-Jan	1401954	NOx	5.0	2.7	1.016	3.5	1.0	101.1
			NO	-2.0	2.7	0.985	3.5	1.0	
Hull Freetown	14-Jan	8050056	NOx	-3.8	2.5	0.994	3.9	3.3	100.7
			NO	-0.8	2.5	1.048	3.9	3.2	
Ladybower	22-Jan	72	NOx	-0.6	2.6	1.276	3.5	1.8	100.5
			NO	-0.5	2.6	1.266	3.5	1.8	
Leamington Spa	26-Feb	1011842	NOx	0.0	2.6	1.201	3.5	0.4	101.0
			NO	0.0	2.6	1.192	3.5	0.9	
Leamington Spa Rugby Road	27-Feb	3365	NOx	2.9	2.4	0.781	3.5	0.9	99.6
			NO	3.1	2.4	0.689	3.5	1.1	
Leeds Centre	13-Jan	8050066	NOx	-1.2	2.5	0.966	3.6	3.0	101.6
			NO	-1.4	2.5	0.966	3.8	3.4	
Leeds Headingley Kerbside	13-Jan	342	NOx	-0.6	2.6	1.096	3.5	3.0	100.5
			NO	-0.4	2.6	1.083	3.5	2.2	
Leicester University	19-Feb	08050021	NOx	0.0	2.4	0.786	3.5	1.1	98.8
			NO	0.5	2.4	0.725	3.5	0.9	
Leominster	10-Feb	346	NOx	0.8	2.6	0.984	3.5	1.0	100.1
			NO	0.7	2.5	0.953	3.5	0.2	

Lincoln Canwick Road	25-Feb	3394	NOx	0.6	2.6	1.165	3.5	0.5	99.2
			NO	0.7	2.6	1.162	3.5	0.8	
Liverpool Queen's Drive Roadside	09-Jan	1734	NOx	-0.8	2.6	1.222	3.5	0.7	98.8
			NO	1.1	2.6	1.260	3.5	1.1	
Liverpool Speke	09-Jan	08050069	NOx	-0.4	2.5	0.918	3.5	1.7	100.3
			NO	0.1	2.5	0.936	3.5	1.6	
Lullington Heath	13-Feb	787	NOx	-0.3	2.5	0.995	3.5	1.0	98.1
			NO	0.6	2.5	0.994	3.5	1.3	
Manchester Piccadilly	15-Jan	12190	NOx	1.0	2.6	1.055	3.9	2.9	98.8
			NO	1.3	2.5	1.039	3.9	2.9	
Manchester South	15-Jan	17311	NOx	0.5	2.6	1.140	3.5	2.1	99.5
			NO	0.0	2.6	1.149	3.5	2.3	
Market Harborough	20-Feb	08050068	NOx	0.9	2.4	0.519	3.5	1.0	101.3
			NO	1.0	2.4	0.493	3.5	1.2	
Middlesbrough	29-Jan	2287	NOx	-5.5	2.6	1.103	3.5	2.9	98.5
			NO	-1.6	2.6	1.115	3.5	4.7	
Newcastle Centre	27-Jan	08050063	NOx	0.8	2.5	0.948	4.1	0.6	98.5
			NO	0.6	2.5	0.978	3.7	0.7	
Newcastle Cradlewell Roadside	27-Jan	1011853	NOx	2.0	2.8	1.044	3.5	2.3	98.9
			NO	0.0	2.7	1.039	3.5	4.9	
Northampton Kingsthorpe	17-Feb	8ATJ6APR	NOx	1.0	2.6	1.000	3.5	0.3	99.2
			NO	0.0	2.6	1.007	3.5	0.5	
Norwich Lakenfields	05-Feb	08050067	NOx	-0.3	2.5	0.892	3.5	1.1	98.6
			NO	0.0	2.5	0.885	3.5	0.9	
Nottingham Centre	24-Feb	08050072	NOx	0.3	2.5	0.932	3.5	0.2	98.9
			NO	0.7	2.5	0.929	3.5	0.5	
Oxford Centre Roadside	28-Feb	1011844	NOx	2.0	2.6	1.222	3.5	1.3	99.5
			NO	0.0	2.6	1.215	3.5	1.9	
Oxford St Ebbes	25-Feb	1011830	NOx	0.0	2.6	1.136	3.5	5.3	99.5
			NO	-1.0	2.6	1.134	3.5	5.4	
Plymouth Centre	14-Jan	08050062	NOx	-0.1	2.5	0.899	3.5	1.0	100.9
			NO	0.1	2.5	0.870	3.5	0.7	
Portsmouth	25-Feb	P0T7CYA5	NOx	-0.1	2.7	1.088	3.5	0.4	99.2
			NO	-1.1	2.8	1.101	3.5	0.4	
Preston	15-Jan	08050664	NOx	2.2	2.5	0.893	3.5	0.5	98.9
			NO	1.8	2.5	0.899	3.5	0.5	
Reading New Town	24-Feb	08050059	NOx	-0.2	2.5	0.853	3.5	3.0	99.3
			NO	0.0	2.5	0.829	3.5	1.8	
Rochester Stoke	11-Feb	3095	NOx	-3.0	2.8	1.167	3.5	0.4	99.5
			NO	1.0	2.8	1.173	3.5	0.4	
Salford Eccles	14-Jan	1011831	NOx	3.0	2.7	1.108	3.5	1.6	101.8
			NO	-1.0	2.7	1.086	3.5	1.8	
Sandy Roadside	03-Feb	2585	NOx	0.3	2.8	1.324	3.5	0.1	98.4
			NO	-0.1	2.7	1.298	3.5	0.5	
Scunthorpe Town	13-Jan	1011847	NOx	41.0	3.4	2.450	3.5	2.1	98.2
			NO	44.0	3.4	2.444	3.5	2.3	

Sheffield Devonshire Green	20-Jan	8050055	NOx	0.8	2.5	0.890	3.8	3.1	99.7
			NO	0.6	2.5	0.895	3.8	3.2	
Sheffield Tinsley	21-Jan	571	NOx	0.4	2.6	1.095	3.8	3.3	100.0
			NO	0.6	2.6	1.112	3.6	2.8	
Southampton Centre	26-Feb	08030106	NOx	0.4	2.5	0.999	3.5	1.0	100.0
			NO	0.4	2.5	1.001	3.5	1.5	
Southend-on-Sea	13-Feb	08050071	NOx	0.2	2.5	0.968	3.5	0.5	100.0
			NO	0.4	2.5	0.962	3.5	0.4	
St Osyth	13-Feb	08050073	NOx	-5.4	2.4	0.668	3.5	0.3	100.5
			NO	-1.7	2.4	0.673	3.5	0.4	
Stanford-le-Hope Roadside	12-Feb	191	NOx	0.8	2.6	1.223	3.5	0.7	98.6
			NO	1.6	2.6	1.251	3.5	0.7	
Stockton-on-Tees Eaglescliffe	28-Jan	0	NOx	-0.1	2.7	1.315	3.5	1.2	92.2
			NO	0.8	2.7	1.327	3.5	2.0	
Stoke-on-Trent Centre	23-Jan	08050070	NOx	-0.2	2.5	0.971	3.5	2.4	99.3
			NO	0.7	2.5	0.966	3.5	2.0	
Storrington Roadside	28-Jan	09040022	NOx	0.3	2.6	1.153	3.5	1.0	100.4
			NO	0.6	2.6	1.157	3.5	1.0	
Sunderland Silksworth	28-Jan	1011854	NOx	1.0	2.6	1.161	3.5	4.1	100.0
			NO	0.0	2.7	1.149	3.5	2.9	
Thurrock	12-Feb	192	NOx	0.6	2.7	1.233	3.5	0.6	99.9
			NO	0.6	2.6	1.227	3.5	0.3	
Walsall Woodlands	22-Jan	3391	NOx	0.9	2.6	1.173	3.5	0.7	98.0
			NO	-0.8	2.6	1.193	3.5	0.5	
Warrington	08-Jan	1011826	NOx	1.0	2.6	0.987	3.5	0.6	99.0
			NO	0.0	2.6	0.973	3.5	0.4	
Wicken Fen	04-Feb	2223	NOx	-1.3	2.5	0.965	3.5	0.4	97.0
			NO	0.5	2.5	0.984	3.5	0.3	
Wigan Centre	14-Jan	1011832	NOx	1.0	2.5	0.902	3.5	0.9	98.6
			NO	0.0	2.5	0.902	3.5	0.5	
Wirral Tranmere	06-Jan	08050060	NOx	-1.6	2.5	0.832	3.5	0.9	101.6
			NO	-0.8	2.5	0.831	3.5	1.2	
Yarner Wood	12-Feb	1784	NOx	-0.1	2.5	0.912	3.5	1.0	99.5
			NO	-0.2	2.5	0.918	3.5	0.9	
York Fishergate	14-Jan	1011848	NOx	-1.2	2.5	0.997	3.5	2.5	99.3
			NO	-0.8	2.5	1.058	3.5	3.1	
London Sites									
Camden Kerbside	19-Feb	1011846	NOx	4.0	2.8	1.176	3.5	0.2	100.5
			NO	3.0	2.6	1.176	3.5	0.4	
Haringey Roadside	18-Feb	1011827	NOx	4.0	3.0	1.443	3.6	3.8	101.7
			NO	1.0	3.0	1.424	3.7	4.4	
London Bexley	14-Feb	327	NOx	0.1	2.6	1.230	3.5	1.2	98.9
			NO	0.2	2.7	1.335	3.5	1.0	
London Bloomsbury	12-Feb	74	NOx	6.3	2.7	1.290	3.5	1.9	94.8
			NO	6.7	2.7	1.296	3.5	1.4	

London Eltham	27-Jan	1011834	NOx	2.0	3.1	0.996	3.5	0.9	99.3
			NO	-1.0	3.1	0.993	3.5	1.1	
London Haringey Priory Park South	18-Feb	1084	NOx	-0.5	2.7	1.244	3.5	1.5	98.2
			NO	0.5	2.6	1.266	3.5	1.3	
London Harlington	03-Jan	1090	NOx	0.5	2.8	1.168	3.5	2.9	100.9
			NO	1.6	2.7	1.175	3.5	2.7	
London Hillingdon	06-Feb	8050017	NOx	-0.3	2.5	0.901	3.5	0.7	99.3
			NO	-0.1	2.5	0.905	3.5	0.8	
London Marylebone Road	29-Jan	19210	NOx	1.3	2.7	1.306	3.5	0.8	97.2
			NO	0.6	2.7	1.296	3.5	0.9	
London N. Kensington	31-Jan	3273	NOx	0.9	4.9	1.094	3.5	0.7	95.2
			NO	0.6	3.0	1.096	3.5	0.6	
London Teddington	20-Feb	3406	NOx	1.6	2.8	1.300	3.6	1.0	99.7
			NO	3.3	2.7	1.297	3.5	0.8	
London Westminster	04-Feb	573	NOx	0.8	3.2	1.288	3.5	1.5	90.3
			NO	0.5	2.7	1.334	3.7	3.0	
Southwark A2 Old Kent Road	05-Feb	1954	NOx	0.7	2.7	1.406	3.5	1.2	89.2
			NO	-0.2	2.8	1.399	3.5	0.1	
Tower Hamlets Roadside	13-Feb	1011838	NOx	1.0	3.1	1.419	3.5	1.0	98.9
			NO	0.0	2.9	1.419	3.5	1.1	
Northern Irish Sites									
Armagh Roadside	19-Feb	1011845	NOx	-0.2	2.6	1.148	3.6	2.5	98.5
			NO	-0.3	2.6	1.133	3.5	2.1	
Belfast Centre	24-Feb	08050074	NOx	-0.6	2.5	0.996	3.5	0.5	99.6
			NO	-0.4	2.5	0.961	3.5	0.9	
Derry	20-Feb	2130	NOx	1.1	2.6	1.064	3.5	1.0	99.6
			NO	0.9	2.5	1.056	3.5	1.1	
Scottish Sites									
Aberdeen	11-Feb	519	NOx	0.1	2.6	1.077	3.5	0.9	99.1
			NO	0.2	2.6	1.078	3.5	1.3	
Aberdeen Union Street Roadside	11-Feb	299	NOx	1.2	2.8	1.513	4.6	4.4	101.4
			NO	1.3	2.8	1.535	3.5	3.8	
Bush Estate	05-Feb	2244	NOx	1.6	2.5	1.030	3.5	0.7	99.7
			NO	0.7	2.5	1.015	3.5	0.3	
Dumbarton Roadside	20-Jan	1011833	NOx	1.0	2.6	1.158	3.5	0.7	100.4
			NO	0.0	2.9	1.167	3.5	1.2	
Dumfries	13-Jan	1494	NOx	-6.5	2.6	1.070	3.5	2.7	99.1
			NO	-6.5	8.4	1.071	3.5	1.9	
Edinburgh St Leonards	04-Feb	73	NOx	1.7	2.7	1.428	3.5	1.5	98.0
			NO	1.7	2.7	1.434	3.5	1.3	
Eskdalemuir	16-Jan	347	NOx	2.3	2.4	0.786	3.5	1.3	99.2
			NO	1.7	2.4	0.783	3.5	0.2	
Fort William	22-Jan	344	NOx	4.2	2.6	1.078	3.5	1.2	102.1
			NO	4.2	2.6	1.078	3.5	0.4	
Glasgow Kerbside	21-Jan	08050061	NOx	0.5	32.6	1.277	7.6	0.6	101.9

			NO	0.1	34.3	1.273	8.0	0.7	
Glasgow Townhead	21-Jan	1713	NOx	0.5	2.6	1.209	4.6	1.5	101.6
			NO	0.7	2.6	1.209	4.5	1.6	
Grangemouth	03-Feb		NOx	0.0	2.5	1.034	3.5	1.0	100.0
			NO	-1.0	2.7	1.039	3.5	2.0	
Grangemouth Moray	03-Feb		NOx	1.0	2.8	1.112	3.5	0.5	98.8
			NO	0.0	2.7	1.115	3.5	0.9	
Inverness	12-Feb	1489	NOx	-1.4	2.6	1.119	3.5	2.3	100.8
			NO	-1.4	2.6	1.113	3.5	1.4	
Peebles	04-Feb	2213	NOx	-0.8	2.6	1.073	3.5	0.3	99.4
			NO	-0.1	2.6	1.086	3.5	0.3	
Welsh Sites									
Aston Hill	10-Feb	2302	NOx	0.0	2.7	1.153	3.5	1.0	99.9
			NO	0.1	2.6	1.161	3.5	0.2	
Cardiff Centre	23-Jan	#071	NOx	1.0	2.6	1.028	3.5	2.0	99.6
			NO	0.5	2.5	1.027	3.5	1.7	
Chepstow A48	24-Jan	1011828	NOx	2.0	3.2	1.570	3.5	1.2	100.6
			NO	-1.0	2.8	1.568	3.5	1.4	
Cwmbran	23-Jan		NOx	0.1	2.5	0.976	3.5	0.2	99.8
			NO	0.4	2.5	1.008	3.5	0.5	
Mold	07-Jan	345	NOx	0.5	2.6	1.094	3.5	1.3	98.4
			NO	0.5	2.6	1.099	3.5	0.7	
Narberth	21-Jan	2577	NOx	1.0	2.5	0.934	3.5	0.7	99.4
			NO	0.5	2.5	0.958	3.5	0.6	
Newport	23-Jan	1011829	NOx	3.0	2.5	1.067	3.5	2.3	99.4
			NO	0.0	2.5	1.057	3.5	0.6	
Port Talbot Margam	22-Jan	2036	NOx	0.3	2.5	0.985	3.5	0.2	99.0
			NO	0.1	2.5	0.983	3.5	0.1	
Swansea Roadside	22-Jan	1160	NOx	1.1	2.6	1.142	3.5	0.4	100.1
			NO	0.0	2.6	1.189	3.5	0.2	
Wrexham	07-Jan	1490	NOx	0.1	2.6	1.146	3.5	1.0	98.8
			NO	-0.2	2.6	1.160	3.5	0.5	

5. Particulate Analysers

English Sites

Site	Date Year =2014		Analyser number	Calculated Spring Constant k_0	[4]k_0 accuracy (%)	Uncertainty (%)	[3]Measured Main Flow (l/min)	Uncertainty (%)	[3]Measured Total Flow (l/min)	Uncertainty (%)
Barnstaple	11/12/13	PM10	300811	17217	-0.3	1	2.91	2.2	16.17	2.2
A39		PM2.5	821002	14134	-0.2	1	2.98	2.2	15.93	2.2
Birmingham Acocks Green	20-Jan	PM2.5	900702	15770	0.17	1	3.04	2.2	15.70	2.2
Birmingham	21-Jan	PM10	200390809	14826	-0.77	1	2.82	2.2	15.96	2.2
Tyburn		PM2.5	200860809	14742	0.39	1	2.91	2.2	15.97	2.2
Birmingham Tyburn	21-Jan	PM10	20603	12069	-2.48	1	2.92	2.2	16.17	2.2
Roadside		PM2.5	220606	14237	-1.35	1	2.96	2.2	16.50	2.2

Blackpool Marton	14-Jan	PM2.5		analyser	not	present				
Bournemouth	27-Feb	GR2.5	21863						16.58	2.2
Brighton Preston Park	28-Jan	GR2.5	650603						16.08	2.2
Bristol St	16-Jan	PM10	420209	13237	0.45	1	3.10	2.2	16.06	2.2
Paul's		PM2.5	540701	13513	-2.93	1	**3.18**	**2.2**	**17.75**	**2.2**
Carlisle	13-Jan	PM10	27257	14292	-1.36	1	**3.04**	**2.2**	**17.10**	**2.2**
Roadside		PM2.5	27320	14948	-1.46	1	**3.01**	**2.2**	**16.96**	**2.2**
Chatham Centre	11-Feb	PM10	840809	14446	-0.53	1	3.07	2.2	16.61	2.2
Roadside		PM2.5	90810	15878	-0.76	1	3.00	2.2	16.36	2.2
Chesterfield	21-Jan	PM10	27316	16187	-0.82	1	2.99	2.2	16.20	2.2
		PM2.5	27341	15536	0.47	1	2.95	2.2	16.05	2.2
Chesterfield	21-Jan	PM10	22299	11309	-0.32	1	3.05	2.2	16.36	2.2
Roadside		PM2.5	27339	10961	-1.12	1	3.04	2.2	16.40	2.2
Coventry Memorial Park	18-Feb	PM2.5	192890 702	14863	-0.70	1	**2.83**	**2.2**	**15.86**	**2.2**
Eastbourne	29-Jan	PM10	380809	14323	-1.25	1	3.06	2.2	17.22	2.2
		PM2.5	440809	14816	-0.12	1	3.04	2.2	16.75	2.2
Harwell	28-Jan	PM10	670811	14847	-0.6	1	3.19	2.2	16.84	2.2
		PM2.5	570401	12340	-0.4	1	3.01	2.2	16.26	2.2
		GR10	39802						16.41	2.2
		GR2.5	90603						16.97	2.2
Hull Freetown	14-Jan	PM10	24445	14245	0.96	1	3.09	2.2	16.29	2.2
		PM2.5	26498	14385	1.35	1	3.00	2.2	16.13	2.2
Leamington	26-Feb	PM10	510809	15071	0.50	1	2.84	2.2	15.76	2.2
Spa		PM2.5	110310	14198	0.12		2.92	2.2	16.04	2.2
Leamington Spa	27-Feb	PM10	320808	13983	0.38	1	3.00	2.2	16.48	2.2
Rugby Road		PM2.5	440809	15942	-0.58	1	3.01	2.2	16.79	2.2
Leeds Centre	13-Jan	PM10	24451	13329	-0.50	1	3.07	2.2	16.68	2.2
		PM2.5	27254	17212	1.01	1	3.24	2.2	17.77	2.2
Leeds Headingley	13-Jan	PM10	27287	17660	0.43	1	3.05	2.2	16.59	2.2
Kerbside		PM2.5	27249	14542	-1.09	1	2.98	2.2	16.01	2.2
Leicester Uni	19-Feb	PM2.5	192490701	14796	-1.13	1	2.99	2.2	16.38	2.2
Liverpool	09-Jan	PM10	172220302	15758	-0.34	1	3.04	2.2	16.27	2.2
Speke		PM2.5	192860702	14761	-0.98	1	3.01	2.2	16.30	2.2
Manchester Piccadilly	15-Jan	PM2.5	26038	14044	0.14	1	2.86	2.2	17.10	2.2
Middlesbrough	29-Jan	PM10	250210	13737	-2.80	1	2.97	2.2	16.99	2.2
		PM2.5	950806	15687	-2.01	1	2.84	2.2	15.93	2.2
Newcastle	27-Jan	PM10	244480302	13777	-0.33		3.00	2.2	17.25	2.2
Centre		PM2.5	244470302	14839	0.02	1	3.01	2.2	16.62	2.2
Northampton Kingsthorpe	17-Feb	PM2.5							0.00	2.2
Norwich	05-Feb	PM10	204981105	15623	-0.54	1	3.06	2.2	16.78	2.2
Lakenfields		PM2.5	201180810	15719	0.74	1	3.06	2.2	16.65	2.2
Nottingham	24-Feb	PM10	201580811	15513	-0.43	1	2.77	2.2	16.35	2.2

Centre		PM2.5	177400401	12191	0.06	1	3.01	2.2	16.61	2.2
Oxford St	25-Feb	PM10	200870809	14786	-0.20	1	2.98	2.2	16.58	2.2
Ebbes		PM2.5	160808	16999	-0.99	1	3.01	2.2	16.53	2.2
Plymouth	14-Jan	PM10		12311	0.26	1	3.05	2.2	16.74	2.2
Centre		PM2.5		14213	-0.89	1	2.92	2.2	16.14	2.2
Portsmouth	25-Feb	PM10	276281101	16750	-1.38	1	2.95	2.2	15.92	2.2
		PM2.5	272500809	18305	-1.28	1	2.91	2.2	15.30	2.2
Preston	15-Jan	PM2.5	22881	12773	-1.40	1	3.06	2.2	17.05	2.2
Reading New	24-Feb	PM10	154940003	13181	-0.14	1	3.00	2.2	16.62	2.2
Town		PM2.5	265750702	14012	-0.88	1	3.00	2.2	16.37	2.2
Rochester	11-Feb	PM10	200750809	14725	-1.26	1	2.93	2.2	16.42	2.2
Stoke		PM2.5	200890810	15876	-0.43	1	2.92	2.2	15.93	2.2
Salford Eccles	14-Jan	PM10		13754	0.46	1	2.88	2.2	15.72	2.2
		PM2.5		14616	-0.14	1	2.84	2.2	13.52	2.2
Saltash	14-Jan	PM10	168160208	14084	-0.40	1	2.88	2.2	16.29	2.2
Callington Road		PM2.5	201690811	12339	-0.22	1	2.99	2.2	17.43	2.2
Sandy	03-Feb	PM10	139399707	11332	0.35	1	3.09	2.2	15.02	2.2
Roadside		PM2.5	204841102	16025	-0.34	1	2.95	2.2	16.49	2.2
Scunthorpe Town	13-Jan	PM10	27366	15046	0.30	1	3.06	2.2	16.31	2.2
Sheffield	20-Jan	PM10	25024	12012	-1.94	1	3.01	2.2	16.23	2.2
Devonshire Grn		PM2.5	27253	15538	-0.64	1	2.98	2.2	16.21	2.2
Southampton	26-Feb	PM10	244840303	13946	0.52	1	3.03	2.2	15.85	2.2
Centre		PM2.5	272560809	16555	0.19	1	3.05	2.2	15.89	2.2
Southend-on-Sea	13-Feb	PM2.5	177760401	12385	-0.39	1	2.97	2.2	15.73	2.2
Stanford-le-	12-Feb	PM10	172660303	12773	0.83	1	3.01	2.2	10.67	2.2
Hope Roadside		PM2.5	144209804	13187	1.10	1	3.02	2.2	16.73	2.2
Stockton-on-Tees	28-Jan	PM10	H4554						16.09	2.2
Eaglescliffe		PM2.5	H4558						16.10	2.2
Stoke-on-	23-Jan	PM10	177470401	12459	-0.34	1	2.98	2.2	16.38	2.2
Trent Centre		PM2.5	200570809	13348	-1.14	1	3.04	2.2	16.53	2.2
Storrington	28-Jan	PM10	272360808	15782	0.66	1	3.36	2.2	17.28	2.2
Roadside		PM2.5		12765	0.15	1	3.07	2.2	16.42	2.2
Sunderland Silksworth	28-Jan	PM2.5	272427809	15606	-1.24	1	2.93	2.2	14.46	2.2
Thurrock	12-Feb	PM10	201270810	13910	-0.99	1	2.91	2.2	15.69	2.2
Warrington	08-Jan	PM10	175980309	11923	-0.66	1	2.91	2.2	15.74	2.2
		PM2.5	100060808	16335	-0.14	1	2.92	2.2	15.74	2.2
Wigan Centre	14-Jan	PM2.5	27291	14888	0.16	1	2.85	2.2	15.73	2.2
Wirral Tranmere	06-Jan	PM2.5	153660001	13311	0.13	1	0.00	2.2	11.58	2.2
York Bootham	14-Jan	PM10	21877	14731	-0.04	1	3.11	2.2	16.27	2.2
		PM2.5	27209	16055	-1.39	1	3.05	2.2	16.39	2.2
York	14-Jan	PM10	27232	15861	1.04	1	2.97	2.2	15.89	2.2
Fishergate		PM2.5	27348	18106	-0.75	1	2.93	2.2	15.97	2.2
London Sites										

Camden	19-Feb	PM10	211529602	11950	-0.33	1	3.03	2.25	16.68	2.2
Kerbside		PM2.5	232480009	12943	1.47	1	2.92	2.25	16.24	2.2
Haringey	18-Feb	PM10	272380810	15315	0.34	1	3.06	2.25	15.95	2.2
Roadside		PM2.5	272600809	13649	-1.09	1	3.14	2.25	18.47	2.2
London Bexley	14-Feb	PM2.5	177540401	11732	1.20	1	2.98	2.25	16.51	2.2
London	12-Feb	PM10	172180302	13701	-0.29	1	2.96	2.25	15.24	2.2
Bloomsbury		PM2.5	200610809	14718	-0.29	1	2.98	2.25	12.48	2.2
London Eltham	27-Jan	PM2.5	197840801	14079	1.90	1	3.08	2.25	16.21	2.2
London	03-Jan	PM10	249020311	12301	0.12	1	3.10	2.25	16.99	2.2
Harlington		PM2.5	23950202	12836	0.24	1	3.09	2.2	17.22	2.2
London Harrow Stanmore	19-Feb	PM2.5	272740809	16145	-0.62	1	2.97	2.2	15.53	2.2
London	29-Jan	PM10	177410401	13105	-0.62	1	3.28	2.2	17.74	2.2
Marylebone		PM2.5	200450809	13074	2.05	1	3.45	2.2	17.53	2.2
Road		GR10	209439811						16.85	2.2
		GR2.5	202210001						16.93	2.2
London N.	31-Jan	PM10	201780811	12775	0.81	1	3.28	2.2	17.41	2.2
Kensington		PM2.5	100070808	15848	0.39	1	3.11	2.2	16.51	2.2
		GR10							16.42	2.2
		GR2.5	21019						17.00	2.2
London Teddington Bushy Park	20-Feb	PM2.5	272650809	15296	-0.5	1	2.47	2.2	8.88	2.2
London Westminster	04-Feb	GR2.5	209399811						16.79	2.2
Southwark A2 Old Kent Road	05-Feb	PM10	264800612	15049	-0.49	1	2.97	2.2	16.37	2.2
Northern Irish Sites										
Armagh Roadside	19-Feb	PM10	2000	13786	1.58	1	3.01	2.2	16.35	2.2
Belfast Centre	24-Feb	PM10	172110302	14257	0.45	1	**3.04**	**2.2**	**16.82**	**2.2**
		PM2.5	192980702	15371	-2.28	1	**3.03**	**2.2**	**16.54**	**2.2**
Derry	20-Feb	PM10	2701	16048	1.52	1	3.16	2.2	16.84	2.2
		PM2.5	21313	10954	0.59	1	3.13	2.2	16.72	2.2
Lough Navar	19-Feb	PM10	21196	12966	1.15	1	**3.08**	**2.2**	**16.95**	**2.2**
Scottish Sites										
Aberdeen	11-Feb	PM10	24427	11373	-1.69	1	**2.99**	**2.2**	**16.13**	**2.2**
		PM2.5	27368	12099	-0.99	1	**3.00**	**2.2**	**16.11**	**2.2**
Auchencorth	05-Feb	PM10	187680602	12890	-2.27	1	2.96	2.2	16.78	2.2
Moss		PM2.5	187960603	13612	-2.89	1	2.99	2.2	15.74	2.2
		GR10	15500112						16.96	2.2
		GR2.5	215480112						16.84	2.2
Edinburgh St	04-Feb	PM10	199970808	13347	-2.51	1	3.23	2.2	16.61	2.2
Leonards		PM2.5	200190808	16847	-0.97	1	3.20	2.2	16.45	2.2
Glasgow	21-Jan	PM10	220139803	14489	-0.64	1	**3.23**	**2.2**	**17.50**	**2.2**
Kerbside		PM2.5	273370810	15152	0.21	1	**3.27**	**2.2**	**17.94**	**2.2**
Grangemouth	03-Feb	PM10	201210810	15775	-0.89	1	2.99	2.2	16.54	2.2
		PM2.5	100110808	13517	-1.77	1	3.01	2.2	16.14	2.2

Inverness	12-Feb	GR10	21255						17.06	2.2
		GR2.5	21861						17.10	2.2
Welsh Sites										
Cardiff Centre	23-Jan	PM10	192550701	13588	-2.09	1	2.94	2.2	16.31	2.2
		PM2.5	177700401	10985	-0.09	1	3.02	2.2	16.32	2.2
Chepstow A48	24-Jan	PM10	197340712	14062	-0.86	1	3.11	2.2	17.22	2.2
		PM2.5	200250808	15736	-1.62	1	3.15	2.2	17.22	2.2
Narberth	21-Jan	PM10	192470701	13745	-0.92	1	2.88	2.2	15.31	2.2
Newport	23-Jan	PM10	150509906	13775	-1.52	1	1.41	2.2	14.11	2.2
		PM2.5	100010808	16519	-0.62	1	2.96	2.2	16.07	2.2
Port Talbot Margam	22-Jan	PM10		13931	0.0	1	3.12	2.2	16.92	2.2
		PM2.5		10436	-1.2	1	3.02	2.2	17.09	2.2
		GR10							16.73	2.2
Swansea Roadside	22-Jan	PM10	M9305						10.68	2.2
		PM2.5	M9306						14.79	2.2
Wrexham	07-Jan	GR10	212240001						16.43	2.2
		GR2.5	210119902						16.77	2.2

The above factors have been calculated using certified standards. The analysers listed above have been tested for zero response, calibration factor, linearity, converter efficiency (NOx analysers), m-xylene interference (SO_2 analysers), k_0 / main flow rate (for TEOM analysers) and total flow rate (for particulate analysers), by documented methods. Note that the test results are valid on the day of test only, as analyser drift over time cannot be quantified.

The calibration results for NOx, NO, CO, SO_2, O_3 and Particulates are those that fall within our scope of accreditation. Results marked with an asterisk (*) on this certificate fall outside our accreditation, but have been included for completeness.

[1] The zero response is the zero reading on the logging system of the analyser when audit zero gas was introduced to the analysers under test.

[2] The calibration factor is the multiplying factor required to scale the reading on the data logging system into concentration units (ppb for NO, NOx and SO_2, ppm for CO – 1ppm = 1000 ppb). It should be used in conjunction with the analyser output and the zero response, according to the following equation:

Concentration = (output – zero response) x Calibration factor

The scaling factor for gaseous analysers is calculated using mole fraction concentrations.

[3] The measured main flow rate (where this is applicable) is the flow rate through the sensor unit of a TEOM analyser. The measured aux flow rate (where this is applicable) is the flow rate through the bypass tubing of the TEOM particulate analyser under test. The measured total flow rate is the total flow rate through the particulate analyser under test. Units of flow are $l.min^{-1}$. Measurements shown in **bold** are not made at the normal sample inlet and may not therefore accurately represent the actual flow through the inlet.

[4] The k_0 accuracy value (specifically for TEOM analysers) indicates the closeness of the calculated result (in g/s^2 units) to the manufacturer's specified value of k_0.

* The maximum residual is the percentage maximum deviation of the worst linearity point from the line of best fit

* Converter is the measured efficiency of the NO_2 to NO converter in the Nitrogen Oxides analyser

* meta-xylene interference is the response of the SO_2 analyser when supplied with approx 1ppm meta-xylene.

This certificate is an electronic representation of a certificate signed by **Stewart Eaton** and held by Ricardo-AEA at the above address. Hard copies are available on request.

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