REPORT

UK Air Quality Forecasting: Operational Report for April to June 2007

A report produced for the Department for Environment, Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and the Department of the Environment in Northern Ireland

AEA

AEAT/ENV/R/2498 Issue 1, August 2007

UK Air Quality Forecasting: Operational Report for April to June 2007

A report produced for the Department for Environment, Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and the Department of the Environment in Northern Ireland

AEAT/ENV/R/2498 Issue 1
August 2007

Title	UK Air Quality Forecasting: Operational Report for April to June 2007.
Customer	Department for Environment Food and Rural Affairs, the Scottish Executive, the Welsh Assembly Government and the Department of the Environment in Northern Ireland
Customer reference	EPG 1/3/179
Confidentiality, copyright and reproduction	UNRESTRICTED Copyright AEA Technology plc. All rights reserved. Enquiries about copyright and reproduction should be addressed to the Commercial Manager, AEA Technology plc.
File reference	ED45099
Report number	AEAT/ENV/R/2498 Issue 1
Report status	Issue 1

AEA Technology plc
AEA Energy & Environment
Building 551.11
Harwell
Didcot
Oxfordshire
OX11 0QJ
UK
+44 (0) 870 190 6441 tel.
+44 (0) 870 190 6608 fax.

Andy.cook@aeat.co.uk

AEA Energy & Environment is an operating division of AEA Technology plc
AEA Technology is certificated to BS EN ISO9001:(1994)

	Name		Date
Author	Andy Cook		15/08/2007
Reviewed by	Paul Willis		20/08/2007
Approved by	Jon Bower		22/08/2007

Executive Summary

This report covers the operational activities carried out by AEA Energy & Environment and the Met Office under the UK Air Quality Forecasting Contract from April to June 2007. The work is funded by the Department for Environment Food and Rural Affairs (Defra), the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland.

During the second quarter of 2007, there were five days on which HIGH or above air pollution was recorded. All of the HIGH or above exceedences were due to PM_{10}. Two days were the result of car park resurfacing work near the Birmingham Tyburn AQM site and three days due to a combination of meteorological conditions and the proximity of steelworks to the AQM site at Port Talbot, in South Wales.

Overall forecast success and accuracy rates for the HIGH band were 0 % for both zones and agglomerations during this quarter due to the inherent difficulty of forecasting these localised particulate emissions.

Many MODERATE days were measured (mainly for ozone but a considerable contribution from PM_{10}) and were forecast with a high degree of success and a very reasonable accuracy. These MODERATE periods are recorded within the forecasting success and accuracy calculations. The forecasting success and accuracy for this quarter for HIGH and MODERATE episodes is summarised in Table 1 below.

Success figures for MODERATE forecasts issued show that a significant proportion of measured polluted days were successfully forecast (percentage above 100 %). An average accuracy figure of around 86 % indicates that 14 % of the forecast MODERATE levels were not measured and remained LOW. The accuracy figures often tend to be lower due to the precautionary approach that AEA Energy & Environment takes when issuing the daily forecasts- we intentionally issue a forecast for MODERATE pollution when there is only a small chance that it will be recorded.

Table 1 – Forecast success/accuracy for incidents above 'HIGH' and above 'MODERATE', April 1st to June 30th 2007.

Region/Area	HIGH		MODERATE	
	% success	% accuracy	% success	% accuracy
Zones	0	0	112	86
Agglomerations	0	0	155	87

We continue to research ways of improving the air pollution forecasting system by:

1. Investigating new approaches to using automatic software systems to streamline the activities within the forecasting process, thus allowing forecasters to spend their time more productively considering the most accurate forecasts.
2. Researching the chemistry used in our models, for example the chemical schemes for secondary PM_{10} and ozone.
3. Improving the NAME model used for ad-hoc analyses. In particular, recent improvements have assisted with investigations of the possible long-range transport of PM_{10} pollution from forest fires in Russia and the long-range transport of particles from Saharan Dust Storms.
4. Improving and updating the emissions inventories used in our models.

There were no reported breakdowns in the forecasting service between April and June; all bulletins were successfully delivered to the Air Quality Communications contractor on time.

Contents

1 Introduction

In collaboration with the Met Office, a forecast of the following day's air pollution is prepared every day by AEA Energy & Environment. The forecast consists of a prediction of the air pollution descriptor for the worst-case situation in 16 zones and 16 agglomerations over the following 24-hours. Forecasts can be updated and disseminated through Teletext, the World Wide Web and a Freephone telephone number at any time of day, but the most important forecast of the day is the “daily media forecast”. This is prepared at 3.00 p.m. for uploading to the Internet and Air Quality Communications contractor before 4.00 p.m. each day, and is then included in subsequent air quality bulletins for the BBC, newspapers and many other interested organisations.

This report analyses and reviews the media forecasts issued during the second quarter of 2007. Results from forecasting models are available each day and are used in constructing these forecasts. The forecasters issue predictions for rural, urban background and roadside environments but, for the purposes of this report, these have been combined into a single “worst-case” category.

Twice every week, on Tuesdays and Fridays, we also provide a long-range pollution outlook. This takes the form of a short text message; this is emailed to approximately sixty recipients in Defra and other Government Departments, together with the BBC weather forecasters. The outlook is compiled by careful assessment and review of the outputs from our pollution models- which currently cover up to 3 days ahead- and by also considering the long-term weather situation.

We continue to provide a comprehensive quality control system to ensure that the 5-day forecasts provided by the Met Office to the BBC are consistent with the “daily media forecasts” and long-range pollution outlook provided by AEA Energy & Environment for Defra and the Devolved Administrations. The BBC requires 5-day air pollution index forecasts for 230 UK towns and cities on their BBC Online service. The quality control checks are carried out at around 3.00 p.m. daily, with the forecast updating onto the BBC Online Web site at 4.00 a.m. the following morning.

2 New developments during this period

2.1 MET OFFICE DEVELOPMENTS

A new version of NAME has been implemented in the development version of the air quality modelling system and there has been considerable work towards improving the system in line with the outcome of a recent technical meeting. Time series plots of the forecast levels at all the Defra locations are now being produced on a daily basis and a means of accessing and displaying these using internal web pages has been developed. The Met Office has been testing different ways of producing maps of the forecast index and concentration levels using different graphical software and the best product to use will be discussed with AEA.

During this quarter a new system for producing the trajectories required for the ozone forecast has also been developed. This uses NAMEIII to produce both the trajectories and necessary met data. Discussion is ongoing with AEA to ensure that the most appropriate met parameters are provided. The new system extends the number of sites for which trajectories will be produced and also the number of days ahead for which they will be available. Limited sensitivity tests comparing the current 2D trajectories at 500 m agl to fully 3D trajectories have shown that the agreement is reasonably good. This suggests that the current requirement for 2D trajectories is probably sufficient for representing the airflow, although it is noted that other work has shown that the correct representation of the presence or absence of the particle in the boundary layer is vital for correctly modelling ozone levels. The new trajectory system is still under development, but will be rolled out during the autumn.

In addition to these research and development activities, the Met Office provided an ad-hoc response to AEA following the fire at an industrial factory in Crewe in mid-June. Separate runs of the NAME model were made to simulate the transport of smoke from the fire and provide detail on where it might have been detected on the ground (see section 6.2).

2.2 AEA ENERGY & ENVIRONMENT DEVELOPMENTS

AEA Energy & Environment hosted a project review meeting in July at Harwell, with representatives of Defra and the Met Office attending. Draft reports were discussed, together with forthcoming operational changes to the modelling and software methodologies utilised within the project.

3 Analysis of Forecasting Success Rate

Analysis of the forecasting performance is carried out for each of the 16 zones and 16 agglomerations used in the daily forecasting service. Further details of these zones and agglomerations are presented in Appendix 2. Forecasting performance is analysed for a single, general pollutant category rather than for each individual pollutant and has been aligned to the forecasting day (a forecasting day runs from the issue time, generally 3 pm). This analysis of forecasting performance is based on provisional data, as used in the daily forecasting process. Any obviously faulty data have been removed.

The analysis treats situations where the forecast index was within ±1 of the measured index as a successful prediction, as this is the target accuracy we aim to obtain in the forecast. Because the calculations of accuracy and success rates are based on a success being ±1 of the measured index, it is possible to record rates in excess of 100% rather than 'true' percentages. Appendix 3 shows a worked example of how accuracy and success rates are calculated. Further details of the text descriptions and index code used for the forecasting are given in Appendix 1.

The forecasting success rates for each zone and agglomeration for the quarter reported on are presented in Tables 3.1 (forecasting performance in zones) and 3.2 (forecasting performance in agglomerations) for 'HIGH' days. Table 3.5 provides a summary for each pollutant of the number of days on which HIGH and above pollution was measured, the maximum exceedence concentration and the day and site at which it was recorded. The forecasting performance Tables 3.1 and 3.2 give:

- The number of 'HIGH' days measured in the PROVISIONAL data
- The number of 'HIGH' days forecast
- The number of days with a correct forecast of 'HIGH' air pollution, within an agreement of ±1 index value. A HIGH forecast is recorded as correct if air pollution is measured HIGH and the forecast is within ±1 index value, or it is forecast HIGH and the measurement is within ±1 index value. For example measured index 7 with forecast index 6 counts as correct, as does measured index 6 with forecast index 7.
- The number of days when 'HIGH' air pollution was forecast ('f' in the tables) but not measured ('m') on the following day to within an agreement of 1 index value.
- The number of days when 'HIGH' air pollution was measured ('m') but had not been forecast ('f') to within an agreement of 1 index value.

The two measures of forecasting performance used in this report are the 'success rate' and the 'forecasting accuracy'.

The forecast success rate (%) is calculated as:

- (Number of episodes successfully forecast/total number of episodes measured) x 100

The forecast accuracy (%) is calculated as:

- (Number of episodes successfully forecast/[Number of successful forecasts + number of wrong forecasts]) x 100

The forecasting success rates for 'MODERATE' days or above for each zone and agglomeration are presented in Tables 3.3 (zones) and 3.4 (agglomerations). Table 3.3 and 3.4 give the same information as in Tables 3.1 and 3.2, but summarised for 'MODERATE' days and above.

3.1 FORECAST ANALYSIS FOR APRIL 1ST TO JUNE 30TH 2007.

Table 3.1 - Forecast Analysis for UK Zones 'HIGH' band and above *

ZONES	Central Scotland	East Mids	Eastern	Greater London	Highland	North East	North East Scotland	North Wales	North West & Merseyside	Northern Ireland	Scottish Borders	South East	South Wales	South West	West Midlands	Yorkshire & Humberside	Overall
measured days	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
forecasted days	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2
ok (f and m)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
wrong (f not m)	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2
wrong (m not f)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
success %	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0
accuracy %	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.2 - Forecast Analysis for UK Agglomerations 'HIGH' band and above *

AGGLOMERATIONS	Belfast UA	Brighton/Worthing/ Littlehampton	Bristol UA	Cardiff UA	Edinburgh UA	Glasgow UA	Greater Manchester UA	Leicester UA	Liverpool UA
measured days	0	0	0	0	0	0	0	0	0
forecasted days	0	1	0	0	0	0	0	0	0
ok (f and m)	0	0	0	0	0	0	0	0	0
wrong (f not m)	0	1	0	0	0	0	0	0	0
wrong (m not f)	0	0	0	0	0	0	0	0	0
success %	100	100	100	100	100	100	100	100	100
accuracy %	0	0	0	0	0	0	0	0	0

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	0	0	0	3	0	2	0	5
forecasted days	0	0	0	0	0	0	0	1
ok (f and m)	0	0	0	0	0	0	0	0
wrong (f not m)	0	0	0	0	0	0	0	1
wrong (m not f)	0	0	0	3	0	2	0	5
success %	100	100	100	0	100	0	100	0
accuracy %	0	0	0	0	0	0	0	0

*** All performance statistics are based on provisional data. Obviously incorrect data due to instrumentation faults have been removed from the analyses.**

Please refer to the start of section 3 for an explanation of the derivation of the various statistics. Figures >100 % may occur.

Table 3.3 - Forecast Analysis for UK Zones 'MODERATE' band and above *

ZONES	Central Scotland	East Mids	Eastern	Greater London	Highland	North East	North East Scotland	North Wales	North West & Merseyside	Northern Ireland	Scottish Borders	South East	South Wales	South West	West Midlands	Yorkshire & Humberside	Overall
measured days	14	39	71	70	55	28	11	27	53	16	14	49	26	53	36	47	609
forecasted days	21	42	53	44	35	37	17	24	31	21	19	47	27	39	42	38	537
ok (f and m)	30	46	67	55	59	41	24	33	52	28	26	48	27	51	47	49	683
wrong (f not m)	0	4	6	4	2	3	0	3	2	0	2	7	6	2	4	3	48
wrong (m not f)	0	0	7	19	2	2	0	2	6	0	1	8	6	5	1	2	61
success %	214	118	94	79	107	146	218	122	98	175	186	98	104	96	131	104	112
accuracy %	100	92	84	71	94	89	100	87	87	100	90	76	69	88	90	91	86

Table 3.4 - Forecast Analysis for UK Agglomerations 'MODERATE' band and above *

AGGLOMERATIONS	Belfast UA	Brighton/Worthing/ Littlehampton	Bristol UA	Cardiff UA	Edinburgh UA	Glasgow UA	Greater Manchester UA	Leicester UA	Liverpool UA
measured days	18	41	27	19	11	4	24	23	9
forecasted days	16	47	34	22	16	18	25	30	21
ok (f and m)	26	45	36	25	22	18	32	33	24
wrong (f not m)	0	10	1	3	0	3	2	4	1
wrong (m not f)	2	4	3	3	0	0	1	2	2
success %	144	110	133	132	200	450	133	143	267
accuracy %	93	76	90	81	100	86	91	85	89

AGGLOMERATIONS	Nottingham UA	Portsmouth UA	Sheffield UA	Swansea UA	Tyneside	West Midlands UA	West Yorkshire UA	Overall
measured days	15	34	14	21	12	40	11	323
forecasted days	30	43	27	25	25	38	25	442
ok (f and m)	34	47	27	29	28	45	29	500
wrong (f not m)	2	4	6	2	0	4	0	42
wrong (m not f)	0	1	1	3	1	8	0	31
success %	227	138	193	138	233	113	264	155
accuracy %	94	90	79	85	97	79	100	87

*** All performance statistics are based on provisional data. Obviously incorrect data due to instrumentation faults have been removed from the analyses.**
Please refer to the start of section 3 for an explanation of the derivation of the various statistics, figures >100 % may occur.

Table 3.5 – Summary of episodes April to June 2007 (Based on latest provisional data)

Pollutant	High or above days	Moderate days	Max. conc. (µg /m³) *	Site with max. conc.	Zones or Agglomeration	Date of max conc.	Forecast success HIGH days (%)*** [no. incidents, zone or agglomeration days] **
Ozone	0	82	178	Southend on Sea	Eastern zone	07/06/07	N/a
PM_{10} gravimetric equivalent	5	25	166	Birmingham Tyburn	West Midlands UA	09/06/07	0 % [5]
NO_2	0	5	332	London A3 Roadside	London UA	23/05/07	N/a
SO_2	0	1	314	Edinburgh St Leonards	Edinburgh UA	03/05/07	N/a
CO	0	0	2.0	Brentford Roadside	London UA	05/04/07	N/a

* Maximum concentration relate to 8 hourly running mean or hourly mean for ozone, 24 hour running mean for PM_{10}, hourly mean for NO_2, 15 minute mean for SO_2 and 8 hour running mean for CO (CO units are mg/m3).
** the number of incidents is the total of the number of HIGH days in all zones and agglomerations (ie a HIGH day on the same day in many zones or agglomerations is counted as many incidents, not just one)

*** The success rates for the number of HIGH days in table 3.5 have been calculated using calendar days (ie midnight to midnight) and therefore may not necessarily agree with the success rates calculated within the forecast analysis tables 3.1 and 3.2, which are calculated based on media forecast days starting generally at 3 pm each day.

General Observations

There were five zone or agglomeration-day incidents of HIGH band pollution measured during this quarter, each measured on a separate day for PM_{10}.

Twenty five MODERATE-only days were seen due to PM_{10}. More than 60% of these MODERATE days were measured at urban sites, 10% at industrial sites and around 30% at roadside sites. Two episodes of note occurred during April. The first two days of April were affected by the end of the particulate episode caused by fires in the Ukraine / Russia area. A period of easterly, European air trajectories was experienced from Thursday 12th to Sunday 15th April.

Eighty-two MODERATE days were measured for ozone during this quarter, a typical number associated with this period of the year. Two periods of note occurred in late April / early May where more than 20 sites per day measured a MODERATE band exceedence. Daily maximum temperatures reached around 20 degrees C in England and air mass back-trajectories were preliminarily European. A second period of note occurred from the 1st to 12th June. Daily maximum temperatures reached 20 – 25 degrees C in the south of England and air mass back-trajectories became increasingly European, culminating in an exceedence at more than 50 sites on three consecutive days over Saturday 9th – Monday 11th June. Secondary ozone formation, as a result of polluted air arriving from Europe, is often experienced most intensely during UK weekends due to the lag time associated with the transport of the air mass.

Five MODERATE days were measured for nitrogen dioxide, all measured at roadside sites.

One MODERATE day was measured for SO_2 at Edinburgh St Leonards on 3rd May due to an unknown cause.

No MODERATE or above days were measured for CO during the reporting period. The highest 8-hour running mean calculated was 2 mg/m^3 at Brentford Roadside.

Figures 3.1 – 3.3 show the trends of pollutants in graphical form. A site-by-site breakdown is given in Figures 3.4a and 3.4b.

O_3

MODERATE band exceedences were experienced on more than 90% of the days of this quarter. Many exceedences were seen in April during a period of light breezes. In early May wind speeds increased, bringing cool air to the UK, and the number of daily exceedences decreased. From the beginning to mid-June increasingly European air trajectories encouraged the formation of secondary ozone at more than 30 sites on 5 separate days during that spell.

Figure 3.1 shows the trends in O_3 levels over this period.

PM_{10}

Three HIGH days were measured during this quarter and two VERY HIGH days. The two VERY HIGH days were the result of nearby car park resurfacing works near the Birmingham Tyburn AQM site in mid June. Three HIGH days were measured at the Port Talbot monitoring site, caused by its proximity to the steel works combined with meteorological conditions for 2 days in April and one in May. MODERATE exceedences occurred mainly in the first half of the quarter, with a significant number of sites experiencing MODERATE levels during a period of European air in mid April.

Figure 3.2 shows the trends in PM_{10} levels over this period.

NO_2

Five MODERATE days were measured fairly evenly throughout the period exclusively at London roadside sites.

SO_2

One MODERATE day was measured at Edinburgh St Leonards on the 3rd May after several days of a build up in concentrations. No immediate cause has yet been identified for the build up, which appears to have been carried on an easterly breeze.

Figure 3.3 shows the trends in SO_2 levels over this period with NO_2 also included.

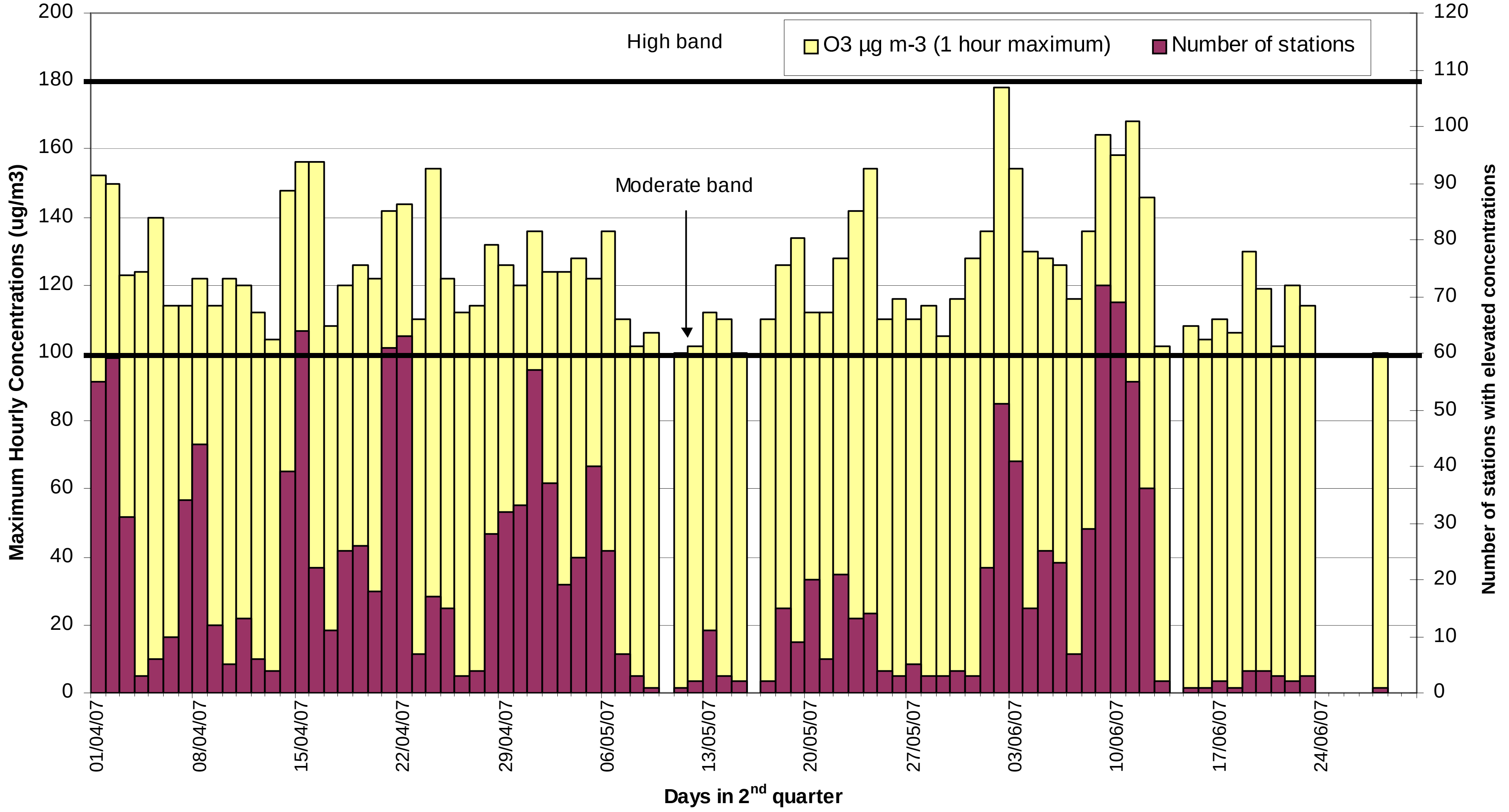


Figure 3.1 Daily maximum hourly ozone concentration across AURN Network with total number of stations measuring MODERATE or above levels of ozone over 2nd quarter 2007.

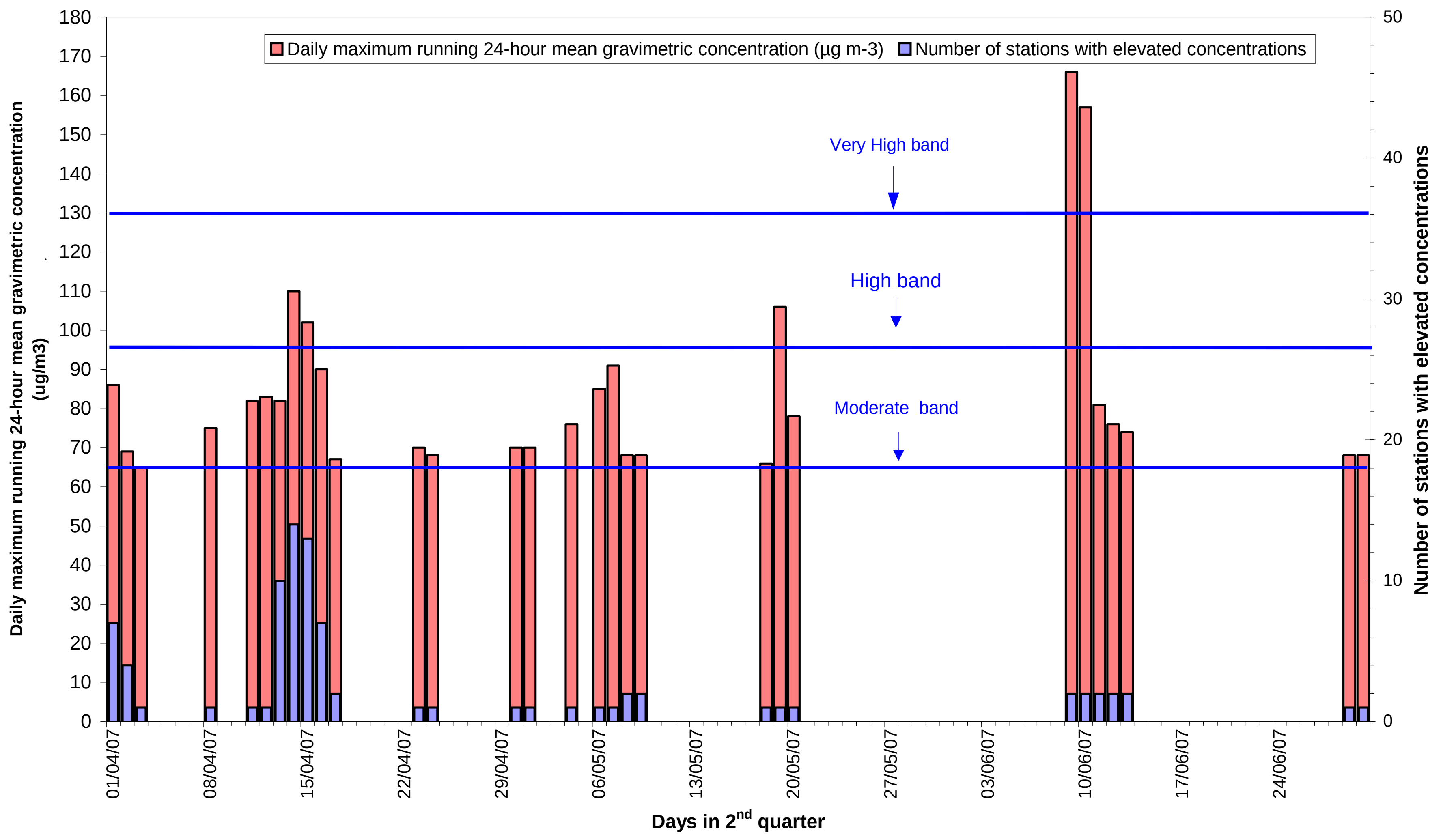


Figure 3.2 Daily maximum running 24-hour mean PM_{10} concentration across AURN Network with total number of stations measuring MODERATE or above levels over the 2nd quarter 2007.

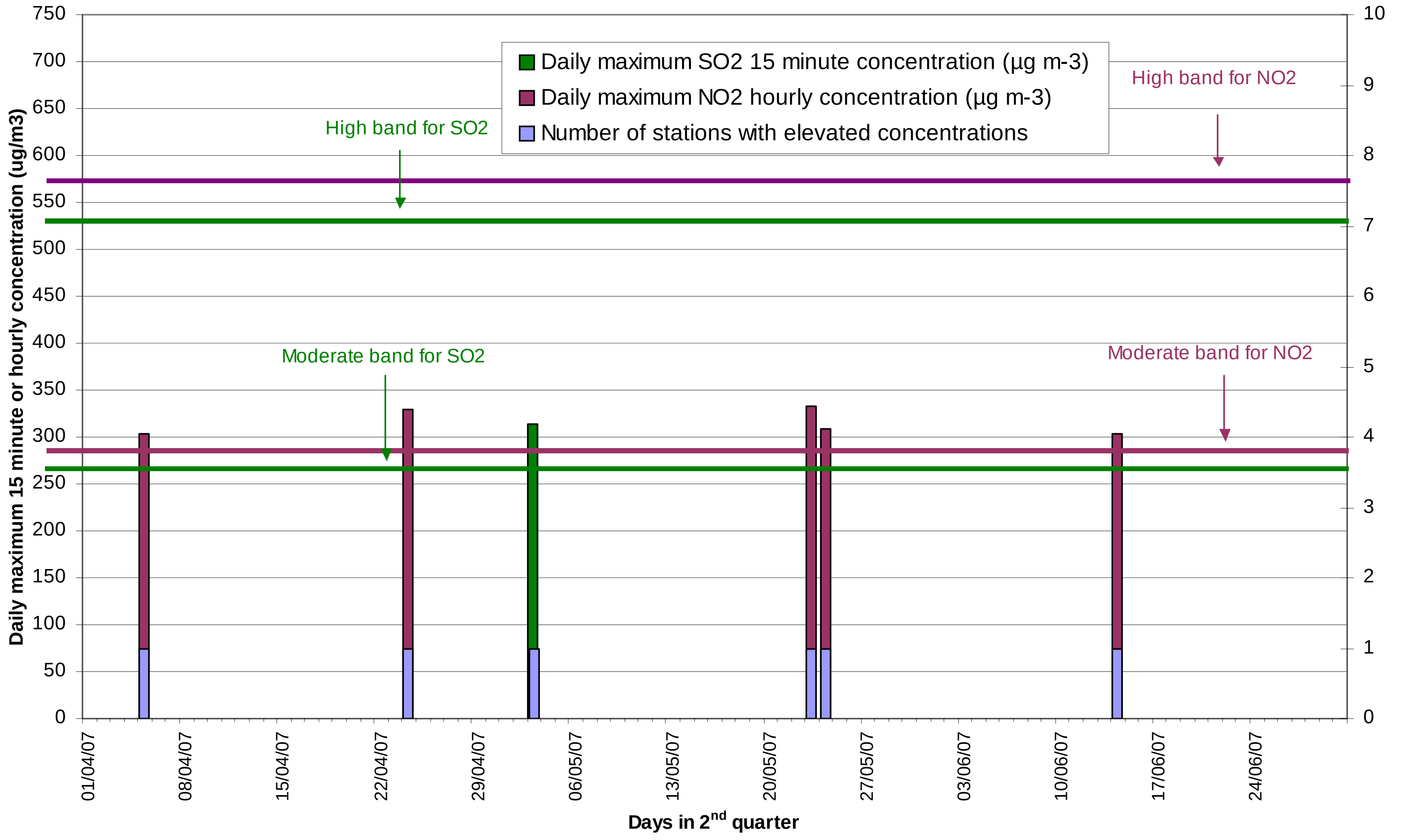


Figure 3.3 Maximum 15 minute average concentrations of SO_2 and hourly average of NO_2 across AURN Network with total number of stations measuring MODERATE or above levels over the 2nd quarter 2007.

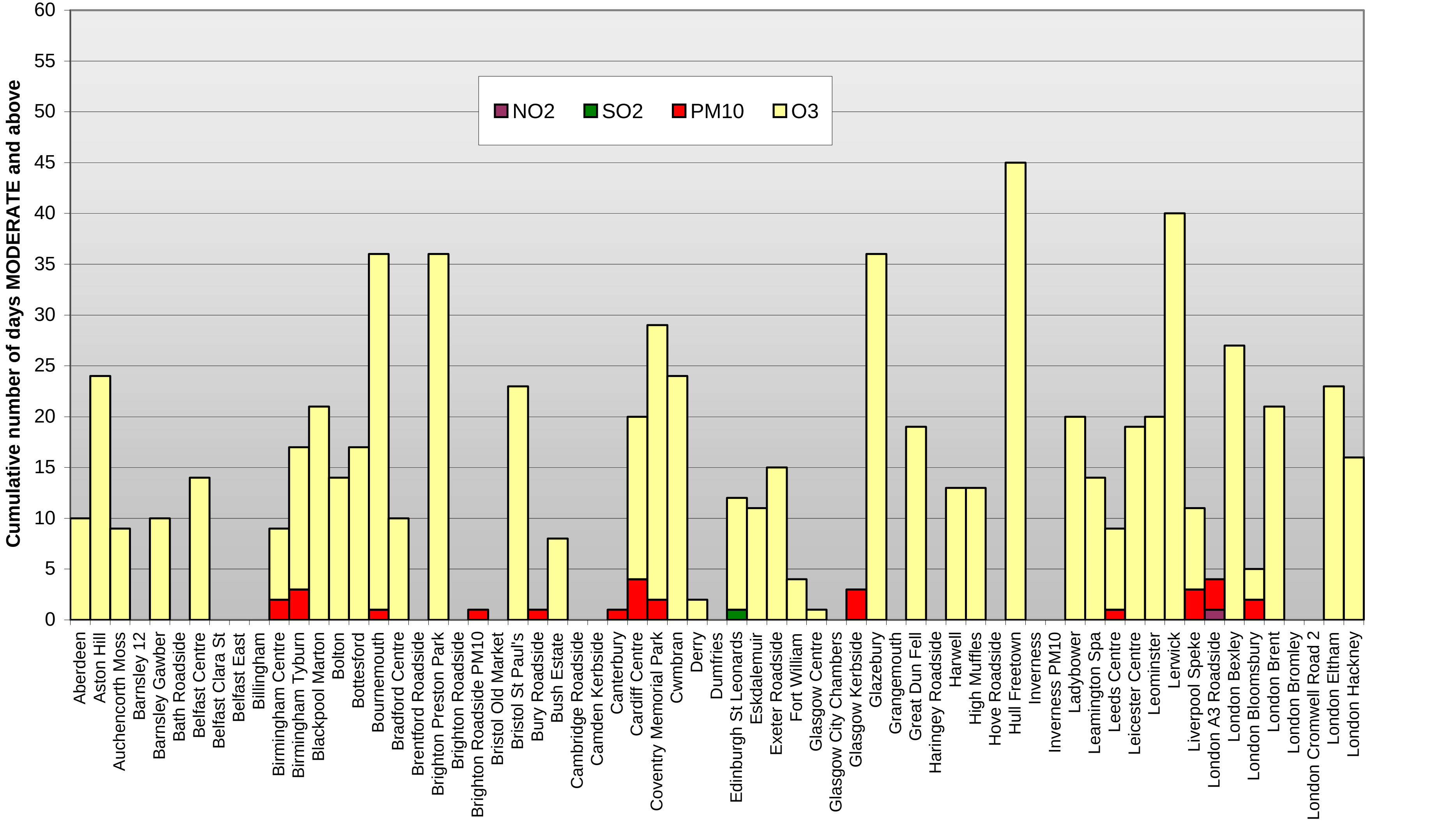


Figure 3.4a Number of days moderate and above for each AURN Network station over 2nd quarter 2007 – provisional data

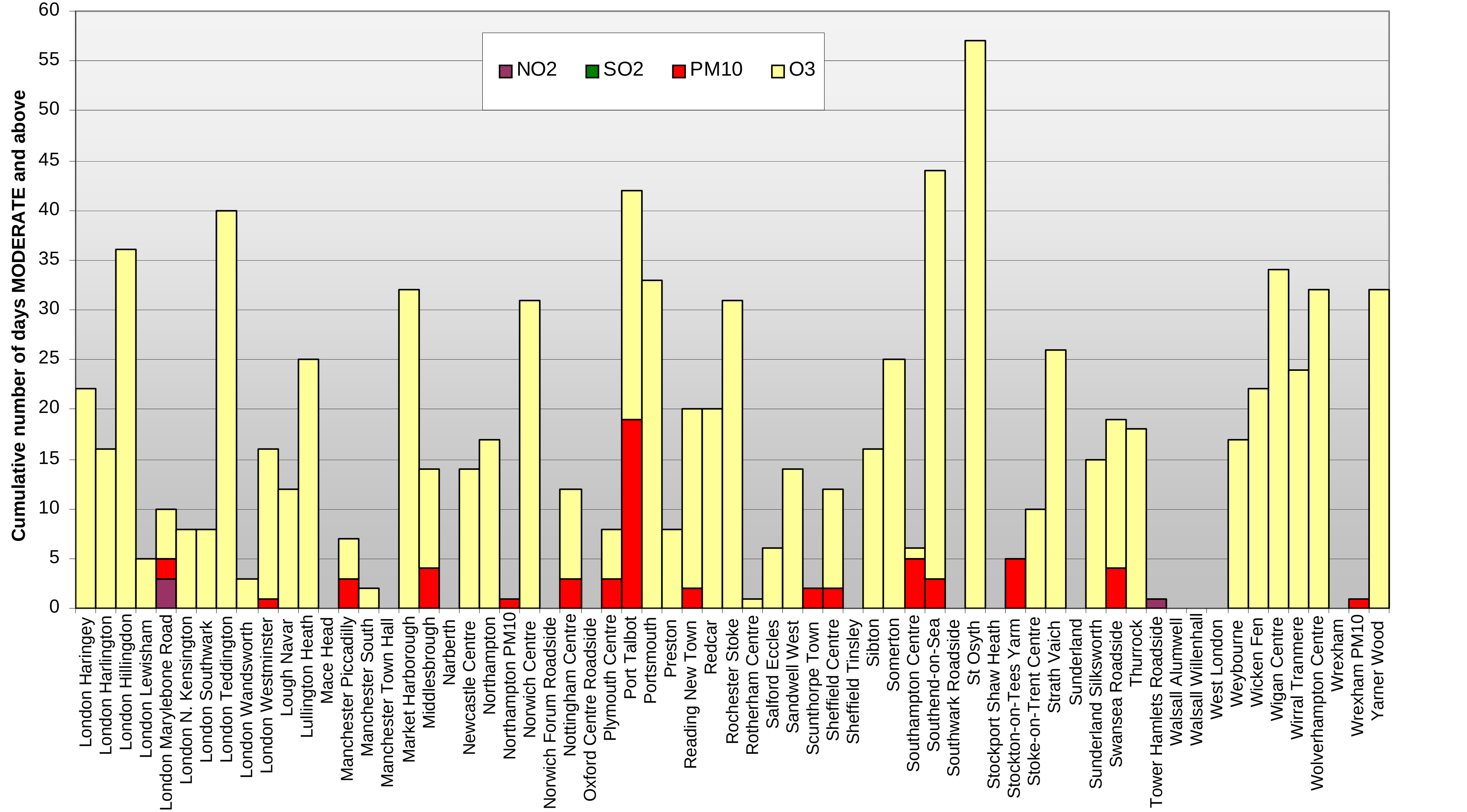


Figure 3.4b Number of days moderate and above for each AURN Network station over 2nd quarter 2007 – provisional data

4 Breakdowns in the service

All bulletins were successfully delivered to the Air Quality Communications contractor on time. There were no reported breakdowns in the service over this three-month period.

5 Additional or enhanced forecasts

No formal enhanced forecasts can be issued until the format of the enhanced service has been agreed with Defra and the Devolved Administrations.

The air pollution forecast is always re-issued to Teletext, Web and Freephone services at 10.00 local time each day, but will only be updated when the pollution situation is changing.

The bi-weekly air pollution outlooks have continued to be delivered successfully to Defra and other government departments by email on Tuesdays and Fridays.

6 Ad-hoc services and analysis

6.1 PARTICULATE CLOUD FROM EASTERN SOURCES IN LATE MARCH 2007

An ad-hoc report has been drafted for comment by Defra and the DAs detailing this episode. This includes global satellite imagery, measurements made, and subsequent NAME model runs performed by the Met Office to analyse various scenarios.

6.2 CHEMICAL FIRE IN CREWE

AEA Energy & Environment undertook an assessment of the effects of a chemical fire at a factory in Crewe on the afternoon of Monday 4th June 2007 based on some Met Office's NAME model results. Two AQM sites possibly measured an effect; AURN Wrexham at 4 p.m. on the 4th June and non-AURN Anglesey Llynfaes on the evening of the same day, although the short lived elevated measurements could equally have been caused by other localised pollution effects. Figures 6.1 and 6.2 show the NAME model run results for two periods of the morning of the 5th June. The approximate position of Wrexham is marked by a red cross on figure 6.1, the position of Anglesey Llynfaes is shown on figure 6.2. Figures 6.3 and 6.4 show hourly timeseries plots of PM_{10} as measured at these sites indicating where an elevation in concentrations was observed.

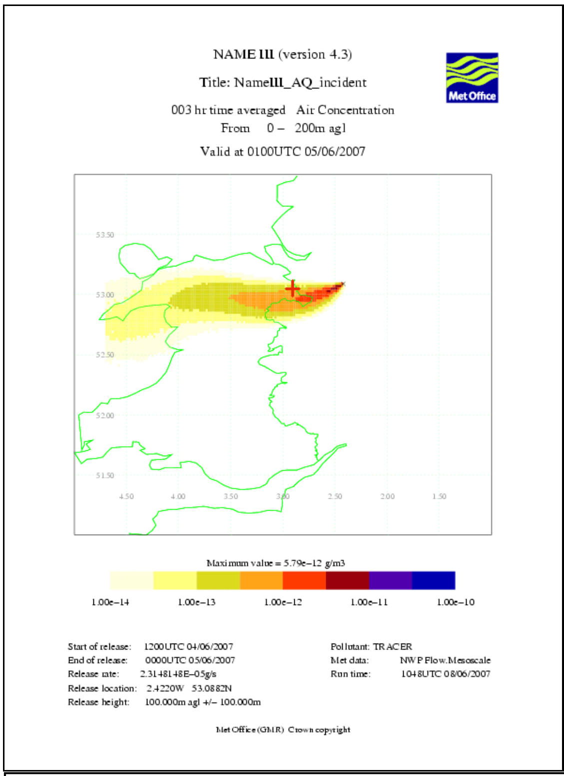


Figure 6.1 NAME air trajectory model result for the 5th June at 01:00 UTC

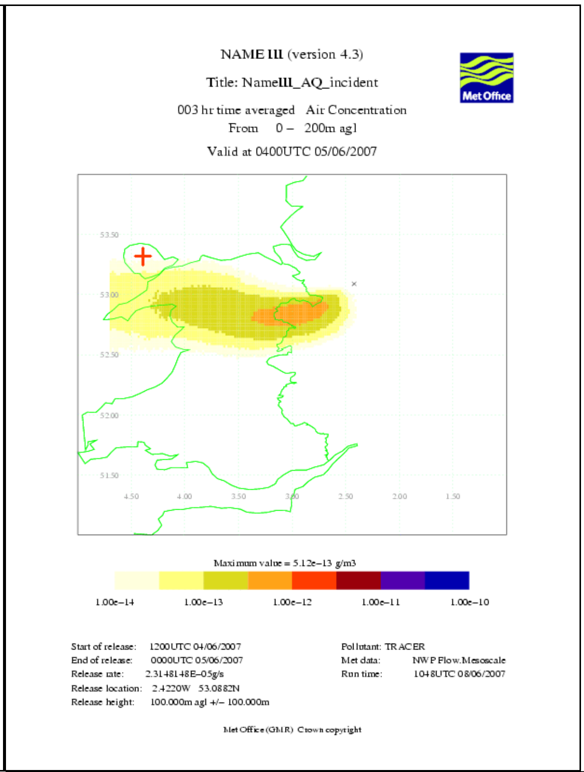


Figure 6.2 NAME air trajectory model result for the 5th June at 04:00 UTC

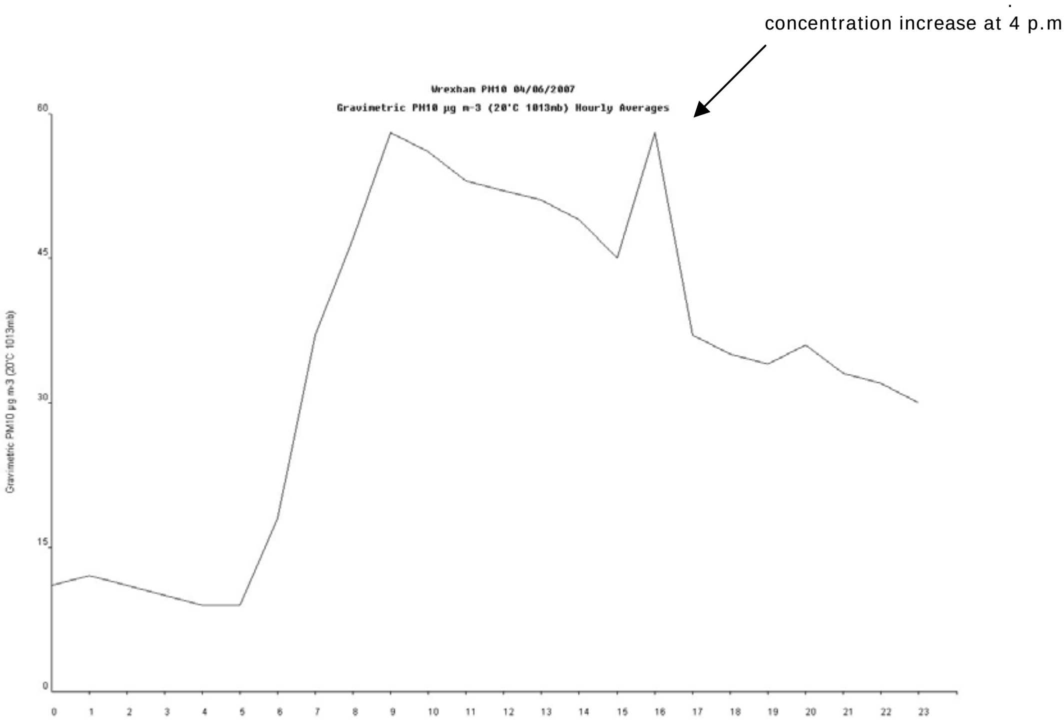


Figure 6.3 Indicative gravimetric PM_{10} in hourly averages measured at Wrexham AQM site on the 4th June.

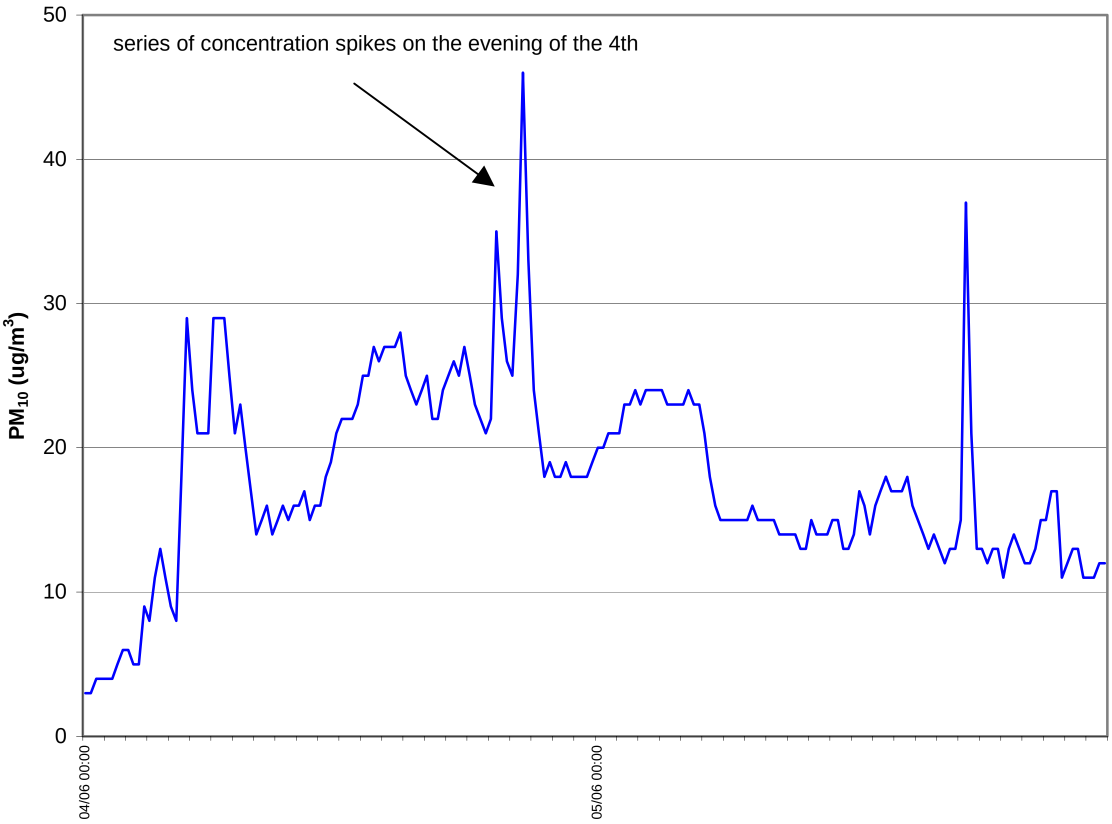


Figure 6.4 Hourly averaged PM_{10} levels measured by the Osiris instrument at Angelsey Llynfaes non-AURN AQM site on the 4th and 5th of June.

7 Ongoing research

AEA Energy & Environment and the Met office will also continue to:

1. Investigate ways of using automatic software systems to streamline the activities within the forecasting process, thus allowing forecasters to spend their time more efficiently considering the most accurate forecasts.
2. Research the chemistry used in our models, for example the chemical schemes for secondary PM_{10} and ozone.
3. Improve the NAME model runs that can be used for ad-hoc analyses, in particular with regard to investigating the possible long-range transport of PM_{10} pollution from European sources and the long-range transport of particles from Saharan Dust Storms.
4. Improve and update the emissions inventories used in our models.

8 Forward work plan for July to September 2007

Major tasks include:

- Ongoing daily air pollution forecasting activities.
- Ongoing improvements to the NAME model, including:
  - Increase in the horizontal model domain
  - An upgrade providing enhanced chemistry modelling for ozone, nitrates and sulphates.
  - Update of emissions inventory used in the model.
- Publication of the annual 2006 report, 2007 quarterly reports and one ad-hoc report on the Air Quality Archive Web Site.

9 Hardware and software inventory

Defra and the Devolved Administrations own the code for the ozone and secondary PM_{10} models, but not the graphical interface for these. Defra and the Devolved Administrations own the software for delivering the air pollution forecast to the Air Quality Communications system. Defra and the Devolved Administrations also own the web pages used to display the forecasts.

No computer hardware currently being used on this project is owned by Defra or the Devolved Administrations.

Appendix 1 - Air Pollution Index

CONTENTS

The UK Air Pollution Indices

Old Banding	Index	Ozone 8-hourly / Hourly mean		Nitrogen Dioxide Hourly Mean		Sulphur Dioxide 15-Minute Mean		Carbon Monoxide 8-Hour Mean		PM_{10} Particles 24-Hour Mean
		μgm^{-3}	ppb	μgm^{-3}	ppb	μgm^{-3}	ppb	mgm^{-3}	ppm	gravimetric μgm^{-3}
LOW										
	1	0-32	0-16	0-95	0-49	0-88	0-32	0-3.8	0.0-3.2	0-21
	2	33-66	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	22-42
	3	67-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	43-64
MODERATE										
	4	100-126	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	65-74
	5	127-152	63-76	382–477	200-249	355-442	133-166	13.5-15.4	11.6-13.2	75-86
	6	153-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	87-96
HIGH										
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	97-107
	8	240-299	120-149	636-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	108-118
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	119-129
VERY HIGH										
	10	$\geq 360\ \mu gm^{-3}$	$\geq$ 180 ppb	$\geq 764\ \mu gm^{-3}$	$\geq$ 400 ppb	$\geq 1064\ \mu gm^{-3}$	$\geq$ 400 ppb	$\geq 23.2\ mgm^{-3}$	$\geq$ 20 ppm	$\geq 130\ \mu gm^{-3}$

Old Banding	New Index	Health Descriptor
LOW		
	1	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
	2	
	3	
MODERATE		
	4	Mild effects unlikely to require action may be noticed amongst sensitive individuals
	5	
	6	
HIGH		
	7	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their “reliever inhaler is likely to reverse the effects on the lung.
	8	
	9	
VERY HIGH		
	10	The effects on sensitive individuals described for “HIGH” levels of pollution may worsen.

Appendix 2 - Forecasting Zones and Agglomerations

CONTENTS

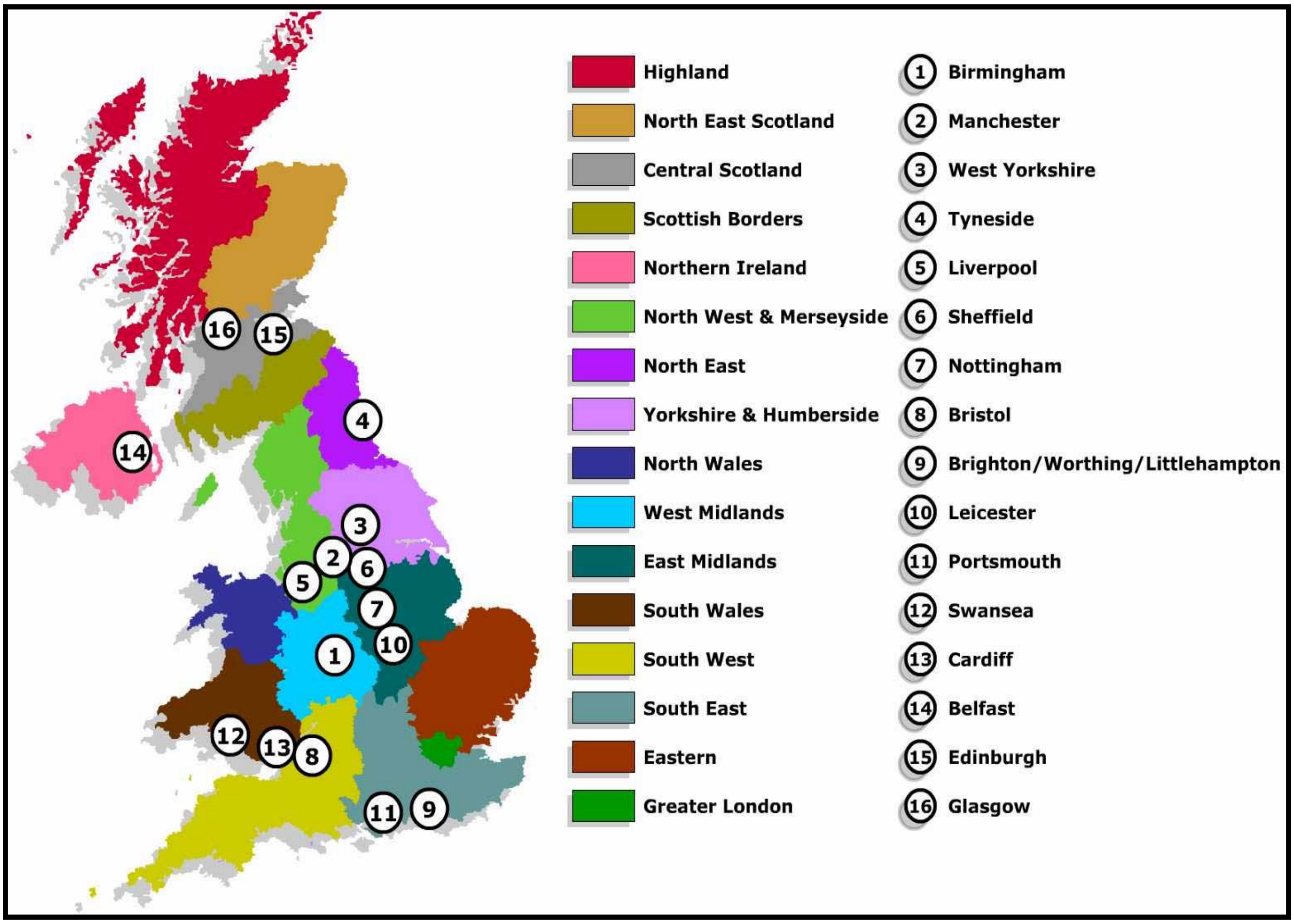
Forecasting Zones

Zone	Population
East Midlands	3084598
Eastern	5119547
Greater London	8278251
North East	1635126
North West and Merseyside	3671986
South East	6690881
South West	4364704
West Midlands	2970505
Yorkshire and Humberside	2816363
South Wales	1578773
North Wales	720022
Central Scotland	1813314
Highland	380062
North East Scotland	1001499
Scottish Borders	254690
Northern Ireland	1104991

Forecasting Agglomerations

Agglomeration	Population
Brighton/Worthing/Littlehampton	461181
Bristol Urban Area	551066
Greater Manchester Urban Area	2244931
Leicester	441213
Liverpool Urban Area	816216
Nottingham Urban Area	666358
Portsmouth	442252
Sheffield Urban Area	640720
Tyneside	879996
West Midlands Urban Area	2284093
West Yorkshire Urban Area	1499465
Cardiff	327706
Swansea/Neath/Port Talbot	270506
Edinburgh Urban Area	452194
Glasgow Urban Area	1168270
Belfast	580276

Map of UK forecasting zones and agglomerations



Appendix 3 – Worked Example of How UK Forecasting Success and Accuracy Rates are Calculated.

CONTENTS

A worked example showing how forecasting accuracy and success rate are defined and calculated in this report

This analysis is based on an imaginary period of high pollution concentrations in South East England – which occurred during warm weather and resulted in the formation of photochemical ozone. There were 4 days on which HIGH concentrations were measured; 29th July, 30th July, 1st August and 2nd August. Over the slightly longer period from 29th July – 3rd August, there were 6 days on which HIGH levels were either measured or forecast. During the whole reporting period, there were no other observations of HIGH band measurements, either forecast or actual. 31st July was a cooler day and measurements did not reach the HIGH band, despite being forecasted. Measured air pollution and previous day forecast are shown below for each day during this period, in terms of index and descriptive bands:

Date	28/7	29/7	30/7	31/7	1/8	2/8	3/8	4/8
Measured Index value (M)	**5** (MOD)	7 (HIGH)	7 (HIGH)	6 (MOD)	7 (HIGH)	7 (HIGH)	5 (MOD)	5 (MOD)
Forecast Index value (F)	5 (MOD)	6 (MOD)	7 (HIGH)	7 (HIGH)	8 (HIGH)	5 (MOD)	7 (HIGH)	6 (MOD)

Based on the figures above, the success and accuracy of predicting HIGH episodes (>= Air Pollution index 7) for the South East Zone may be analysed as shown below:

Date	28/7	29/7	30/7	31/7	1/8	2/8	3/8	4/8
Measured Index value (M)	**5** (MOD)	7 (HIGH)	7 (HIGH)	6 (MOD)	7 (HIGH)	7 (HIGH)	5 (MOD)	5 (MOD)
Forecast Index value (F)	5 (MOD)	6 (MOD)	7 (HIGH)	7 (HIGH)	8 (HIGH)	6 (MOD)	7 (HIGH)	6 (MOD)
HIGH forecast or measured	No, so not used in calculations	Yes	Yes	Yes	Yes	Yes	Yes	No, not used in calcs
OK- Agreement of F and M to +/- 1 index band	N/A	Yes	Yes	Yes	Yes	Yes	No	N/A

HIGH days measured	4
HIGH days forecast	4
OK (M and F) [i.e. Agreement of F and M to +/- 1 index band	5
Wrong (F not M)	1
Wrong (M not F)	0

The forecasting **success** during this period is calculated as:

[OK (M and F) / HIGH days measured]*100 = [5/4]*100 **= 125 %**

The corresponding **accuracy** is calculated as:

[OK (M and F) / {OK (M and F) + Wrong (M not F) + Wrong (F not M)}]*100

= [5 / {5+0+1}]*100 = [5/6]*100 = **83**

The analysis is then repeated for each of the 16 UK zones and 16 UK agglomerations.