



## **Ambient Air Monitoring**

**In**

**Bray**

**21<sup>st</sup> October 2005 – 10<sup>th</sup> May 2006**



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### **Summary**

An air quality assessment was carried out in Bray, Co. Wicklow from 21<sup>st</sup> October 2005 until 10<sup>th</sup> May 2006. No limit values were exceeded during the assessment period.

Concentrations of carbon monoxide, sulphur dioxide, nitrogen dioxide, benzene and lead were below their respective lower assessment thresholds. Levels of PM<sub>10</sub> exceeded the upper assessment threshold for this parameter.

	<b>Below Lower Assessment Threshold</b>	<b>Below Upper Assessment Threshold</b>	<b>Above Upper Assessment Threshold</b>	<b>Above Limit</b>
<b>PM<sub>10</sub></b>				
<b>NO<sub>2</sub></b>				
<b>CO</b>				
<b>SO<sub>2</sub></b>				
<b>Benzene</b>				
<b>Pb</b>				

Bray is in Zone C of the country. The implications of this assessment are that within Zone C (specified urban centres with populations in excess of 15,000)

- Levels of PM<sub>10</sub> will need to be monitored continuously
- Levels of CO, SO<sub>2</sub>, NO<sub>2</sub>, benzene and lead can be assessed using modelling or objective estimation techniques.

The European Union framework directive on air quality states that modelling or objective estimation techniques may be used to assess ambient air quality if levels of the pollutant in question in that zone are below the lower assessment threshold. Continuous monitoring is required if levels exceed the upper assessment threshold.

## ***Introduction***

The European Union introduced a new approach to the monitoring, assessment and management of air quality in 1996 when it introduced a framework directive on air quality (96/62/EC, 2<sup>nd</sup> September 1996). The basic principle of the framework directive is that each country should be divided into zones and that the monitoring, assessment, management and reporting of air quality will be undertaken in relation to these zones. For the purposes of the directive, Ireland has been divided into four zones; Dublin (Zone A), Cork Urban Area (Zone B), specified population centres > 15,000 inhabitants (Zone C) and non-urban areas (Zone D).

Limit values are set for each individual pollutant which need to be met by a specific attainment date. Upper and lower assessment thresholds are also set for each pollutant, assessment thresholds are levels below the limit value, used solely in the determination of the level of monitoring needed for that pollutant in a particular zone. The extent of monitoring in any zone is determined by population size and air quality status. Measurement is mandatory in agglomerations (population >250,000) and where concentrations are above the lower assessment threshold. The greatest monitoring effort applies if concentrations are above the upper assessment threshold. Less intensive monitoring is required when concentrations are between the two assessment thresholds.

Limit values, assessment thresholds, measurement techniques and other specifics for each pollutant are defined in a series of daughter directives. The first daughter directive was adopted in April 1999 (1999/30/EC) and covered SO<sub>2</sub>, NO<sub>x</sub>, particulate matter and lead. The second daughter directive was adopted in November 2000 (2000/69/EC) and covers CO and Benzene. The directives were transposed into Irish law as the Air Quality Standard Regulations 2002 (S.I. No. 271 of 2002).

To comply with the directive the Environmental Protection Agency uses mobile laboratories to carry out assessments in areas with no history of air pollution measurements. These trailers contained the following instruments:

- Monitoring instruments which continuously measure and record concentrations of the pollutants PM<sub>10</sub>, sulphur dioxide, nitrogen oxides and carbon monoxide.
- Instrument which continuously measures and records the levels of total suspended particles, PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>.
- Gas chromatograph which measures levels of benzene and toluene
- Sampler for lead and other metals in air (collection on filter for determination in the laboratory).

The sample inlets are at a height of ~3m.

For further information please contact

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### ***Time Period***

Monitoring commenced on 20<sup>th</sup> October 2005 and continued until Wednesday 10<sup>th</sup> May 2006.

### ***Siting***

The trailer was sited on Killarney Road, Bray in premises owned by the Health Service Executive, East Coast Region. In this location, the trailer was within a 300m of the centre of Bray.

### **Site location**



Fig. 1 Map of site location (courtesy of OSI)

## ***Monitoring Methods***

### *Carbon Monoxide*

Carbon monoxide was monitored using a Gas Filter Correlation CO Analyser (Model 300, Advanced Pollution Instrumentation, 6565 Nancy Ridge Drive, San Diego, California). This is a continuous analyser whose measurement technique is based on the absorption of infrared radiation by CO molecules at wavelengths near 4.7µm.

### *Sulphur Dioxide*

Sulphur dioxide was monitored using an Advanced Pollution Instrumentation SO<sub>2</sub> Fluorescent Analyser - Model 100A. This is a continuous analyser which measures the fluorescence of SO<sub>2</sub> molecules after excitation by ultraviolet radiation.

### *Nitrogen Dioxide and Oxides of Nitrogen*

NO<sub>x</sub> species were monitored using an Advanced Pollution Instrumentation Chemiluminescent NO/NO<sub>2</sub>/NO<sub>x</sub> Analyser - Model 200A. This is a continuous analyser which utilises the chemiluminescent reaction between nitric oxide in the sample and ozone to measure NO concentrations. Any NO<sub>2</sub> present is then reduced to NO by a molybdenum converter giving a second value for total NO<sub>x</sub> concentration. The amount of NO<sub>2</sub> present is found by subtraction.

### *Particulate Matter*

Concentrations of PM<sub>10</sub> were measured using an instrument which employed tapered element oscillating microbalance technology (TEOM, Rupprecht & Patashnick Co. Inc., 25 Corporate Circle, Albany, New York). This is a continuous method in which the air from the sampling head is passed through a filter placed on a tapered element. A mass transducer relates changes in the frequency of the tapered element to changes in particulate matter on the filter, the difference between the filter's current weight and its initial weight gives the total mass of collected particulate matter. An inertial impactor sampling head restricted the sampled particles to those with a diameter less than 10µm. PM<sub>10</sub> concentrations measured by the TEOM were multiplied by a correction factor of 1.3 to compensate for the loss of volatile matter as recommended by the EC working group on particulate matter.

Particulate matter was also measured using an OSIRIS Environmental Dust Monitor (Turnkey Instruments, 1&2 Dalby Court, Gadbrook Business Centre, Northwich, Cheshire CW9 7TN). This instrument uses a light scattering technique to determine the concentration of airborne particles and dust; it is not an approved method. Results are given for total suspended particulates, PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>.

### *Benzene*

Benzene was measured using a gas chromatograph (BTX Analyser GC855 supplied by Syntech Spectras, G. Meirstraat 11, 9728 TB Groningen, Nederland). This gas chromatograph samples automatically over a fifteen minute cycle and is equipped with a photoionisation detector.

### *Lead and Other Metals*

Ambient air was pumped through a Metrical membrane filter (Gelman, 37mm, 0.8µm) situated in a calming chamber. The filters were changed every 3-4 weeks. They were digested in conc. HNO<sub>3</sub> and analysed for lead and other metals using ICP-MS (Inductively Coupled Plasma-Mass Spectrometry).

All results for CO, SO<sub>2</sub> and NO<sub>x</sub> were integrated to give 1-hour average values as required for comparison with the Directive limit values.

## Results

### Carbon Monoxide

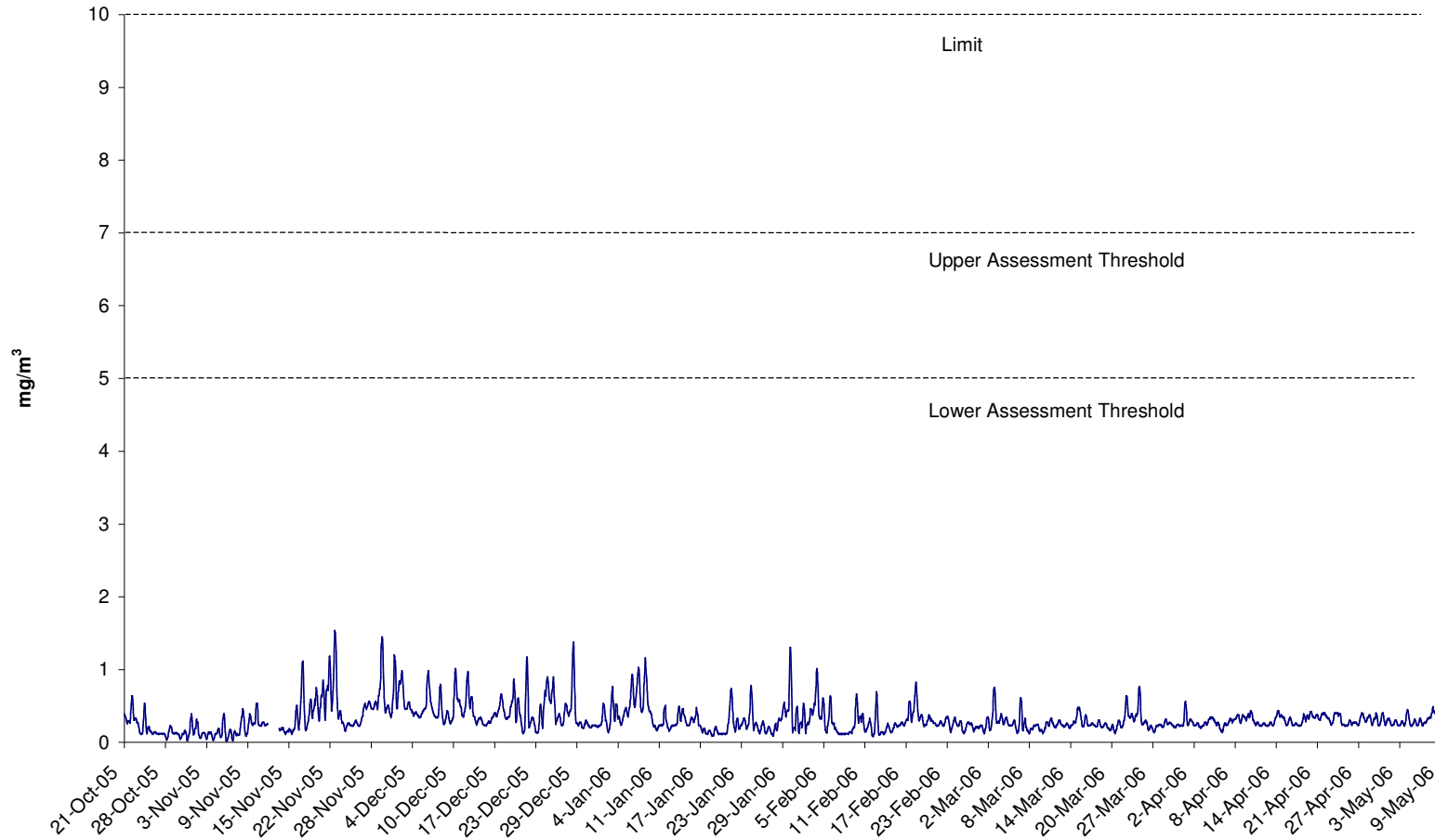
No. of hours	4848	
Missing values (including routine maintenance)	47 34	
No. of measured values	4801	
Percentage covered	99.7	
Maximum hourly value	2.8	mg/m <sup>3</sup>
98 percentile for hourly values	1.0	mg/m <sup>3</sup>
Mean hourly value	0.3	mg/m <sup>3</sup>
Maximum 8-hour mean	1.5	mg/m <sup>3</sup>
98 percentile for 8-hour mean	0.9	mg/m <sup>3</sup>

### Directive Limits

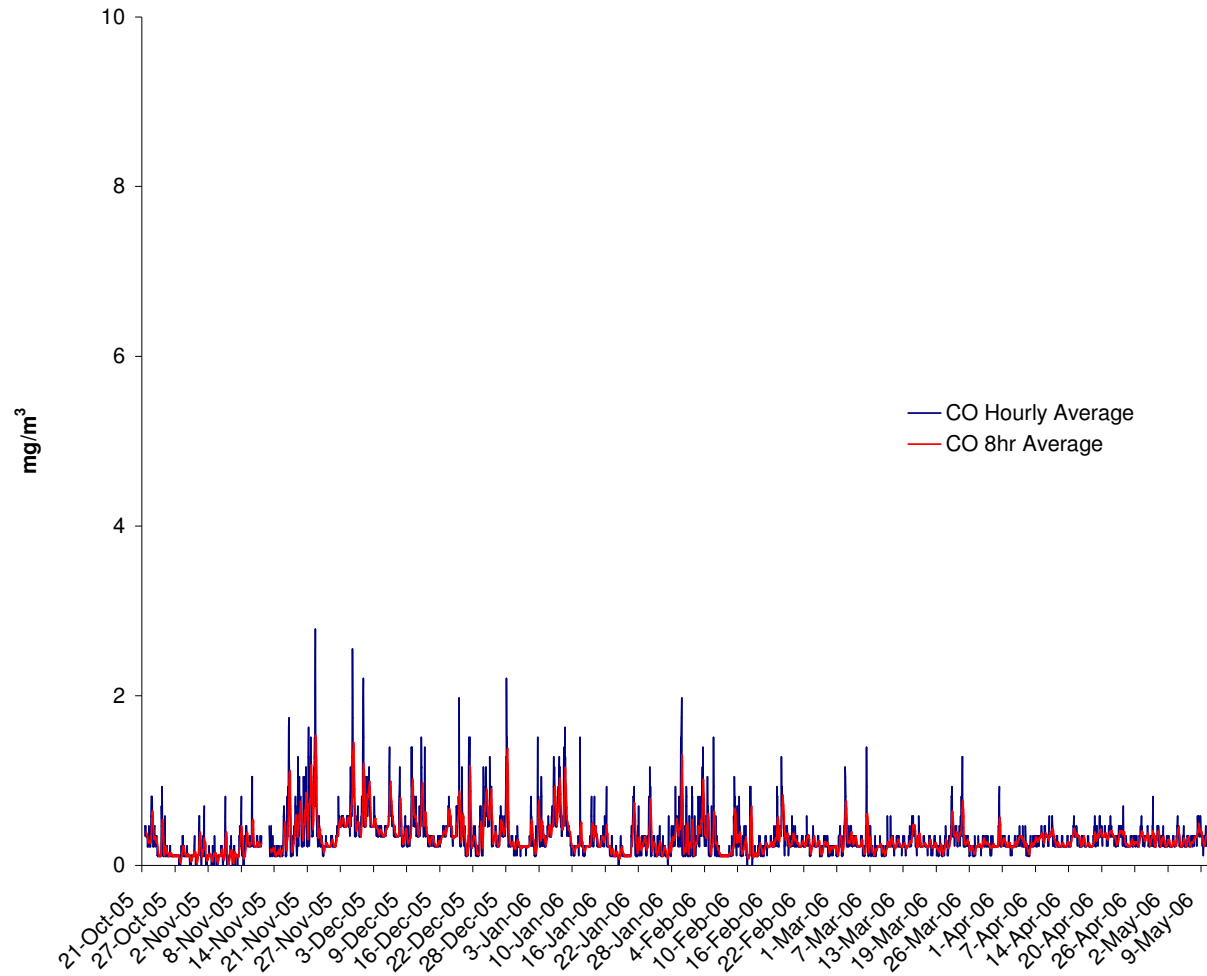
	Averaging Period	Limit Value	Date by which limit value is to be met
Limit Value for the protection of human health	8-hour running average	10 mg/m <sup>3</sup>	1 January 2005
Upper assessment threshold	8-hour running average	7 mg/m <sup>3</sup>	
Lower assessment threshold	8-hour running average	5 mg/m <sup>3</sup>	

The lower assessment threshold was not exceeded during the measurement period (Figure 2).

**Fig. 2 Carbon Monoxide 8 hr Running Average  
Trailer 3 in Bray 21/10/05 - 10/5/06**



**Fig.3 Carbon Monoxide  
Trailer 3 in Bray 21/10/05 - 10/5/06**



## Sulphur Dioxide

No. of hours	4848
Missing values (including routine maintenance)	228 37
No. of measured values	4620
Percentage covered	96.1
Maximum hourly value	48.9 $\mu\text{g}/\text{m}^3$
99.7 percentile for hourly values	26.4 $\mu\text{g}/\text{m}^3$
Mean hourly value	3.8 $\mu\text{g}/\text{m}^3$
Maximum 24-hour value	11.8 $\mu\text{g}/\text{m}^3$
99.2 percentile for 24-hour values	11.0 $\mu\text{g}/\text{m}^3$

### Directive Limits (1999/30/EC)

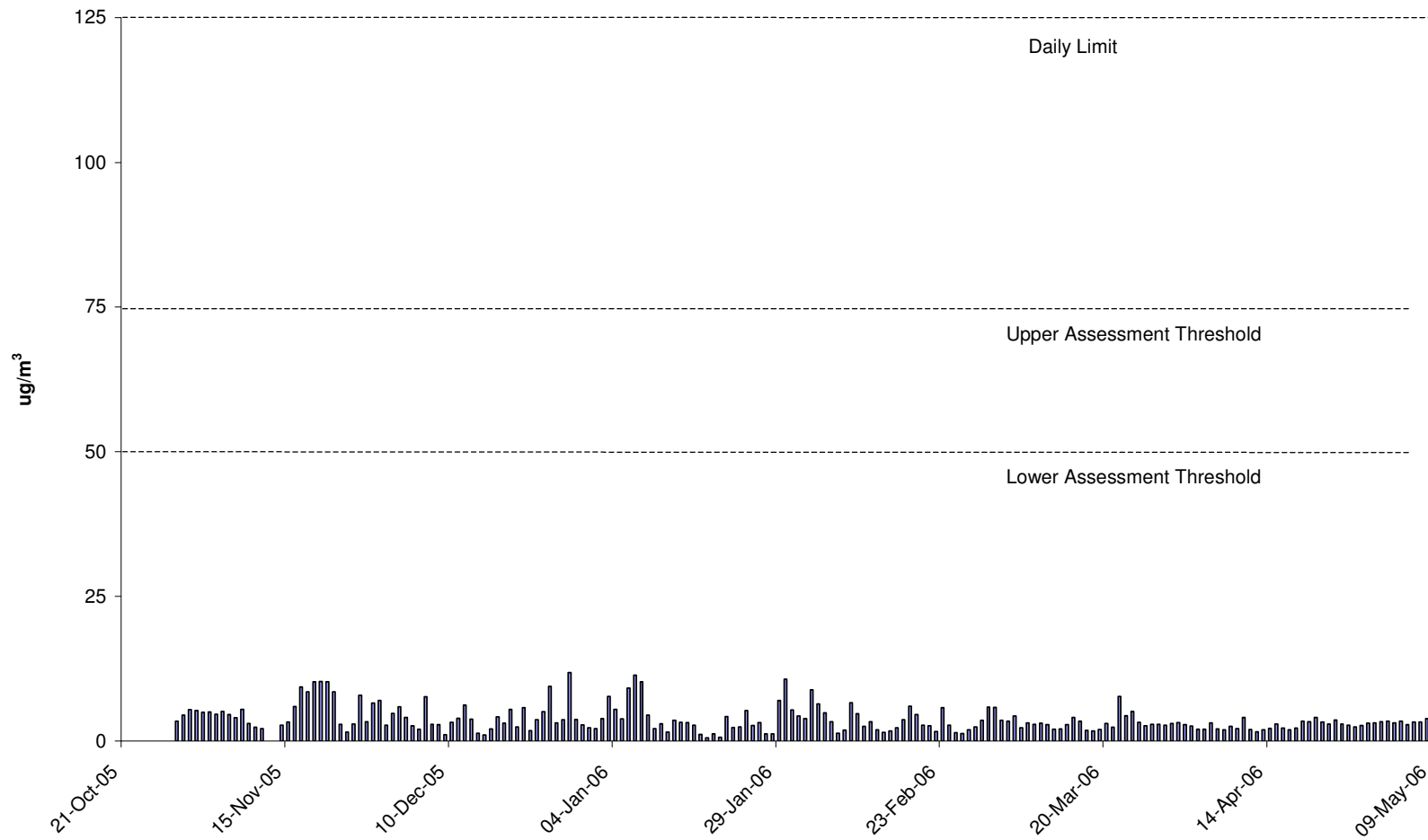
	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	350 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 24 times a calendar year	1 January 2005
Daily limit value for the protection of human health	24 hours	125 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 3 times a calendar year	1 January 2005
Limit value for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	20 $\mu\text{g}/\text{m}^3$	19 July 2001
Alert threshold		500 $\mu\text{g}/\text{m}^3$ over three consecutive hours	

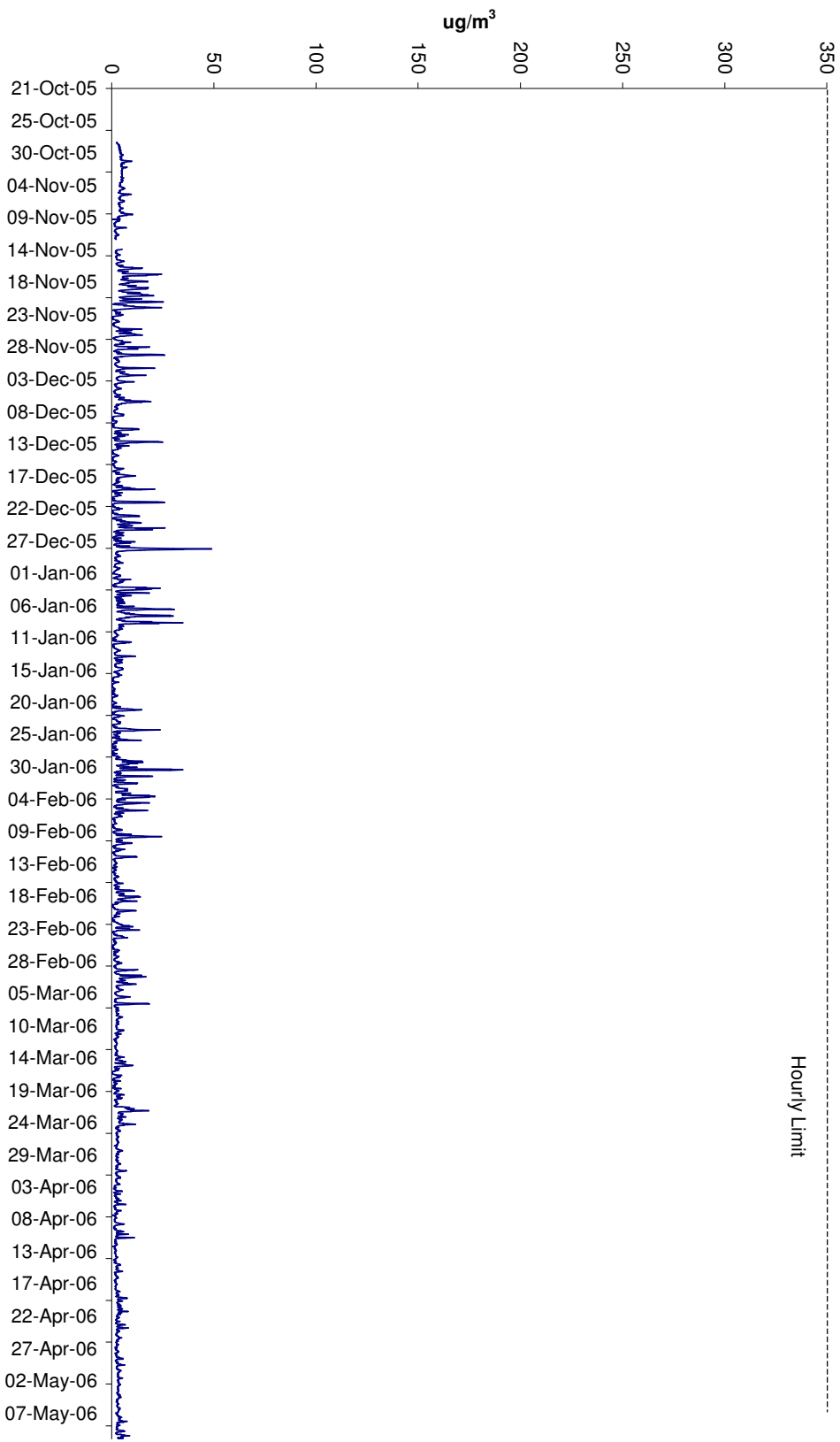
**Directive Limits (1999/30/EC) continued**

	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	24 hours	75 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 3 times a calendar year	
Lower assessment threshold for the protection of human health	24 hours	50 $\mu\text{g}/\text{m}^3$ not to be exceeded more than 3 times a calendar year	
Upper assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	12 $\mu\text{g}/\text{m}^3$	
Lower assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	8 $\mu\text{g}/\text{m}^3$	

The lower assessment thresholds for the protection of human health and the protection of ecosystems were not exceeded during the measurement period.

**Fig. 4 Sulphur Dioxide 24 Hour Averages  
Trailer 3 in Bray 21/10/05 - 10/5/06**





**Fig. 5 Sulphur Dioxide Hourly Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**

## Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	4848
Missing values (including routine maintenance)	35
No. of measured values	4813
Percentage covered	100
Maximum hourly value (NO <sub>2</sub> )	146.3 µg/m <sup>3</sup>
99.8 percentile for hourly values (NO <sub>2</sub> )	82.7 µg/m <sup>3</sup>
Mean hourly value (NO <sub>2</sub> )	16.1 µg/m <sup>3</sup>
Mean hourly value (NO <sub>x</sub> )	25.0 µg/m <sup>3</sup> NO <sub>2</sub>

### Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	200 µg/m <sup>3</sup> NO <sub>2</sub> not to be exceeded more than 18 times a calendar year	1 January 2010
Annual limit value for the protection of human health	Calendar year	40 µg/m <sup>3</sup> NO <sub>2</sub>	1 January 2010
Annual limit value for the protection of vegetation	Calendar year	30 µg/m <sup>3</sup> NO <sub>x</sub>	19 July 2001
Alert threshold		400 µg/m <sup>3</sup> NO <sub>2</sub> over three consecutive hours	

**Directive Limits (1999/30/EC) continued**

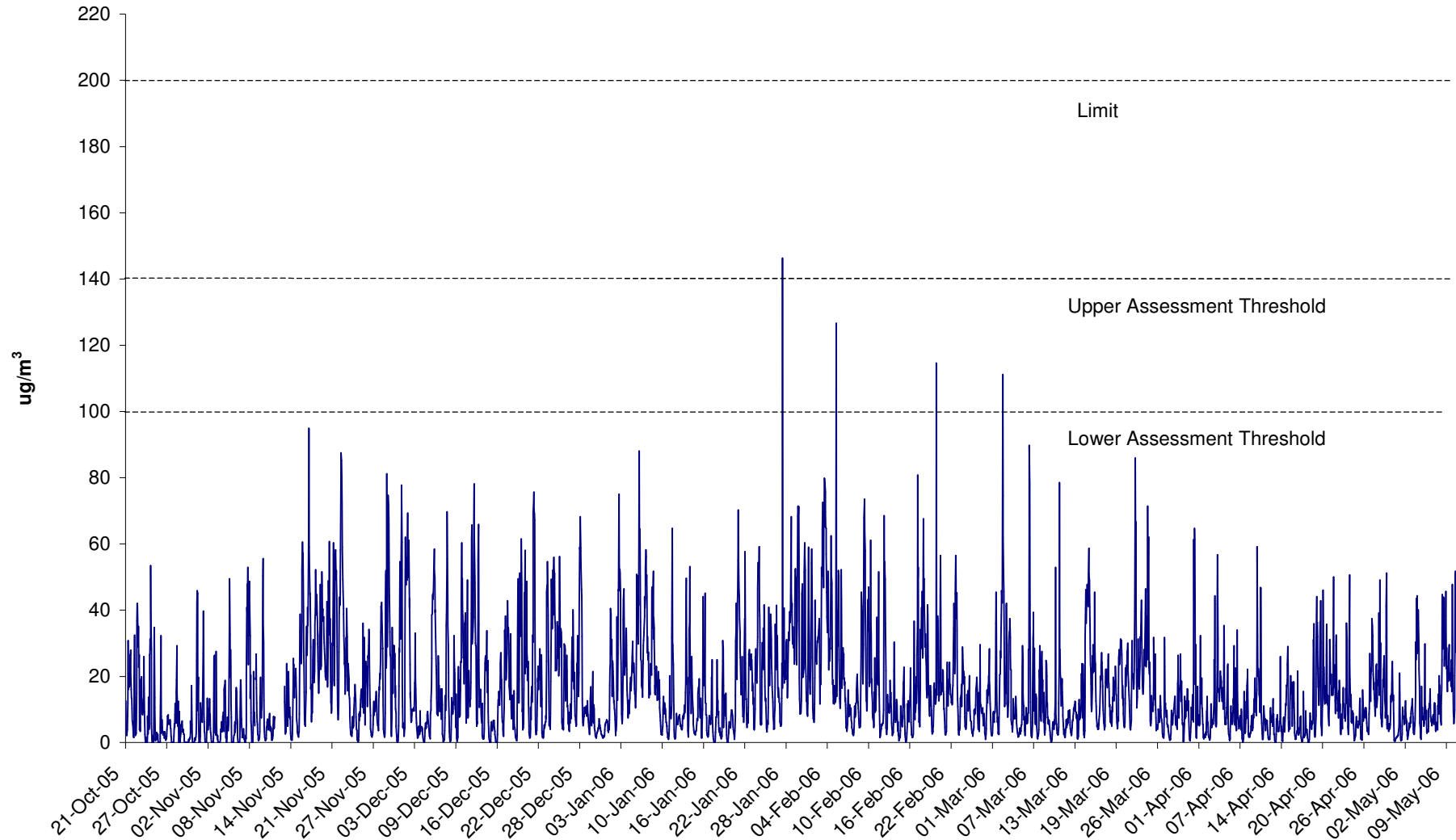
	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	1 hour	140 $\mu\text{g}/\text{m}^3$ $\text{NO}_2$ not to be exceeded more than 18 times a calendar year	
Upper assessment threshold for the protection of human health	Calendar year	32 $\mu\text{g}/\text{m}^3$ $\text{NO}_2$	
Lower assessment threshold for the protection of human health	1 hour	100 $\mu\text{g}/\text{m}^3$ $\text{NO}_2$ not to be exceeded more than 18 times a calendar year	
Lower assessment threshold for the protection of human health	Calendar year	26 $\mu\text{g}/\text{m}^3$ $\text{NO}_2$	
Upper assessment threshold for the protection of vegetation	Calendar year	24 $\mu\text{g}/\text{m}^3$ $\text{NO}_x$	
Lower assessment threshold for the protection of vegetation	Calendar year	19.5 $\mu\text{g}/\text{m}^3$ $\text{NO}_x$	

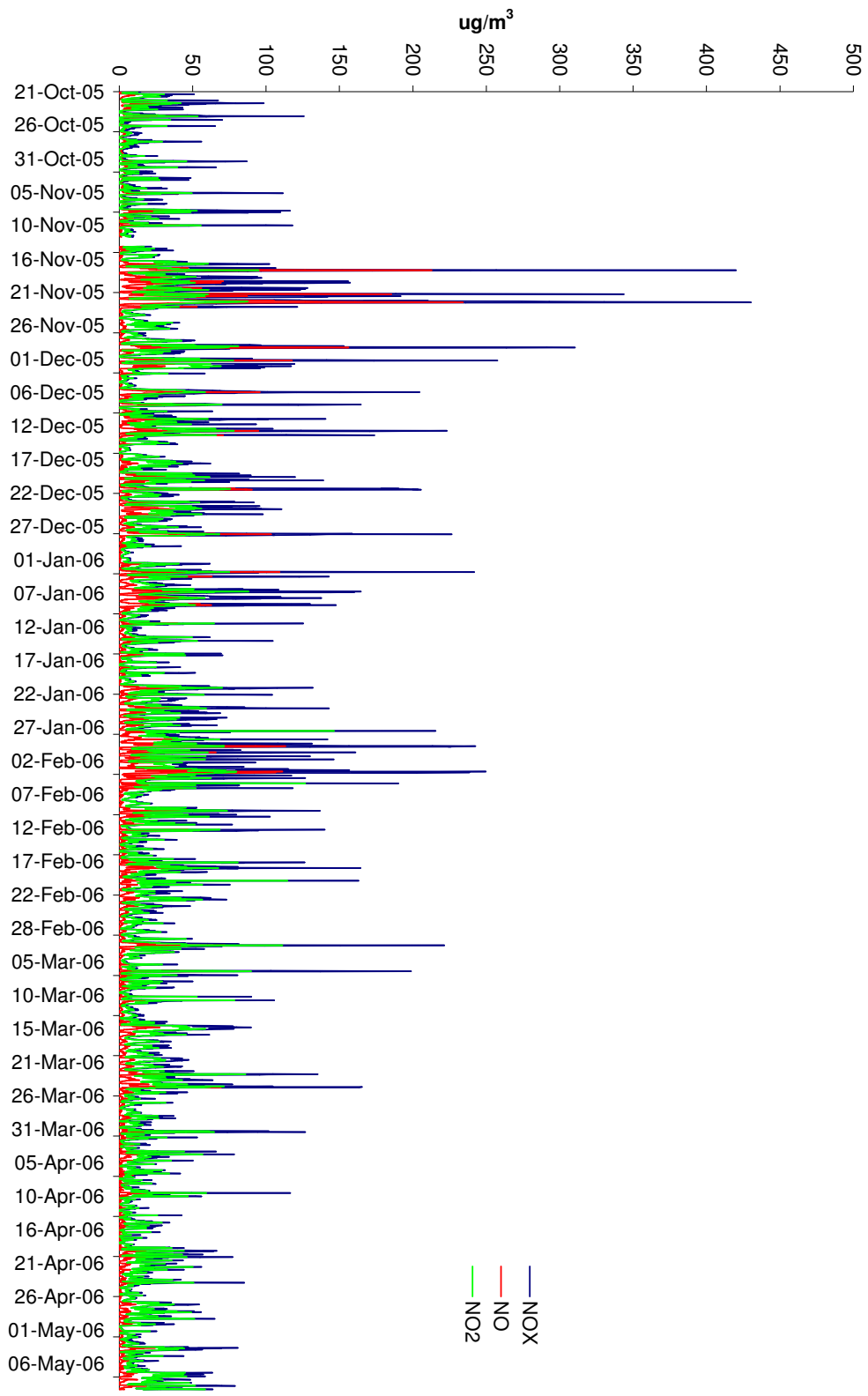
The lower assessment threshold for the protection of human health was exceeded four times during the assessment while the upper assessment threshold for the protection of human health was exceeded once. However, Bray is still classified as being below the lower assessment threshold for NO<sub>2</sub> since the Directive permits assessment thresholds to be exceeded 18 times in a calendar year.

The average NO<sub>x</sub> concentration (expressed as NO<sub>2</sub>) exceeded both the lower and upper assessment thresholds for the protection of ecosystems, the limit value was not exceeded. However, the applicability of these standards for urban air quality monitoring is questionable.

NO, NO<sub>2</sub> and NO<sub>x</sub> are measured as ppb (parts per billion) by volume. To convert to µg/m<sup>3</sup>, a factor (1.25 for NO, 1.91 for NO<sub>2</sub>) is used. No formula is specified for NO<sub>x</sub>, the directive requires it to be expressed as NO<sub>2</sub> (i.e. ppb\*1.91). This applies even when most of the NO<sub>x</sub> is present as NO.

**Fig. 6 NO<sub>2</sub> Hourly Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**





**Fig. 7 NO<sub>x</sub> Hourly Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**

## Particulate Matter

### PM<sub>10</sub> : automatic gravimetric method

No. of days	202
Missing values (including routine maintenance)	98 0
No. of measured values	104
Percentage covered	51.5
Maximum daily value	46.9 $\mu\text{g}/\text{m}^3$
90.4 percentile for daily values	33.4 $\mu\text{g}/\text{m}^3$
Mean daily value	22.7 $\mu\text{g}/\text{m}^3$

### Directive Limits (1999/30/EC)

#### STAGE I

	Averaging Period	Limit Value	Date by which limit value is to be met
24-hour limit value for the protection of human health	24 hour	50 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub> not to be exceeded more than 35 times a calendar year	1 January 2005
Annual limit value for the protection of human health	Calendar year	40 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub>	1 January 2005
Upper assessment threshold for the protection of human health	24 hour	30 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub> not to be exceeded more than 7 times a calendar year	<i>based on the indicative limit values for 1 January 2010</i>
Upper assessment threshold for the protection of human health	Calendar year	14 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub>	<i>based on the indicative limit values for 1 January 2010</i>

**Directive Limits (1999/30/EC) continued**

	Averaging Period	Limit Value	Date by which limit value is to be met
Lower assessment threshold for the protection of human health	24 hour	20 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub> not to be exceeded more than 7 times a calendar year	<i>based on the indicative limit values for 1 January 2010</i>
Lower assessment threshold for the protection of human health	Calendar year	10 $\mu\text{g}/\text{m}^3$ PM <sub>10</sub>	<i>based on the indicative limit values for 1 January 2010</i>

The limit value for the protection of human health was not exceeded during the assessment. The lower assessment threshold was exceeded on 56 occasions while the upper assessment threshold was exceeded on 25 occasions. The directive only allows the assessment thresholds to be exceeded 7 times in a calendar year. Bray is thus classified as being above the upper assessment threshold for PM<sub>10</sub>.

## Particulate Matter : PM<sub>2.5</sub>

Article 5 of Council Directive 1999/30/EC of 22 April 1999 states that

*“Member States shall ensure that measuring stations to supply data on concentration of PM<sub>2.5</sub> are installed.”*

The concentration of PM<sub>2.5</sub> was measured with an OSIRIS Environmental Dust Monitor in the mobile laboratory. This also measured total suspended particles (TSP), PM<sub>10</sub> and PM<sub>1</sub>. All measurements were hourly values.

The concentration of PM<sub>10</sub> measured by the OSIRIS and that measured using the TEOM were compared to give a daily correction factor. The correction factor was used to estimate the concentration of PM<sub>2.5</sub> using the formula:

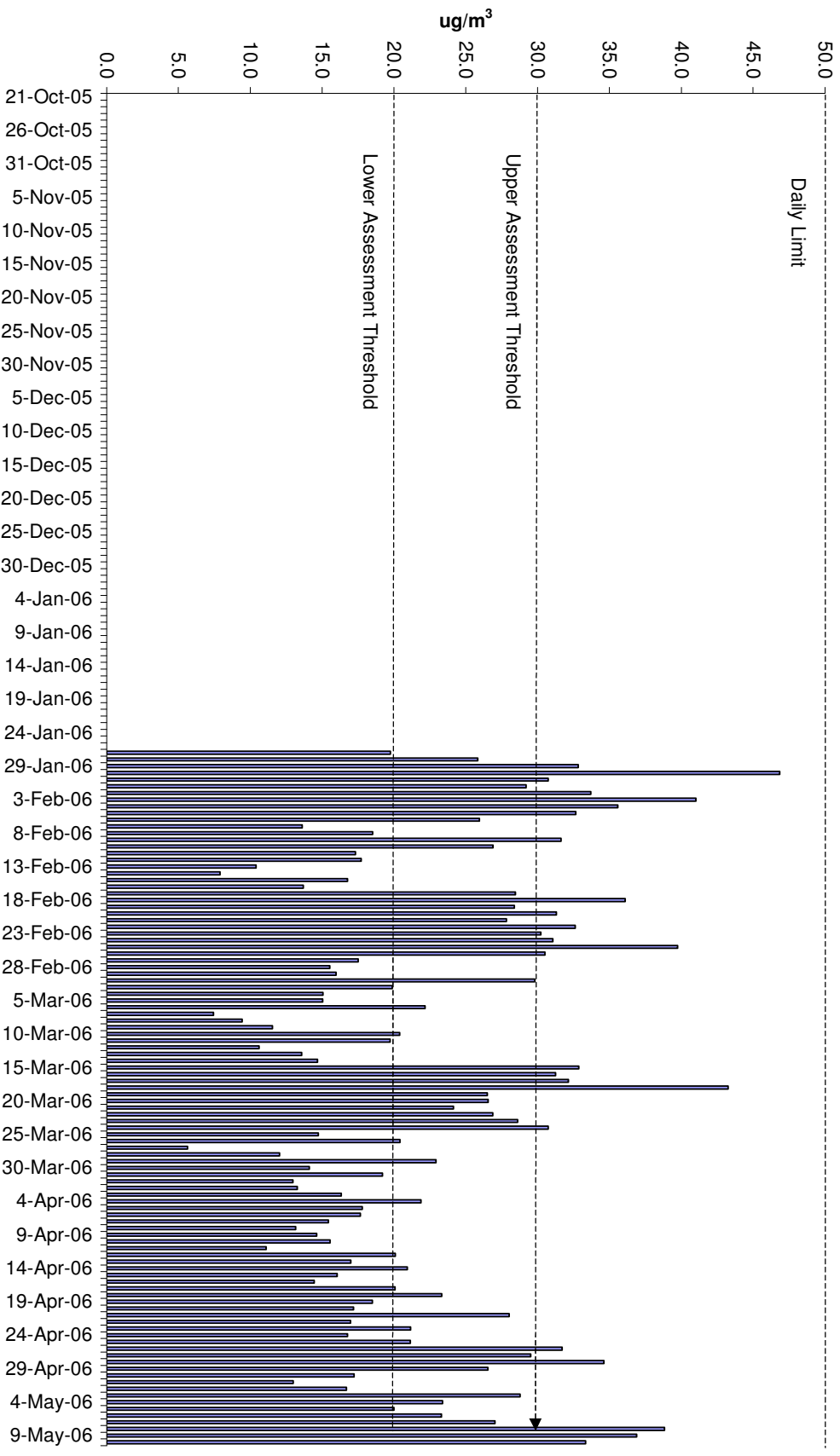
$$\begin{array}{l} \text{24-hour average} \\ \text{concentration} \\ \text{of PM}_{2.5} \end{array} = \begin{array}{l} \text{OSIRIS 24-hour} \\ \text{average concentration} \\ \text{of PM}_{2.5} \end{array} \times \frac{\text{TEOM 24-hour average PM}_{10}}{\text{OSIRIS 24-hour average PM}_{10}}$$

### *Results:*

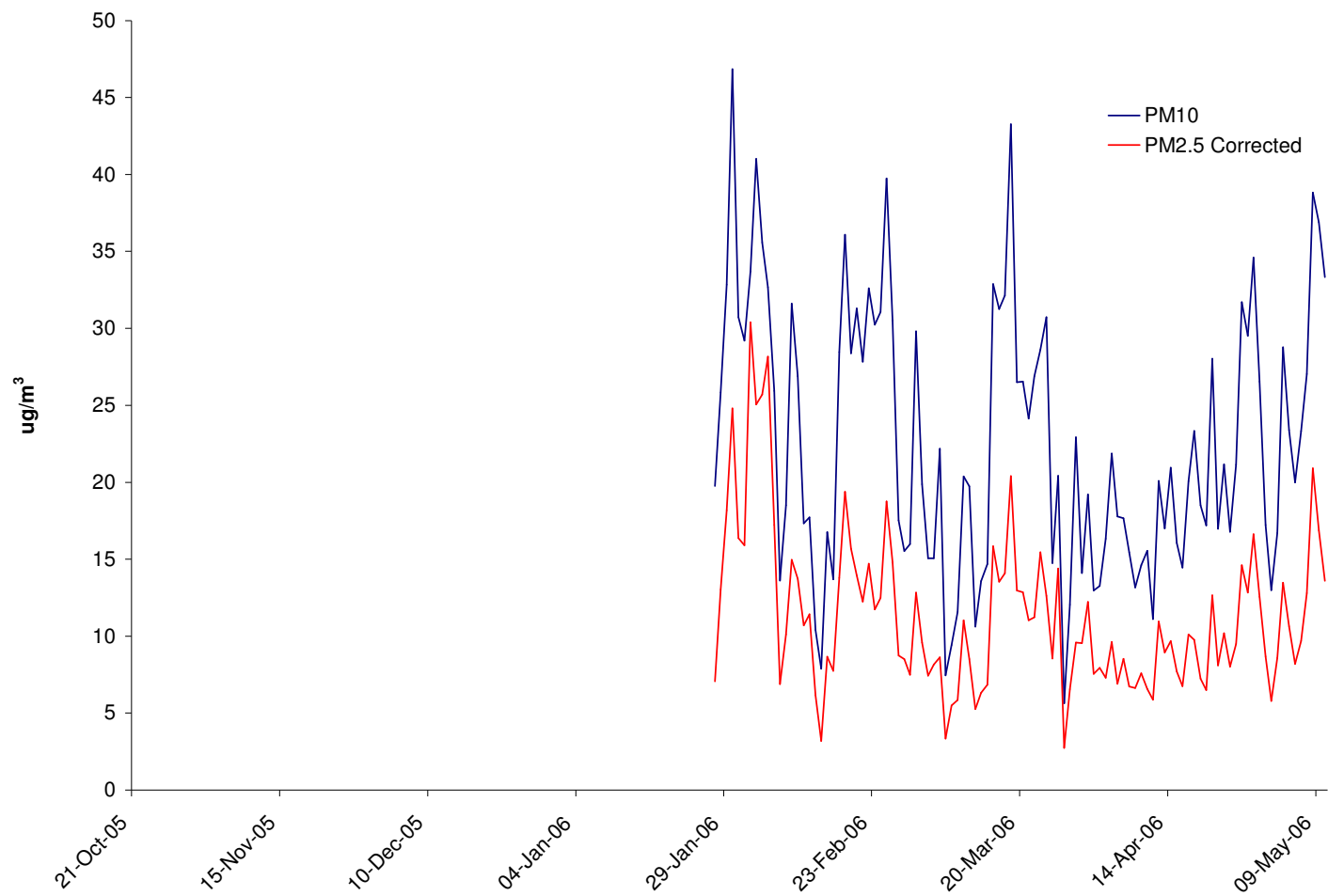
No. of days	202
Missing values (including routine maintenance)	98 0
No. of measured values*	104
Percentage covered	51.5
Maximum daily value	30.4 µg/m <sup>3</sup>
98 percentile for daily values	25.7 µg/m <sup>3</sup>
Mean daily value	11.4 µg/m <sup>3</sup>
Median daily value	10.1 µg/m <sup>3</sup>

\* no. of days with measurements from both the OSIRIS monitor and the TEOM.

**Fig. 8 PM<sub>10</sub> Daily Values**  
**Trailer 3 in Bray 21/10/05 - 10/5/06**



**Fig. 9 PM<sub>10</sub> and PM<sub>2.5</sub> Daily Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**



## Benzene

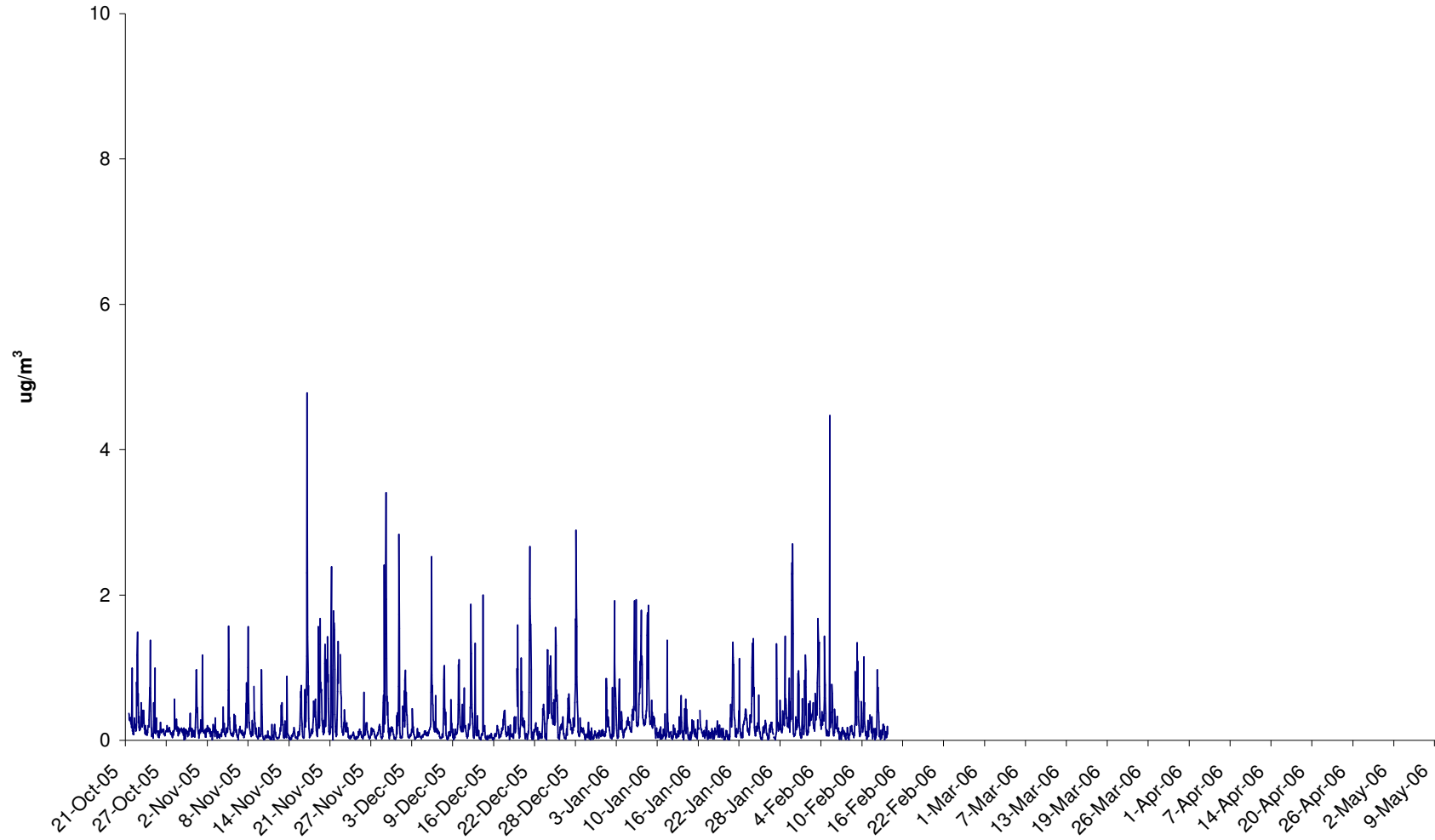
No. of hours	4848
Missing values (including routine maintenance)	2079 12
No. of measured values	2769
Percentage covered	57.4
Maximum hourly value	4.8 $\mu\text{g}/\text{m}^3$
98 percentile for hourly values	1.4 $\mu\text{g}/\text{m}^3$
Mean hourly value	0.2 $\mu\text{g}/\text{m}^3$

### Directive Limits

	Averaging Period	Limit Value	Date by which limit value is to be met
Limit value for the protection of human health	Calendar year	5 $\mu\text{g}/\text{m}^3$	1 January 2010
Upper assessment threshold for the protection of human health	Calendar year	3.5 $\mu\text{g}/\text{m}^3$	
Lower assessment threshold for the protection of human health	Calendar year	2 $\mu\text{g}/\text{m}^3$	

The lower assessment threshold was not exceeded.

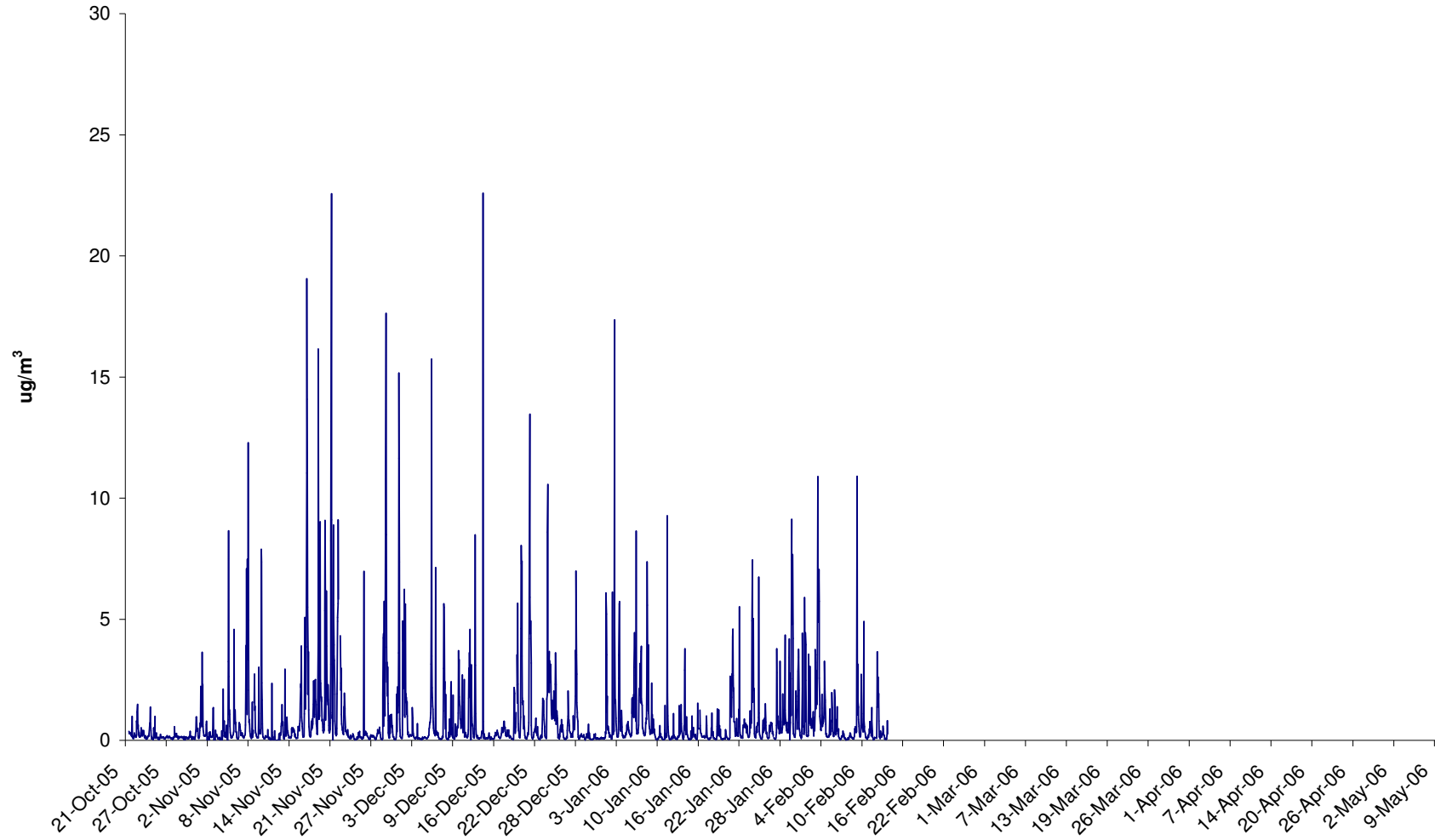
**Fig. 10 Benzene Hourly Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**



## Toluene

No. of hours	4848
Missing values (including routine maintenance)	2079 12
No. of measured values	2769
Percentage covered	57.4
Maximum hourly value	22.6 $\mu\text{g}/\text{m}^3$
98 percentile for hourly values	6.1 $\mu\text{g}/\text{m}^3$
Mean hourly value	0.8 $\mu\text{g}/\text{m}^3$

**Fig. 11 Toluene Hourly Values  
Trailer 3 in Bray 21/10/05 - 10/5/06**



## Lead

No. of days	203
Missing days (including routine maintenance)	0
No. of measured days	203
Percentage covered	100
Concentration of Pb	0.01 $\mu\text{g}/\text{m}^3$

### Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Annual limit value for the protection of human health	Calendar year	0.5 $\mu\text{g}/\text{m}^3$	1 January 2005
Upper assessment threshold	Calendar year	0.35 $\mu\text{g}/\text{m}^3$	
Lower assessment threshold	Calendar year	0.25 $\mu\text{g}/\text{m}^3$	

The lower assessment threshold was not exceeded.

## **Other Metals:**

Annex I of council directive 96/62/EC (Air Framework Directive) lists four metals other than lead to be taken into consideration in the assessment and management of ambient air quality. These are cadmium, arsenic, nickel and mercury . Limit values and measurement methods for these metals as well as certain polycyclic aromatic hydrocarbons will be set out in the fourth daughter directive.

An indicative method was used during this assessment to measure prevailing concentrations of cadmium, nickel and arsenic in air. This method is detailed above and essentially involves pumping air through a filter for several weeks before digesting the filter and analysing the digest for lead and other metals using ICP-MS. The problem with this method is that the detection limit is influenced by any traces of metal in the filter paper as well as by the volume of air passed through the filter. The results, although indicative, do provide some indication of the concentrations of these metals in air.

During this assessment

The maximum concentration of arsenic in air was lower than trace levels of arsenic known to exist on the filter papers

The maximum concentration of cadmium in air was lower than trace levels of cadmium known to exist on the filter papers

The maximum concentration of nickel in air was lower than trace levels of nickel known to exist on the filter papers

