

# Transport Research Laboratory

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## CLIENT PROJECT REPORT CPR2684

Monitoring of Ambient Dioxin, Furan, PCB and PAH concentrations in the vicinity of the fire at Lawrence Recycling, Kidderminster during July 2013

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## 1 Introduction

This report describes the measurements of ambient concentrations of dioxins, furans, PCBs and PAHs in Kidderminster during July 2013. This work was undertaken by TRL on behalf of Wyre Forest District Council (WFDC).

In this report the term “Dioxins” refers to PCDDs (Polychlorinated Dibenzodioxins) and the term “Furans” refers to PCDFs (Polychlorinated Dibenzofurans).

Measurements were conducted in response to concerns regarding emissions of “Dioxins” from a fire at Lawrence Recycling in Kidderminster. This report describes the methodology employed used and presents results and conclusions from the study.

The fire started at Lawrence Recycling on the Stourport Road, Kidderminster on Sunday 16<sup>th</sup> June 2013. The fire service quickly brought it under control, but pockets continued to burn and smoulder until it was reported as extinguished on Wednesday 7<sup>th</sup> August. Following enquiries and discussions, TRL was contracted to measure dioxins, furans, poly aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) on Wednesday 3<sup>rd</sup> July. Sampling commenced on site on Friday 5<sup>th</sup> July and continued to 22<sup>nd</sup> July (a period of 17 days). Following analysis of samples, the results were reported to WFDC on 31<sup>st</sup> July 2013 prior to preparation of this full report.

Dioxins and furans are formed from the interaction of hydrocarbons and chlorine containing compounds at temperatures above 200<sup>o</sup>C. They are destroyed if heated above 450<sup>o</sup>C in the presence of excess air (oxygen).

The optimum conditions for Dioxin and Furan formation are:

- Temperatures between 250<sup>o</sup>C and 450<sup>o</sup>C
- Limited oxygen from the fuel or air (this prevents oxidation)
- The presence of:
  - Chlorine, especially chlorinated hydrocarbons (e.g. PVC)
  - Other hydrocarbons. These are present in plastic, paper and organic waste
- The reaction is catalysed (promoted) by:
  - Fine particulate matter (smoke). Finer particles are especially effective as they provide a greater catalytic surface area.
  - Metals such as copper
  - Strong UV radiation (e.g. strong sunshine)

The following statement was issued by the Environment Agency.

<sup>7</sup> “The Environment Agency has reported that most of the material burnt in the fire at Lawrence Recycling was Refuse Derived Fuel (RDF). RDF has no specific standard but is typically a fuel produced by shredding and dehydrating non-hazardous solid wastes. RDF consists largely of combustible components of municipal waste such as plastics and biodegradable waste. RDF is used for energy recovery in incineration or co-incineration plants in the UK and abroad. Other wastes involved in the fire were separated bales of hard plastic, cardboard, and paper, and also an amount of Trommel Fines stored on site which had started to smoulder. Trommel Fines are small fractions of waste produced when solid, non-hazardous waste is mechanically segregated.”

<sup>7</sup>Email from Laura Baker, Environment Agency, Midlands to WFDC 16 August 2013 15:56

## 2 Sampling methodology

The air quality team at TRL has extensive experience in providing air quality monitoring services and currently operate a network of about 60 continuous monitoring sites across the UK and has monitored at over 200 sites since 2004. Measurements in this study used a robust method developed by TRL for monitoring dioxins, furans, PCBs and PAHs. This method is similar to that used by the Environment Agency's monitoring team and follows USEPA Method IO-2.3. It has been used by TRL since 2009 to measure dioxins, furans, PCBs and PAHs over prolonged periods at more than a dozen sites across the UK. The samplers used were Ruprecht and Patashnik Partisol 2000s fitted with USEPA PM<sub>10</sub> size selective inlets. Partisols can sample for extended periods without filter blocking. This avoids "snapshot" sampling which often misses peaks in concentrations. (In this study sampling for just the first three days would have missed the plume and the results would not been representative of levels of pollutants in the area.)

It was important that WFDC received the results as quickly as possible. We therefore deployed two identical Partisol 2000 samplers both of which sampled for 17 days and combined the samples, instead of our normal practice of deploying one sampler for four weeks. In all other respects, we followed our standard practice.

The total sampled volume for each filter-PUF combination was logged on the samplers and recorded manually after the sampling period. These were added together to provide a total sampled volume through both filter-PUF combinations. Extra checks were made to ensure that no transcription error could have occurred.

Samples were provided to SAL Ltd for analysis including a blank sample consisting of a PUF and filter from the same batch as the sample filters and PUFs. All sample filters and PUFs from both samplers were combined into a single sample for analysis in order to maximise the sensitivity of measurement. The blank filter and PUF were similarly combined prior to analysis.

The quality assurance processes put in place for this study are summarised in Appendix "A".

## 3 Site selection and location

### 3.1 Site criteria

The following factors were taken into consideration when deciding on a suitable site to sample:

- The site needed to be downwind of the fire during sampling. The prevailing wind prior to sampling was from the North-East so a site was chosen South-West of the fire.
- The equipment required mains power.
- The site needed to be secure against vandalism and other interference.
- The location needed to be in line of sight of the fire site.
- The site was as far from other confounding sources (including traffic) as possible
- Site access was required for installation and removal and any maintenance work which might have been required.
- Permission of the site owner needed to be obtained quickly.

TRL undertook a site survey and confirmed WFDC's view that the roof of WFDC's offices met these criteria. The same site had already been chosen as one of the PM monitoring sites for monitoring undertaken by AEA Ricardo. This allowed comparison to concurrent measurements of PM, wind speed and wind direction.

### 3.2 Site location

The monitoring site was approximately 230m south west of the nearest point of Lawrence's Recycling buildings. Both sample inlets were in a direct line of sight of the site of the fire and elevated above the surrounding ground by about 8m (from architect's drawings shown in Appendix B). The ground slopes down from the office site to the fire site by about 2m and the inlets for both samplers are approximately 2m above the roof line. Therefore the height difference between the fire and the sample inlets is approximately 12m. Pollution rose data showed that the prevailing wind at the sampling point was from the direction of the fire.

The nearest residential receptors were approximately 600m to the west/north west, north west and north, all other residential receptors were located over 1 km away in other directions. The main receptors were the adjacent business locations where exposure was mainly during working hours. Some business premises operate 24 hours a day and 7 days a week.

Table 1 provides coordinates of the sampling site location and Figure 1 and Figure 2 provides a map and aerial view of the site.

Table 1: Coordinates of sampling site.

OS X (Eastings)	381694
OS Y (Northings)	273612
Nearest Post Code	DY11 7WF
Latitude (WGS84)	N52:21:37 (52.360256)
Longitude (WGS84)	W2:16:13 (-2.270234)



- Location of fire, Lawrence Recycling
- Samplers and Monitors (WFDC offices)

Figure 1: Location of sampling site in relation to fire.



Figure 2: Location of sampling points.

## 4 Equipment installation and operation

Two Partisol 2000 samplers were installed by TRL on the rooftop of WFDC's offices on 5<sup>th</sup> July 2013. A Turnkey Osiris Monitor with wind speed and direction sensor was also installed by AEA Ricardo on the same day at the same position.

Figure 3 shows a photograph of the two R&P Partisol 2000 units with the Turnkey Osiris particulate monitor (smaller unit to the right). The Osiris was fitted with a wind speed and direction sensor. The Osiris together with its wind speed and direction sensor was removed on 9<sup>th</sup> July. The two Partisol samplers continued to sample until 22<sup>nd</sup> July (a total period of 17 days).



Figure 3: Photograph of monitoring units on roof of Council offices.

## 5 Sample analysis

Initially, the period of sampling was due to be for two weeks to end on Friday 19<sup>th</sup> July 2013. However, this was extended to the following Monday 22<sup>nd</sup> July as the wind was due to blow from the northwest over the weekend. This extension was to ensure that there was sufficient sample to obtain results for all compounds above their limit of detection. (It was still assumed at this time that concentrations would be at about normal background levels).

On completion of sampling, the filters and PUFs were removed from both Partisols. At the same time readings were taken, including the total sampled volumes for both samplers. Filters and PUFs were supplied to SAL Ltd. for analysis along with a blank filter and PUF.

Laboratory analysis was carried out using a UKAS accredited method<sup>1</sup> by SAL Ltd as summarised below. All results are UKAS accredited and analysis was in full compliance with the UKAS accreditation held by SAL Ltd.

The two sample filters and two sample PUFs were combined. The PUFs were spiked with a mixture of <sup>13</sup>C labelled dioxins and PCBs (all WHO-12) and deuterated PAHs. These spiked standards are non-radioactive isotopes of the compounds to be measured. They are measured separately to estimate any losses from the filter during analysis so that an allowance can be made for any compounds lost from the plug during analysis. (Similar spiking prior to sampling provides a check that the compounds of interest are not lost during sampling.)

<sup>13</sup>C is heavier than the common isotope of Carbon (<sup>12</sup>C). Deuterated compounds contain the heavier isotope of hydrogen, deuterium, (<sup>2</sup>H) as opposed to the common isotope <sup>1</sup>H. None of the isotopes used are radioactive. Compounds containing the heavy isotopes react chemically like their normal counterparts but are easily distinguished during analysis by GC-MS (Gas Chromatograph with Mass Spectrometer).

Both sample and blank were Soxhlet extracted for more than 20 hours with toluene. The extracts were then evaporated down to a volume where an accurate 10% aliquot could be removed for PAH analysis, prior to further clean-up of the remaining 90%. The clean-up consisted of passing the extract through a column containing acidic and basic silicas to remove interfering substances, after which the purified solvent extract was submitted to further clean up using Florisil chromatography and speciation into fractions containing the dioxins and non-ortho PCBs and another fraction containing the mono and di-ortho congeners. These extracts were then further evaporated, and subjected to further clean up using a carbon column. Measurements were made using a high resolution GC-MS.

The laboratory results were reported back to TRL in both digitally signed PDF and Excel formats. It was noted that the results were substantially higher than those found at other sites measured by TRL with similar sampled volumes. Two separate additional checks by senior analysts at SAL Ltd confirmed that all results reported were correct.<sup>2</sup>

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<sup>1</sup> Details of the laboratory method are available at [http://www.salltd.co.uk/about\\_us/method\\_statement?label=dioxins](http://www.salltd.co.uk/about_us/method_statement?label=dioxins)

<sup>2</sup> Personal communication with David Wood et al, SAL Ltd.

## 6 Calculation of concentrations

This section describes the calculations performed to obtain concentrations in air.

### 6.2 Calculation of PAHs and PCBs

Results from the laboratory were received both as digitally signed PDFs (according to their UKAS accreditation) and csv files. These have been checked against each other and both show the same results and units. (The signed PDF reports were generated by SAL Ltd. from the Excel reports by copying and pasting).

All calculations were carried out following import of the csv result sheet supplied by SAL into a copy of TRL's standard MS Excel calculation workbook. Values (including the names of the compounds) were linked into the calculation sheet to ensure traceability and to remove any risk of transcription error. The calculation workbook is a fixed template which has been repeatedly checked and shown to calculate values correctly. All data are reported in terms of the original mass units from the analysis per the volume units from the Partisols (m<sup>3</sup>) to exclude errors when changing units. Results were confirmed by separate manual calculation.

The sampled volumes from the two samplers, supplied in MS Excel were also copied and linked into the MS Excel calculation workbook. The total of the sample volumes from the two samplers was used in all calculations. For each compound, the blank mass was subtracted from the sample mass. Values less than the limit of detection are assumed to be at the limit of detection. (None of the results were below the limit of detection.)

### 6.3 Calculation of dioxin and furans (toxic equivalents)

In order to account for the variation in toxicity of the various congeners, all dioxin and furan values were expressed by SAL Ltd. as International Toxic Equivalents (I-TEQ). These values were calculated by systems, inspected and approved under their UKAS accreditation. I-TEQ values are calculated by multiplying by I-TEFs (International Toxic Equivalent Factors). Data can also be expressed in terms of WHO-TEQ (WHO Toxic Equivalents) which use a slightly different set of TEFs as shown below.

Table 2: Toxic equivalent factors.

Pollutant	I-TEF	WHO-TEF
<b><u>Dioxins</u></b>		
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0001
<b><u>Furans</u></b>		
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.05
2,3,4,7,8-PeCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

## 7 Results and Comparisons

This section presents the results of concentrations of each pollutant type in ambient air, as given in Table 3 to Table 5. These results are compared to objectives, standards and background DATA in Section 7.2.

### 7.1 Concentrations of Dioxins, Furans, PCBs and PAHs in Ambient Air

Table 3: Concentrations of Dioxins & Furans in ambient air.

Congener	Concentration (I-TEQ ng/m <sup>3</sup> )
2,3,7,8-TCDD	0.001490
1,2,3,7,8-PeCDD	0.004163
1,2,3,6,7,8-HxCDD	0.000745
1,2,3,4,7,8-HxCDD	0.002410
1,2,3,7,8,9-HxCDD	0.001621
1,2,3,4,6,7,8-HpCDD	0.001205
OCDD	0.000090
2,3,7,8-TCDF	0.000723
1,2,3,7,8-PeCDF	0.000613
2,3,4,7,8-PeCDF	0.010955
1,2,3,4,7,8-HxCDF	0.002081
1,2,3,6,7,8-HxCDF	0.001775
2,3,4,6,7,8-HxCDF	0.003944
1,2,3,7,8,9-HxCDF	0.000307
1,2,3,4,6,7,8-HpCDF	0.000942
1,2,3,4,7,8,9-HpCDF	0.000090
OCDF	0.000024
<b>Total</b>	<b>0.033178 I-TEQ ng/m<sup>3</sup></b>

Table 4: Concentrations of PCBs in ambient air.

Congener	Concentration (ng/m <sup>3</sup> )
Pentachloro, BZ #105	0.033
Pentachloro, BZ #114	0.017
Pentachloro, BZ #118	0.053
Pentachloro, BZ #123	0.008
Hexachloro, BZ #156	0.031
Hexachloro, BZ #157	0.013
Hexachloro, BZ #167	0.007
Heptachloro, BZ #189	0.019
Tetrachloro, BZ#81	0.033
Tetrachloro, BZ#77	0.037
Pentachloro, BZ#126	0.031
Hexachloro, BZ#169	0.008
<b>Total</b>	<b>0.289 ng/m<sup>3</sup></b>

Table 5: Concentrations of PAHs in ambient air.

Congener	Concentration (µg/m <sup>3</sup> )
Naphthalene	0.00031
Acenaphthylene	0.00002
Acenaphthene	0.00302
Fluorene	0.00188
Phenanthrene	0.01643
Anthracene	0.00081
Fluoranthene	0.02103
Pyrene	0.02191
Benzo(a)Anthracene	0.00329
Chrysene	0.01337
Benzo(b/k)Fluoranthene	0.01556
<b>Benzo(a)Pyrene</b>	<b>0.00077 µg/m<sup>3</sup></b>
Indeno(123-cd)Pyrene	0.00092
Dibenzo(ah)Anthracene	0.00074
Benzo(ghi)Perylene	0.00191
<b>Total</b>	<b>0.10197 µg/m<sup>3</sup></b>

## 7.2 Comparison with objectives, standards and Background Data

It was not possible to make background measurements during the fire.

### 7.2.1 Comparison with relevant objectives and standards

There are no ambient concentration limit or guideline values for Dioxins, Furans, PAHs or PCBs in the UK, US or EU.

Target and Objective values are quoted for the PAH, Benzo(a)pyrene as described in the excerpt from the Defra UK-Air website below<sup>5</sup>

- The European Community's fourth Air Quality Daughter Directive (2005/107/EC) specifies a target value of  $1\text{ng/m}^{-3}$  for the annual mean concentration of benzo[a]pyrene as a representative PAH, to be achieved by 2012 and maintained thereafter.
- The UK Air Quality Objective for PAHs, based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS), is for a maximum annual air concentration of  $0.25\text{ng/m}^3$  benzo[a]pyrene.

These terms are defined by Defra<sup>6</sup> as

An objective is the target date on which exceedences of a Standard must not exceed a specified number.

Target values are used in some EU Directives and are set out in the same way as limit values. They are to be attained where possible by taking all necessary measures not entailing disproportionate costs.

WHO have published a "safe" limit value for dioxins and furans but this is in terms of dose per kg of body weight of  $70\text{pg/Kg/month}$  based on the risk of lifetime accumulation in human and animal tissue.

### 7.2.2 Ambient concentrations from the national network

Tables 6, 7 and 8 present the most up-to-date data<sup>3</sup> from the national networks that were available at the time of writing. All values are for the calendar year 2010. These sites are operated under contract from DEFRA<sup>4</sup> as part of their toxic organic micro pollutant network (TOMPS).

The tables provide a comparison of the annual average of all sites in the national network during 2010 with the concentration monitoring during the 17-day sampling period in Kidderminster. These compare 17-day mean values at Kidderminster with 365-day mean values at other sites in the UK. (The effect of extending the averaging period can be seen by comparing the hourly means in figure 6 with the daily means in figure 7.)

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<sup>3</sup> Data downloaded on 31<sup>st</sup> July 2013

<sup>4</sup> <http://uk-air.defra.gov.uk/networks/network-info?view=tomps>

<sup>5</sup> <http://uk-air.defra.gov.uk/networks/network-info?view=pah>

<sup>6</sup> <http://uk-air.defra.gov.uk/air-pollution/uk-eu-limits>

Table 6: Annual mean concentrations of Dioxins and Furans.

Site	Concentration - WHO-TEQ (fg/m <sup>3</sup> )				
	Q1.10	Q2.10	Q3.10	Q4.10	Average 2010
Manchester	196.24	57.58	29.88	137.61	92.18
Hazelrigg	38.00	25.67	14.89	31.19	28.05
London	77.81	47.90	18.47	210.80	89.63
High Muffles	0.03	24.02	18.59	26.07	21.23
Auchencorth	37.52	25.98	14.94	18.02	24.53
Weybourne	22.50	21.77	15.49	17.46	19.56
UK Annual Average (2010)					45
Kidderminster (17 day)					33,178

Table 7: Annual mean concentrations of PCBs.

Site	Concentration (pg/m <sup>3</sup> )				
	Q1.10	Q2.10	Q3.10	Q4.10	Average 2010
Manchester	240	316	68	456	271
Hazelrigg	36	404	13	63	138
London	128	510	9	85	188
High Muffles	55	350	95	270	209
Auchencorth	101	68	23	10	51
Weybourne	8	19	30	35	24
UK Annual Average (2010)					147
Kidderminster (17 days)					289

Table 8: Annual mean concentrations of PAHs.

Site	Annual Mean 2010 (ng/m <sup>3</sup> )	Site	Annual Mean 2010 (ng/m <sup>3</sup> )
Auchencorth Moss	0.84	Liverpool Speke	3.60
Ballymena Ballykeel	12.82	London Brent	3.54
Birmingham Tyburn	4.10	London Crystal Palace Parade	4.33
Bolsover	4.37	London Marylebone Road	4.41
Cardiff Lakeside	3.66	Lynemouth 2	3.05
Derry Brandywell	10.64	Middlesbrough	6.56
Edinburgh St Leonards	1.77	Newcastle Centre	2.50
Glasgow Centre	1.94	Newport	3.92
Harwell	1.37	Port Talbot Margam	6.86
Hazelrigg	1.53	ROYSTON	12.11
High Muffles	1.24	Salford Eccles	4.68
Hove	2.68	Scunthorpe Low Santon	37.40
Kilmakee Leisure Centre	9.15	Scunthorpe Town	20.23
Kinlochleven	2.48	South Hiendley	7.86
Leeds Millshaw	5.09	Stoke Ferry	2.19
Lisburn Dunmurry High School	7.33	Swansea CWM level park	4.42
UK Annual Average (2010)		6.21	
Kidderminster (17 days)		101.97	

### 7.2.3 Results from background samples

Since 2009, TRL has conducted more than 12 similar monitoring campaigns at other sites across the UK. Most of this work has been carried out to provide a baseline prior to the construction of proposed developments. This data is the property of our clients and most is covered by confidentiality agreements. However for comparative purposes, we have been given permission to state that “background monitoring in relation to a proposed development in an industrial area of Northern England” produced the following annual mean values.

Dioxins and Furans: 0.52 pg I-TEQ/m<sup>3</sup> (Annual Mean)

PCBs: 46pg/m<sup>3</sup> (Annual Mean)

PAHs: 4.3pg/m<sup>3</sup> (Annual Mean)

These values were obtained by taking the average of four monthly values which were obtained using our standard methodology. Similar values were obtained by TRL at other sites in the UK during 2013. (We usually take consecutive monthly values for 3-12 months).

## 7.3 PM<sub>10</sub> concentrations, wind speed and direction

Continuous particulate monitoring was carried out under a separate contract by AEA Ricardo adjacent to the sampling point, from 5<sup>th</sup> July to 9<sup>th</sup> July 2013. The figures and tables presented in this section have been derived by TRL from data supplied to WFDC by AEA Ricardo.

### 7.3.1 Wind direction and speed

The wind rose for the sampling site shows that the predominant wind direction was from the direction of the fire (north-east) during the sampling period (Figure 4). Data for this chart were derived from hourly mean values. The mean wind speed over this period was 1.42 m/s.

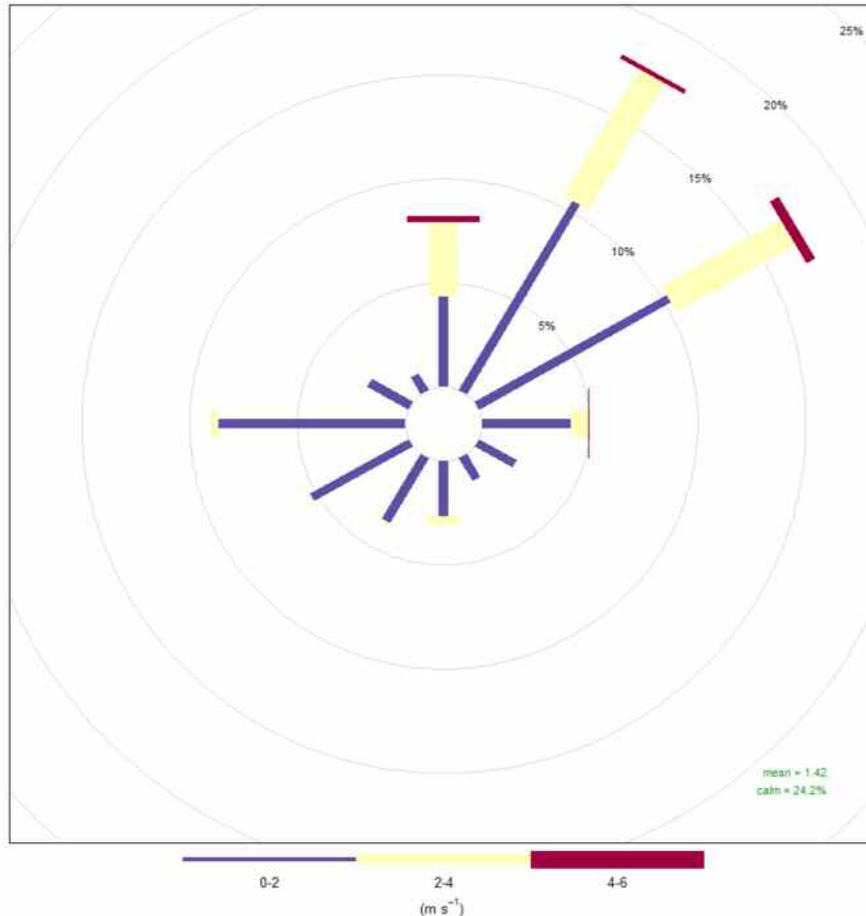


Figure 4: Wind rose indicating predominated wind direction and speed.

### 7.3.2 Visual observations at the site

The photograph in Figure 3 shows the Lawrence Recycling site in the background. All samplers were in direct line of sight of the fire. At the time the photograph was taken, the winds were light and variable. This is shown by the initial readings from the wind speed and direction sensor mounted on the Osiris monitor in Table 9. The plume can be discerned as a slight white haze in the background.

Table 9: Initial readings of wind direction and speed

Date & Time	Wind Speed (m/s)	Wind Heading (degrees)
05/07/2013 15:37	0	290
05/07/2013 15:38	0.1	30
05/07/2013 15:39	0	345
05/07/2013 15:40	0	345
05/07/2013 15:41	0.2	5
05/07/2013 15:42	1	290



Hourly concentrations measured over this period are given in Figure 6. The results show that the highest PM<sub>10</sub> levels were overnight on the 8<sup>th</sup> to 9<sup>th</sup> of July. During this period the wind direction varied between 27° and 53° with a mean bearing of 40°. This correlates with the wind blowing from the site of the fire towards the sampling point. We understand that WFDC staff reported particularly high levels of white smoke on Monday 8<sup>th</sup> July. The highest recorded hourly mean concentration was 585µg/m<sup>3</sup> at 21:00 on Monday 8<sup>th</sup> July.

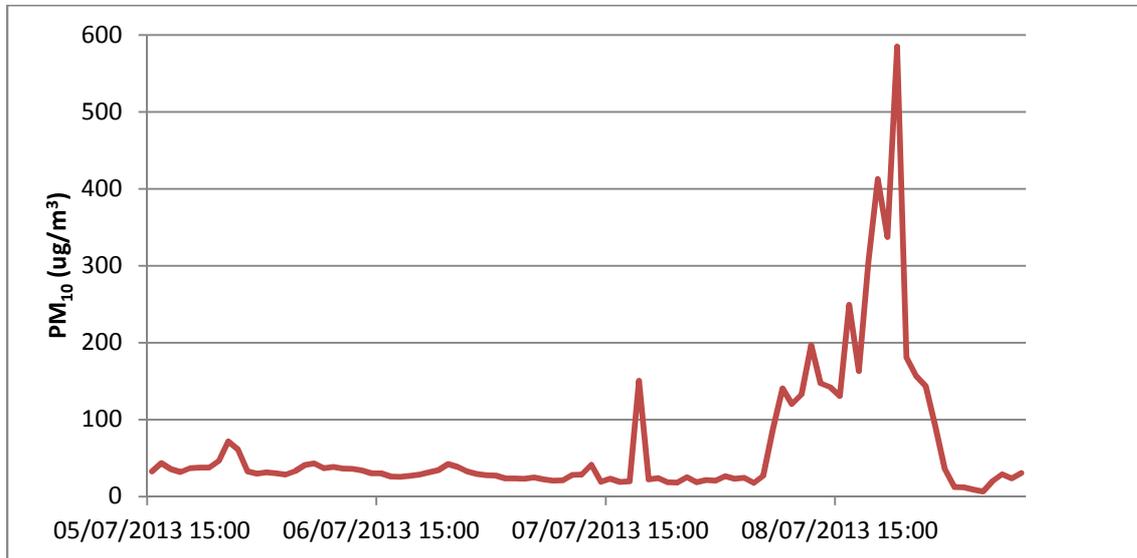


Figure 6: Hourly PM<sub>10</sub> concentrations over sampling period.

The 24-hour PM<sub>10</sub> objective value of 50µg/m<sup>3</sup> was exceeded on 8<sup>th</sup> July, as shown in (see Figure 7. The UK objective states that this value should not be exceeded more than 35 times in any year.

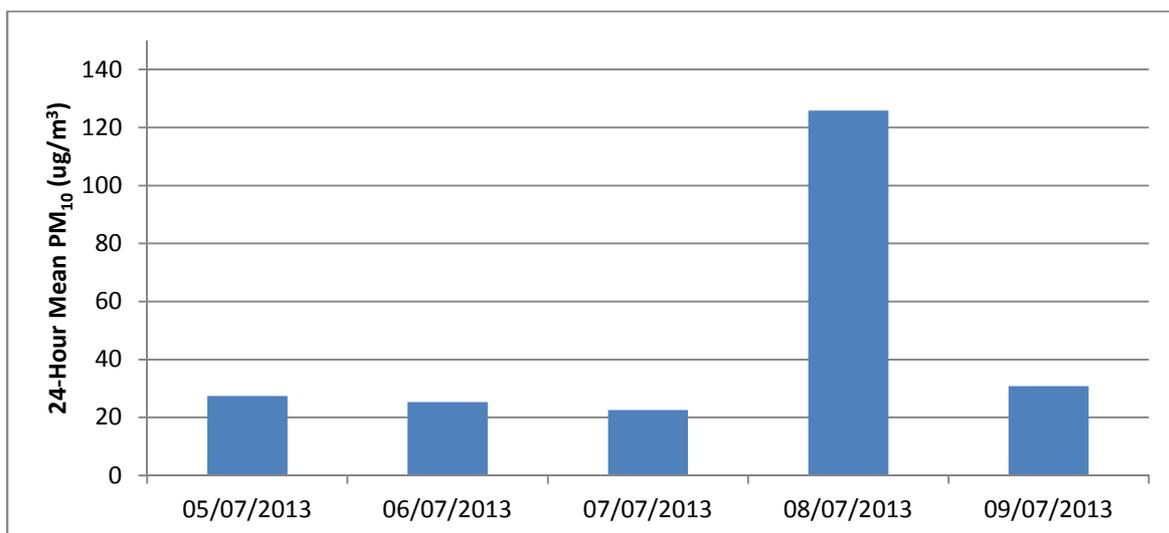


Figure 7: 24-hour PM<sub>10</sub> concentrations over the sampling period.

(Data for the 5th and 9th July 24-hour means are derived from less than 18 hourly values)

## 8 Confounding factors

This section provides details of any other local emission sources that may be contributing to the concentrations measured and thus be acting as a confounding factor.

WFDC has confirmed that their building is heated by ground heat recovery and has no emission points apart from a kitchen extract, which would not be a source of compounds measured at the levels recorded.

A list of premises in the area around the fire site is given in Table 10 below. None are Part B (LA) permitted processes apart from Lost Wax Developments Limited. We are not aware of any which fall under Part A (EA) permitting. There is no reason to believe that any of these processes would contribute significantly to the levels of Dioxins, Furans, PCBs or PAHs found.

Table 10: List of industrial premises in local area.

	Company	Comment
DY11 7QR	LAWRENCES SKIP HIRE LTD	
DY11 7BB	STANDARD MOTOR TRANSPORT LTD	Transport, Distribution Business
DY11 7PJ	HICKMANS OF KIDDERMINSTER	Transport, Distribution Business
DY11 7PT	VISION LABS LTD	Lense producer for national opticians, chemicals used for the processes
DY11 7PS	WYRE FOREST COMMUNITY HOUSING	Grounds Dept, associated machinery, Fuels etc
DY11 7QL	WHITTLE COACH & BUS LTD	Coach company and collecting pit for chemical toilets
DY11 7QL	SEVERN TRENT WATER LTD	Sewage Treatment works 24:7 operations
DY11 7QN	BREAKWELLS LLP	Distribution Hauliers
DY11 7QN	BREAKWELLS LLP	Distribution Hauliers
DY11 7QN	TRUELINE EXPANDED PRODUCTS LTD	Plastic Fabricated products
DY11 7QN	KIDDERMINSTER TIMBER LTD	Timber treatments / Merchants
DY11 7QN	HARD ANODISING LTD	Anodising
DY11 7QN	CEETEK CHEMICALS LTD	Manufacturer of Cleaning Chemicals
DY11 7QN	READYPRINT LTD	Printers
DY11 7QN	CENTRAL PROFILES LTD	Fabrication
DY11 7QN	LOST WAX DEVELOPMENTS LTD	Wax processes , Furnaces etc
DY11 7QN	WYRE FOREST WOODCRAFT	Paints, treatments for wood products
DY11 7QN	HARD ANODISING LTD	Anodising
DY11 7QN	TRUSTY MOTOR BOATS LTD	Boat makers, Fibre Glass, Paints
DY11 7QN	DMS (CHROMIUM PLATING) LTD	Plastic injection moulding and chromium plating
DY11 7QN	FASTRAK A.R.C. LTD	Accident Repair Centre , degreasers, oils etc
DY11 7QN	WORCESTER AUTOS LTD	Servicing, Restoration, Paints, degreasers etc
DY11 7FB	OBO BETTERMANN LTD	Electrical component manufacturer and distribution
DY11 7FB	ROBOVISION LTD	Paints, coatings for climbing frames etc
DY11 7QY	HANNAFIN CONTRACTORS LTD	Construction company
DY11 7QY	GLASSFIBRE SOLUTIONS LTD	Fibre glass roofing products
DY11 7QY	NICOL TRANSMISSIONS	Garage, degreasers, oils etc
DY11 7QY	LOWLAND SHEET METAL LTD	Cleaning Fluids
DY11 7QY	ADVANCED CNC SERVICES LTD	Metal cleaning products on site
DY11 7QY	BUTTON BADGE CO LTD	Enamaling, metal cleaning products
DY11 7QY	MILLSON ENGINEERING LTD	Metal chemicals
DY11 7QY	WOODHOUSE BROS	Degreasers, Paints finishers (Cars)
DY11 7HJ	MIDAS KLARK TEKNIK LTD	Metal cleaning products on site
DY11 7QH	STARGOLD LTD	Printers
DY11 7QH	FOCUS PRINT AND MARKETING LTD	

## 9 Discussion and Conclusions

A summary of the concentrations in ambient area for the sampling period, compared to UK annual mean averages are given in Table 11.

Table 11: Measured concentrations in Kidderminster compared to UK annual average (2010).

	Concentrations		
	Dioxin & Furans pg/m <sup>3</sup>	PCBs pg/m <sup>3</sup>	PAHs ng/m <sup>3</sup>
UK Annual Average (2010)	0.045 WHO-TEQ	147	6.21
Kidderminster (17 days)	33 I-TEQ	289	101.97

These results show that the 17-day mean values of PCBs and PAHs recorded in Kidderminster were above the UK annual averages.

The result for total Dioxins and Furans was significantly higher than the 2010 UK annual mean. Initial reactions, of some involved in this study, were to doubt the measurements, analysis or calculation. However, despite exhaustive checks, no error has been found and we are confident that the readings are a true reflection of the average concentrations of these compounds, for the period measured and at the point measured. Several factors are believed to have contributed to the elevated readings.

- The fuel for the fire may have been of a type which could produce these compounds.
- The conditions of the fire were in line with conditions which can produce these compounds.
- The prevailing wind was towards the sampling point.
- The sampling point was in direct line site of the fire and elevated 12m above it

The concentrations recorded are entirely plausible under these conditions.

Similar high levels of dioxins and furans have been recorded by Lee et al <sup>(1)</sup>. They recorded a value of 23pg/m<sup>3</sup> at Hazelrigg, a site described as “a meteorological station located in a semirural area outside Lancaster”. The sample was described as being “taken during bonfire weekend”. These measurements were not recorded close to any specified source and as such may well represent background levels of Dioxins and Furans across the UK on or around November 5<sup>th</sup>. It would further be expected that concentrations would be much higher close to bonfires or other uncontrolled combustion sources, especially if the fuel contains high levels of chlorine.

In 2003 the BBC<sup>7</sup> (and others) reported results from the French environmental campaign group “Robin des Bois”<sup>8</sup> that “the average concentrations of dioxins in the vicinity of the barbecue ranged from 0.6 to 0.7 ng/m<sup>3</sup> (600-700pg/m<sup>3</sup>)”.

<sup>7</sup> <http://news.bbc.co.uk/1/hi/health/3106039.stm>

<sup>8</sup> <http://www.robindesbois.org/>

## Reference

- <sup>(1)</sup> Robert G. M. Lee, Nicholas J. L. Green, Rainerlohmann and Kevin C .Jones  
Seasonal, Anthropogenic, Air Mass, and Meteorological Influences on the Atmospheric Concentrations of Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (PCDD/Fs): Evidence for the Importance of Diffuse Combustion Sources.  
Department of Environmental Science, Institute of Environmental and Natural Sciences, Lancaster University, Lancaster, LA1 4YQ, United Kingdom

## Appendix A Quality Assurance Issues

### A.1 Flow

The final result is based on two critical measurements, flow and analytical result. Both units passed pre- and post- installation flow and leak checks performed using a calibrated flow meter and flow checks were repeated immediately following installation.

During operation the samplers recorded the total volume passed through the filter and displayed this on the display. This was read manually and recorded. Readings were confirmed by both engineers on site and were in line with expected values. The percentage difference in sample volume reading between the two samplers was +/-0.17 percent.

### A.2 Equipment Checks

Both Partisol 2000 units were serviced and checked in the workshop prior to installation and checked at site on installation and on removal. A brief synopsis of the checks performed is shown below. A completed checklist for both instruments may be viewed on request. This checklist is part of the intellectual property of TRL Ltd and as such cannot be provided for public display.

#### A.2.1 Workshop actions prior to installation

- Note Front Screen Checks
- Condition checks
- Remove and clean PM<sub>10</sub> head
- System leak check
- Temperature checks
- Flow Audit against a calibrated flow meter
- Check fan Operation
- Check large DFU filter and replace if necessary.

#### A.2.2 At site during installation

- Performed flow check against a calibrated Bios flow meter at installation
- Front Screen checks; no instrument faults or alarms displayed and all status values were recorded as normal.

#### A.2.3 On removal

- All status values checked and seen to be normal
- Total flows recorded and within expected values

### A.3 Sample Handling Precautions

Careful handling of samples is important in order to avoid contamination. The following are included in our standard operating procedure to be used at all such monitoring sites.

- Filter holders were cleaned in the laboratory prior to use.
- All PUF (Polyurethane foam) plugs were cleaned and spiked with standards by SAL Ltd. prior to use.
- Thorough cleaning minimised the values of the blanks to be deducted.
- All filters and PUFs were transported in clean, sealed containers within clean sealed plastic bags, and within cool bags. PUFs are sealed in foil before and after exposure to minimise the loss of organic material through plastic and to prevent degradation by sunlight. Filters are held in sealed Petri dishes; PUFs are held in cleaned glass bottles.
- Sample and blank filters are handled similarly.
- All filters and PUF plugs are handled with clean tweezers to minimise any contamination.

In addition, blank filters and PUF plugs from the same batches were also analysed. Values for the blank filter and PUFs are subtracted from the sample values to account for background levels and any potential contamination in the raw media.

### A.4 Analysis

Analysis was carried out by a reputable UKAS accredited laboratory using a UKAS accredited method and all results hold UKAS accreditation. Despite this (and due only to the unexpectedly high results) two senior analysts at SAL Ltd carried out additional checks and confirmed that the results were correct.

### A.5 Data Calculation

Data was calculated from a standard spreadsheet which has been checked repeatedly over the last few years. The calculation was also checked separately against a different version of the spreadsheet twice. As an additional check the values were also calculated manually from the analytical results. All calculations agreed.

## Appendix B Architects Drawings for WFDC Offices

These drawings have been used to estimate the height of the rooftop monitoring site above ground

