Ricardo Energy & Environment

# Air Quality Monitoring for Hyndburn Borough Council

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Report for Hyndburn Borough Council

ED10301

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**Hyndburn Council**

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# Executive Summary

This report provides details of air quality monitoring conducted by Ricardo Energy & Environment for Hyndburn Borough Council between March and July 2017. The aims of the programme are to monitor air pollution in the Harwood area, where there is an issue with burning of unknown waste in the Meadow Street area of Great Harwood and to assess compliance with relevant national air quality objectives.

Automatic monitoring was carried out at a single location and monitored Particulate Matter, Total Suspended Particles TSP, $PM_{10}$, $PM_{2.5}$ and $PM_1$.

$PM_{10}$ may exceed the 24-hour mean limit of 50 µg $m^{-3}$ no more than 35 times per year to meet the AQS objective. During the monitoring period 3 exceedances to the 24-hour mean limit value were registered at the site. The annual mean AQS target for $PM_{10}$ is 40 µg $m^{-3}$ and the period average was below this at 18.76 µg $m^{-3}$.

Average concentrations of $PM_{10}$ and $PM_{2.5}$ at the site were generally comparable to those measured at AURN urban background air pollution monitoring sites in the north west zone when compared with regional provisional data.

Wind speed and direction data gathered from the NOAA Integrated Surface Database using the R package Worldmet[5] were used to investigate effects on pollutant concentrations and potential sources. Bivariate plots of pollutant concentration indicated that nearby sources to the north and south east were the main pollution sources, with a third source to the west and south west.

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# 1 Introduction

## 1.1 Background

Local residents have reported an issue with burning of unknown waste in the Meadow Street area of Great Harwood. Recent evidence suggests the waste comprises of miscellaneous construction materials such as wood and plastic etc. Waste is transported in via vehicles on a daily basis and either burnt in an Air Curtain Burner or on adjacent open land within the site. Currently burning takes place most days, through the evening and into the night. The burning process produces grey smoke and fumes and its direction is affected by local MET and topography. The council subsequently contracted Ricardo Energy & Environment to undertake air quality monitoring.

## 1.2 Aims and objectives

Ricardo Energy & Environment undertook a three-month study of Particulate Matter using an AQ MESH sensor in order to provide a data set for the council along with a summary report.

## 1.3 UK air quality strategy

Within the European Union, controls on ambient air quality are covered by Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[1], known as the Air Quality Directive. This consolidated three previously existing Directives, which set limit values for a range of air pollutants with known health impacts. The original Directives were transposed into UK law through The Environment Act 1995 which placed a requirement on the Secretary of State for the Environment to produce a national Air Quality Strategy (AQS) containing standards, objectives and measures for improving ambient air quality.

The Environment Act 1995 also introduced the system of local air quality management, the latest version being LAQM.TG16[4]. This requires local authorities to review and assess air quality in their areas against the national air quality objectives. Where any objective is unlikely to be met by the relevant deadline, the local authority must designate an air quality management area (AQMA). Local authorities then have a duty to carry out further assessments within any AQMAs and draw up an action plan specifying the measures to be carried out, and the timescales, to achieve the air quality objectives. The legal framework given in the Environment Act has been adopted in the UK through the UK AQS. The most recent version of the AQS was published by Defra in 2007[2], and the currently applicable air quality objectives are summarised in Appendix 1 of this report.

# 2 Air Quality Monitoring

## 2.1 Pollutants monitored – Particulate Matter ($PM_{10}$, $_{2.5}$, $_{1}$ and TSP)

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The subscript number is used to describe the size of the particle with $PM_{10}$ having an effective size less than 10 µm, $PM_{2.5}$ an effective size less than 2.5 µm and $PM_1$ less than 1 µm. These are of greatest concern with regard to human health, as they are small enough to penetrate deep into the lungs. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface absorbed carcinogenic compounds into the lungs. Larger particles, meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation.

The main sources of airborne particulate matter in the UK are combustion (industrial, commercial and residential fuel use). The next most significant source is road vehicle emissions[3].

## 2.2 Monitoring sites and methods

Automatic monitoring was carried out at a single site during a three-month period of 2017 in Clayton-le-Moors using an AQMesh analyser.

The AQMesh analyser measures particulates using a light scattering optical particle counter.

On completion of the survey the AQMesh was installed at Blackpool Marton AURN station for a co-location study, on review of the results it was deemed there was acceptable agreement and no correction scaling was required for the AQMesh data.

During ratification the first three days of monitoring at the Clayton-le-Moors site were nulled so as to allow the analyser time to settle and acclimatise after storage and transportation.

Figure 2.1 shows a map with the location of the proposed pollution source (red dot). Figure 2.2 shows the AQ Mesh.

**Figure 2.1** - Location of the Hyndburn AQMesh

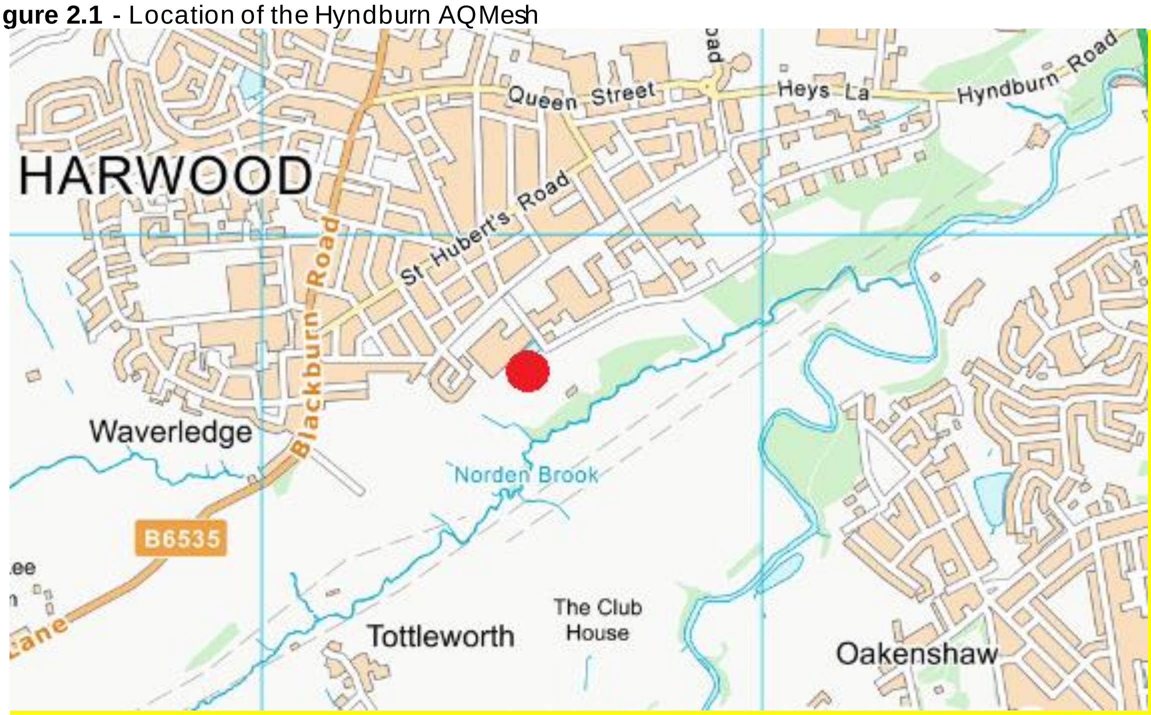


**Figure 2.2** –Example photo as an AQMesh (AQMesh Brochure, 2016)[7]

# 3 Results and Discussion

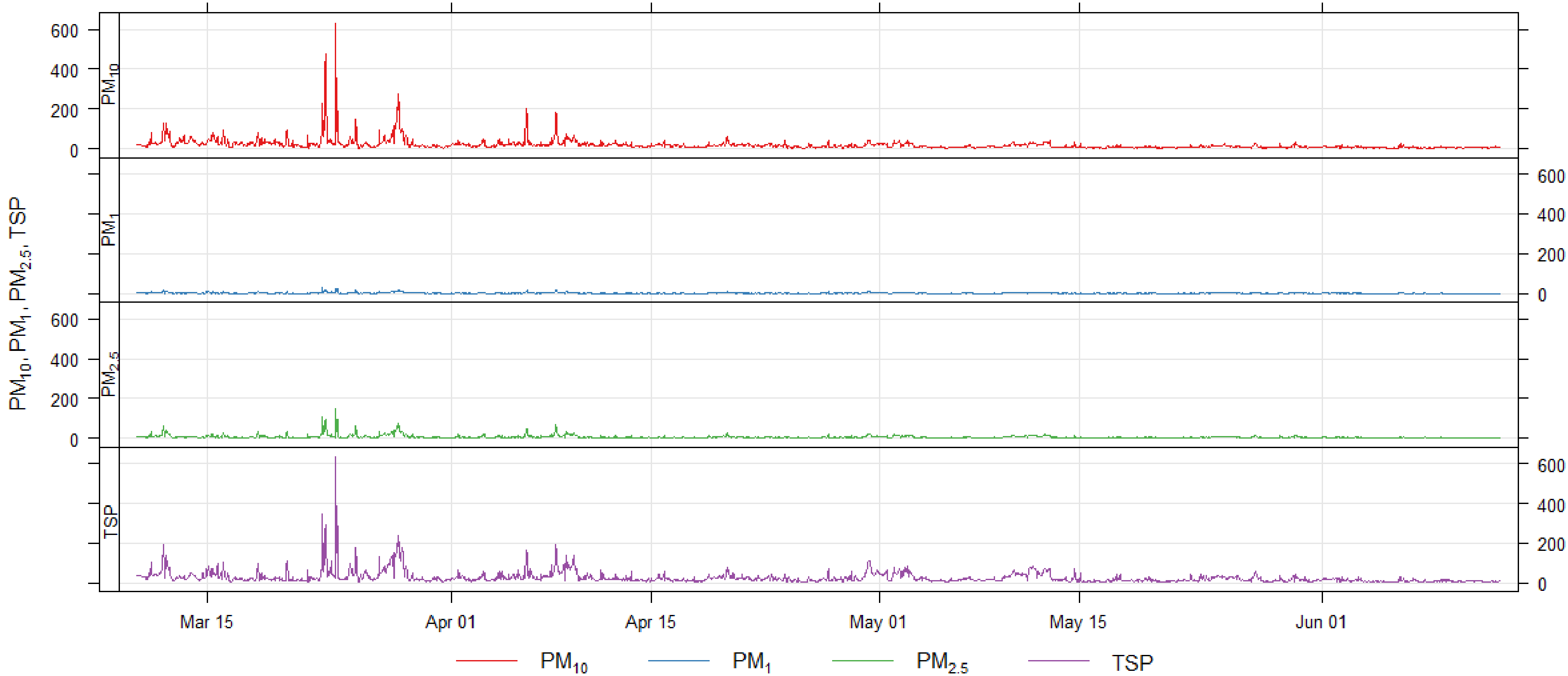
## 3.1 Automatic monitoring data

The summary statistics for the monitoring period are presented in Table 3.1. The time series of data for the monitoring period, as measured by the automatic monitoring sites, are shown in Figure 3.1 with seasonal and diurnal variations in Figure 3.11.

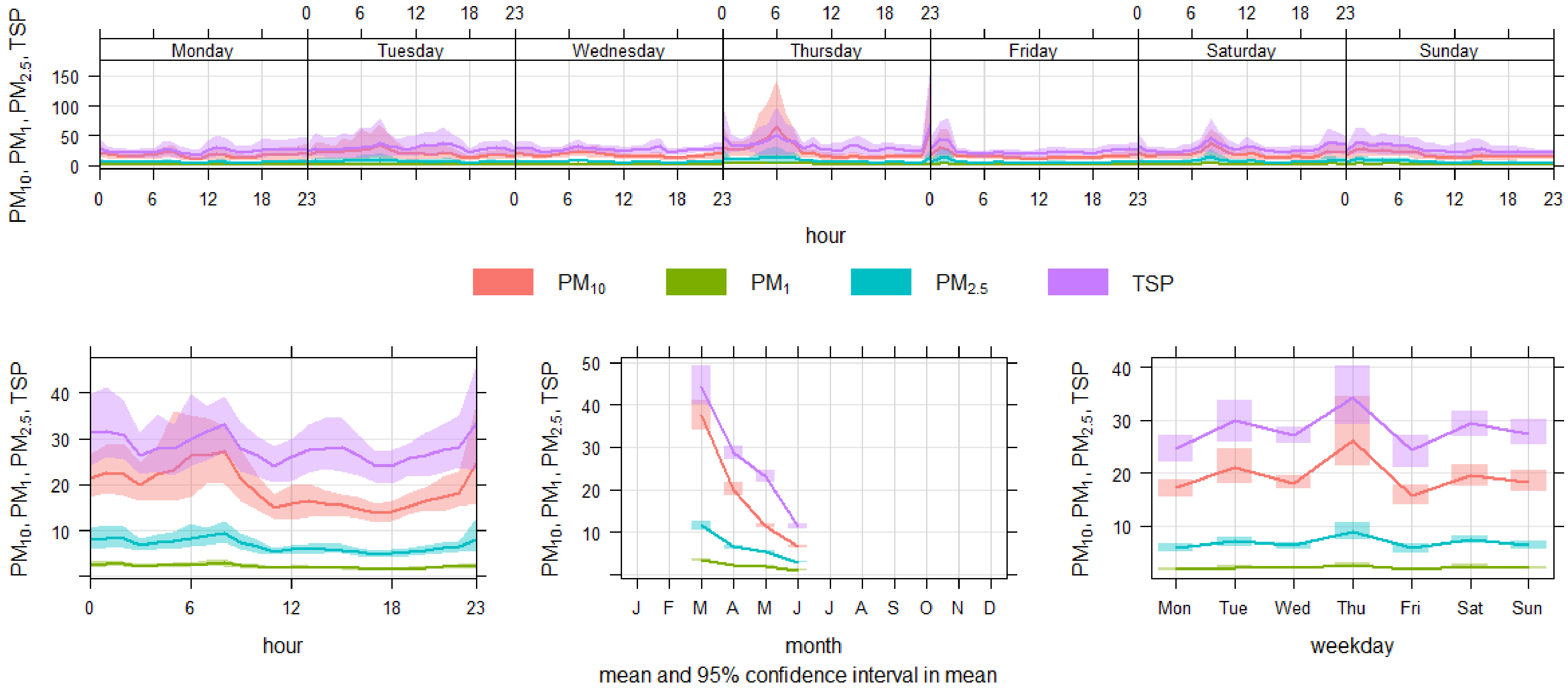
**Table 3.1** – Air pollution statistics for the Hyndburn AQmesh from the 13th March to the 13th June 2017.

| | $PM_{10}$ (µg $m^{-3}$) | $PM_{2.5}$ (µg $m^{-3}$) | $PM_1$ (µg $m^{-3}$) | TSP (µg $m^{-3}$) |
|---|---|---|---|---|
| Maximum hourly mean | 632.82 | 147.71 | 29.34 | 638.03 |
| Maximum running 8-hour mean | 218.27 | 58.38 | 13.89 | 212.07 |
| Maximum running 24-hour mean | 138.13 | 40.77 | 10.60 | 151.46 |
| Maximum daily mean | 127.37 | 34.85 | 9.17 | 129.79 |
| Average | 18.76 | 6.54 | 2.08 | 27.34 |
| Data capture (%) | 100.0 | 100.0 | 100.0 | 100.0 |

**Figure 3.1** – Time series of hourly averaged concentrations of $PM_{10}$, $PM_{2.5}$, $PM_1$ and TSP for the Hyndburn AQMesh site.



**Figures 3.11** - Time series of seasonal and diurnal variations of $PM_{10}$, $PM_{2.5}$, $PM_1$ and TSP for the Hyndburn AQMesh site.



## 3.2 Comparison with air quality objectives

The hourly $PM_{10}$ mean limits specified by DEFRA were exceeded three times during the monitoring period. All other analysed pollutants were within the limits. The Details of UK air quality standards (AQS) and objectives specified by DEFRA are provided in Appendix 1.

The AQS objective for $PM_{10}$ is a maximum of 50 µg $m^{-3}$ for 24h mean periods, not to be exceeded more than 35 times a year. The results show that there were three exceedances, the maximum value being 138.13 µg $m^{-3}$. However, the site was well within the yearly maximum permitted number of exceedances of 35 times, therefore on course to meeting the AQS objective for 24-hour mean $PM_{10}$.

The annual mean AQS objective for $PM_{10}$ is 40 µg $m^{-3}$. The site registered a period average of 18.76 µg $m^{-3}$, this objective is therefore on track to be met.

$PM_{10}$ was recorded in the DEFRA Very High banding for 2 days on the 23/03/2017 and 28/03/2017. $PM_{10}$ was recorded in the DEFRA Moderate band on 08/04/2017 the bandings are shown in Appendix 2.

No objective has been set for $PM_{2.5}$, but a target of an annual mean of 25 µg $m^{-3}$ has been set for 2020. The period average for the Hyndburn AQMesh was 6.54 µg $m^{-3}$.

All $PM_{2.5}$ measurements were in the DEFRA Low banding the bandings are shown in Appendix 2.

## 3.3 Temporal variation in pollutant concentrations

### 3.3.1 Seasonal variation

Seasonal variations are common for the pollutants measured at this site and while there are only a few months' data this trend can still be seen, with higher concentrations present during the cooler spring period when emissions may be higher, and periods of cold, still weather reduce pollutant dispersion.

### 3.3.2 Diurnal variation

The diurnal variation analyses viewed in the 'hour' plots in figure 3.11 showed typical urban area daily patterns.

The diurnal patterns for PM are determined by two main factors. The first is emissions of primary particulate matter, from sources such as vehicles or burning. The second factor is the reaction that occurs between sulphur dioxide, $NO_x$ and other chemical species, forming secondary sulphate and nitrate particles. Morning and afternoon road traffic rush-hour peaks for $PM_{10}$ can be identified, with the morning rush hour being more pronounced and the afternoon flatter and broader, incorporating school closing time. A third peak can be seen during the night which doesn't correspond with normal traffic emission patterns.

### 3.3.3 Weekly variation

The analyses of the pollutants weekly variation showed that the diurnal pattern of morning and afternoon rush hours are common on most week days. It also shows significant peaks on Thursday, Friday and Saturday, which, due to the short length of monitoring time could have been caused by one off pollution events.

# 3.4 Source investigation

In order to investigate the possible sources of air pollution being monitored at this site meteorological data gathered from the National Oceanic and Atmospheric Administration (NOAA) meteorological database[5] was used. A station near Bradford (Bingley No2, code 033440-99999) was found to be the closest with a complete data set.

Figure 3.4 shows the measured wind speed and direction data. The lengths of the "spokes" against the concentric circles indicate the percentage of time during the period that the wind was measured from each direction. The prevailing wind can be seen to be from the west. Each "spoke" is divided into coloured sections representing wind speed intervals of 2 $ms^{-1}$ as shown by the scale bar in the plot. The mean wind speed was 3.85 $ms^{-1}$. The maximum measured wind speed was 12.3 $ms^{-1}$.

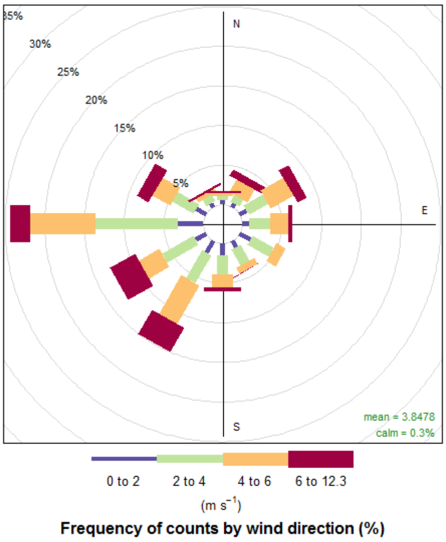



**Figure 3.4** - Wind rose showing the wind speeds and directions at Hyndburn AQMesh during the monitoring period

Figure 3.41 to Figure 3.43 show bivariate plots of hourly mean concentrations of $PM_{10}$, $PM_{2.5}$ and $PM_1$ at the monitoring station against wind speed and wind direction.

These plots should be interpreted as follows:

- The wind speed is indicated by the distance from the centre of the plot; the grey circles indicate wind speeds in 2 $ms^{-1}$ intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentrations varied with wind direction and wind speed.

The plots do not show distance of pollutant emission sources from the monitoring site. However, in the case of primary pollutants the concentrations at very low wind speeds are dominated by emission sources close by, while at higher wind speeds, effects are seen from sources further away. It must be considered that the metrological data used was not measured at the site. Due to the distance between the sites, and possible variations in local topography, conditions actually seen at the monitoring site at any given time may vary from those at the metrological station. Therefore, these plots must be considered indicative.

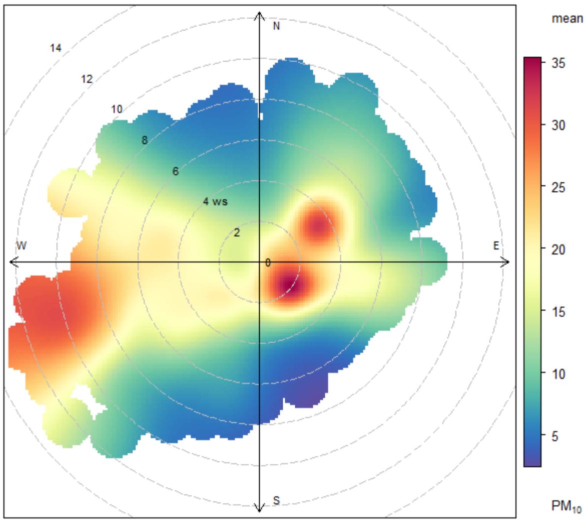



**Figure 3.41** – Pollution rose for $PM_{10}$

Figure 3.41 shows that the highest concentrations of $PM_{10}$ occurred under relatively calm conditions. Such conditions will have allowed $PM_{10}$ emitted from nearby sources, mainly vehicle emissions from the nearby residential areas and the skip hire yard to the north east, to build up, reaching high concentrations. There were also high concentrations at greater wind speeds from west and south west, this is the direction of the business in question and the land of a local farm.

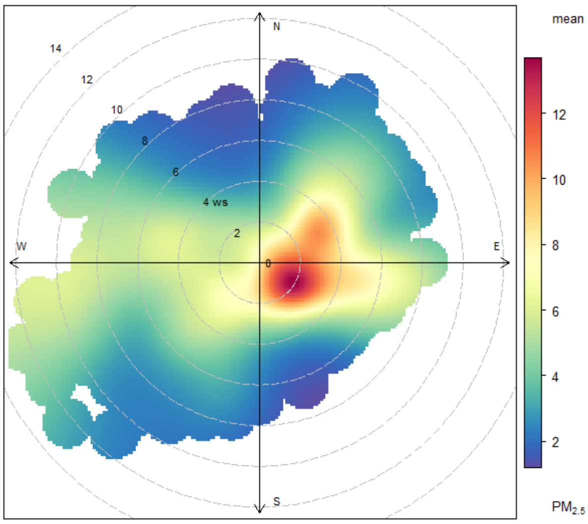



**Figure 3.42** – Pollution rose for $PM_{2.5}$

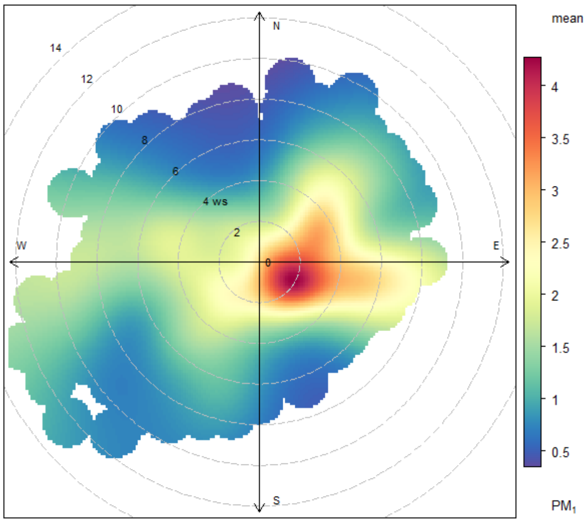



**Figure 3.43** – Pollution rose for $PM_1$

Figures 3.42 and 3.43 show that the highest concentrations of $PM_{2.5}$ and $PM_1$ were associated with light winds (<5 $ms^{-1}$) from the south and north west, with calm conditions also contributing, these are the main built up areas of Clayton-le-Moors. Elevated levels were also associated with stronger winds from the west. This matches the pattern shown by the $PM_{10}$.

## 3.5 Periods of elevated pollutant concentration

The AQS objective establishes a daily mean limit value of 50 µg $m^{-3}$ for $PM_{10}$, not to be exceeded more than 35 times a year. This was breached three times during the monitoring period on the 23/03/2017, 28/03/2017 and 08/04/2017. Upon identifying the raised data on these dates the wind direction and speed were looked at:

During the 23rd of March the highest data recordings have wind directions of north east (50-60°), at speeds of 3 to 4 $ms^{-1}$.

The highest data recordings on the 28th of March have wind directions of south west (124-145°), at speeds of 1 to 5 $ms^{-1}$.

The highest data recordings for the 8th of April have wind directions of (40-360 °), at speeds of 0 to 3 $ms^{-1}$.

These speeds and directions match the two concentration peaks, to the north and south east, shown in the three pollution roses.

## 3.6 Comparison with other UK sites

Period mean $PM_{10}$ and $PM_{2.5}$ concentrations from the AQMesh station site are compared in Table 3.6 with the current 2017 annual means, which include provisional data, measured at other air quality monitoring sites in the north west zone. The sites selected are all part of the Defra UK national Automatic Urban and Rural Network (AURN) and are as follows:

- Blackpool Marton: an urban background site located in the grounds of a school.
- Bury Whitefield Roadside: an urban traffic site located on the A56 Manchester road.
- Leeds Centre: an urban background site near busy inner city roads in Leeds city centre.
- Preston: an urban background site situated in a residential area.

**Table 3.6-** Period mean for Hyndburn AQMesh $PM_{10}$ and $PM_{2.5}$ pollutant concentrations compared with current annual mean in 2017 of other sites.

| Site | Type | $PM_{10}$ ($\mu g\ m^{-3}$) | $PM_{2.5}$ ($\mu g\ m^{-3}$) |
|---|---|---|---|
| Hyndburn AQMesh | | 17 | 14 |
| Blackpool Marton | Urban background | - | 9 |
| Bury Whitefield Roadside | Urban traffic | 16 | - |
| Leeds Centre | Urban background | 19 | 12 |
| Preston | Urban background | - | 9 |

– means the pollutant was not measured at that location.

The annual mean $PM_{10}$ is broadly comparable with the urban background and traffic sites listed, while the $PM_{2.5}$ mean is currently higher than those of the urban background and traffic sites listed. Figures 3.6 and 3.61 show $PM_{10}$ and $PM_{2.5}$ respectively against the AURN station provisional data, you can see the elevated periods in March whilst being higher from the Hyndburn AQMesh, they do agree with regional elevated periods at the AURN stations. It should be noted the AURN stations uses equivalent instrumentation with better accuracy than the AQMesh PM analyser that provides indicative data.

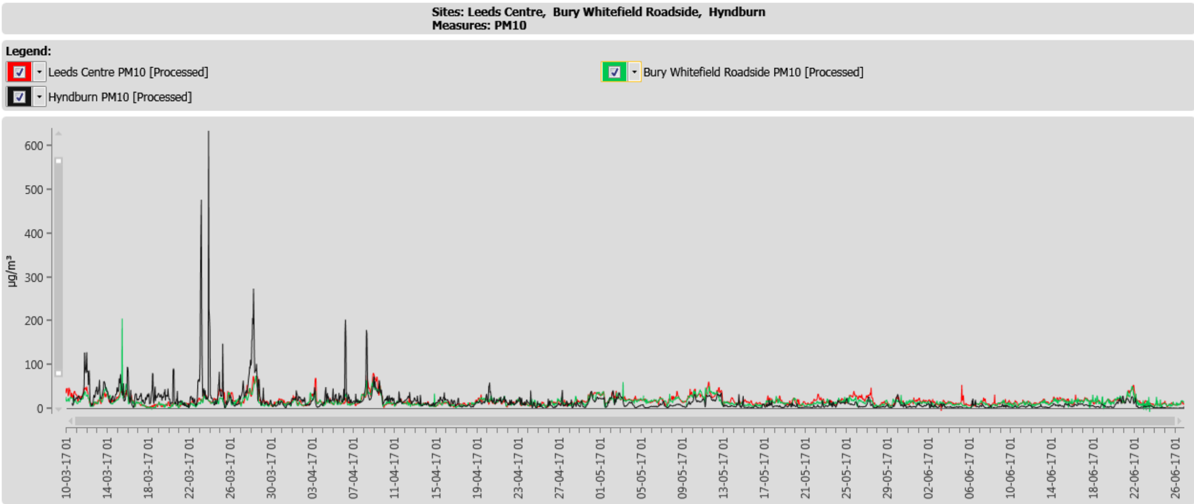



**Figure 3.6** Hyndburn $PM_{10}$ against other AURN stations provisional hourly data sets

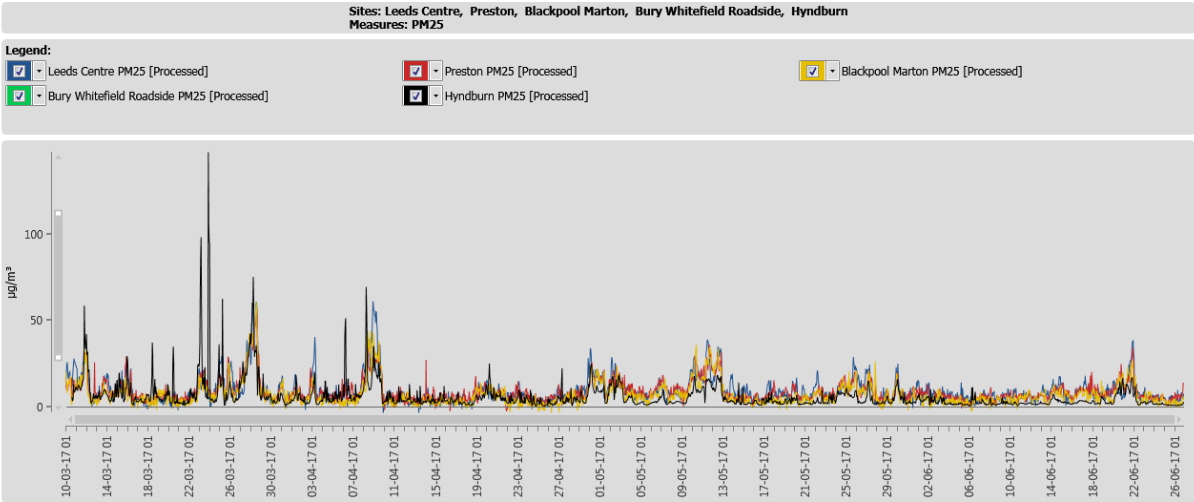



**Figure 3.61** Hyndburn $PM_{2.5}$ against other AURN stations provisional hourly data sets

# 4 Conclusions

The following conclusions have been drawn from the results of the air quality monitoring programme at the Hyndburn AQMesh monitoring site.

Particulate matter (as $PM_{10}$ and $PM_{2.5}$) were monitored for a three-month period during 2017 at a single site located in Clayton-le-Moors and at a co-location study site – Blackpool Marton AURN station. The conclusions of the monitoring programme are summarised below:

1. Data capture of at least 90% was achieved at the site.

2. There were three exceedances of the AQS objective for 24-hour mean of 50 µg $m^{-3}$ (not to be exceeded more than 35 times a year).

3. The period mean was less than the annual mean objective of 40 µg $m^{-3}$ for $PM_{10}$.

4. The diurnal patterns of concentrations of all pollutants were similar to those observed at other urban monitoring sites. Peak concentrations of particulate matter coincided with the morning and afternoon rush hour periods though exceptions were seen.

5. Meteorological data was used allowing the effect of wind direction and speed to be investigated. A bivariate plot of $PM_{10}$ and wind data showed that concentrations of $PM_{10}$ were typically highest in relatively calm conditions with winds from the north and south east. Further signals were recorded from the west and south west at higher wind speeds. This pattern was repeated for $PM_{2.5}$ and $PM_1$.

6. Mean concentrations of pollutants in the monitoring period were comparable with those measured at urban background monitoring sites around the north west zone.

It should be noted and considered when using conclusions from this report that the AQMesh instrumentation does not demonstrate equivalence against the UK reference standard for $PM_{10}$, it application is best suited for indicative monitoring.

# 5 Acknowledgements

Ricardo Energy & Environment would like to thank Hyndburn Borough Council for their assistance with this work.

# 6 References


1. Directive 2008/50/EC of the European Parliament and of the Council of 21st May 2008 on ambient air quality and cleaner air for Europe [online]. Official Journal of the European CommunitiesL152/1.Availableat:http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm [Accessed 12th July 2017].

2. Department for Environment, Food and Rural Affairs (2007). The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1) [online]. London, UK: Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. Also original Air Quality Strategy published 2000 and addendum 2003.

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5. David Carslaw (2017). worldmet: Import Surface Meteorological Data from NOAA Integrated Surface Database (ISD). R package version 0.7.5. https://CRAN.R-project.org/package=worldmet

6. Department for Environment, Food and Rural Affairs (2009). QA/QC procedures for the UK Automatic and Urban Rural Air Quality Monitoring Network (AURN) [online]. London, UK: Department for Environment, Food and Rural Affairs and the Devolved Administrations. Available http://ukair.defra.gov.uk/reports/cat13/0910081142_AURN_QA_QC_Manual_Sep_09_FINAL.pdf [Accessed 12th July 2017].

7. AQMesh (2016). A Revolution in Air Quality Monitoring [online] Available at http://www.aqmesh.com/about-aqmesh/ [Accessed 2nd October 2017]

# Appendices

Appendix 1: Air Quality objectives and Index bands

Appendix 2: Monitoring apparatus and techniques

Appendix 3: Quality assurance and quality control

# Appendix 1 – Air Quality objectives and Index bands

**Table A1.1:** UK air quality objectives for protection of human health, July 2007

| Pollutant | Air Quality objective | | Date to be achieved by |
|---|---|---|---|
| | Concentration | Measured as | |
| **Benzene**<br>All authorities | 16.25 µg $m^{-3}$ | Running annual mean | 31/12/2003 |
| England and Wales only | 5.00 µg $m^{-3}$ | Annual mean | 31/12/2010 |
| Scotland and Northern Ireland | 3.25 µg $m^{-3}$ | Running annual mean | 31/12/2010 |
| **1,3-Butadiene** | 2.25 µg $m^{-3}$ | Running annual mean | 31/12/2003 |
| **Carbon monoxide**<br>England, Wales and Northern Ireland | 10.0 mg $m^{-3}$ | Maximum daily running 8-hour mean | 31/12/2003 |
| Scotland | 10.0 mg $m^{-3}$ | Running 8-hour mean | 31/12/2003 |
| **Lead** | 0.5 µg $m^{-3}$ | Annual mean | 31/12/2004 |
| | 0.25 µg $m^{-3}$ | Annual mean | 31/12/2008 |
| **Nitrogen dioxide** | 200 µg $m^{-3}$ not to be exceeded more than 18 times a year | 1-hour mean | 31/12/2005 |
| | 40 µg $m^{-3}$ | Annual mean | 31/12/2005 |
| **Particles ($PM_{10}$) (gravimetric)**<br>All authorities | 50 µg $m^{-3}$, not to be exceeded more than 35 times a year | 24-hour mean | 31/12/2004 |
| | 40 µg $m^{-3}$ | Annual mean | 31/12/2004 |
| Scotland | 50 µg $m^{-3}$, not to be exceeded more than 7 times a year | 24-hour mean | 31/12/2010 |
| | 18 µg $m^{-3}$ | Annual mean | 31/12/2010 |
| **Particles ($PM_{2.5}$) (gravimetric)***<br>All authorities | 25 µg $m^{-3}$ (target) | Annual mean | 2020 |
| | 15% cut in urban background exposure | Annual mean | 2010-2020 |
| Scotland only | 12 µg $m^{-3}$ (limit) | Annual mean | 2020 |
| **Sulphur dioxide** | 350 µg $m^{-3}$, not to be exceeded more than 24 times a year | 1-hour mean | 31/12/2004 |

| | | | |
|---|---|---|---|
| | 125 µg $m^{-3}$, not to be exceeded more than 3 times a year | 24-hour mean | 31/12/2004 |
| | 266 µg $m^{-3}$, not to be exceeded more than 35 times a year | 15-minute mean | 31/12/2005 |
| **PAH*** | 0.25 ng $m^{-3}$ | Annual mean | 31/12/2010 |
| **Ozone*** | 100 µg $m^{-3}$ not to be exceeded over 10 days a year | 8-hour mean | 31/12/2005 |

** Not included in regulations.*

**Table A1.2:** UK air quality objectives for protection of vegetation and ecosystems, July 2007

| Pollutant | Air Quality objective | | Date to be achieved by |
|---|---|---|---|
| | Concentration | Measured as | |
| Nitrogen oxides measured as $NO_2$ | 30 µg $m^{-3}$ | Annual mean | 31st December 2000 |
| Sulphur dioxide | 20 µg $m^{-3}$ | Annual mean | 31st December 2000 |
| | 20 µg $m^{-3}$ | Winter average (October to March) | 31st December 2000 |
| Ozone | 18 µg $m^{-3}$ | AOT40+, calculated from 1-hour values May to July. Mean of 5 years, starting 2010 | 1st January 2010 |

*+ AOT40 is the sum of the differences between hourly concentrations greater than 80 µg $m^{-3}$ (= 40 ppb) and 80 µg $m^{-3}$ over a given period using only 1-hour averages measured between 08:00 and 20:00.*

## DEFRA Air Pollution bands and index values

**Table A1.3:** Air pollution bandings and descriptions

| Band | Index | Health descriptor |
|---|---|---|
| Low | 1 to 3 | Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants. |
| Moderate | 4 to 6 | Mild effects, unlikely to require action, may be noticed amongst sensitive individuals. |
| High | 7 to 9 | 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. |
| Very High | 10 | The effects on sensitive individuals described for 'High' levels of pollution may worsen. |

**Table A1.4:** Air pollution bandings and descriptions

| Band | Index | $O_3$ Daily max 8-hour mean (µg $m^{-3}$)* | $NO_2$ Hourly mean (µg $m^{-3}$) | $SO_2$ 15 minute mean (µg $m^{-3}$) | $PM_{2.5}$ 24 hour mean (µg $m^{-3}$) | $PM_{10}$ 24 hour mean (µg $m^{-3}$) |
|---|---|---|---|---|---|---|
| Low | 1 | 0-33 | 0-67 | 0-88 | 0-11 | 0-16 |
| | 2 | 34-66 | 68-134 | 89-177 | 12-23 | 17-33 |
| | 3 | 67-100 | 135-200 | 178-266 | 24-35 | 34-50 |
| Moderate | 4 | 101-120 | 201-267 | 267-354 | 36-41 | 51-58 |
| | 5 | 121-140 | 268-334 | 355-443 | 42-47 | 59-66 |
| | 6 | 141-160 | 335-400 | 444-532 | 48-53 | 67-75 |
| High | 7 | 161-187 | 401-467 | 533-710 | 54-58 | 76-83 |
| | 8 | 188-213 | 468-534 | 711-887 | 59-64 | 84-91 |
| | 9 | 214-240 | 535-600 | 888-1,064 | 65-70 | 92-100 |
| Very High | 10 | 241 or more | 601 or more | 1,065 or more | 71 or more | 101 or more |

# Appendix 2 – Monitoring apparatus and techniques

## Monitoring equipment

The following monitoring methods were used at the Hyndburn air quality monitoring station:

- AQMesh for PM measurement which uses a light-scattering optical particle counter.

# Appendix 3 – Quality assurance and Quality control

Ricardo Energy & Environment operates air quality monitoring stations within a tightly controlled and documented quality assurance and quality control (QA/QC) system. These procedures are documented in the AURN QA/QC manual[6].

Elements covered within this system include: definition of monitoring objectives, equipment selection, and site selection, protocols for instrument operation calibration, service and maintenance, integrity of calibration gas standards, data review, scrutiny and validation.

All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards at the Gas Standards Calibration Laboratory at Ricardo Energy & Environment. The calibration laboratory operates within a specific and documented quality system and has UKAS accreditation for calibration of the gas standards used in this survey.

An important aspect of QA/QC procedures is the regular six-monthly inter calibration and audit check undertaken at every monitoring site. This audit has two principal functions: firstly, to check the instruments and the site infrastructure, and secondly to recalibrate the transfer gas standards routinely used on-site, using standards recently checked in the calibration laboratory. Ricardo Energy & Environment's audit calibration procedures are UKAS accredited to ISO 17025.

In line with current operational procedures within the Defra AURN, full inter calibration audits take place at the end of winter and summer. At these visits, the essential functional parameters of the monitors such as noise, linearity and, for the $NO_x$ monitor, the efficiency of the $NO_2$ to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked.

All air pollution measurements are reviewed daily by experienced staff at Ricardo Energy & Environment. Data are compared with corresponding results from AURN monitoring stations and with expected air pollutant concentrations under the prevailing meteorological conditions. This review process rapidly highlights any unusual or unexpected measurements, which may require further investigation. When such data are identified, attempts are made to reconcile the data against known or possible local air pollution sources or local meteorology, and to confirm the correct operation of all monitors. In addition, the results of the daily automatic instrument calibrations (see Appendix 2) are examined to identify any possible instrument faults. Should any faults be identified or suspected, arrangements are made for Ricardo Energy & Environment personnel or equipment service contractors to visit the site as soon as possible.

At the end of every quarter, the data for that period are reviewed to check for any spurious values and to apply the best daily zero and sensitivity factors, and to account for information which only became available after the initial daily processing. At this time, any data gaps are filled with data from the data logger back-up memory to produce as complete a data record as possible.

Finally, the data are re-examined on an annual basis, when information from the six-monthly inter calibration audits can be incorporated. After completion of this process, the data are fully validated and finalised, for compilation in the annual report.

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