

AIR QUALITY EXPERT GROUP

# UNDERSTANDING PM<sub>10</sub> IN PORT TALBOT



**Advice note prepared for:**

**Department for Environment, Food and Rural Affairs;  
Scottish Government; Welsh Assembly Government; and  
Department of the Environment in Northern Ireland**

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This is an advice note from the Air Quality Expert Group to the Department for Environment, Food and Rural Affairs; Scottish Government; Welsh Assembly Government; and Department of the Environment in Northern Ireland, on Understanding PM<sub>10</sub> in Port Talbot.

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## Terms of reference

The Air Quality Expert Group (AQEG) was set up in 2001 to provide independent scientific advice on air quality, in particular on the air pollutants contained in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland and those covered by the EU Directives on Clean Air for Europe (CAFE Directive) and the 4<sup>th</sup> Daughter Directive of the Air Quality Framework Directive.

AQEG report to the Secretary of State for Environment, Food and Rural Affairs, Scottish Ministers, the National Assembly for Wales and the Department of the Environment in Northern Ireland (the Government and Devolved Administrations).

AQEG's main functions are:

- to give advice on levels, sources and characteristics of air pollutants in the UK;
- to analyse trends in pollutant concentrations;
- to assess current and future ambient concentrations of air pollutants in the UK; and
- to suggest potential priority areas for future research aimed at providing a better understanding of the issues that need to be addressed in setting air quality objectives.

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## **Acknowledgements**

AQEG would like to thank all those who responded to the call for evidence, without whom this advice note would have not been possible. The organisations and individuals who gave presentations at the hearings on 15<sup>th</sup> November are listed in Appendix 3.

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## Table of contents

Executive summary.....	1
Introduction .....	3
Scope .....	3
Background .....	3
Approach.....	3
Structure of advice note .....	4
What is the problem that needs addressing?.....	5
Summary .....	5
Observations .....	5
What data are available to address the problem? .....	9
Summary .....	9
Observations .....	9
PM <sub>10</sub> monitoring.....	9
Speciation studies .....	9
Analyses of pollution roses.....	9
Correlations of concentrations with on-site activity .....	10
Recent opportunities .....	10
What do the data already collected show? .....	11
Summary .....	11
PM <sub>10</sub> monitoring.....	11
Speciation studies .....	11
Analyses of pollution roses.....	12
Correlations of concentrations with on-site activity .....	12
What clear answers have existing studies provided? .....	14
Summary.....	14
Observations .....	14
What further analyses of existing data would be helpful?.....	15
Summary .....	15
Observations .....	15
What, if any, new measurements are required? .....	17
Summary .....	17
Observations .....	17
How would new modelling studies help? .....	19



Summary .....	19
Observations .....	19
AQEG recommendations .....	22
General.....	22
Modelling.....	22
PM <sub>10</sub> monitoring.....	23
Chemically speciated measurements.....	24
Organisation .....	24
Programme of work .....	25
References.....	27
Appendix 1: Call for evidence .....	28
Appendix 2: Documents received .....	30
Appendix 3: Organisations and individuals in attendance at the evidence session.....	31
Appendix 4: Measurement of PM <sub>10</sub> .....	33
Appendix 5: PM <sub>10</sub> data from 2009/10.....	35
Appendix 6: Sources of PM <sub>10</sub> identified by Tata.....	39
Appendix 7: Receptor modelling .....	40

## Executive summary

The Air Quality Expert Group has been asked by the Department of Food and Rural Affairs and the Welsh Assembly Government to provide an independent expert opinion on:

*“What methodologies or approaches are required to advance the evidence base in order to assess the impact of the different current particle sources within the Port Talbot area on the resultant particulate matter (PM) levels in the local area?”*

AQEG reviewed a range of evidence, including published reports and an evidence gathering session held at Port Talbot, demonstrating that a large amount of data has been collected over many years. It was not clear from the evidence that data collection had been undertaken according to an overall strategy. The observational evidence indicates that the industrial complex is by far the largest source of particulate matter in the local area, and that it is highly likely that fugitive emission sources play a significant role in the observed PM levels. However, it has not been possible in the past to quantify the contribution of fugitive sources relative to the many other sources across the industrial complex that contribute to the total PM load.

The review has led the Air Quality Expert Group to produce a series of recommendations to drive forwards the future evidence gathering in a systematic way. These recommendations can be broken down into four key areas:

### Strategy

- the actions set out in this advice note should be developed as a programme of work to be taken forward in a coherent and consistent manner (recommendation 10);
- the working arrangements currently in place should be continued, with all parties contributing in an open and transparent manner (recommendation 11);
- there would be merit in the involvement of external peer reviewers to help ensure that the future programme remains focussed and is making best use of the scientific data and analysis resources (recommendation 12).

### Monitoring

- an early review should be carried out of the available meteorological data to establish whether the meteorological monitoring sites are sufficient to characterise the air flows over the industrial complex and the surrounding area (recommendation 3);
- an FDMS PM<sub>10</sub> monitor should be located to the west of the industrial complex on the coast, co-located with a wind monitor 10 m from the ground. This will allow the upwind flux of PM<sub>10</sub> to be subtracted hour by hour from downwind measured concentrations, so as to isolate the contribution of the sources within the industrial complex (recommendation 6);

- all the PM<sub>10</sub> measurement sites currently operating should be retained for a minimum of a further two years (recommendation 5);
- an on-site measurement programme should be developed to quantify the emissions from fugitive sources (recommendation 9);
- a high time resolution monitoring programme in support of multivariate receptor modelling should be developed (recommendation 8);

### **Modelling**

- a priority for further work should be to model the impact of all the sources within the industrial complex on PM<sub>10</sub> concentrations observed in Port Talbot (recommendation 1);
- an initial dispersion modelling exercise should be carried out using readily available information on emissions from all sources , which can be supplemented over time with a more detailed time-resolved emission inventory (recommendation 2);
- CFD modelling at the building scale would be of limited benefit and should not be pursued (recommendation 4);

### **Data**

- a central repository, ideally web-based, should be established to hold all long-term monitoring data (recommendation 7).

## Introduction

### Scope

1. The Air Quality Expert Group (AQEG) has been asked by the Department of Food and Rural Affairs (Defra) and the Welsh Assembly Government (WAG) to provide an independent expert opinion on:

*“What methodologies or approaches are required to advance the evidence base in order to assess the impact of the different current particle sources within the Port Talbot area on the resultant particulate matter (PM) levels in the local area?”*

### Background

2. The town of Port Talbot experiences elevated concentrations of PM<sub>10</sub> (Particulate Matter less than 10 micrometres aerodynamic diameter), over and above those seen in the local area. These were first identified when a national network monitoring site was set up in 1996. There have been a number of years since then where the daily average concentration of PM<sub>10</sub> exceeded 50 µg m<sup>-3</sup> for more than 35 days, hence exceeding the national air quality objective and the EU limit value for PM<sub>10</sub>. However, such exceedences have reduced over recent years and levels are now below the objective and limit value.
3. It is recognised that elevated PM<sub>10</sub> concentrations are linked to the industrial activities in the Port Talbot area, which are dominated by a major steelworks (Hayes & Chatterton, 2009). There are numerous industrial operations taking place across the industrial area including the individual processes involved in the steel-making, as well as related operations using the by-products, and it is still unclear which of these are the principal contributors to the elevated PM<sub>10</sub> levels. The attribution of sources remains unclear even after numerous measurement and analysis programmes extending back over a decade, carried out by Neath Port Talbot County Borough Council (NPTCBC), Environment Agency Wales, and Corus (now Tata Steel Strip Products UK (Tata), the operators of the steelworks that represents the predominant industrial activity in the area. Recently WAG commissioned a review of the available information. This was carried out by the University of the West of England, Bristol (UWE) (Hayes & Chatterton, 2009).
4. Without a clear understanding of the main contributing sources it will be difficult to develop appropriate programmes to limit the emissions contributing to the high levels of PM<sub>10</sub>.

### Approach

5. AQEG established a subgroup to fulfil the request for advice from Defra and WAG. A call for evidence was issued on 1<sup>st</sup> October 2010 (see Appendix 1) and a one-day session was held at Port Talbot on 15<sup>th</sup> November 2010, at which a range of evidence was presented. The evidence was supplemented by numerous published

documents. The subgroup followed this up with a visit to the steelworks on 24<sup>th</sup> January 2011, to gain a better understanding of the layout of the different industrial activities and their potential as sources of PM<sub>10</sub>. The subgroup has examined the published material and discussed the evidence provided and draws together its observations in this advice note.

6. It is not intention of this advice note to summarise or review the vast quantity of material provided. The recent review commissioned by WAG (Hayes & Chatterton, 2009) provides a useful starting point for readers who wish to examine the material in more detail. A full list of the documents considered by AQEG is provided in Appendix 2.
7. It should be made clear that this advice note gives no consideration to the health impacts arising from the elevated PM<sub>10</sub> concentrations at Port Talbot, nor does it recommend any specific measures to reduce emissions or give consideration to the potential impacts of possible future developments in the Port Talbot area.

### **Structure of advice note**

8. The advice note is structured around the series of questions posed in the call for evidence
  - What is the problem that needs addressing as you see it?
  - What data or other evidence do you hold and are able to provide which will help in considering this question?
  - Have you analysed this data and evidence – and if so what does this show/ conclude?
  - Have existing studies provided any clear answers?
  - What further analyses of existing data and other evidence would be helpful?
  - What, if any, new measurements are required?
  - How would new modelling studies help provide the required understanding?

It concludes with a series of recommendations on how to take the matter forwards.

## What is the problem that needs addressing?

### Summary

9. The context of the problem is the occurrence of PM<sub>10</sub> concentrations in the town of Port Talbot that are elevated above those measured at nearby rural and urban monitoring stations, such as in Swansea and Narberth (Pembrokeshire). The industrial activities taking place within the large industrial complex to the west of the town have been clearly identified as the cause of these elevated concentrations (Hayes & Chatterton, 2009). The focus is on high 24 hour PM<sub>10</sub> concentrations rather than the annual mean concentrations.
10. AQEG has been asked to provide an opinion on:

*“What methodologies or approaches are required to advance the evidence base in order to assess the impact of the different current particle sources within the Port Talbot area on the resultant particulate matter (PM) levels in the local area?”*
11. The responsibility for resolving the problem is shared amongst several organisations: Environment Agency Wales are responsible for regulating the industrial complex in terms of its environmental impacts; NPTCBC are responsible for addressing local air quality; Welsh Assembly Government are responsible for the delivery of EU and National legislative commitments on air quality; and the site operators (principally Tata, but also Civil & Marine Ltd., Tarmac Western Ltd., Cambrian Stone and Harsco Metals Group Ltd.) are responsible for the activities within the industrial complex. The site operators have recently introduced a joint working arrangement. AQEG sees the clarity and openness of this working arrangement as a key component in resolving any problems.

### Observations

12. A monitoring station was established in Port Talbot in 1996 as part of the national Automatic Urban and Rural Network (AURN). This was located at Groeswen Hospital (see Figure 1), around 350 m to the east of the industrial complex and 135 m to the west of the M4 motorway. The site was moved in 2007 to its current location at Margam (fire station) (Figure 1). Details of the monitoring methods employed for PM<sub>10</sub>, which have changed over time are set out in Appendix 4.
13. Environment Agency Wales has summarised the measurements made with the TEOM analyser at the AURN site over the period 1997 to 2007, with the results multiplied by 1.3 (Environment Agency Wales, 2009). In 1997 there were 59 days with PM<sub>10</sub> concentrations greater than (>) 50 µg m<sup>-3</sup>, compared with the 35 days allowed under the Directive. There is evidence of a decline over the 10 years from 1997 to 2007, but results for 2005-2007 were not reliable owing to poor data capture in 2005 and 2006 and relocation of the monitoring site in 2007, and a reliable trend cannot be established. Clear evidence was also found of much lower concentrations

in 2002, when one of the blast furnaces was shut down and throughput of materials was reduced.

14. Measured PM<sub>10</sub> concentrations over the period 1997 to 2010 at sites in and around Port Talbot are summarised in Figure 2 as days with daily mean concentrations above 50 µg m<sup>-3</sup>, which can be compared with the limit value of no more than 35 days above this concentration. It is clear that there are more days with concentrations above 50 µg m<sup>-3</sup> in Port Talbot than in the nearby urban area of Swansea, while there are more days above 50 µg m<sup>-3</sup> in Swansea than at the nearby rural monitoring site of Narbeth. The monitoring results are also shown in Figure 3 as 90.4<sup>th</sup> percentiles of daily mean concentrations. This method is used where there is less than 90% data capture to give an indication if there has been an exceedance of the limit value over the year. A 90.4<sup>th</sup> percentile will approximate to an exceedance of the limit value if it is above 50 µg m<sup>-3</sup>. The 90.4<sup>th</sup> percentile values in Swansea are broadly 10 µg m<sup>-3</sup> higher than the rural background, while the Port Talbot values are around 20 µg m<sup>-3</sup> higher than the rural background. The concentrations in Port Talbot are clearly higher than those measured in the surrounding area. The downward trend apparent in the Port Talbot data between 1997 and 2006, will, in part, be owing to the declining rural background, as observed at Narbeth over this period (Figure 3).
15. It was suggested to AQEG that the PM<sub>10</sub> monitoring was not being carried out in the location where concentrations are highest. Unfortunately, no reliable modelling has been undertaken to help identify the location of maximum impact from the industrial complex. Identification of the location with the highest concentration (which may vary from year to year) is, however, being addressed with the more comprehensive monitoring network now in place (see Figure 1).



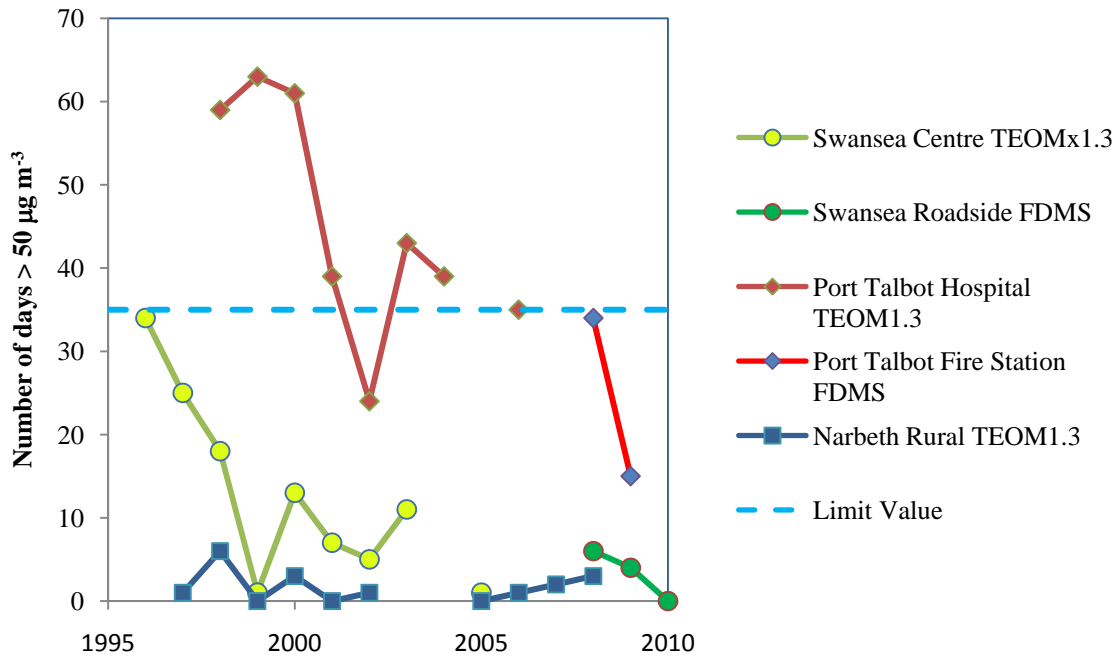


**Figure 1:** Locations of PM<sub>10</sub> monitoring sites.

Red dots indicate current sites. Green dot indicates former site. 1) Docks (NPTCBC), 2) Talbot Road (NPTCBC), 3) Theodore Road (NPTCBC), 4) Margam (AURN - fire station), 5) Prince Street (EAW), 6) Groeswen (AURN – hospital), 7) Twll-yn-y-Wal Park (NPTCBC), 8) Dyffryn School (NPTCBC), 9) Coastal Site (Tata). NPTCBC = Neath Port Talbot County Borough Council, EAW = Environment Agency Wales.

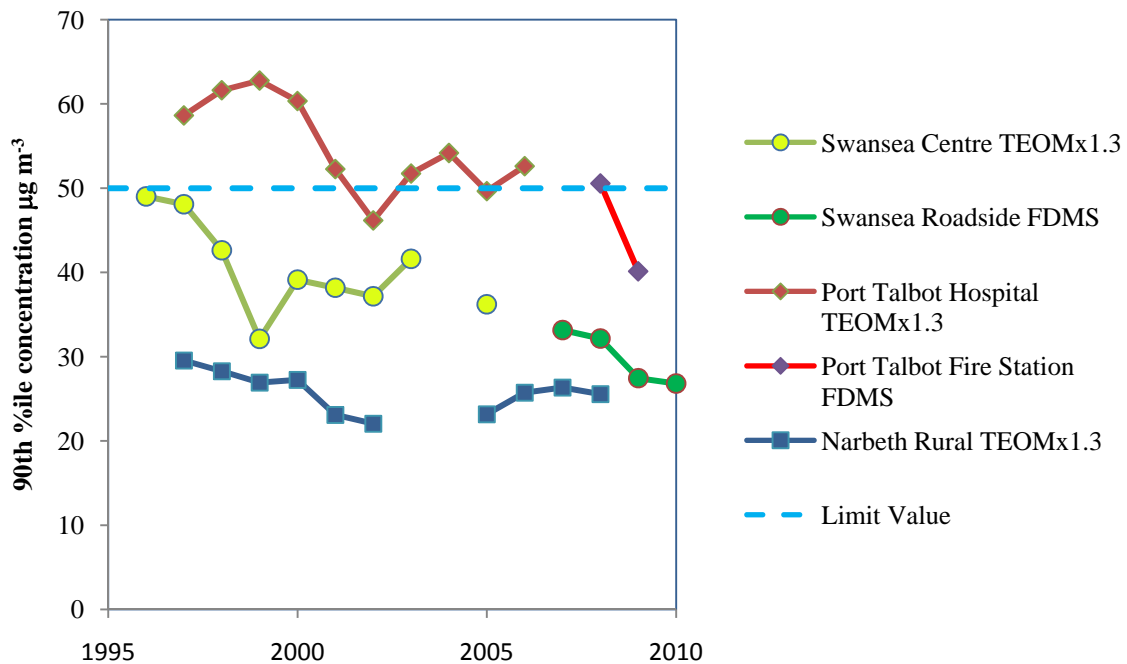
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**Figure 2:** Numbers of days with daily mean PM<sub>10</sub> > 50 µg m<sup>-3</sup>, 1996-2010.

Data are for AURN sites, for years with data capture >90%. See Appendix 4 for description of the monitoring methods. The results show more days with PM<sub>10</sub> > 50 µg m<sup>-3</sup> in Port Talbot than is observed in the urban area of Swansea and the rural area represented by Narbeth.



**Figure 3:** 90.4<sup>th</sup> percentiles of daily mean PM<sub>10</sub> concentrations, 1996-2010.

Data are for AURN sites, for years with data capture >75%. See Appendix 4 for description of the monitoring methods. The results show higher 90 percentile concentrations in Port Talbot than is observed in the urban area of Swansea and the rural area represented by Narbeth.

## What data are available to address the problem?

### Summary

16. There is a plethora of data available on PM<sub>10</sub> and its constituents, collected through a number of studies that have been carried out over the last 12 years. These studies have been somewhat ad-hoc in nature and many have involved analysis of data collected over a limited time period in an un-coordinated way. They have included the analysis of PM<sub>10</sub> data and measurements of the composition of the particulate matter, and have been brought together in recent data compilations.

### Observations

17. The information available includes results from:
  - PM<sub>10</sub> monitoring
  - speciation studies;
  - analyses of pollution roses; and
  - correlation of concentrations with on-site activity.

### PM<sub>10</sub> monitoring

18. PM<sub>10</sub> monitoring was instigated in Port Talbot in 1996, and developed as described in the previous section of the advice note. Tata has carried out additional on-site monitoring using TEOM and Osiris analysers. The off-site monitoring data have been analysed to show time-of-day and seasonal dependencies, which may help identify sources.

### Speciation studies

19. Early studies were carried out in 1998 and 1999 using a range of procedures to examine the particles being collected. This included the use of ion chromatography, scanning electron microscopy and x-ray diffraction to characterise the particulate matter. Subsequent studies have characterised the soluble and insoluble components of the PM<sub>10</sub>.

### Analyses of pollution roses

20. A number of studies have involved analysis of pollution roses which show the dependence of concentrations on wind direction (sometimes in combination with wind speed). They have been derived from 1-hour PM<sub>10</sub> data, using wind data measured at different locations in the general area. More recently the OpenAir software (<http://www.openair-project.org/>) has been used to produce polar plots, which show

the joint influence of wind direction and wind speed on concentrations. These analyses are set out in the UWE report (Hayes & Chatterton, 2009)

### **Correlations of concentrations with on-site activity**

21. Tata has carried out studies that aim to identify any on-site activities that might be associated with days where PM<sub>10</sub> is greater than 50 µg m<sup>-3</sup> (exceedence days). The Environment Agency Wales has considered the association between concentrations and the general throughput of the site. Consideration has also been given to the effect of the shut-down of one of the blast furnaces in 2002 and to the effect of measures introduced in recent years to reduce emissions.

### **Recent opportunities**

22. In addition to the studies noted above, there is now a comprehensive network of monitoring stations in place (see Figure 1). The majority use FDMS analysers which provide reference equivalent PM<sub>10</sub> data. The Environment Agency Wales monitoring site at Prince Street has used a TEOM (although an FDMS is being installed) and the Tata coastal site still employs a TEOM. The results from the TEOM monitors can be made approximately reference equivalent using the volatile correction model (see Appendix 4). The data from this more comprehensive network of monitors have yet to be fully analysed. An initial indicative analysis has been carried out by AQEG using the OpenAir software and is presented in Appendix 5.

## What do the data already collected show?

### Summary

23. The most comprehensive analysis of the available data is provided in the review carried out by UWE for WAG (Hayes & Chatterton, 2009). Environment Agency Wales has also reviewed the available information in its permit review (Environment Agency, 2009). More recently, Tata has provided AQEG with a summary of the findings of its own studies over the decade (Landeg, 2010). The findings set out in these documents clearly show the influence of the industrial activities on PM<sub>10</sub> concentrations in Port Talbot. There is much less clarity as to the relative importance of the different sources within the industrial complex, although both the UWE and the Tata report conclude that fugitive sources are likely to be more important than emissions from the point sources, such as the sinter plant chimney stack.

### PM<sub>10</sub> monitoring

24. There is a strong diurnal pattern in PM<sub>10</sub> concentrations measured at Port Talbot, with a daytime increase to a peak during mid-afternoon and higher concentrations during May and June (Figure 4). These features are consistent with a greater amount of dust being re-suspended during the daytime, as the ground dries out and wind speeds increase as well as potential grounding of elevated plumes under the more unstable conditions of daytime. The higher PM<sub>10</sub> concentrations during the spring and summer months (Figure 4) are also in part consistent with more re-suspended dust arising during the drier months and more plume grounding associated with the greater atmospheric instability during the summer months. However, this is not entirely consistent with the lower average values observed in July and August. The simple analysis set out above is based on average concentrations for all weather conditions, and would be improved by taking account of the influence of wind direction and wind speed.

25. Correlations of the PM<sub>10</sub> data with carbon monoxide and sulphur dioxide help associate elevated PM<sub>10</sub> with combustion or non-combustion sources. The results set out in the UWE review show that both sources are playing a role (Hayes & Chatterton, 2009).

26. The UWE review has also shown that the industrial complex has only a small impact on PM<sub>2.5</sub> concentrations in Port Talbot (Hayes & Chatterton, 2009). The elevated PM<sub>10</sub> concentrations are thus mainly in the PM coarse fraction, i.e. that between PM<sub>2.5</sub> and PM<sub>10</sub>. The role of the PM coarse fraction is consistent with fugitive sources rather than combustion or process sources predominating.

### Speciation studies

27. Early studies were carried out in 1998 and 1999 using a range of procedures to examine the particles being collected. These studies identified the presence of iron

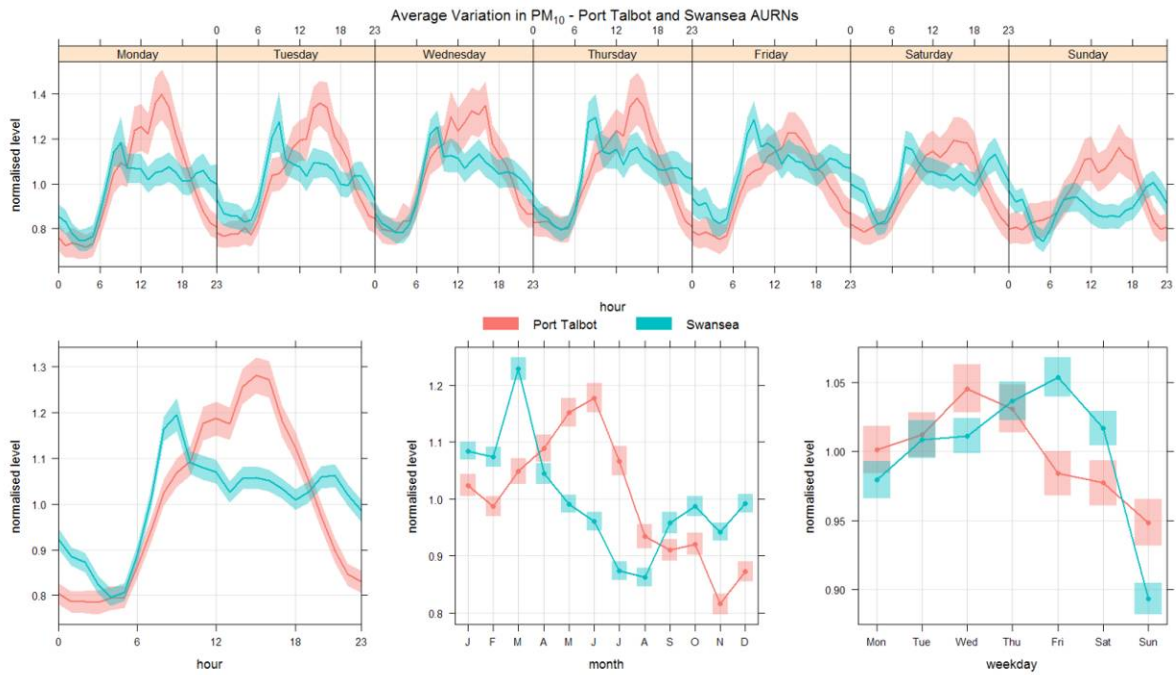
fly ash particles and indicated a contribution from the blast furnace. They did not however help quantify the importance of the different sources within the industrial complex. They merely confirmed that the steelworks was the main contributor of PM<sub>10</sub> (Hayes & Chatterton, 2009)

## Analyses of pollution roses

28. The pollution roses have provided useful information on the sources of PM<sub>10</sub>, especially the polar plots prepared using the OpenAir software. However, the analysis has been constrained by uncertainty about the wind data and by the limited number of monitoring sites, both of which constrain the use of triangulation to help identify sources.

## Correlations of concentrations with on-site activity

29. The clearest correlation with on-site activity relates to the shut-down of one of the two blast furnaces in 2002. During this time there was a significant reduction in PM<sub>10</sub> in Port Talbot (see Figures 2 and 3). This was originally interpreted as being due to the emissions from the blast furnace itself, and the plant was fitted with abatement equipment when it re-opened in 2003. However, concentrations were not noticeably affected by the abatement. It is most likely that the reduced emissions in 2002 were because of the reduced activity, such as in the handling of raw materials, across the whole complex, and hence reduced emissions from all sources and not just the blast furnace.
30. More recently, Tata has been carrying out detailed analyses of days when 50 µg m<sup>-3</sup> has been exceeded, attempting to relate these exceedences to information collected on process activity. The findings have, however, been inconclusive to date (Landeg, 2010).
31. In addition, AQEG is aware from its own observations, and those of members of the public, that the sinter plant stack is at times the source of a visible brown plume. This draws attention to this source and to the complex as a whole as a source of PM emissions. AQEG emphasises that this is just one of the PM emission sources on site, and its visual appearance does not necessarily mean that it is a dominant source. Indeed the evidence obtained to date would suggest that it is not a dominant source.
32. The findings discussed in this section would caution against looking for single causes of the elevated PM<sub>10</sub> and against focussing on the most obvious processes. The observations are consistent a significant component of the emission being fugitive in nature; a view that was strengthened following AQEG's site visit.



**Figure 4:** Variation in average concentrations of PM<sub>10</sub> at Port Talbot and Swansea AURN monitoring stations 2000-2009 (reproduced from Hayes and Chatterton, 2009). Includes TEOMx1.3 and FDMS data from different sites (see Appendix 7 for description of monitoring techniques).

## What clear answers have existing studies provided?

### Summary

33. There is no clear overall picture of the contributions of the wide range of sources on site to concentrations of PM<sub>10</sub> off site. The early focus was on the most obvious point sources, such as the sinter plant and the smelters, however, subsequent work has questioned the importance of these sources. The recent reviews and assessments by UWE, Environment Agency Wales and Tata show that diffuse and/or fugitive sources make a significant contribution to the observed PM<sub>10</sub> in Port Talbot.

### Observations

34. The UWE report has concluded that the blast furnaces and sinter plant stack are unlikely to be contributing significantly to concentrations within Port Talbot (Hayes and Chatterton, 2009). The report does identify five most likely sources contributing to off-site PM<sub>10</sub> as being:

- Cambrian Stone granulation
- Metal plating pits
- Furnace slag pits
- Multiserve briquetting; and
- Multiserve steel slag solidification/demetalling/cutting.

35. Tata has also presented an analysis that identifies predominant sources of on-site PM<sub>10</sub> on days when the 50 µg m<sup>-3</sup> objective is exceeded and on average days (Landeg, 2010). The findings are summarised in Appendix 6, and show that the predominant sources are fugitive. The Tata study does not, however, allow the contribution of these on-site sources to off-site PM<sub>10</sub> concentrations to be quantified.

36. Tata has put in place a system to investigate the on-site activities taking place during all off-site breaches. The outcome of operating this system for a period of a year, from October 2009 to September 2010, is reported as being inconclusive, in part due to conflicting evidence (Landeg, 2010). As noted in the previous section, this would not be surprising if the predominant sources are fugitive.

37. During the site visit, AQEG formed the view that fugitive sources arising from vehicle movements on paved and unpaved roads, and the large amount of material handling, are likely to be significant contributors.

## What further analyses of existing data would be helpful?

### Summary

38. Considerable analysis of existing data from the Port Talbot area has been carried out. Over the last two years PM<sub>10</sub> data have been collected at a greater number of sites than in previous years. There is also a coastal PM<sub>10</sub> monitoring site operated by Tata, data from which would be invaluable in allowing a clearer analysis of the contribution from the industrial site, by subtraction of upwind concentrations from those at downwind sites in Port Talbot. AQEG strongly encourages Tata to make the monitoring data from the coastal site widely available to allow future data analyses.
39. Data from the larger network of sites should now be analysed in detail using OpenAir software. Such analyses should help identify areas of the industrial complex that are giving rise to the greatest contributions to off-site concentrations. These analyses should be carried out using wind data from the AURN and Environment Agency Wales monitoring sites, and from other appropriate sites in the area, including those operated by Tata (AQEG strongly encourage Tata make these data available for analysis). Account should also be taken of rainfall, which reduces the opportunity for fugitive emissions to arise. In order to provide all interested parties with the opportunity to carry out these analyses, it is considered important that a central repository of data is set up with easy web-based access.
40. AQEG has, however, formed the view that the complexity of the site is such that the analysis of monitoring data alone will never be sufficient to distinguish the relative importance of all the sources within the industrial complex.

### Observations

41. Since 2009/10 there has been a comprehensive network of monitoring sites within Port Talbot (see Figure 1). There has not to date been a comprehensive analysis of the data from these sites. AQEG has carried out an initial examination of the monitoring data from the seven sites operating in Port Talbot over the period 2009-2010 (Appendix 5). The data from these seven sites should continue to be analysed in greater detail.
42. Key to the analysis will be suitable wind data. AQEG considers that suitable wind data will only be obtained from a mast that is in a reasonably open setting with the monitor 10 m above the ground to be consistent with Met Office standards. The meteorological masts at the AURN (fire station) site and the EAW (Prince Street) site are probably reasonably well located, but their heights may not be optimum. The location of the elevated wind monitor operated by Tata on the gas holder, which is centrally located on the site, is probably also suitable as a location to monitor wind speeds and directions at height across the industrial complex (assuming the monitor is on a mast extending above the top of the gas holder). AQEG would place considerably less reliance on wind monitors that are located around 2 m above the



ground alongside PM<sub>10</sub> monitors, as is the case at many of the Tata monitoring sites, because the wind direction and speed will be strongly affected by nearby structures, such that they will not reflect the movement of air across the general area. There is a much greater likelihood that these wind monitors will be affected by local perturbations to the wind field, such that they will not reflect the general movement of air across the industrial complex. In all cases it is important that the directional accuracy of the monitor is checked regularly.

43. Given that fugitive sources appear to be important, it is relevant to include rainfall in the analysis of monitoring data. Hayes and Chatterton (2009) have carried out a limited analysis of the data in relation to rainfall, and the results they present in their report are supportive of the influence of rainfall in reducing off-site PM<sub>10</sub> concentrations.

## What, if any, new measurements are required?

### Summary

44. AQEG has identified an immediate requirement for an additional PM<sub>10</sub> monitoring site located to the west of the industrial complex, on the coast. A monitoring site in this location will allow the contribution of the industrial complex to concentrations within Port Talbot to be clearly defined on an hour by hour basis. Tata operates a TEOM monitor at a suitable location on the coast. AQEG would like to see an FDMS monitor established as near to the Tata coastal site as possible, with the data made freely available through the central repository discussed in the previous section. This coastal monitor should be operated to the standard of the AURN sites. The site should be accompanied by a wind monitor on a mast 10 m above the ground.
45. AQEG considers the current deployment of sites within Port Talbot to be appropriate and recommends that this network is retained for a minimum of 2 years to provide sufficient data for appropriate analysis. The Environment Agency Wales Prince Street site is considered to be an important part of this network and should be retained. Currently this site uses a TEOM analyser and it is considered important that an FDMS instrument is installed at this site to provide hourly mean data for use in detailed data analyses. If the Agency is unable to retain this site, then it would be appropriate to consider relocating one of the sites operated by NPTCBC (possibly the Theodore Road site)
46. There would also be value in measurement programmes to define source strengths for fugitive sources. In addition, there would be value in a source apportionment study involving receptor modelling, which would require a suitable monitoring campaign.
47. Any future measurements should only be carried out as part of a clear and co-ordinated programme of further work.

### Observations

48. AQEG has formed the view that measurements alone will be insufficient to identify the dominant sources within the industrial complex. However, this is not to say that measurements are not important. They are crucial and AQEG welcomes the scale of the current network. It considers that it will be important to maximise the value of the data from the current network. The sites should operate with the same instruments, which should be reference equivalent, provide hourly mean concentrations, and achieve a high level of data capture. In this regard, AQEG is concerned that the AURN site achieved poor data capture during 2010. Given the importance of the data from this site, AQEG would expect to see a high priority given to ensuring a high level of data capture in future. It is also important that the monitoring data are readily available to those wishing to investigate PM<sub>10</sub> at Port Talbot and AQEG would like to

see a central web-based repository created, where the results can be easily accessed.

49. Receptor modelling can be a powerful tool to help identify sources. Receptor modelling refers to the use of monitoring data collected in the atmosphere to infer the sources responsible for the measured concentrations. In many situations receptor modelling can yield quantitative as well as qualitative estimates of the sources contribution at the monitoring site. There are two procedures used most commonly for receptor modelling of airborne concentrations: chemical mass balance and multivariate statistical methods. Both require the collection of temporally resolved chemically speciated data on the composition of airborne particles, often supplemented in the case of the multivariate statistical method by meteorological and gas phase pollutant data. These two methods are discussed more fully in Appendix 7, where it is concluded that a multivariate statistical approach would be the most suitable for application at Port Talbot. The aim would be to analyse data collected at an off-site location (probably the AURN site at the fire station, given the species currently monitored at the site), with a view to identifying up to 10 different sources contributing to PM<sub>10</sub> at the monitoring site.
50. AQEG would like to see a monitoring programme developed with a high time resolution (probably one-hour or better), to be carried out over a period of around one month, with a view to allowing receptor modelling to be carried out (see Appendix 7).

## How would new modelling studies help?

### Summary

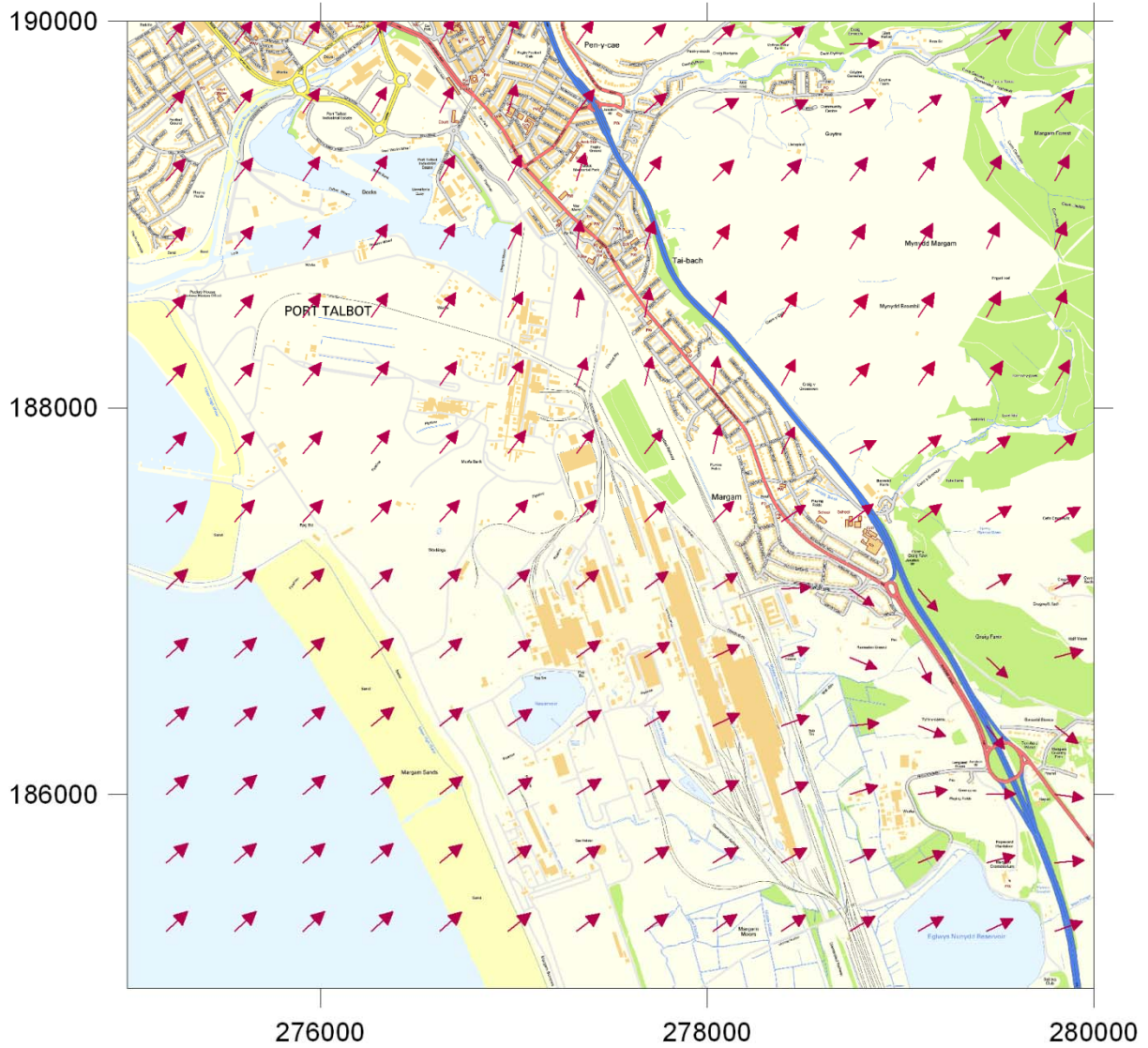
51. AQEG considers that a comprehensive modelling study should be undertaken in short order, as no such study has been carried out to date. Initial modelling should be carried out using an emissions inventory based on best available emissions estimates for the full range of sources. Ultimately a comprehensive inventory will be required. AQEG recognises that the preparation of such an inventory will be challenging, as emissions data will need to be collated for a wide range of sources, many of which are fugitive, and hence difficult to quantify. However, these difficulties should not constrain the early implementation of modelling, as the initial results will help identify those sources for which improved emissions data are required. Indeed, the development of both the emissions inventory and the subsequent modelling should be an iterative and on-going feature of the future work programme. Comparison of model results with monitoring data will also be an essential part of this work.
52. AQEG has considered the benefits of CFD modelling to establish the wind field across the industrial complex. It does not consider that this would add greatly to resolving the issue.

### Observations

53. The modelling conducted to date has been limited and largely confined to consideration of the more easily characterised point sources (Hayes & Chatterton, 2009). The available evidence suggests that fugitive sources may be the dominant source of elevated PM<sub>10</sub> levels in Port Talbot. AQEG considers that modelling will provide an important pathway to quantifying the contributions of the different sources within the industrial complex to off-site concentrations.
54. The first step in any modelling is the development of a detailed emission inventory. It is recognised that this is not straightforward for fugitive sources, however, generic emission factors are available that can be used as a starting point. Activity data are key, for instance the number of loaders operating and their typical duration of operation and the numbers of movements along paved and unpaved roads. It is understood that Tata does not have this information, however, as the operations are continuous on site, it is likely that a survey over a few weeks will be sufficient to characterise the movements of plant and vehicles. AQEG would emphasise that emissions from the paved roads should be assessed in as much detail as other sources.
55. The modelling should take account of the time variations of the emissions in as much detail as is possible. The findings of modelling studies should be used to assess those sources that are likely to be most significant. This information should then be used to help refine the emissions inventory for these sources. The model output

should also be compared with monitoring data, as this will help confirm whether the appropriate sources have been identified. The OpenAir software may be useful in this regard.

56. AQEG has already advised Environment Agency Wales that it does not see any great benefit arising from the application of CFD modelling to the Port Talbot industrial complex. CFD is suited to the modelling of dispersion in the near field, i.e. within a few tens to hundreds of metres, where the flow is disturbed by buildings and other structures, and not to the modelling of impacts on more distant receptors. The receptors within Port Talbot are several hundred meters from the sources and structures within the industrial complex and as such will be affected by the overall movement of air across the complex from the source to the receptors, which is best captured using dispersion models. Furthermore CFD modelling is limited to model runs for one wind direction and one wind speed at a time, and thus not suited to determining concentrations affected by a wide range of meteorological conditions throughout a year. .
57. AQEG recognises that the topography of the land to the east of Port Talbot is likely, on occasions, to affect the wind field. Some preliminary modelling using FLOWSTAR software has shown that topography can affect wind direction, such that the measured direction in Port Talbot may not reflect the general direction of movement across the site. In particular, it is likely that on occasions the direction at the AURN (fire station) site will be more southerly than the flow across the site (Figure 5).



**Figure 5:** Analysis of topographic effect on wind flow across the Port Talbot area using FLOWSTAR. Wind southwest at  $5 \text{ ms}^{-1}$  with an inversion at 500 m. Provided by David Carruthers, CERC (a member of AQEG).

## AQEG recommendations

### General

58. AQEG observes that fugitive sources are likely to make a significant contribution to the measured PM<sub>10</sub> levels in Port Talbot. These fugitive sources are widely dispersed across the site and will include PM<sub>10</sub>:
- raised by vehicle movements;
  - from the handling of materials; and
  - as a result of wind-blown dust.
59. **An output focussed work programme should be developed to understand these fugitive sources, as well as the more tangible process sources. AQEG believes that modelling should be the cornerstone of the work programme, supported by appropriate analysis of monitoring data and a programme of additional monitoring to allow receptor modelling to be carried out.**
60. AQEG would also note that the construction of the Peripheral Distributor Road around Port Talbot, which will run along the eastern boundary of the industrial complex to the west of the railway line, may have some impact on PM<sub>10</sub>, especially during construction, although it will be some 150 m from the Prince Street monitoring site and 200 m from the AURN (fire station) site, and impacts at these distances should be minimal (with appropriate mitigation in place).

### Modelling

61. **AQEG recommends that a priority for further work should be to model the impact of all the sources within industrial complex on PM<sub>10</sub> concentrations observed in Port Talbot [1].** The modelling should have an hourly resolution covering the whole year, with the results verified by comparison with the monitoring data. There will need to be close linkage between the modelling and the emission inventory, with feedback from the modelling used to highlight areas for improvement within the inventory. The modelling should allow for terrain effects on wind flow and dispersion, which will require a model domain extending beyond the immediate vicinity of the site to include the hills to the east. The modelling should also consider buildings, in so far as they will affect initial dispersion (not wind flow); both these effects can be accounted for in readily available dispersion models.
62. **AQEG recommends that an initial dispersion modelling exercise should be carried out using readily available information on emissions from all sources, which can be supplemented over time with a more detailed time-resolved emission inventory [2].** It is recognised that some components of the inventory will be difficult to quantify with a high degree of accuracy, but this should not constrain the development of an initial best possible inventory using available information.



Once an inventory is established and modelling carried out the results will help identify those sources for which more accurate data are required, i.e. there should be a feedback loop between the emission inventory and the modelling. AQEG would expect to see an initial modelling study carried out within 6 months.

63. Meteorological data are a key element of the modelling; however, AQEG has been unable to form a clear view of the existing sources of meteorological data such as to recommend the most appropriate data set to use. Therefore, **AQEG recommends that an early review should be carried out of the available meteorological data to establish whether the meteorological monitoring sites are sufficient to characterise the air flows over the industrial complex and the surrounding area [3]**. The review should identify the most appropriate site(s) to use and whether new sites should to be established, or existing sites modified (such as installing a new mast to ensure the wind monitor is 10 m above the ground). This review should consider all existing monitoring data and recognise the potential for local factors to influence the wind data near to a monitoring site that might make the site unrepresentative of the general flow across the industrial complex. AQEG has given careful consideration to the potential benefits of CFD modelling of the wind field across the site and **recommends that CFD modelling at the building scale would be of limited benefit and should not be pursued [4]**.

## PM<sub>10</sub> monitoring

64. AQEG has evaluated the PM<sub>10</sub> monitoring in the Port Talbot area and while recognising that the number of sites has in the past been too limited to allow detailed analysis, it considers the current network of one AURN (fire station) site, six NPTCBC sites and one Environment Agency Wales site is sufficient to characterise PM<sub>10</sub> in the urban area. **AQEG recommends that all of the monitoring sites currently in operation should be retained for a minimum of a further two years [5]**. This will provide sufficient data to allow for robust data analysis. After this period it would be appropriate to evaluate the results with a view to reducing the number of sites. AQEG recognises that Environment Agency Wales has deployed one of its mobile monitors at the Prince Street site and as such its permanence is unknown. If the Prince Street site is to be decommissioned, then AQEG suggests that consideration be given to relocating one of the Council's FDMS monitors to the Prince Street location. The Theodore site may be suitable for this relocation. If it is required, this relocation should occur as soon as possible, to allow data from comparable instrumentation to be made available for analysis. AQEG is also aware that there was poor data capture from the FDMS instrument at the AURN site during 2010. Given the importance of the data from this site, AQEG would expect to see a high priority given to ensuring a high level of data capture in future.
65. AQEG has identified an important need for an up-wind monitor to allow the contribution of the industrial complex to be isolated from the background PM<sub>10</sub> being imported into the area. **AQEG recommends that an FDMS monitor should be located to the west of the industrial complex on the coast, co-located with a**



**wind monitor 10 m from the ground [6].** The use of an FDMS monitor is to ensure consistency with the monitors currently operational in Port Talbot (which would be appropriate for the purposes of hourly subtraction of up-wind data). It should be operated to AURN standards. The location of the TEOM monitor currently operated by Tata near the coast is considered suitable for this monitor and AQEG would encourage Tata to make this site available.

66. **AQEG recommends that a central repository, ideally web-based, should be established to hold all long-term monitoring data [7]** (for all sites with a minimum of 6-months data). This repository should hold data on the monitoring sites, including accurate 6 figure grid references, as well as a full set of 1-hour data, clearly marked as hour beginning (or hour ending), whether GMT or local time, whether provisional or ratified and with the method used. It is important that the repository includes wind data as well as PM<sub>10</sub> data. The wind data should be from as many sites as possible. The data on the repository should be freely available to any external party. The Welsh Air Quality website ([www.welshairquality.co.uk](http://www.welshairquality.co.uk)) is an example of a good model for the data repository.

## Chemically speciated measurements

67. AQEG has reservations about the source apportionment work that has been conducted to date, as there have been no sampling campaigns able to generate the comprehensive datasets needed. Receptor modelling based on multivariate statistical analysis does though offer the potential to be a useful tool for separating the principal sources on site. **AQEG recommends that a high time resolution monitoring programme in support of a multivariate receptor modelling study should be developed [8].** Such a programme would need to employ both comprehensive chemical speciation and a high time resolution (of one hour or better) in order to differentiate between sources of similar composition (see Appendix 7).
68. In addition, **AQEG recommends that an on-site measurement programme should be developed to quantify the emissions from fugitive sources [9].** This should include the temporal variation in emissions and the factors influencing this; and emissions arising from vehicle movements. The latter will require information on vehicle movements across the site.

## Organisation

69. **AQEG recommends that the actions set out in this advice note should be developed as a programme of work to be taken forward in a coherent and consistent manner [10].** The programme of work should be resourced as an overall package and not carried out in an ad-hoc manner. This should replace the rather *ad-hoc* approach to studies that appears to have been in place for the last decade and will build on the recent programme of work developed to implement the recommendations of the UWE report. It will require clear leadership from one organisation. **AQEG recommends that the working arrangements currently in**

place should be continued, with all parties contributing in an open and transparent manner [11]. In support of this work programme, AQEG recommends that there would be merit in the involvement of external peer reviewers to help ensure that the future programme remains focussed and is making best use of the scientific data and analysis resources [12].

### Programme of work

70. The recommendations set out above form a programme of work that AQEG would envision taking place over the next two to three years as illustrated in Figure 6. The linkage of the different strands of work to the AQEG recommendations is set out in Figure 7. A number of the recommendations also link to the recommendations of the UWE review, as illustrated in Figure 8.

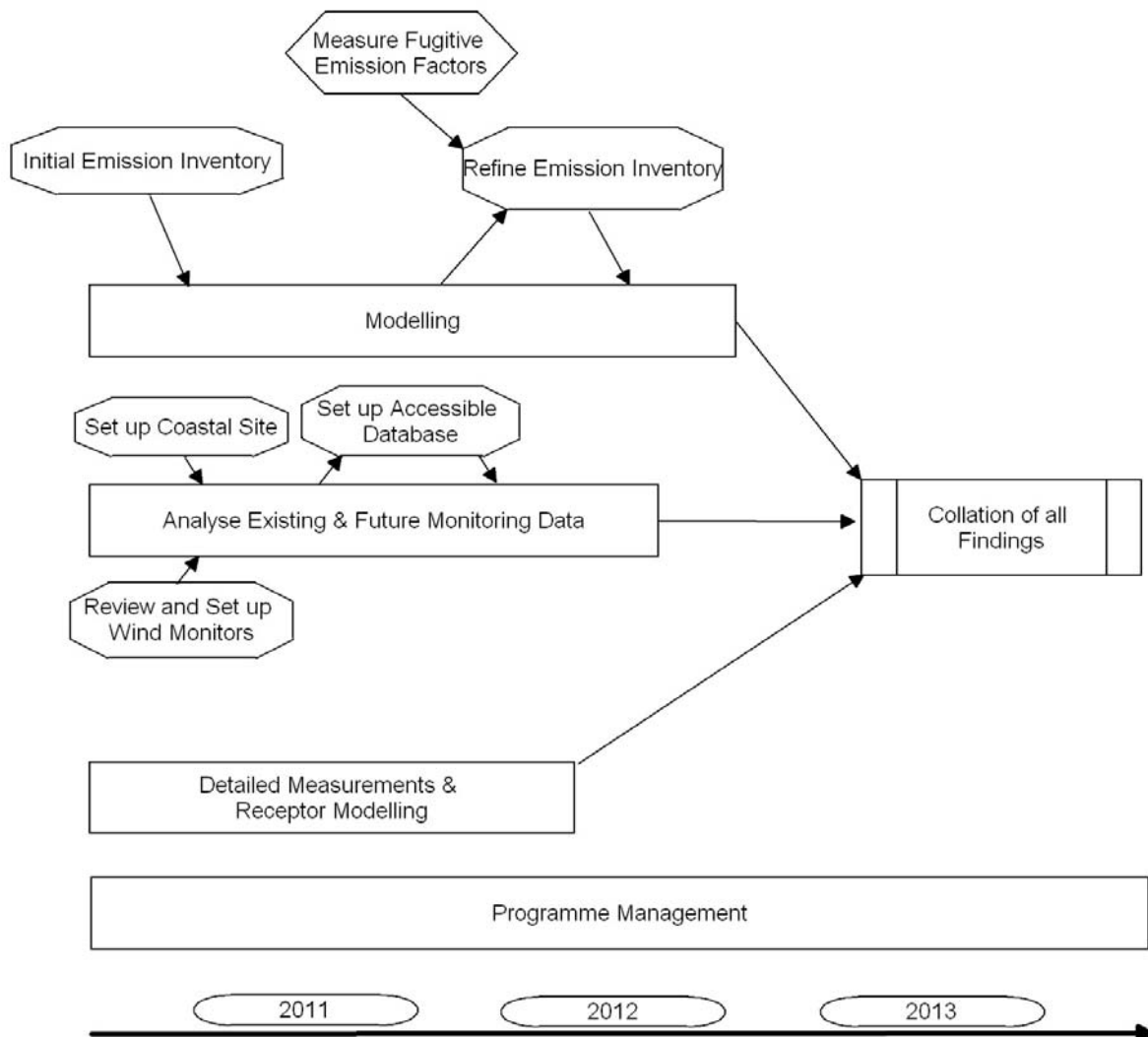
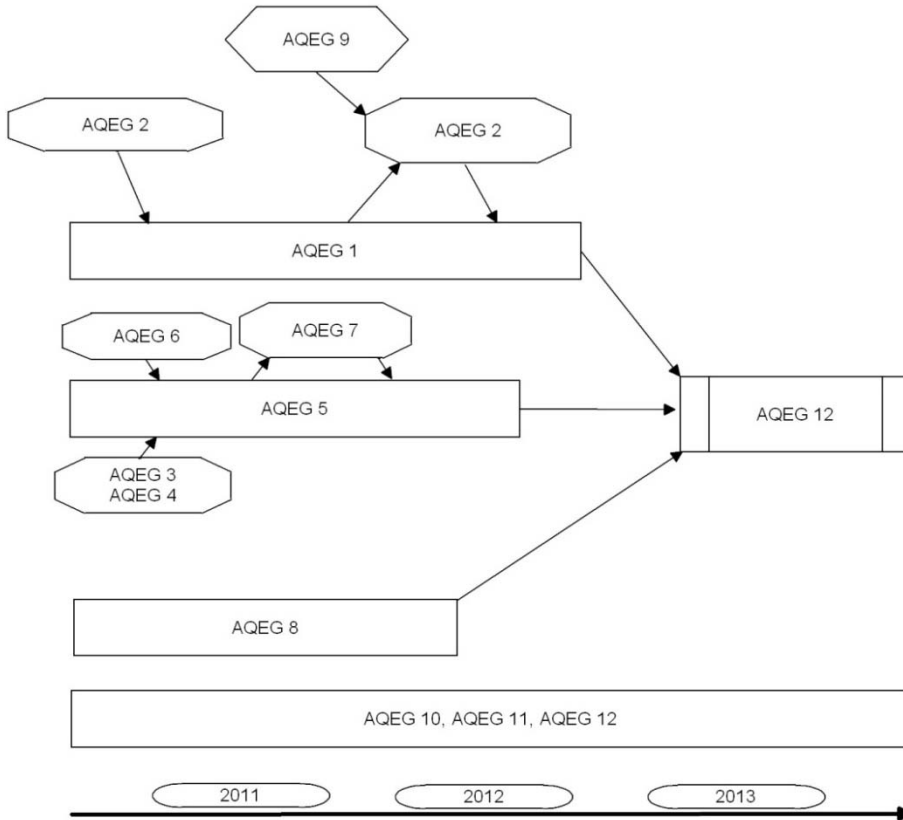
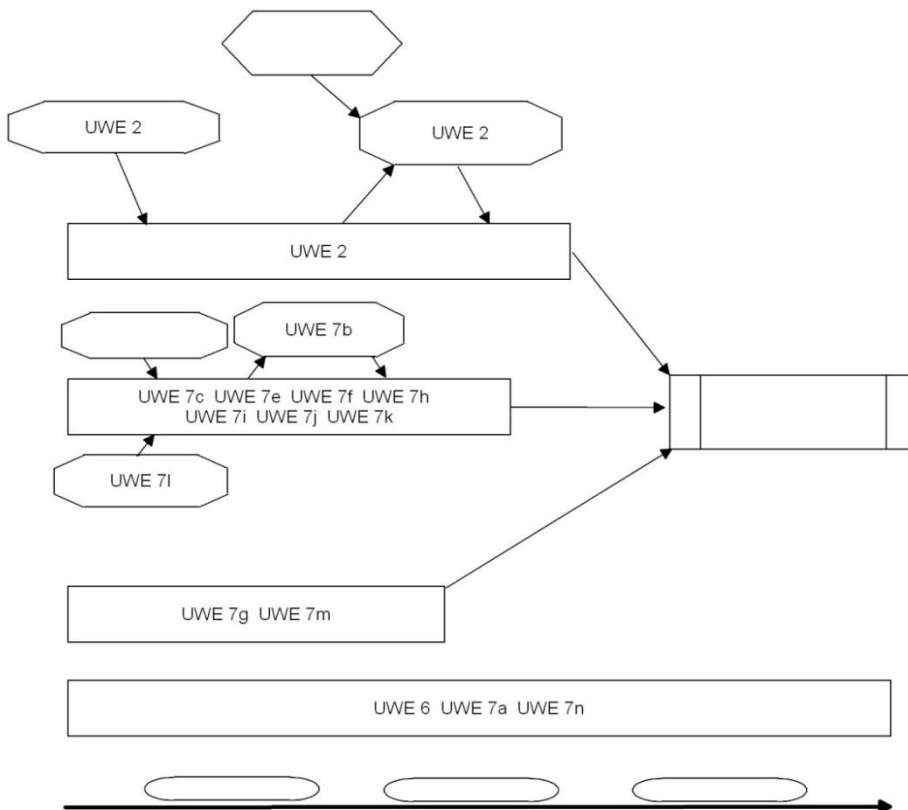


Figure 6: AQEG proposed work programme



**Figure 7:** Linkage of AQEG proposed work programme to AQEG recommendations



**Figure 8:** Linkage of AQEG proposed work programme to UWE recommendations

## **References**

Air Quality Expert Group (2005) Particulate Matter in the United Kingdom, available at <http://www.defra.gov.uk/environment/quality/air/airquality/publications/particulate-matter>

Environment Agency Wales (2009) Port Talbot Steelworks PM<sub>10</sub> permit review, January 2009

Hayes, E. and Chatterton, T. (2009) An independent review of monitoring measures undertaken in Neath Port Talbot in respect of particulate matter (PM<sub>10</sub>), Report prepared for the Welsh Assembly Government by the University of the West of England, Bristol, October 2009.

Landeg, G. (2010) Summary of investigative work undertaken to identify the source or sources of PM<sub>10</sub> from within the steelworks site, Version 1, November 2009, Tata Steel Strip Products UK, Port Talbot.

## Appendix 1: Call for evidence

The Air Quality Expert Group (AQEG) is an independent advisory group providing scientific advice on air quality to Ministers in Defra and the Devolved Administrations in Scotland, Wales and Northern Ireland. This advice focuses on the air pollutants contained in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland and those covered by the EU Directive on ambient air quality assessment and management. Specifically AQEG gives advice on levels, sources and characteristics of air pollutants in the UK. It does not advise on health impacts or air quality standards.

AQEG has been asked by Defra/WAG to provide an independent expert opinion on:

*“What methodologies or approaches are required to advance the evidence base in order to assess the impact of the different current particle sources within the Port Talbot area on the resultant particulate matter (PM) levels in the local area?”*

AQEG will thus seek to provide advice on how current evidence can be utilised better to apportion particulate matter to the different sources in the area (for example further analysis of local ambient air monitoring data) or whether additional evidence is required (such as more or different types of monitoring). AQEG will not be considering health impacts of air quality at Port Talbot, nor recommending specific measures to reduce emissions. It will not be considering the potential impact of possible future developments in the Port Talbot area.

To this end AQEG will be holding a session to hear scientific evidence from a range of stakeholders that can provide insight into the central question. The evidence session will be held on the 15<sup>th</sup> November 2010 in Port Talbot between 10.00 am and 4.00 pm.

If you are interested in providing evidence or would like further information, please contact Dr Clare Bayley from the AQEG secretariat at [Clare.Bayley@defra.gsi.gov.uk](mailto:Clare.Bayley@defra.gsi.gov.uk) by midday on Tuesday 12<sup>th</sup> October 2010.

In providing us with evidence you may wish to address some or all of the following questions:

- What is the problem that needs addressing as you see it?
- What data or other evidence do you hold and are able to provide which will help in considering this question?
- Have you analysed this data and evidence – and if so what does this show/ conclude?
- Have existing studies provided any clear answers?
- What further analyses of existing data and other evidence would be helpful?
- What, if any, new measurements are required?

- How would new modelling studies help provide the required understanding?

AQEG will be seeking brief written evidence on these questions in advance of the evidence session in order to inform its discussions with stakeholders at the session. There will be an opportunity for stakeholders to ask AQEG questions at the end of the session. Because of the size of the venue organisations may be asked to limit the number of representatives that they send to the evidence session. Details of the venue and arrangements for the evidence session will be forwarded separately.

AQEG will publish its advice following the evidence session.

## Appendix 2: Documents received

### Submissions

The submissions provided aimed to address the questions posed by AQEG in the call for evidence. Submissions were received from:

Tata Steel Products UK

Environment Agency (includes other relevant reference material)

Environment Agency Wales (includes other relevant reference material)

Neath Port Talbot County Borough Council

Peter Wilson

Mr JB Hughes

David Muir

Max Wallis

### Other documentation

- An independent review of monitoring measures undertaken in Neath Port Talbot in respect of particulate matter (PM<sub>10</sub>), University of West England, October 2009.
- Summary of investigative work at Port Talbot Oct 2009 to Oct 2010, Tata Steel
- Review and Assessment of Air Quality 2000, NPTCBC
- Corus permit reviews 2009, NPTCBC
- Local Air Quality Review and Assessment: Air Quality Progress report 2010, NPTCBC
- Port Talbot Steelworks PM<sub>10</sub> permit review, Environment Agency Wales, January 2009
- Modelling of PM at Santon, AEA report to Defra, May 2010
- An assessment of heavy metals concentrations at Port Talbot 1988, DTI
- Moreno, T., Merolla, L., et al. (2004), Variations in the source, metal content and bioreactivity of technogenic aerosols: a case study from Port Talbot, Wales, UK, Science of the Total Environment, 333, 59-73.
- Moreno, T., Jones, T. P., et al. (2004), Characterisation of aerosol particulate matter from urban and industrial environments: examples from Cardiff and Port Talbot, South Wales, UK, Science of the Total Environment, 334-335, 337-346.

## **Appendix 3: Organisations and individuals in attendance at the evidence session**

### AQEG members

Professor Paul Monks (Chair of session)

Dr David Carslaw

Professor Dick Derwent

Professor Duncan Laxen.

### AQEG Secretariat

Clare Bayley

Tim Williamson

### Welsh Assembly Government (WAG)

Ross Hunter

Helena Bird

Simon Baldwin

### Environment Agency (EA) and Environment Agency Wales

Barbara Tate

Mark Broom

Jim Storey

Isobel Moore

Environment Agency Wales gave a presentation to the expert panel on their work on particulate matter in the Port Talbot region.

### Neath Port Talbot County Borough Council (NPTCBC)

Geoff Marquis

Martin Hooper

NPTCBC gave a presentation to the expert panel on their work on particulate matter in the Port Talbot region.

### Tata Steel

Neil Haines, Principal Scientist



Gavin Landeg, Environmental Improvement

Katherine Liddle, Environmental Services

Peter Quinn, Environmental Policy & Strategy

Richard Leonard, Environmental Compliance

Phil Conway, Energy and Environmental Optimisation

Tata gave a presentation to the expert panel including site operations and sources of particulate matter, on-site monitoring, and existing studies relating to PM.

#### AEA

John Stedman gave a presentation to the expert panel on the modelling of PM at the Santon Steelworks

#### UWE

Enda Hayes gave a presentation to the panel on UWE's independent review of monitoring measures undertaken in Neath Port Talbot in respect of PM<sub>10</sub>

#### University of Birmingham

Roy Harrison gave a presentation to the expert panel on his air quality research conducted in the Port Talbot area.

#### Other

Peter Wilson gave a presentation to the expert panel on his observations relating to PM in the Port Talbot area and raising public concerns.

David Muir

Eleanor Owen

Mr JB Hughes

Max Wallis

## Appendix 4: Measurement of PM<sub>10</sub>

### European Air Quality Directive Requirements for Monitoring Particulate Matter (PM<sub>10</sub> and PM<sub>2.5</sub>)

The European Ambient Air Quality Directive (2008/50/EC, referred hereafter as the Directive) set out very detailed requirements for air quality monitoring in Member States, including the pollutants to be monitored, the number and location of monitoring stations and the techniques which must be used in monitoring. These techniques are known as the “reference methods”, established by working groups of experts under the guidance of the European Commission.

The reference methods for monitoring particulate matter are based on “gravimetric” sampling: drawing air through a very fine filter at a set flow rate and for a set period of time. The monitor is fitted with a special inlet which only allows particulate matter up to a specific size, e.g. up to 10 or 2.5 micrometers (for PM<sub>10</sub> or PM<sub>2.5</sub>) to be drawn through, and trapped by, the filter. In order to obtain consecutive daily averages, the filters must be changed every 24 hours. The filters are carefully weighed and preconditioned before being installed in the samplers, then conditioned and weighed again (under laboratory conditions) once they have been exposed and collected. The concentration of PM<sub>10</sub> (or PM<sub>2.5</sub>) is calculated using the difference in weight of the filter before and after sampling and the volume of air sampled. Because of the need for manual filter collection, filter conditioning and very precise weighing, the monitoring results will not be known for some days or weeks after the sample has been taken.

The Directive also places a general requirement on Member States that “up to date information on concentrations of all regulated pollutants [which includes particulate matter] in ambient air shall ... be readily available to the public”. The UK, along with other Member States, has systems in place to provide “real time” information on pollution levels via the internet. Clearly, having a monitoring system which only provides information some days after the event is not sufficient for this approach. There is also a great deal to be learned from the variation in pollution levels on an hourly basis, which is not readily obtained from gravimetric sampling.

The Directive recognises this dilemma and allows Member States to use method which are shown to be equivalent to the reference methods, and has issued highly detailed guidance on how such “**equivalence**” should be demonstrated. There are several PM monitoring techniques which provide near real time measurement data and there is a great deal of benefit from using these where they can be shown to be equivalent. One of the most popular of these near real time methods, and the one used in the UK national monitoring network (the Automatic Urban and Rural Network or AURN), is the Tapered Element Oscillating Microbalance (TEOM)<sup>1</sup>. The TEOM provides a relatively continuous stream of results which can be collected remotely and made available to the public, in the same way

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<sup>1</sup> Note that TEOM is a proprietary name and that other near real time systems for monitoring particulate matter exist.

that monitoring results for other, gaseous pollutants are (the website UK-Air is updated with results on an hourly basis).

The TEOM uses an inlet heated to 50°C to drive off any water from the sample which would otherwise interfere with the results. Unfortunately, soon after the UK national network was first established, it became apparent that heating the inlet was also driving off part of the mass of particulate matter, the “volatile fraction”. Therefore, TEOM under-read PM<sub>10</sub> concentrations compared to the gravimetric method. While a solution was found and equivalence trials were undertaken, a correction factor of 1.3 was applied to all TEOM data, based on the relationship between gravimetric and TEOM results. This relationship changes on a daily basis and with location – 1.3 was known to be at the conservative (high) end of possible correction factors, i.e. TEOM data “corrected” by multiplying by 1.3 were probably higher than the gravimetric equivalent for most locations.

In the past few years, an additional piece of equipment has been developed – the Filter Dynamics Measurement System or FDMS – which corrects for the lost volatile fraction in real time. This has been tested and shown to be equivalent to the reference methods, i.e. it is “**reference equivalent**”. In addition, King’s College London developed a technique, the volatile correction model (VCM), for using one of the data outputs from TEOM units fitted with FDMS (TEOM-FDMS) to correct data from non-FDMS fitted TEOM units. TEOM-FDMS have now been installed in the AURN to monitor PM<sub>10</sub> and PM<sub>2.5</sub>, and a website has been developed ([www.volatile-correction-model.info](http://www.volatile-correction-model.info)) to allow local authorities and others to correct TEOM data using the AURN outputs.

## **Monitoring Particulate Matter PM<sub>10</sub> at Port Talbot**

The PM<sub>10</sub> monitor used initially at the Port Talbot AURN site was a TEOM, and as such the results were adjusted using the 1.3 factor. This was replaced with an FDMS analyser in February 2007. The AURN site was relocated to Margam (fire station) in July 2007. Care should be used in interpretation of any TEOM data, certainly where the concentrations have been adjusted by a factor of 1.3. As noted above, the VCM has recently been developed to allow TEOM data to be adjusted. This cannot provide adjustments to historic data, however it has been used to correct the TEOM data collected during 2010 by Environment Agency Wales.

## Appendix 5: PM<sub>10</sub> data from 2009/10

Data from the seven sites operational in Port Talbot over the period 2009-2010 have been collated – see Figure 1 for locations.

The sites are listed in Table A5.1, with the monitoring method used. They have not all been operational throughout the two years, thus only period mean results are presented. The periods with available data are illustrated in Figure A5.1, which shows daily average concentrations. The largest daily average concentrations are observed at the Prince Street site. Again, some caution should be exercised in interpreting the findings for this site, as the TEOM-VCM method only approximates the reference method.

**Table A5.1:** Summary of PM<sub>10</sub> measurements in Port Talbot in 2009-2010.

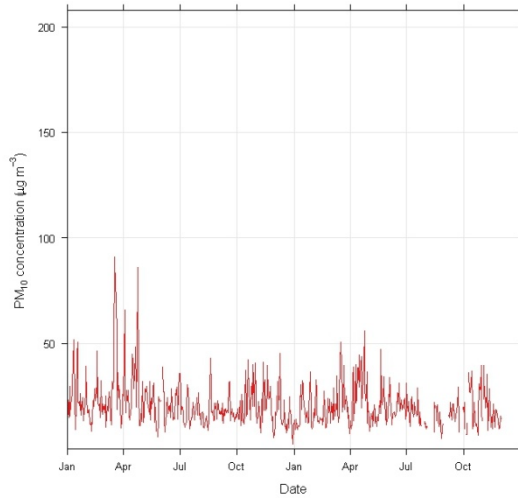
Site No.	Site	Operator	Method	Period Mean
1	Docks	NPTCBC	FDMS	20.4
2	Talbot Road	NPTCBC	FDMS	22.4
3	Theodore Road	NPTCBC	FDMS	18.8
4	Margam (fire station)	Defra - AURN	FDMS	23.2
5	Prince Street	EAW	TEOM-VCM	24.3
7	Twill-yn-y-Wal Park	NPTCBC	FDMS	24.4
8	Dyffryn School	NPTCBC	FDMS	19.4

Site numbers are as shown in Figure 1

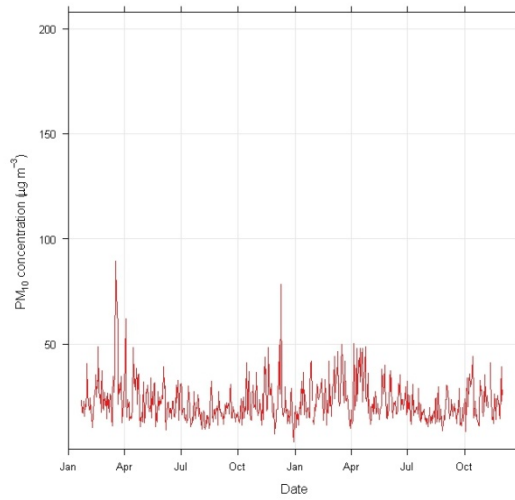
NPTCBC = Neath Port Talbot County Borough Council

EAW = Environment Agency Wales

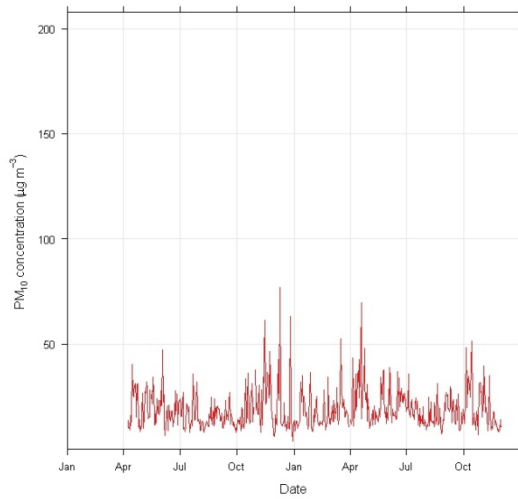
The data are also shown as polar plots of the hourly averages, prepared using the OpenAir software with wind data from the Margam (fire station) site (Figure A5.2). Again, some care should be exercised in interpreting the findings, as the data are not for matched periods, however, the analysis points to the main source area within the industrial complex, affecting concentrations in Port Talbot, as being that circled. This is consistent with the findings of the UWE analysis (Hayes & Chatterton, 2009).



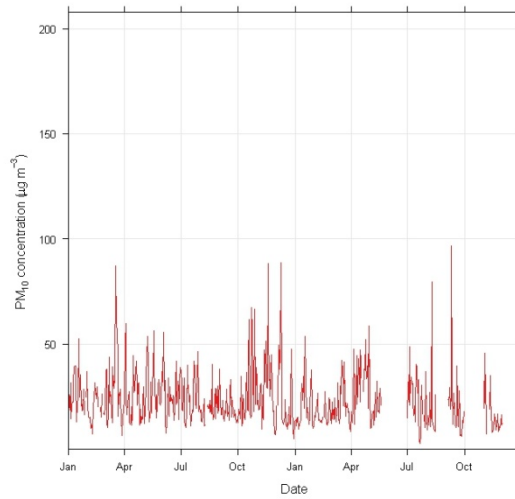
**Docks (Site 1)**



**Talbot Road (Site 2)**

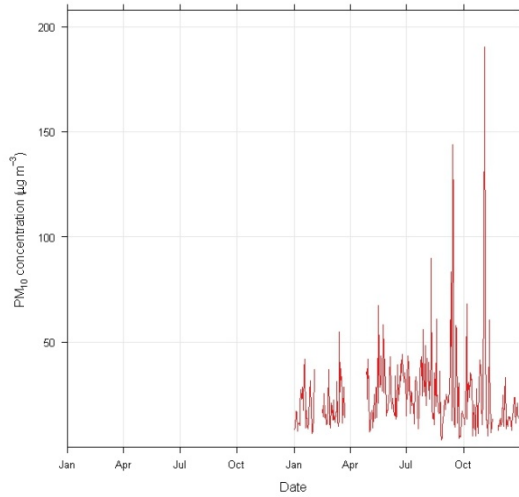


**Theodore Road (Site 3)**

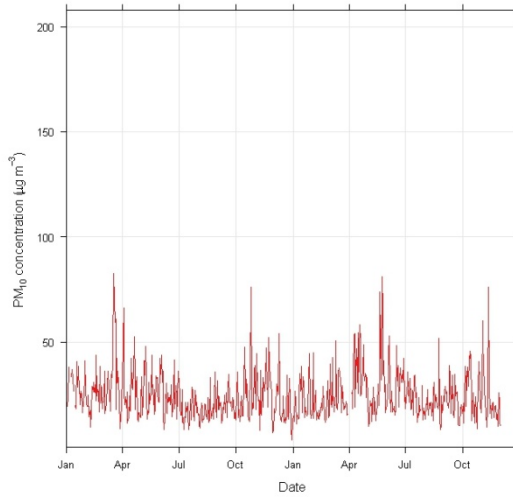


**Margam (fire station) (Site 4)**

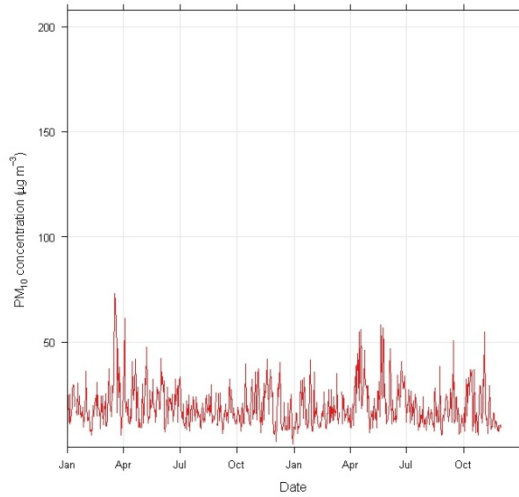
**Figure A5.1:** Summary of Daily Average PM<sub>10</sub> measurements in Port Talbot in 2009-2010. All the plots are to the same scale.



**Prince Street (Site 5)**

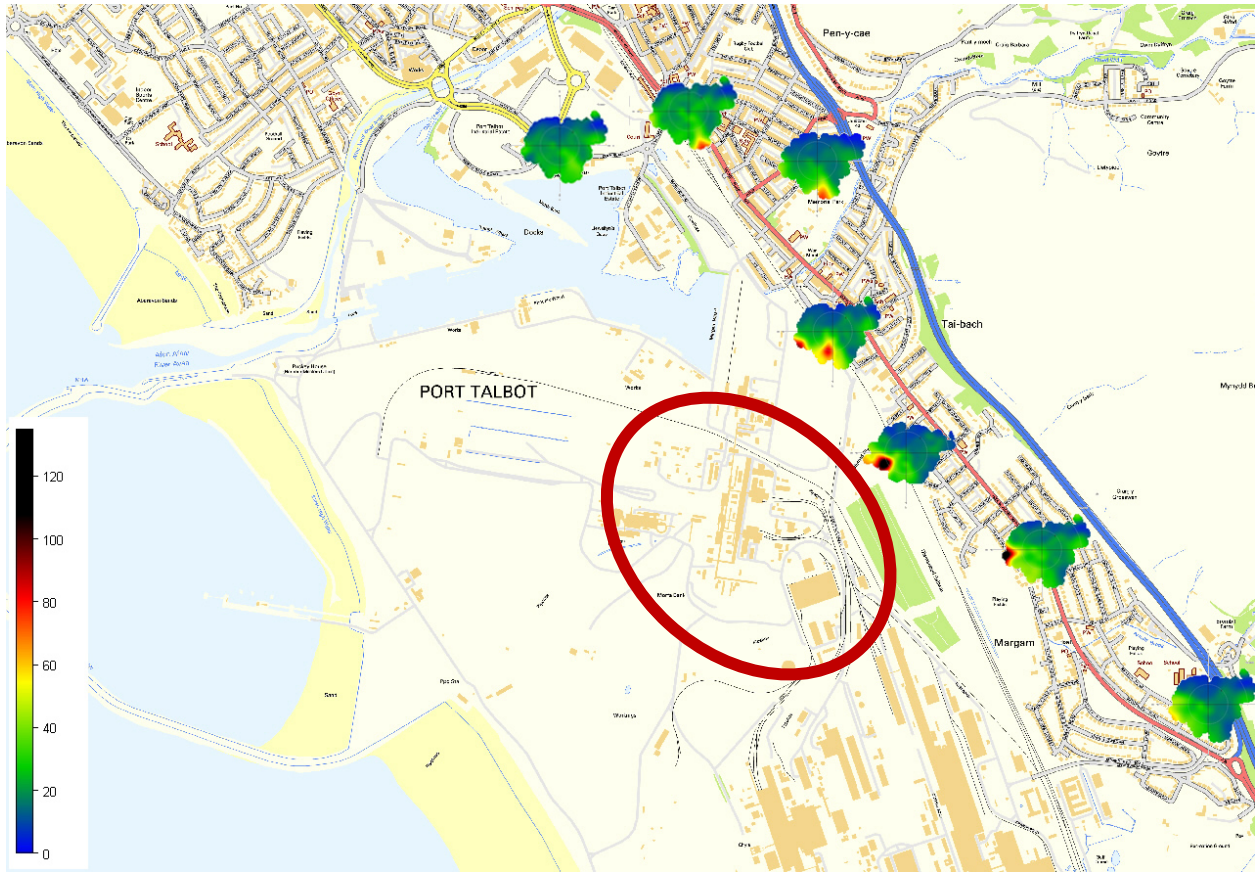


**Twll-yn-y-Wal Park (Site 7)**



**Dyffryn School (Site 8)**

**Figure A5.1 contd:** Summary of daily average PM<sub>10</sub> measurements in Port Talbot in 2009-2010. All the plots are to the same scale.



**Figure A5.2:** Polar plots of PM<sub>10</sub> measurements in Port Talbot in 2009-2010. The concentration scale is in  $\mu\text{g m}^{-3}$ , with values yellow and above being  $>50 \mu\text{g m}^{-3}$ . The plots show concentrations by wind direction and by wind speed, with the speed increasing from the centre outwards. The circle shows the general area from which the higher concentrations appear to emanate.

## Appendix 6: Sources of PM<sub>10</sub> identified by Tata

Tata has identified the following predominant sources impacting the on-site monitors (Landeg, 2010). The findings apply to predominant sources on days when the PM<sub>10</sub> objective was being breached and to the longer-term average concentrations. These findings do not necessarily relate to sources affecting off-site locations.

Predominant sources on breach days:

- The conveyors from the harbour unloaders to the ore stockyards;
- the primary ore stockyards;
- the rubble ore beds and stockyard haulage roads;
- slag handling;
- coke pushing;
- coke quenching; and
- coal and coke handling.

Predominant sources on all days:

- The Betsi stockpiles;
- primary ore beds and associated conveyors;
- the coast road;
- the slag stockpile;
- conveyor systems linking the harbour to the stockyards;
- the fines beds;
- conveyors to the highline;
- the slab yards;
- a slag stockpile; and
- unsurfaced roads.



## Appendix 7: Receptor modelling

There are two principal methods that can be applied to receptor modelling;

- (a) **Chemical mass balance.** This method requires *a priori* knowledge of the composition of all sources contributing to the airborne pollution, but not their emission rates. The measured air quality is assumed to be a linear sum of the contributions of the known sources, whose contributions are summed over each different sampling period to give the best match to the concentrations of the many chemical species measured in the atmosphere. In many studies, organic “molecular markers” which may be only minor constituents of emissions are measured, as these help to discriminate between similar sources (e.g. petrol and diesel engines). This method has been applied to airborne particles sampled in the UK West Midlands (Yin et al., 2010).
- (b) **Multivariate statistical methods.** There are a suite of methods based upon factor analysis, of which Positive Matrix Factorization has been developed specifically for the purpose of source apportionment of air quality data, and is the most commonly applied. The method requires no *a priori* knowledge of source composition, but such data are valuable in discriminating between similar sources. The method requires a substantial number (at least 50) of separate air samples which are analysed for a wide range of chemical constituents. Those constituents from the same source have the same temporal variation, and if unique to that source are perfectly correlated. Typically, however, a given chemical constituent will have multiple sources and the programme is able to view correlations in a multidimensional space and can generate chemical profiles of “factors” with a unique temporal profile characteristic of a source. Past knowledge of source chemical profiles is used to assign factors to sources, and typically up to 10 different sources can be assigned. The method works best with a large dataset in which the number of samples far exceeds the number of analytical variables, and gives a clearer distinction of sources if sampling times are short, so that overlap of multiple point source contributions to a given sample is minimised.

Both receptor modelling methods are potentially applicable to atmospheric composition at Port Talbot, but in the absence of quantitative source profiles, the multivariate statistical method is more likely to succeed. This would best be applied to size-resolved data (as different sources have different size distributions), and used with short sample averaging periods in order to distinguish emissions from different parts of the site. There is substantial qualitative information available upon the composition of on-site materials subject to wind-blown dispersal, and of the composition of particles from specific process emissions (e.g. Dall’Osto et al., 2008) which will assist in source identification. Inclusion of meteorological measurements and gas phase pollutant data in the model will also assist in identifying the location of sources. The combined dataset of size resolved and chemically speciated particle concentrations together with meteorological and gaseous pollutant concentrations will be a very powerful probe into the sources. While it is anticipated that some sources may have a similar chemical composition, there are likely to be differences in trace element abundances, and in dependences on wind speed and direction which will allow them to be distinguished. Inclusion of additional real-time instruments, such as a single particle mass

spectrometer (previously deployed successfully at Port Talbot; Dall'Osto et al., 2008) and a particle shape analyser will considerably enhance the capability to distinguish particles from different sources. The highly time resolved measurements are resource intensive and therefore best conducted in campaigns of about one month's duration and would need to be supplemented by longer time-average measurements in order to allow extrapolation of the results to a longer time period.

## **Appendix 7 References**

Dall'Osto, M., Booth, M.J., Smith, W., Fisher, R. and Harrison, R.M., 2008. A study of the size distributions and the chemical characterisation of airborne particles in the vicinity of a large integrated steelworks, *Aerosol Sci. Technol.*, 42, 981-991.

Yin, J., Harrison, R.M., Chen, Q., Rutter, A. and Schauer, J.J., 2010. Source apportionment of fine particles at urban background and rural sites in the UK atmosphere, *Atmos. Environ.*, 44, 841-851.