BMT Cordah

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Local Air Quality Management Detailed Assessment 2007

Client: Angus Council
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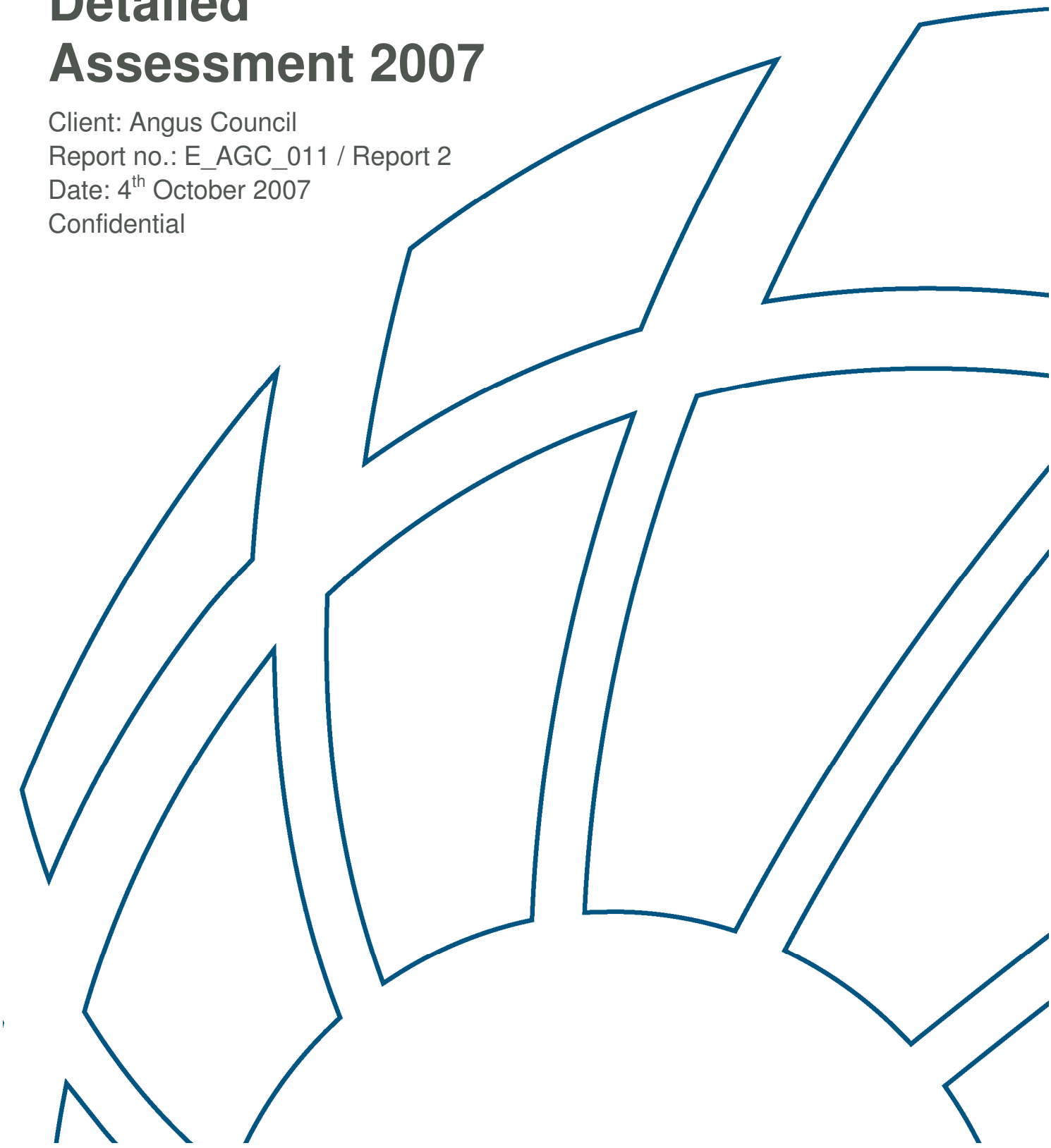

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1 INTRODUCTION

BMT Cordah Ltd has been commissioned by Angus Council to undertake a Detailed Assessment of fine particulate material (PM_{10}) in Forfar. The report has been completed in collaboration with personnel from Angus Council.

1.1 Purpose

The aim of the report is to assess in detail the emission sources and atmospheric concentrations of PM_{10} in the Forfar area.

The assessment uses up to date information on industrial, transport, commercial and domestic atmospheric emissions combined with current monitoring data to identify if there is potential for PM_{10} concentrations to exceed the air quality objectives for PM_{10} contained within the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2000 (NAQS)[1].

The report follows guidance set out in LAQM.TG(03) technical guidance[2], LAQM.PG(04) policy guidance[3] and subsequent guidance amendments[4].

1.2 Review and Assessment process

The Environment Act 1995 and subsequent regulations require local authorities to assess compliance of air quality in their area with the standards and objectives set out in the NAQS. For local authorities within Scotland further regulations are set out in the Air Quality (Scotland) Regulations 2000 and Air Quality (Scotland) Amendment Regulations 2002.

The LAQM framework requires that local authorities carry out regular reviews of air quality. The Review and Assessment process comprises two phases. The first phase of the Review and Assessment is an Update and Screening Assessment (U&SA). The U&SA considers any changes that have occurred in pollutant emissions and sources since the last round of Review and Assessment that may affect air quality. The second phase is either a Detailed Assessment or a Progress Report depending upon the outcome of the U&SA.

The Review and Assessment process requires that where a risk of exceedence of an air quality objective at a location with relevant public exposure is identified then a Detailed Assessment is undertaken. A Detailed Assessment considers any risk of exceedence of an objective to greater

[1] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Working together for clean air, Defra, January 2000.
[2] Part IV of the Environment Act 1995, Local air quality management technical guidance, LAQM.TG(03), Defra et al, January 2003.
[3] Part IV of the Environment Act 1995, Local air quality management policy guidance, LAQM.PG(03), Defra et al, January 2003.
[4] Part IV of the Environment Act 1995, Local air quality management technical guidance update, LAQM.TG(03) – update: January 2006, Defra et al, January 2006.

depth in order to determine whether it is necessary to declare an Air Quality Management Area (AQMA).

Where it is shown that an air quality objective has been or is predicted to be exceeded by the objective deadline an AQMA is should be declared.

1.3 Assessment criteria

The NAQS details assessment criteria for eight pollutants in the form of atmospheric concentration levels for which an objective deadline is set. The NAQS objectives for PM_{10} applicable in this assessment are presented in Table 1.

Table 1: Particulate objectives outlined in the NAQS and Air Quality Regulations

Concentration	Measured as	Equivalent percentile	Date to be achieved by
50 $\mu g/m^3$ not to be exceeded more than 35 times a year	24-hour mean	90.4th percentile of 24-hour-means	31 / 12 / 2004
40 $\mu g/m^3$	annual mean	-	31 / 12 / 2004
50 $\mu g/m^3$ not to be exceeded more than 7 times a year	24-hour mean	98th percentile of 24-hour-means	31 / 12 / 2010
18 $\mu g/m^3$	annual mean	-	31 / 12 / 2010

1.4 Human health effects of atmospheric particulates

There is widespread evidence that adverse human health effects can be caused by both long-term (years) and short-term (days) exposure to elevated concentrations of PM_{10}. Adverse human health effects of exposure to PM_{10} include respiratory and cardiovascular morbidity and mortality and cancer[5].

It is recognised that a reduction in both short-term peak PM_{10} concentrations and long-term ambient background PM_{10} concentrations will be beneficial to the local population.

1.5 Forfar and the surrounding area

Forfar is located in the Angus Council area, which is located on the East Coast of Scotland between Dundee and Aberdeen. A map locating Forfar and the Angus Council area is presented in Figure 1.

The area surrounding Forfar is primarily used for agricultural purposes. There is a significant amount of light industry and commercial operations located in Forfar much of which is associated with the processing of natural resources such as ancillary suppliers to the surrounding agricultural businesses, mineral extraction, and timber processes and seed wholesalers. There is also a large landfill site to the north-east of the town.

[5] Particulate matter in the UK, Air Quality Expert Group, DEFRA et al. 2004

The population of Forfar is approximately 13,200. The town has approximately 5,950 residential properties the majority of which are semi–detached, detached or terraced housing; there are a few low-rise flats but no high-rise housing. There are over 300 businesses and organisations operating in Forfar which are distributed predominantly along the High Street and in the industrial estates on the south and west sides of the town.

1.6 Climatic and terrain conditions in the Forfar area

In general, complex terrain acts to increase the atmospheric turbulence and thus increase dispersion. A complex terrain mix generally results in a greater surface friction and thus a greater influence of mechanical turbulence in the area than flatter landscapes.

Forfar is situated in the Strathmore valley which runs north-east from Perth to Stonehaven and represents a swath of lowland bordered to the south by the Sidlaw Hills. The relatively flat valley location of Forfar is likely to result in less turbulent conditions and the creation of inversion layers during cool calm conditions, which act to stabilise the atmosphere and reduce atmospheric dispersion.

The meteorological parameters having the greatest impact upon atmospheric pollutant dispersion and transportation are wind speed and wind direction. Temperature, solar radiation and rainfall also impact upon pollutant concentrations by acting as a catalyst to chemical reactions, creating convective currents or washing pollution out of the atmosphere.

As is the case for the majority of the UK, there is a dominance of south-westerly winds across the area. Wind roses for measured data at RAF Leuchars to the south representing typical wind conditions in the Forfar area are shown in the Figure 2. The wind roses indicate the dominance of westerly winds, which flow along the Strathmore and Tay valleys. There are also a significant proportion of south-easterly winds recorded in the region indicating the influence of weather systems in the North Sea. Calm days are shown to occur predominantly during westerly or north-westerly winds. Wind speeds recorded across the region are generally above the UK average.

The mean temperature in the Forfar area is approximately 8°C, which is below the mean temperature for the UK as a whole. The area has low to medium rainfall compared to the rest of the UK, however, the number hours of sunshine in the area is typical of the UK average.

The low levels of rainfall in the area are likely to result in a low pollutant wash out rate and the cool temperatures are likely to lead to a low level of atmospheric turbulence from convection. The typical atmospheric dispersion conditions in the Forfar area are likely to be lower than the average for the UK.

1.7 Previous air quality assessments

Angus Council undertake regular reviews of air quality throughout the Angus Council area. Historic monitoring data of particulate concentrations have indicated that there is a possibility of the 2010 annual mean air quality objective for PM_{10} being exceeded in Forfar.

In 2006 an Updating and Screening Assessment (U&SA) was undertaken to provide a full update of air quality across the Angus Council area. The U&SA considered monitoring data for Forfar obtained from both gravimetric means (using a Partisol analyser) and an automatic Tapered Element Oscillating Microbalance (TEOM) analyser. Typically, TEOM analysers under-read PM_{10} concentrations by up to 30% in relation to the reference gravimetric method of monitoring. A correction factor (1.14 or 1.3) is therefore applied to TEOM monitoring results to evaluate PM_{10} concentrations against the air quality standard. LAQM Technical Guidance recommends the use of a 1.3 adjustment factor, however correspondence from the Scottish Executive states that it is permissible to use a locally derived factor in preference to the 1.3 factor. Where a local adjustment factor is unavailable the Scottish Executive state that the results should be adjusted using both the 1.3 factor and a 1.14 factor (identified by Edinburgh City Council).

Analysis of PM_{10} concentrations recorded by two types of analyser has indicated that the PM_{10} concentrations measured by the Partisol analyser were significantly lower than the concentrations recorded by the TEOM analyser. This indicates that applying a correction factor to the TEOM-measured results may not be appropriate.

Assessment of various emissions sources including road traffic, domestic and industrial emissions in the U&SA did not indicate any potential for exceedence of PM_{10} objectives. The U&SA, therefore, concluded from the assessment of local emission sources and air quality monitoring data that there was no potential for exceedence of the NAQS objectives for PM_{10} within the Angus Council area.

As previous screening assessments of particulate emissions throughout the Angus Council area have indicated that road traffic, industrial, and domestic emissions are all below thresholds that require a Detailed Assessment to be carried out, the reason for historical high measured concentrations is unknown. Therefore due to the historic predictions of an exceedence of the 2010 annual mean PM_{10} objective it was recommended by SPEA that a detailed assessment of PM_{10} emissions in Forfar be carried out.

2 MONITORING

Since April 2000, Angus Council has undertaken monitoring of particulates at four locations within the Council area. Monitoring of PM_{10} was carried out at Forfar, Carnoustie and Ferryden near Montrose, which are three towns with high levels of industrial and commercial activity and significant levels of road traffic. In 2006, monitoring was also undertaken at Glen Isla to determine the rural background particulate concentrations for the area. The monitoring locations are presented in Figure 3.

2.1 Historic TEOM monitoring

Prior to 2004 monitoring was undertaken using a TEOM analyser which was shared with Perth and Kinross Council, Dundee City Council and Fife Council and rotated on a 3-monthly basis. Between 2004 and 2007 the TEOM analyser was rotated on a 6-monthlty basis in order to reduce the down time and better account for seasonal various in pollutant concentrations.

The annual mean concentrations for each period of monitoring have been estimated using the technique provided in the LAQM.TG(03) technical guidance and data from the Aberdeen and Falkirk automatic network sites, which were the nearest automatic monitor sites operating continuously since 2000. The results from the TEOM measurements have been analysed and corrected for bias by Dundee City Council Scientific Services using the 1.3 factor provided in the LAQM.TG(03) technical guidance. Using the factors provided in the LAQM.TG(03) for projecting pollutant concentrations for future years, the PM_{10} concentration for 2010 for each monitoring period has been calculated and is also reported in Table 2.

Table 2: PM_{10} concentrations recorded in Forfar using the TEOM analyser

Monitoring Period	Period mean ($\mu g/m^3$)	Estimated annual mean ($\mu g/m^3$)	No. of 24-hour means > 50$\mu g/m^3$	Estimated 2010 annual mean ($\mu g/m^3$)	Estimated 2010 No. of 24-hour means > 50$\mu g/m^3$
Apr – May 2000	13	14	0	13	< 1
Jan – Feb 2002	24	28	0	26	14
Jul – Aug 2003	20	24	0	22	6
Nov 2003 – May 2004	29	27	3	25	13
Oct 2005 – Mar 2006	18	15	0	14	< 1

The TEOM was moved back to Forfar in May 2007 and an (FDMS) installed on the 11th July 2007. The monitor will remain in place until November 2007. Concentrations recorded during the 6-month monitoring period will be compared to those recorded by the Partisol in Forfar and reported at the beginning of 2008.

2.2 Partisol monitoring

In 2005 two gravimetric analysers were operational within Angus Council are: one in Ferryden and one in Carnoustie. The partisol located at Ferryden was moved to Forfar at the end of October and commenced monitoring in November 2005. In order to monitor rural background PM_{10} concentrations an additional gravimetric analyser was installed at Glen Isla in January 2006. In line with national monitoring techniques the partisol analyser at Carnoustie was replaced allowing the sampling method of PM_{10} concentrations to change from weekly mean sample filters to 24 hour mean sample filters in November 2006. The available PM_{10} data for the gravimetric analysers recorded during 2006 using 24-hour mean sample filters are presented in Table 3.

The annual data capture rates for Forfar and Caroustie in 2006 are below 90%, the data capture rate recommended as suitable for a Detailed Assessment. The LAQM.TG(03) guidance provides a method for approximating annual mean concentrations using data from nearby automatic monitoring stations. The three nearest automatic monitoring stations are in Inverness, Aberdeen and Edinburgh. Measured concentrations from these sites for 2006 have been used to approximate the annual mean at Forfar and Carnoustie. Using the factors provided in the LAQM.TG(03) for projecting pollutant concentrations for future years the PM_{10} concentration for 2010 at each site has been calculated.

Table 3: 2006 PM_{10} concentrations – Gravimetric analysers

Site	Forfar	Glen Isla	Carnoustie
Monitoring period	02/05/06 – 31/12/06	11/01/06 – 31/12/06	07/11/06 - 31/12/06
Period mean	16.5	-	14.7
Annual mean concentration (µg/m^3)	16.9	6.8	17.5
98th percentile of 24-hour mean concentrations (µg/m^3)	36.4	22.6	30.0
90.4th percentile of 24-hour mean concentrations (µg/m^3)	27.7	13.1	21.5
Maximum 24-hour mean concentration (µg/m^3)	68.3	47.1	38.5
No. of exceedences of the 24-hour mean objective concentration of 50µg/m^3	3	0	0
Annual data capture rate (%)	63.0%	92.9%	11.5%
No. of days of monitoring	244	355	55
Projected annual mean concentration in 2010 (µg/m^3)	16.2	7.1	16.8
Projected No. of exceedences of the 24-hour mean objective concentration of 50µg/m^3 in 2010	< 1	0	< 1

The estimated annual mean concentrations at each of the three monitoring sites were below the 2010 annual mean objective concentration of 18µg/m^3 in 2006 with concentrations predicted to further decrease by 2010.

PM_{10} concentrations in Forfar have been measured for a full year from June 2006 to May 2007. The measured concentrations and projected concentrations for 2010are presented in Table 4.

Table 4: PM_{10} concentrations – Forfar

Measured statistics	Forfar
Monitoring period	01/06/06 – 31/05/07
Annual mean concentration (µg/m^3)	18.5
98th percentile of 24-hour mean concentrations (µg/m^3)	64.0
90.4th percentile of 24-hour mean concentrations (µg/m^3)	30.4
Maximum 24-hour mean concentration (µg/m^3)	133.0
No. of exceedences of the 24-hour mean objective concentration of 50µg/m^3	18
Annual data capture rate (%)	92.3%
No. of days of monitoring	337
Projected annual mean concentration in 2010 (µg/m^3)	17.7
Projected No. of exceedences of the 24-hour mean objective concentration of 50µg/m^3 in 2010	< 2

The measured annual mean PM_{10} concentration from June 2006 to June 2007 is below the 2004 annual mean objective but above the 2010 annual mean objective. The number of 24-hour mean exceedences of 50µg/m^3 is below the 2004 objective of 35 permitted exceedences but greater than the 2010 objective of 7 permitted exceedences.

The projected 2010 concentrations, however, comply with both the annual mean and 24-hour mean objectives. The predicted 2010 annual mean concentration in Forfar is close to the objective and therefore it is recommended that the monitoring in Forfar is continued.

2.3 Particulate sample analysis

Angus Council carried out additional analysis of the Partisol filters at Forfar, GlenIsla and Carnoustie to determine the components of the PM_{10} samples. The samples were taken between June and October of 2006 and the filters were analysed by Dundee City Council Scientific Services. The results of the PM_{10} content analysis are presented in Table 5 and Chart 1.

The components analysed are indicative of different emission activities as described in Particulate Matter in the United Kingdom[6]. The report sets out the following sources for different components of particulate matter:

- Iron representative of suspended soil and road dust (particle re-suspension & break wear);
- Lead representative of vehicle and industrial emissions;
- Other metals representative of metal processing industries;
- Calcium representative of construction dust;
- Sulphate representative of a secondary component of airborne particulate;
- Nitrate representative of secondary component of airborne particulate;
- Chloride representative of marine aerosol;
- Elemental carbon resulting from combustion processes; and
- Organic carbon representing natural organic material and combustion products.

The results indicate that approximately 60% of the particulate samples comprised elements other than those investigated e.g organic carbon. This would indicate that approximately 60% of the particulate concentrations are due to natural sources or combustion.

Significant proportions of the samples comprised sulphate and nitrate, which are representative of secondary particulate formation through chemical reactions from sulphates and nitrates; these are likely to arise from agricultural or natural sources and some industrial processes.

Approximately 4% of the particulate matter samples were shown to be chloride, which is indicative of marine influences. The samples indicated that approximately 1.5% of the particulate matter sampled came from construction sources and 0.3% contained metallic components indicative of road dust or industrial processes.

2.4 Correlation of PM_{10} and NO_2 concentrations

Dundee City Council Scientific Services (DCCSS) have carried out analysis of the correlation between PM_{10} and NO_2 concentrations recorded at Chapel Park Primary School in Forfar between October 2005 and March 2006. A similar analysis was undertaken for the periods of available monitoring between 2000 and 2004. The correlation between 2000 and 2004 was 0.493 and the correlation between PM_{10} and NO_2 concentrations during the monitoring period 07/10/05 – 14/03/06 was 0.502. The correlation reports are provided in Appendix 1. A significant positive correlation is

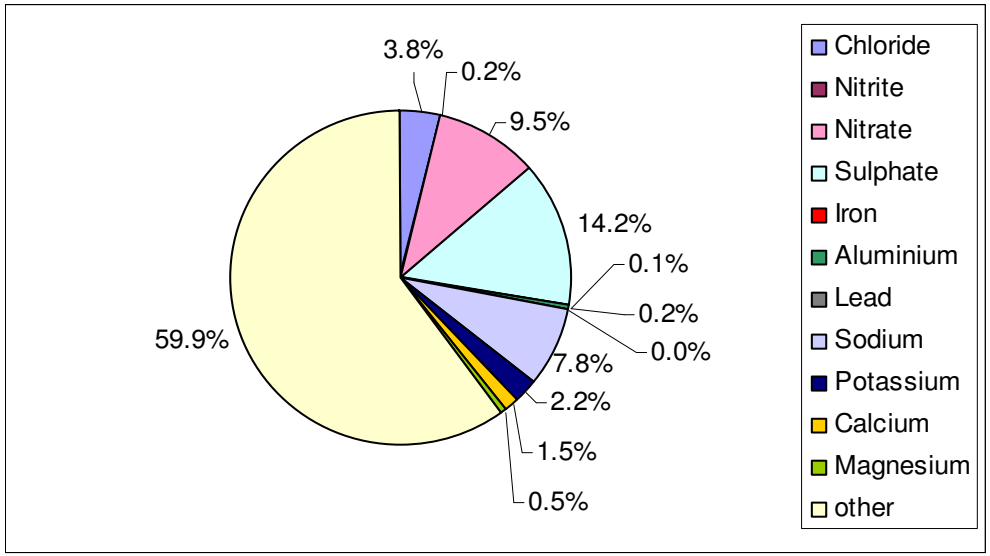
[6] Particulate Matter in the United Kingdom, Air Quality Expert Group, DEFRA, 2004

represented by a correlation coefficient between 0.7 and 1. It is therefore concluded that there is not a significant correlation between NO_2 and PM_{10} concentrations in Forfar. It would therefore suggest that the contributing sources to NO_2 and PM_{10} concentrations within the Forfar area are different and that road traffic and combustion emissions are not the largest contributing source to PM_{10} concentrations.

Table 5: PM_{10} mass composition analysis (µg)

Sample date	Total PM_{10}	Chloride	Nitrite	Nitrate	Sulphate	Iron	Aluminium	Lead	Sodium	Potassium	Calcium	Magnesium
27/06/06 - 10/07/06	4535	104	9.9	264	850	4.9	6.25	0.13	372	124	72	18
11/07/06 - 24/07/06	5920	234	15.6	423	1111	5.1	9.03	0.11	499	136	109	35
25/07/06 - 07/08/06	4781	138	8.3	281	783	4.2	6.47	0.11	386	112	83	24
08/08/06 - 21/08/06	3610	131	5.8	448	436	3.6	1	0.08	273	87	54	14
22/08/06 - 05/09/06	5035	199	18.6	206	237	3.3	16.94	0.05	309	60	69	20
06/09/06 - 18/09/06	6345	146	4.2	934	1058	5.2	7.84	0.1	490	161	88	27
19/09/60 - 02/10/06	5925	326	6.5	792	737	4.8	4.11	0.1	531	121	87	37
03/10/06 - 16/10/06	7420	397	11.0	792	975	5.7	27.4	0.1	559	150	109	43
Mean	5446	209	10.0	518	773	4.6	10	0.1	427	119	84	27

Chart 1: Mean composition of PM_{10} samples from Forfar



3 INVENTORY OF EMISSIONS SOURCES IN FORFAR

As discussed in Section 1.7, previous screening assessments of particulate emissions throughout the Angus Council area have indicated that road traffic, industrial, and domestic emissions are all below thresholds that require a Detailed Assessment to be carried out. However, to fully understand historical monitoring data it is necessary to identify and quantify the emission sources within the Forfar area. The various emission sources are discussed in Sections 3.1 to 3.8

3.1 Industrial and quarry emissions

The public register, maintained by SEPA, was consulted to obtain details of all regulated industrial sites which emit PM_{10} either as fugitive or point emissions. The details of all SEPA regulated sites operated in Forfar are presented in Table 6. The locations of the SEPA regulated processes are presented in Figure 4.

There are currently seven regulated processes operating in the Forfar area, (3 Part A processes and 4 Part B processes). There are no IPPC sites operated in the area.

One part B process is a mobile crusher owned by Delson Contractors Ltd. Emissions from this process have not been included in the emissions inventory as the mobile crusher is not permanently based in Forfar and is unlikely to be in continual use whilst at the Delson site.

Much of the Fledmyre Quarry, owned by Aggregate Industries Ltd, which is located to the north-east of Forfar has recently been restored and is now managed as a wildlife reserve. The site was previously operated as a sand and gravel quarry and landfill site. Some of the exposed sand banks have been retained to encourage waders and other birds. Fugitive emissions from the quarry site are expected to have been reduced since decommissioning of the site as there is now no movement of aggregates across the site and much of it has been vegetated.

Where detailed monitoring data was available from the public register information this was included in the emissions inventory. For sites where the monitoring requirements for process emissions are qualitative or emissions are fugitive, emissions factors from the NAEI were used to estimate site emissions.

The NAEI provides average emission factors to estimate the PM_{10} emissions from various industrial processes. The emissions factors are provided as a kg emission per site and are presented below. The total emissions from industrial sites in Forfar are presented in Table 7.

- Site vehicles: 1,131 kg of PM_{10} per site
- Waste oil burners (< 3MW): 300 kg of PM_{10} per site
- Quarrying: 50,000 kg of PM_{10} per site
- Cement and concrete batching: 146 kg of PM_{10} per site
- Other Part B processes: 958 kg of PM_{10} per site

Table 6: Regulated industrial sites in Forfar emitting PM_{10}

Permit No.	Company	Location	Process	Description of emissions
PPC/E/30070	David Ritchie (Implements) Ltd	Carseview Road, DD8 3BT,	Metal coating	Point emissions from spray booth stacks Emission limit : 50mg/m^3
PPC/E/30093	Fleet Finnish Ltd	Carseview Road, DD8 3BT	Commercial vehicles	• Point emissions from oil fired burner stacks • Emission limit : 10mg/m^3 • Fugitive emissions from sanding and grinding of vehicles and vehicle parts prior to paint application from workshop door
PPC/E/30101	Forfar Galvinisers Ltd	Carseview Road, DD8 3EE	Galvinising	• Point emissions from the fume extraction stack • Emission limit : 15mg/m^3
PPC/E/30181	Delson Contracts Ltd	Orchardbank Industrial Estate DD8 1TD	Mobile crushing plant	• Fugitive emissions from crushing & grinding
PPC/E/30186	Charles Butler Motor Engineers	Queenswell Road,	Combustion (W.O.B)	• point emission of combustion gases from waste oil burner stack
PPC/B/1000001	Laird Bros (Forfar) Ltd	Whitehill brickworks,	Mineral	• 1 point source on bulk storage silo • fugitive emissions from stockpiles, storage bunkers, conveyors and roadways
PPC/B/1000147	Laird Bros (Forfar) Ltd	Lunnanhead, DD8 3NQ	Concrete	• 4 point sources on bulk storage silos • fugitive emissions from stockpiles, storage bunkers, conveyors and roadways

Table 7: Emissions of PM_{10} from regulated industrial sites

Company	National grid reference	Emission point parameters	Emission monitoring	Estimated direct emissions (kg /annum)	Estimated emissions site vehicles (kg /annum)	Total estimated emissions (kg /annum)
David Ritchie (Implements) Ltd	NO 463 517	9m stack (0.85m diameter) 9m stack (0.85m diameter) 10m stacks (0.62m^2 area) 10m stacks (0.62m^2 area)	0.005g/s : 5.5m/s : 17C 0.014g/s : 5.4m/s : 16C 0.010g/s : 11.4m/s : 20C 0.004g/s : 11.2m/s : 19C	1,041	0	1,041
Fleet Finnish Ltd	NO 463 517	12m stack (0.9m diameter) 12m stack (0.9m diameter) 12m stack (0.9m diameter)		958	1,131	2,089
Forfar Galvinisers Ltd	NO 462 518	12m stack (1m diameter)	0.031g/s : 9.1m/s : 33C	990	0	990
Charles Butler Motor Engineers	NO 4551 5093	6m stack (0.5m diameter)		300	1,131	1,431
Laird Bros (Forfar) Ltd	NO 4690 5156 NO 4697 5152	120 tonnes cement silo Aggregate stockpiles		146	1,131	1,278
Laird Bros (Forfar) Ltd	NO 4773 5239 NO4766 5236 NO 4767 5235 NO 4767 5234 NO 4773 5239	50 tonnes cement silo 70 tonnes cement silo 100 tonnes cement silo 150 tonnes cement silo Aggregate stockpiles		146	1,131	1,278

3.2 Road traffic emissions

There are several A and B roads passing through Forfar in addition to the main A90, which by-passes the west side of the town. Particulate emissions from road traffic can originate from vehicle exhaust fumes as well as particulate matter transported by the vehicle or from tyre and break wear that becomes re-suspended by the motion of the car.

The quantity of particulate matter originating from traffic is dependent upon the number, speed and type of vehicles using the road. Emissions factors are provided by the NAEI for LGV and HGV and particulate re-suspension

The Roads department provided the latest road traffic count data for the roads servicing Forfar, which is presented in Table 8.

Table 8: Road traffic emissions of PM_{10} in Forfar

Road	Length of road in assessment area (km)	24 hour AADT	% HGVs	Particulate emission from exhaust fumes (kg/annum)	Particulate emission from re-suspension (kg/annum)
A90	7	17,869	9.5	2,582	1,826
A932, Dundee Road	6.75	6,195	10.8	960	611
A94 east of A90	2.25	4,480	8.3	186	147
A926 west of Pardanaram	1.5	5,059	8.9	148	111
A926 Kirriemuir Road	3.5	4,799	10.2	371	245
A929 Glamis Road	2	5,807	11.3	277	170
B9128 north	1.5	3,377	7.6	87	74
B9128 south	3.5	4,599	5.1	206	235
Total	-	-	-	4,818	3,418

The PM_{10} contributions from road traffic on minor roads were taken from the NAEI estimates for the area. A map indicating the spatial distribution of particulate emissions from road traffic are presented in Figure 5. The particulate emissions from all sources are summarised in Section 4.

3.3 Agricultural emissions

There are several large farms operating in the Forfar area, both arable and live stock. Both types of farming result in fugitive emissions of particulate matter. Arable farming results in the emissions of wind blown dust and pollen particularly during the early spring when fields are bare and during the harvesting period in mid to late summer. During early May of 2007 there was an episode of high pollen concentrations experienced across the whole of the UK, which was thought to have originated from the continent.

Livestock farming results in emissions of dust and nitrate particulate matter formed from ammonia in livestock faeces. Particulate emissions from livestock farms are less seasonal than those from arable farms but the dispersion and transport of dusts and other particulate matter is highly dependent upon the local meteorological conditions.

Meteorological conditions during the autumn and winter are generally wet and cold. The wet conditions typical in these months within the UK mean that dust is naturally suppressed. The warm and often windy conditions typical during April and May are conducive to high levels of dust and particulate matter being emitted.

There are no agricultural sites regulated by SEPA under the PPC legislation operating in the Forfar area, therefore there are no PM_{10} emissions from agricultural sites in Forfar which are monitored.

The NAEI provides average emission factors to estimate the PM_{10} emissions from various industrial processes. The annual emission factors are provided as a kilogramme emission per site or per head of livestock. There was no specific data available on livestock quantities for each farm in the area therefore the emission predictions were taken from the NAEI.

Details of agricultural related businesses operating in the Forfar area are provided in Table 9.

Table 9: Agricultural emissions of PM_{10} in Forfar

Company	Activity	Company	Activity
Angus Heathers	Garden Centre	J & A Steel	Arable & Cattle & Sheep
Agrico UK Ltd	Arable	J &R Black	Arable
AH & HA Pallutto	Arable	MBM Produce Ltd	Arable
Alexander G Spence	Arable	Messrs D & J Simpson	Suppliers machinery
Alexander M Walker & Son	Arable & Livestock	Robert M Adam & Son	Livestock
Alex J Breckenbridge	Arable	Scott & Newman Ltd	Arable
Andrew N Rennie & Son	Arable & Cattle	Sellars Agriculture Ltd	Suppliers machinery
Bruce Soutar	Arable	Strathmore Estates (Holdings) Ltd	Forestry, sawmill, game
Charles Nicoll & Son	Arable & Cattle	Strathtay Potato Company	Arable
DF Watson	Livestock - poultry	Taylors of Tannandice	Arable & Diary & Cattle
G K Robertson	Arable	WM Butler & Son	Arable & Cattle
IA & ER Laird	Suppliers machinery		

The spatial distribution of PM_{10} emissions from agricultural activities in the Forfar area are presented in Figure 6.

3.4 Commercial emissions

Particulate emissions from commercial properties consist primarily of emissions from heating appliances, such as water boilers. Typically emissions from commercial properties do not contribute a significant proportion of local PM_{10} concentrations.

Commercial heating in Forfar is provided by a mixture of electric, gas, oil and solid fuel systems. The commercial emissions of PM_{10} have therefore been estimated using data from the NAEI.

The NAEI provides average emission factors to estimate the PM_{10} emissions from commercial properties. The emissions factors are provided as a kg emission per 1000 population and are presented below. The total emissions from domestic properties in Forfar are presented in Table 10.

- Commercial and light industry: 0.0000171tonnes of PM_{10} per head of population
- Other industry combustion: 0.0000094 tonnes of PM_{10} per head population
- Public services: 0.0000285 tonnes of PM_{10} per head population

3.5 Domestic emissions

Particulate emissions from domestic properties consist primarily of emissions from domestic heating and cooking appliances, such as open fires, oil stoves and water boilers. In areas where there is a high level of solid fuel burning, domestic emissions can contribute a significant proportion to local PM_{10} concentrations.

Domestic heating in Fofar is provided by a mixture of electric, gas, oil and solid fuel systems. Previous air quality assessments have indicated that there is not a significant level of solid fuel use for domestic heating purposes in the area. The domestic emissions of PM_{10} have therefore been estimated using data from the NAEI.

The NAEI provides average emission factors to estimate the PM_{10} emissions from domestic properties. The emissions factors are provided as a kg emission per 1000 population and are presented below. The total emissions from domestic properties in Forfar are presented in Table 10.

- Domestic heating: 0.000464 tonnes of PM_{10} per head of population
- Domestic and garden machinery: 0.00000273 kg of PM_{10} per head of population

The spatial distribution of PM_{10} emissions from domestic properties in the Forfar area presented in Figure 7.

3.6 Emissions from waste disposal sites

Emissions of PM_{10} from waste disposal sites are found in two types either in the form of combustion gases from waste incinerator or as fugitive emissions from landfill and composting sites. There are no waste incinerator processes located in Forfar, however, there is a landfill site located to the north of Forfar.

The PM_{10} contributions from waste disposal sites were taken from the NAEI estimates for the area. The particulate emissions from all sources are summarised in Section 4.

3.7 Naturally occurring emissions

Some emissions of PM_{10} occur naturally primarily these consist of wind blown particulates from soil, sand, vegetation, fauna and marine sources.

The PM_{10} contributions from natural sources were taken from the NAEI estimates for the area. The particulate emissions from all sources are summarised in Section 4.

3.8 Other emissions

There are no rail, ship or aircraft atmospheric emission sources located within the Forfar area. Other emissions therefore include particulate emissions from off-road vehicles, solvent use and energy production. This data was taken from the NAEI as no specific local data was available. The PM_{10} contributions from natural sources were taken from the NAEI estimates for the area. The particulate emissions from all sources are summarised in Section 4.

4 SOURCE APPORTIONMENT

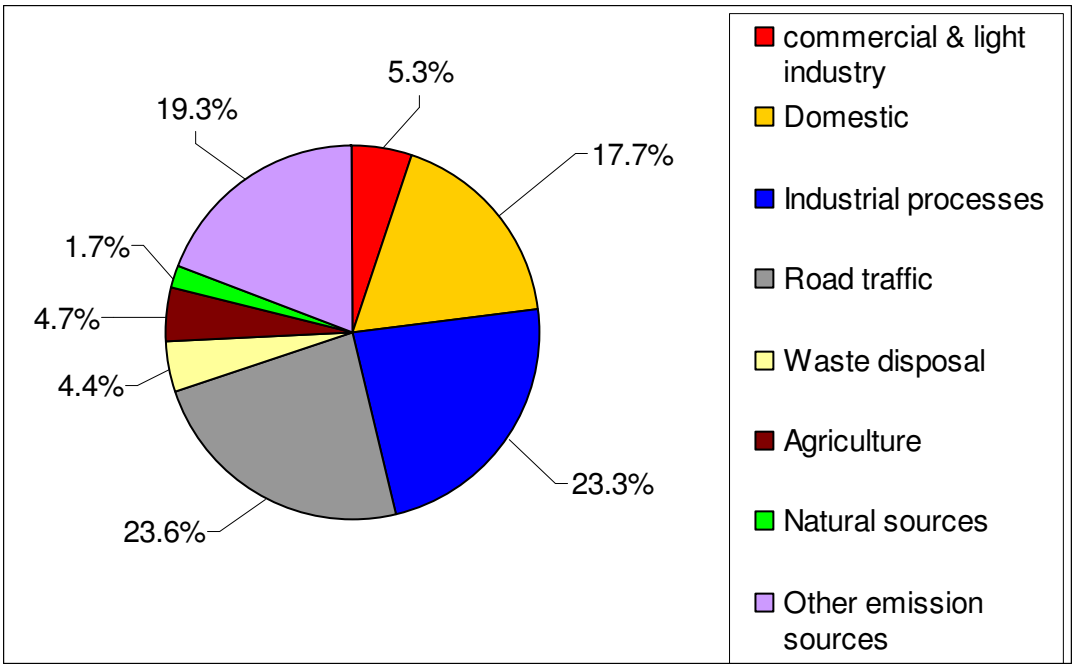
The total PM_{10} emissions from all sources in the Forfar area presented numerically in Table 10 and as 1km x 1km grid square emissions in Figure 8. The source apportionment of particulate emissions within the Forfar area is presented in Chart 2.

Table 10: Domestic and Commercial emissions in Forfar

Activity	Total estimated emissions (kg /annum)
Domestic	6,164
commercial & light industry	1,844
Regulated industrial processes	8,108
Road traffic	8,236
Waste disposal	1,542
Agriculture	1,644
Natural sources	596
Other emission sources	6,730
Total	34,864

The chart indicates that domestic emissions and emissions from commercial properties and light industry make up the largest sources of PM_{10} in the Forfar area.

Chart 2: Particulate emissions – source apportionment for Forfar



An inventory of PM_{10} emissions from the Angus Council area was previously undertaken in 2003. The previous assessment of atmospheric emissions in Angus Council indicated that 136.2 tonnes of PM_{10} were emitted from within the Council area per year. The 1km grid square emission totals indicated that the area covering both Forfar town centre and the surrounding industrial estates

emitted between 1 and 3 tonnes of PM_{10} per annum and that PM_{10} emissions from the area covering the Fledmyre quarry and Restenneath landfill site had estimated emissions of between 3 and 11 tonnes of PM_{10} per year.

The updated inventory indicates that the PM_{10} emissions from the areas encompassing town centre and industrial estates are between 2 and 11 tonnes per annum per km^2 and the emissions from the area covered by Fledmyre quarry are approximately 1 tonne per annum per km^2. The closure of the quarry will account for the decrease in emissions from the north-east area of Forfar.

5 CONCLUSIONS

The PM_{10} concentrations recorded in Forfar during 2006 and 2007 indicate that although levels are currently exceeding the 2010 annual mean objective the concentrations are predicted to decrease below the 18μg/m^3 objective by 2010. There are no recorded or predicted exceedences of the 24-hour mean objective for 2004 or 2010. PM_{10} concentrations are predicted to decline within Forfar, however, it is recommended that the monitoring is maintained as concentrations are predicted to be close to the 2010 annual mean objective.

The source composition and correlation studies indicate that the concentrations of PM_{10} within Forfar originate from a variety of sources. Small proportions of metals, chloride and calcium were found representing contributions from road dust, industry, construction dust, and marine sources. The largest PM_{10} component contribution identified was sulphates followed by nitrates. Both these components arise from chemical reactions with sulphur and nitrogen and may originate from agricultural, industrial or natural sources. More than half of the PM_{10} matter contained in the samples comprised other unidentified constituents. The unidentified constituents would have included organic and elemental carbon which originates from natural and combustion sources.

The correlation between NO_2 and PM_{10} concentrations suggested that road traffic or combustion was not the predominant source of PM_{10} concentrations within Forfar.

The emissions inventory indicates that four sectors which produce the greatest contribution to PM_{10} emissions within Forfar are road traffic sources, industrial processes, domestic sources and other sources comprising energy production, solvent use and off-road vehicle emissions e.g. cranes, tractors, and other mobile engines.

Figures

Appendix 1: Dundee City Council Scientific Services - Test Reports