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Further Assessment of PM_{10} and NO_2 in Bearsden AQMA

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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd (Golder) has been commissioned by East Dunbartonshire Council (the Council) to undertake a Further Assessment of air quality at and around the Air Quality Management Area (AQMA) at Bearsden Cross. The Further Assessment is required following the Council's requirements under Section IV of the Environment Act 1995 - Local Air Quality Management (LAQM).

1.1 LAQM review and assessment framework

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 Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 (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 first round of Review and Assessment commenced in 1998 and comprised a four stage approach to the assessment of air quality.

The Review and Assessment process was revised in 2009 and comprises a phased approach. The first phase is an Updating 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 the completion of a Progress Report which is required to be completed annually, apart from the years when an U&SA is being completed

The LAQM guidance requires that where the U&SA or Progress Report has identified a risk of exceedence of an air quality objective at a location with relevant public exposure then a Detailed Assessment should be undertaken. A Detailed Assessment will consider any risk of exceedence of an objective in greater depth in order to determine whether it is necessary to declare an Air Quality Management Area (AQMA).

When a new AQMA has been declared, local authorities are required to complete a Further Assessment within 12 months of designating the AQMA. The Further Assessment is intended to supplement the information provided in the Detailed Assessment. It should aim to confirm the exceedence of the objectives; define what improvement in air quality, and corresponding reduction in emissions is required to attain the objectives; and provide information on source contributions. The information on source contributions can be used to help develop an Air Quality Action Plan, and assist in the targeting of appropriate measures.

1.2 Background

The 2007 Progress Report identified that measured NO_2 concentrations were close to the annual mean NO_2 objective at several locations in Bearsden and four diffusion tube monitoring sites were in excess of the objective. The Progress Report also identified potential exceedence of the PM_{10} annual mean and 24 hour mean objectives.

In 2008 the Council completed a Detailed Assessment of PM_{10} and NO_2 concentrations. This study concluded that it was likely that there would be exceedence of both the NO_2 and PM_{10} annual mean objectives around Bearsden Cross and the council should continue to monitor pollutant levels before declaring an AQMA.

After further monitoring the Council declared an AQMA at Bearsden Cross in July 2011 in respect of both the PM_{10} and NO_2 annual mean objectives. The boundary of the AQMA is presented in Figure 1.

The air quality objectives for these pollutants in Scotland are set in the NAQS and are presented in Table 1.1.

Table 1.1: Air Quality Objectives for PM_{10} and NO_2 in Scotland Table

Pollutant	Concentration	Measured as	Permitted Exceedences/ Equivalent Percentile	Compliance Date
PM_{10}	40µg/m^3	Annual mean	--	31/12/2004
	18µg/m^3	Annual mean	--	31/12/2010
	50µg/m^3	24-hour mean	35 Exceedences 90.4th Percentile	31/12/2004
	50µg/m^3	24-hour mean	7 Exceedences 98th Percentile	31/12/2010
NO_2	40µg/m^3	Annual mean	--	31/12/2005
	200µg/m^3	1-hour mean	18 Exceedences 99.79th Percentile	31/12/2005

1.3 Further Assessment Outline

A Further Assessment is a detailed review and assessment of air quality within the AQMA to verify that the decision to declare the AQMA for both PM_{10} and NO_2 annual mean objectives and the extent of the AQMA remain valid. The Further Assessment also includes an analysis of the emission sources contributing to the exceedence of the NAQS objective to provide supporting evidence to advise the Air Quality Action Plan.

The Further Assessment comprises of:

- A review of local monitoring data obtained since the Detailed Assessment was undertaken;
- A review of historic monitored data to determine any trends in the monitored concentrations;
- A comparison of monitored concentrations with the dispersion modelling predictions undertaken as part of the Detailed Assessment to verify that the AQMA is still required;
- A review of the Detailed Assessment to identify any weaknesses due to lack of data or due to assumptions which could be improved upon for the Further Assessment;
- An update of the existing emissions inventory for Bearsden based on updated traffic flow data for the area and changes to vehicle emissions;
- An updated dispersion modelling study of emissions to verify the Detailed Assessment findings; and
- Predictions of pollutant concentrations in future years to determine future compliance with the objective without including any Action Plan measures.

An emissions inventory for the grid squares covering the Bearsden AQMA was compiled. Emissions inventory is the generic term used to describe the process of estimating emissions from all sources in an area. The data held in the emissions inventory was utilised in a detailed dispersion modelling study. Results from the modelling study were used to confirm the requirements for the AQMA and its boundaries.

The baseline inventory has been updated for future years. Predictions of pollutant concentrations in future years have also been undertaken to determine future compliance with the objectives without including any Action Plan measures. The emissions inventory and modelling studies were undertaken such that the relative contribution of various sources to air quality levels can be determined.

2.0 MONITORING DATA

The Council monitors PM_{10} and NO_2 at several locations throughout the Council area using both automatic and passive sampling methods and is presented in Figure 2.

All automatic monitoring data have been provided fully ratified. Diffusion tube data have been corrected using local bias correction factors where available and annualised where necessary. Full details of the monitoring under by the Council can be found in their Progress Report 2011. The Council's QA procedures are included in Appendix A.

2.1 Automatic Monitoring

East Dunbartonshire Council currently operates three automatic monitoring sites. Each site has both a NO_X analyser and a PM_{10} monitor. There is one automatic monitoring site located within the Bearsden AQMA.

The details of the automatic monitoring site are presented in Table 2.1.

Table 2.1: Details of Automatic Monitor

Site Name	Site Type	OS Grid Reference		Monitoring Techniques
Bearsden	Roadside	254289	672067	NO_x / (Heated inlet) BAM

2.1.1 NO_2

A summary of the annual mean NO_2 concentrations measured at the automatic monitoring sites from 2007 to 2010 is presented in Table 2.2.

Table 2.2: Measured NO_2 annual mean concentrations 2007 - 2010

Site No.	Location	2010 data capture (%)	Annual mean concentrations (µg/m^3)			
			2007	2008	2009	2010
Bearsden	Bearsden Cross	99.5	39.4	**44.1**	39.6	**47**

The measured annual mean NO_2 concentration at Bearsden Cross in 2010 was 47 µg/m^3 which is above the annual mean objective level of 40 µg/m^3. The monitor is sited at a kerbside location on the north-east corner of the junction between Drymen Road (A809) and Roman Road. There is frequently traffic queuing at the junction and relevant public exposure within 5 to 10m of the junction and along Roman Road and Drymen Road.

2.1.2 PM_{10}

The annual mean automatic monitoring data for 2007 to 2010 are presented in Table 2.3.

Table 2.3: Measured annual mean PM_{10} concentrations

Site No.	Location	2010 data capture (%)	Annual mean concentrations (µg/m^3)			
			2007	2008	2009	2010
Bearsden	Bearsden Cross	95.8	**20.6**	**22.8**	**20.5**	**25**

The measured annual mean PM_{10} concentration in 2010 was 25 µg/m^3 which is well above the annual mean objective of 18 µg/m^3.

Measured PM_{10} and NO_2 concentrations during 2010 indicate that urban PM_{10} and NO_2 concentrations at Bearsden Cross are exceeding their respective annual mean objectives and the decision to declare an AQMA for both NO_2 and PM_{10} remains valid.

2.2 Non-automatic Monitoring

East Dunbartonshire Council operates a network of thirty seven NO_2 diffusion tube sites, located across the council area. The monitoring sites represent public exposure and areas of high pollution concentrations at a variety of kerbside, roadside and urban background locations. There are twelve diffusion tube locations within Bearsden, eight of which are within the AQMA. The details of the diffusion tube sites and the monitoring results from 2007 to 2010 are presented in Table 2.4 and Table 2.5 respectively. Full details of the monitoring under by the Council can be found in their Progress Report 2011.

Table 2.4: Details of non-automatic NO_2 monitoring sites within Bearsden AQMA

Site Name	Site Type	OS Grid Ref	Pollutants Monitored	In AQMA?	Relevant Exposure? (Y/N with distance (m) to relevant exposure)	Distance to kerb of nearest road (N/A if not applicable)	Worst-case Location?
Bearsden 7	K	254269 672069	NO_2	Y	Y (<2m)	1m	Y
Bearsden 8	K	254275 672047	NO_2	Y	N (18m)	1m	Y
Bearsden 9	R	254751 670621	NO_2	N	N (30m)	2m	Y
Bearsden 10	R	255394 670683	NO_2	N	N (24m)	2m	Y
Bearsden 13	K	254809 671057	NO_2	Y	Y (26m)	1m	Y
Bearsden 14	K.	254877 671000	NO_2	Y	Y (8m)	1m	N
Bearsden 15	K	254898 671023	NO_2	Y	Y (2m)	1m	Y
Bearsden 16	K	254269 672067	NO_2	Y	Y (2m)	1m	Y
Bearsden 16B	K	254269 672067	NO_2	Y	Y (2m)	1m	Y
Bearsden 16C	K	254269 672067	NO_2	Y	Y (2m)	1m	Y
Bearsden 17	K	254258 672077	NO_2	Y	Y (<2m)	1m	Y
Bearsden 18	K	254275 672069	NO_2	Y	Y (<2m)	1m	Y

Table 2.5: Diffusion tubes measurements of annual mean NO_2 concentrations

Site No.	Location	2010 data capture (%)	In AQMA?	Annual mean concentrations ($\mu g/m^3$)			
				2007	2008	2009	2010
Bearsden 7	Bearsden Cross Traffic lights	92	Y	**43**	**48**	**42**	**47**
Bearsden 8	Bearsden Cross Hanging basket	100	Y	38	38	**40**	**40**
Bearsden 9	Switchback	100	N	27	29	31	33.
Bearsden 10	Maryhill Road/ Rannoch Drive	100	N	34	33	31	36
Bearsden 13	Canniesburn Toll	100	Y	37	39	38	**44**
Bearsden 14	Milngavie Road at Canniesburn Toll	100	Y	39	38	39	**44**
Bearsden 15	Milngavie Road	100	Y	34	**40**	38	39.8
Bearsden 16	102 Drymen Rd	100	Y	**40**	**46**	**40**	**46**
Bearsden 16B	102 Drymen Rd	92	Y	**41**	**45**	39	**46**
Bearsden 16C	102 Drymen Rd	100	Y	39	**43**	**40**	**48**
Bearsden 17	106 Drymen Road	75	Y	/	/	/	**42**

Site No.	Location	2010 data capture (%)	In AQMA?	Annual mean concentrations ($\mu g/m^3$)			
				2007	2008	2009	2010
Bearsden 18	3 Roman Road	75	Y	/	/	/	39

3.0 EMISSIONS INVENTORY

An emissions inventory for the Council area was compiled using the atmospheric emissions database package EMIT, which aggregates emissions into 1km by 1km grid squares. The inventory includes emissions from the following sources:

- Road traffic;
- Commercial and domestic combustion;
- Industrial combustion;
- Industrial processes;
- Large industrial sources;
- Other transport;
- Waste treatment and disposal;
- Solvent use;
- Agriculture; and
- Nature.

All emissions data were obtained from the National Atmospheric Emissions Inventory (NAEI). The NAEI is a national atmospheric emissions database which holds data on emissions from a variety of sources in 1km by 1km grid squares. Emissions are reported in tonnes per year. The NAEI data can be downloaded from the NAEI website for individual local authority areas, so the emissions are directly attributed to each authority. The East Dunbartonshire Council emissions inventory is based on the most recent NAEI data available, at the time of compiling this inventory were for 2008. The study assumed that 2008 emissions from the NAEI remain unchanged in 2010.

3.1 NAEI Road Traffic Data

The NAEI contains data on emission from all road traffic related emission data aggregated over $1km^2$ grid squares. As most of the major roads in the Bearsden area were being specifically modelled it was not necessary to include the NAEI roads emissions data in the modelling study. Full details of the specifically modelled roads data can be found in Section 7.5.

3.2 NAEI Commercial, Institutional and Domestic Combustion

The NAEI contains data on emissions from commercial and domestic combustion, a group which includes stationary combustion sources in agriculture, domestic combustion, small scale industrial combustion, commercial combustion and public sector combustion. Commercial and domestic combustion is often highest in urban areas with a high concentration of public sector, commercial and domestic buildings. Like road traffic data, emissions are aggregated over the $1km^2$ grid squares.

3.3 NAEI Industrial Combustion and Industrial Processes

The NAEI holds data on the emission of pollutants from large industrial combustion sources. The sources in this group include combustion associated with ammonia production, cement production, iron and steel production, and lime production. Emissions data from sources in this group is often obtained using data submitted to SEPA through IPPC (Integrated Pollution Prevention and Control) process. Emissions are aggregated over the 1km^2 grid squares.

A second group within the NAEI contains emissions data for industrial production processes. The sources in this group include nitric acid use in the chemical industry, primary aluminium production and solid smokeless fuel production. Emissions are aggregated over the 1km^2 grid squares.

3.4 NAEI Other Transport

The "other transport" group covers emissions from air, rail and marine transport. It also includes emissions from off road vehicles. Rail transport includes emissions from freight, intercity and regional. The emissions from "other transport" have been aggregated into the 1km^2 grid squares

3.5 NAEI Waste Treatment and Disposal

The NAEI contains a group with emission data from waste treatment and disposal activities. Sources included in this group are crematoria, incineration of animal carcasses, chemical waste and clinical waste, offshore oil and gas flaring and small-scale waste burning. Emissions from these sources are aggregated into the 1km^2 grid squares.

3.6 NAEI Solvents use

The NAEI also contains a group with emission data from solvent use associated with paints, glues, detergents and industrial processes. This data is often obtained from SEPA who regulate processes involving solvents. As for other pollutant sources, solvent emissions are aggregated into the 1km^2 grid squares.

3.7 NAEI Agriculture

The NAEI also contains a group with emission data from all agricultural livestock, poultry and agricultural off road machinery. Emissions from these sources are aggregated into the 1km^2 grid squares.

3.8 NAEI Nature

The NAEI also contains a group with emission data from naturally occurring emissions from woodlands, mines, quarries and opencast mines. Emissions from these sources are aggregated into the 1km^2 grid squares.

4.0 EMISSIONS TOTALS

The total atmospheric emissions from the 1km grid squares covering the Bearsden AQMA in 2008 are presented in Table 4.1 with the totals broken down by source in Chart 6.1and Chart 6.2.

Chart 1 indicates that 54% of NO_X emissions are attributable to road transport with 40% commercial/residential combustion and other transport (5%) account for the remainder. Chart 2 indicates that the dominant source of PM_{10} in Bearsden is road transport with a range of other sources accounting for the remainder of emissions.

Table 4.1: Emission Totals in Bearsden AQMA

Source	NO_x emitted (tonnes/yr)	PM_{10} emitted (tonnes/yr)
Agriculture	0.0	0.0
Commercial, Domestic and Institutional	55.6	0.5
Industrial Combustion	0.9	0.0
Industrial Processes	0.0	0.4
Minor Roads	75.1	5.3
Nature	0.1	1.0

Source	NO_x emitted (tonnes/yr)	PM_{10} emitted (tonnes/yr)
Other Transport	7.3	0.4
Solvents	0.0	0.1
Waste Treatment	0.2	2.2

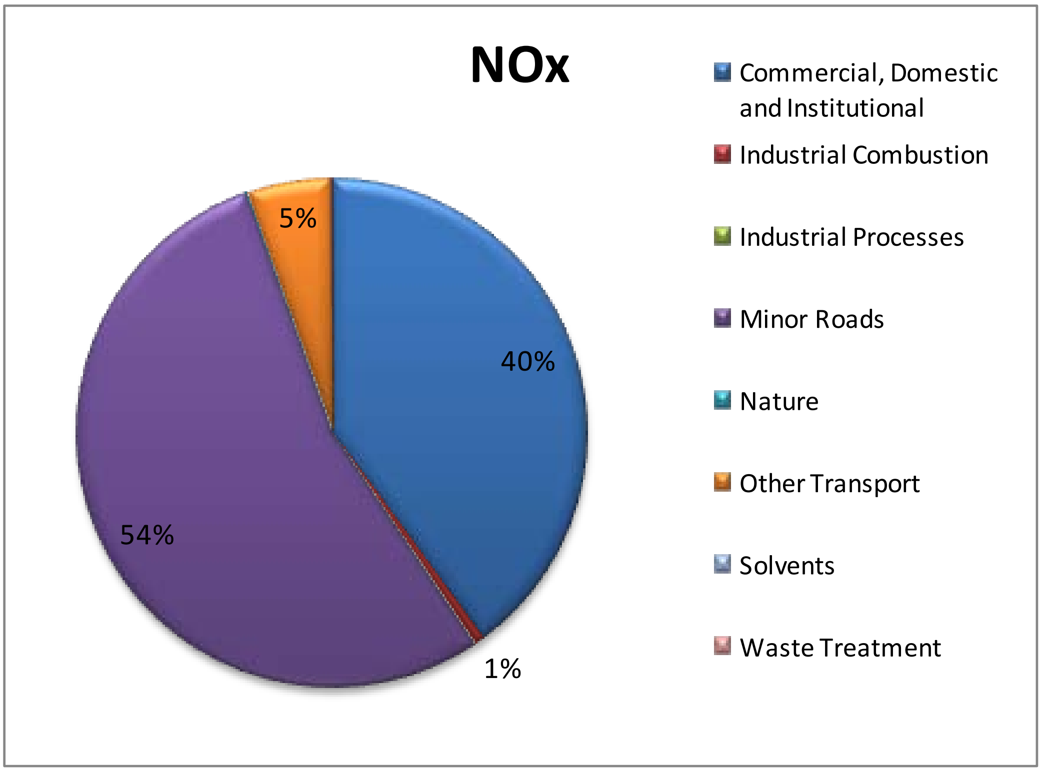


Chart 6.1: Bearsden AQMA NO_X

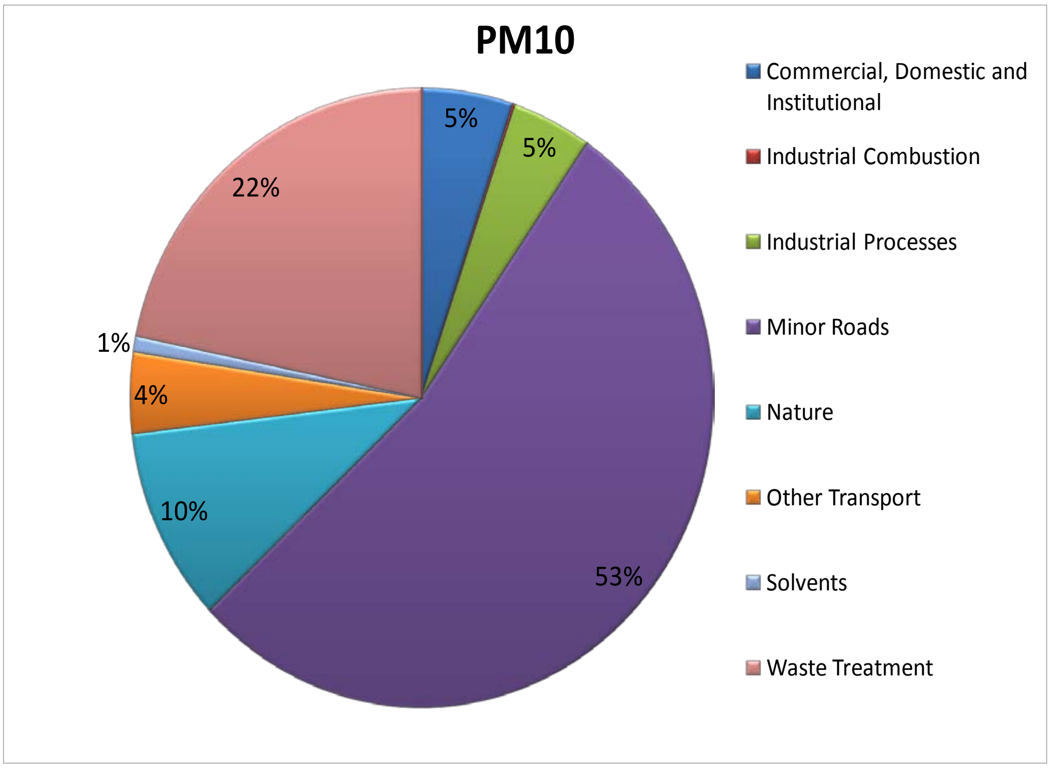


Chart 6.2: Bearsden AQMA PM_{10}

5.0 ATMOSPHERIC MODELLING SETUP

5.1 Model Description

Pollutant emissions were modelled using the advanced atmospheric dispersion modelling software ADMS-Roads 3.0, developed by Cambridge Environmental Research Consultants (CERC). ADMS-Roads is an advanced dispersion model which allows up to 150 road sources and 35 industrial sources (including point, line, area and volume sources) to be modelled simultaneously. The model uses a number of input parameters to simulate the dispersion of pollutant emissions, predicting ambient pollutant concentrations. The input parameters include information on pollutant emissions, local meteorological conditions and background pollutant concentrations.

5.2 Modelled Domain and Receptors

Modelling predictions were undertaken over a modelled domain consisting of a 3.0 km by 2.8 km Cartesian grid pattern which encompasses the Bearsden AQMA. The number of calculation points was set at 100 by 100 which provides predicted concentrations at an approximate maximum resolution of 30 x 28 m. The option of "intelligent gridding" was selected whereby the model predicts pollutant concentrations at a higher spatial density (finer resolution) close to the emission sources and at a lower spatial density at background locations.

The model can also predict pollutant concentrations at specific locations where relevant public exposure may occur and at monitoring locations which are used to verify the model predictions. Nineteen locations within the assessment area were specified as receptors. The receptor locations are presented in Table 5.1 and annotated on Figure 3.

Table 5.1: Specified Receptors

Specified Receptors	Easting	Northing
Auto	254269	672067
Bearsden Cross flat	254261	672069
Bearsden Library	254148	672358
Bearsden Primary	254289	672026
pdt 10	255394	670683
pdt 13	254809	671057
pdt 14	254877	671000
pdt 15	254898	671023
pdt 17	254258	672077
pdt 18	254275	672069
pdt 7	254269	672069
pdt 8	254275	672047
pdt 9	254269	670621
Receptor 1	253515	672813
Receptor 2	253749	672803
Receptor 3	253980	672545
Receptor 4	254165	672047
Receptor 5	254486	672281
St Andrews Primary	253266	672850

5.3 Meteorology and Climate Conditions

ADMS-Roads uses hourly sequential meteorological data to calculate atmospheric dispersion. The meteorological data file contains a number of parameters including wind speed and direction, cloud cover and solar heat flux. The nearest site which records all required parameters is located at Bishopton, close to Glasgow Airport. Meteorological data for 2010 was used in this study, with the wind rose for this year at this location presented in Figure 4.

5.4 Terrain and Surface Characteristics

The interaction of wind flow with the earth's surface generates turbulence, influencing pollutant dispersion. The strength of this turbulence is dependent on the land use, with built-up areas generating more turbulence than open countryside. The ADMS-Roads user guide indicates that a surface roughness length of 1m is suitable for cities, while 0.5m is suitable for parkland and open suburbia. A surface roughness of 0.5m was used as this was deemed to be most appropriate for Bearsden.

5.5 Road Traffic Emissions

Atmospheric emissions from road traffic were calculated by the model based on information of traffic flows and an in-built database of vehicle emission factors. Information on traffic flows on roads were obtained from Transport Scotland and from road traffic counts carried out in Jan 2011 by Count on Us on behalf of Golder at five locations within the Bearsden AQMA. The Council's transport department advised that the growth between 2010 and January 2011 would have been negligible therefore it was assumed, for the purposes of this study, that these counts would be representative of traffic counts for the study year 2010.

Traffic count data were manipulated into ADMS Roads format, which requires the data to be input as vehicle counts per hour, vehicle speed, and road type. The data were further classified into the ADMS Roads vehicle classes; motorcycles, cars, light good vehicles (LGV), buses and heavy goods vehicles (HGV). ADMS Roads then uses information from the in-built emissions factors database to calculate an overall pollutant emission for each road in grams/second/km. The emission factors depend in part on assumptions made of vehicle types of different types of road i.e. Urban, Rural or Motorway.

5.5.1 Diurnal traffic profiles

The ADMS Roads model requires traffic data to be input as an average vehicle flow per hour. The accuracy of the traffic flow information can be improved by use of time varying emissions factors which details the diurnal profile of the traffic flow. The time varying factors allow the average hourly traffic flow to be multiplied by a factor representative of the expected traffic flow at each hour of the day. The traffic flow factors are calculated as a ratio between the hourly flow and the average flow.

Detailed hourly traffic flow data were available for some of the roads modelled and a diurnal profile was calculated for each road where data was available. Each diurnal profile was applied to each respective road. The diurnal profiles used in the model are presented in Appendix A.

5.5.2 Queuing traffic

Traffic is known to become congested at various junctions within the AQMA during peak commuting hours in the morning, early evening and in some location during the mid-day periods. A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC has been used to represent the periodic congestion at the junction. The method assumes that during congested periods a representative traffic flow rate must be estimated.

The method assumes that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 km/hr), with an average vehicle length of 4m, and are positioned close to each other during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods. The AAHT is then factored by the respective composition percentages of light and heavy vehicle types.

Queuing traffic road sections were included for all roads approaching junctions at which congestion is known to occur. A time varying profile was applied to each queue section to account for the congestion periods.

5.6 Building Effects and Street Layout

ADMS-Roads does not allow buildings to be included explicitly but allows various street parameters to be input to simulate the local flow around buildings and other obstacles in the vicinity of the road. The street parameters included in the model are road width, street canyon height and road elevation. The geometry of each road was determined through a combination of GIS mapping data and a site visit by a member of Golder's Air Quality team. The geometry of each road was defined in terms of the kerb-to-kerb road width and, where appropriate, the height of any street canyons.

Street canyons can be included in the model for roads where there are high rise buildings on either side which act as barriers to the air flow and can channel wind along the road or cause localised air circulations that trap pollutants at street level. Canyon effects are significant for streets where the height of the buildings is at least equivalent or greater than the width of the street. No street canyons were identified within the study area, therefore this module was not utilised. The locations and extent of the roads modelled are presented in Figure 5.

5.6.1 Non-exhaust traffic emissions

ADMS-Roads calculates pollutant emission rates from vehicles based on exhaust emissions only; additional road traffic sources were included to represent PM_{10} emissions from non-exhaust emissions. Road traffic processes other than fuel combustion include tyre wear, brake wear, clutch wear, road surface wear, corrosion of chassis, body and other vehicle components, all contributing collectively to road dust. Non-exhaust emissions for each road segment were calculated using PM_{10} emission factors in g/km from the National Atmospheric Emissions Inventory (NAEI)[1] and the number of vehicles per day

[1] www.naei.org.uk

5.7 Emissions from Other Sources

Emissions from other sources in the study area were included in the modelling and were modelled as volume sources. Data for the volume sources were obtained from the emissions inventory. The volume sources were modelled as 1km square grids with a depth of 10m. To avoid double counting of road traffic emissions, no road traffic emission were included in each grid square as the model included explicitly modelled roads. The volume sources included in the modelling study are presented in Table 5.2 and Figure 5

Table 5.2: Volume Sources

Volume Source	Grid Reference	Grid Reference	$NO_x g/m^3/s$	$PM_{10} g/m^3/s$
Volume Source 1	254000	670000	7.37015E-07	4.82663E-08
Volume Source 2	255000	670000	4.0868E-07	3.39634E-08
Volume Source 3	253000	671000	2.75835E-07	2.31894E-08
Volume Source 4	254000	671000	6.11346E-07	4.07138E-08
Volume Source 5	255000	671000	5.53238E-07	3.82253E-08
Volume Source 6	254000	672000	5.20516E-07	3.60142E-08
Volume Source 7	253000	672000	5.55143E-07	4.04789E-08
Volume Source 8	252000	672000	2.4786E-07	1.74346E-08
Volume Source 9	253000	673000	4.70263E-07	3.66997E-08

5.8 Chemistry Scheme and Background Concentrations

ADMS-Roads has an optional chemistry scheme which can model the photochemical reactions that occur between oxides of nitrogen (NO_x), ozone and hydrocarbons leading to the formation of NO_2. The chemistry scheme within ADMS-Roads also models the conversion of sulphur dioxide (SO_2) to sulphate particles, which influence PM_{10} concentrations.

It is important to include chemical reactions when modelling road traffic emissions as NO_2 emissions generally account for only around 10-20% of total NO_X emissions from motor vehicles. While there are numerous reactions which occur between these compounds, the Chemical Reaction Scheme in ADMS-Roads simplifies this to eight reactions known as the Generic Reaction Set. ADMS roads uses a default 10% of total NO_x to NO_2 relationship from motor vehicles, however the primary fraction of NO_2 emitted by road traffic is now known to be greater than this and was estimated at approximately 15% for urban roads outside of London. The NO_x to NO_2 calculator [2] details the primary NO_2 emission rates in the UK projected to 2025. Primary NO_2 emissions from motor vehicles in the Council area are predicted to range from 17% to 26%of NO_x from 2010 to 2015. Using the *"all other urban UK traffic" option* the East Dunbartonshire Council *area has a primary NO_2 of 17% NO_x.* The modelling study predicted both total NO_x and NO_2 concentrations.

Background PM_{10} concentrations were obtained from a monitoring site operated by Glasgow City Council at Waulkmillglen reservoir which is a rural monitoring site on the outskirts of Glasgow. SO_2 is not measured at the Waulkmillglen site therefore background concentrations of SO_2 were taken from the automatic monitoring site at Glasgow Centre. The background concentration data were entered into ADMS-Roads as hourly averaged concentrations. As well as providing the information required by the chemistry module of ADMS-Roads, the Waulkmillglen measurements also represent the regional background contribution (from sources outside the study area) to atmospheric pollutant concentrations in Bearsden. The 2010 annual mean background concentrations used in the model are presented in Table 5.3.

Table 5.3: Background Concentrations 2010

Year	$NO_X (\mu g/m^3)$	$NO_2 (\mu g/m^3)$	Ozone ($\mu g/m^3$)	$PM_{10} (\mu g/m^3)$	$SO_2 (\mu g/m^3)$
2010	26.8	15.8	48.6	12.7	3.7

[2] http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

6.0 MODEL VERIFICATION

In order to assess the model performance, predicted pollutant concentrations from the model are compared with measured pollutant concentrations. The automatic monitoring station is located within the existing AQMA at Bearsden Cross and is the only PM_{10} analyser within the study area. The analyser is located kerbside which means it's not in an ideal location for model verification. TG (09) does not recommend the use of kerbside analysers for model verification and adjustment if required. Comparisons of the measured and predicted pollutant concentrations are further discussed in Section 6.1.1 and 6.1.2.

6.1.1 PM_{10}

Comparison of the measured PM_{10} and predicted concentrations was undertaken and the results presented in Table 6.1.

Table 6.1: Comparison of modelled with monitored 2010

Receptor Name	Monitor type	Site type	Regional Background PM_{10} (µg/m^3)	Monitored total PM_{10} (µg/m^3)	Modelled total PM_{10} (µg/m^3)	% difference
Bearsden	CM*	Kerbside	12.7	**25**	**19.6**	-22%
* Continuous monitor						

The comparison of modelled PM_{10} concentrations with monitored PM_{10} is an under prediction of -22%, this is within the limits of +/-25% which TG (09) recommends before model adjustment is required. This is the only monitoring site within the study and is located at a kerbside location, TG (09) paragraph A3.240 advises that multiple sites should be used to verify the modelling results and the use of one continuous monitor alone is not recommended. TG (09) also advises kerbside monitoring locations are not suitable for the adjustment of road traffic modelling results at their inclusion may lead to an over adjustment at both roadside and background sites.

Before any decision to carry out adjustment was undertaken all of the model input data was fully reviewed to ensure no further improvements could be made.

Although the technical guidance does not recommend model adjustment under these conditions, the Scottish annual mean objective is 18 µg/m^3, therefore an under prediction of 5.4 µg/m^3 could be significant. In order to assist the Council in identifying the worst case extent of the exceedence area, model adjustment has been carried out following the suggested methodology in TG (09). Full details of the adjustment are presented in the Appendix A.

6.1.2 NO_2

Comparison of the measured NO_2 and predicted concentrations was undertaken and the results presented in Table 6.2.

Table 6.2: Comparison of modelled with monitored 2010

Receptor Name	Monitor type	Site type	Regional Background NO_2 (µg/m^3)	Monitored total NO_2 (µg/m^3)	Modelled total NO_2 (µg/m^3)	% difference
Bearsden	CM*	Kerbside	15.8	**47.0**	38.5	-18%
pdt 10	Diffusion Tube	Roadside	15.8	35.6	29.3	-18%
pdt 13	Diffusion Tube	Kerbside	15.8	**43.7**	34.5	-21%
pdt 14	Diffusion Tube	Kerbside	15.8	**43.5**	38.5	-12%

Receptor Name	Monitor type	Site type	Regional Background NO_2 (µg/m^3)	Monitored total NO_2 (µg/m^3)	Modelled total NO_2 (µg/m^3)	% difference
pdt 15	Diffusion Tube	Kerbside	15.8	39.8	33.9	-15%
pdt 16	Diffusion Tube	Kerbside	15.8	**46.6**	38.5	-17%
pdt 17	Diffusion Tube	Kerbside	15.8	**42.2**	37.9	-10%
pdt 18	Diffusion Tube	Kerbside	15.8	38.6	37.6	-2%
pdt 7	Diffusion Tube	Kerbside	15.8	**46.6**	37.4	-20%
pdt 8	Diffusion Tube	Kerbside	15.8	**40.4**	36.4	-10%
pdt 9	Diffusion Tube	Roadside	15.8	33.0	29.1	-12%
						Overall comparison -14%

* Continuous monitor

The comparison of modelled NO_2 concentrations with monitored NO_2 is an average under prediction of -14%, this is well within the limits of +/-25% which TG (09) recommends before model adjustment is required.

In order to assist the Council in identifying the worst case extent of the exceedence area, model adjustment has been carried out following the suggested methodology in TG (09). Full details of the adjustment are presented in the Appendix A.

7.0 MODELLING RESULTS

The modelling results before and after adjustment for 2010 are presented in Table 7.1 and Figures 6 to 9.

Table 7.1: Modelling results

Receptor	Modelled 2010 Annual Mean			Modelled 2010 Adjusted Annual Mean		
	NO_x (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	NO_x (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)
Auto	101.1	38.5	**19.6**	114.0	**48.0**	**25.0**
Bearsden Cross flat	97.6	37.8	**19.2**	109.9	**46.9**	**24.3**
Bearsden Library	69.1	32.2	**16.5**	76.5	36.5	**19.5**
Bearsden Primary	75.5	33.6	16.9	84.0	39.0	**20.2**
pdt 10	58.1	29.3	15.6	63.6	31.8	17.9
pdt 13	77.9	34.5	16.8	86.8	39.9	**20.0**
pdt 14	97.3	38.5	17.9	109.5	46.8	**22.0**
pdt 15	74.5	33.9	16.2	82.8	38.6	**19.0**
pdt 17	98.2	37.9	**18.7**	110.6	47.1	**23.4**
pdt 18	96.1	37.6	**18.9**	108.1	46.4	**23.8**
pdt 7	95.3	37.4	**18.9**	107.1	46.1	**23.7**

Receptor	Modelled 2010 Annual Mean			Modelled 2010 Adjusted Annual Mean		
	NO_x (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)	NO_x (µg/m^3)	NO_2 (µg/m^3)	PM_{10} (µg/m^3)
pdt 8	89.7	36.4	**18.4**	100.7	44.2	**22.8**
pdt 9	60.9	29.1	14.9	66.8	33.0	16.6
Receptor 1	59.1	29.1	15.5	64.7	32.2	17.6
Receptor 2	66.6	31.1	16.6	73.5	35.4	**19.7**
Receptor 3	65.6	31.1	16.3	72.4	35.0	**19.0**
Receptor 4	62.3	30.7	15.2	68.5	33.6	17.2
Receptor 5	62.3	31.0	15.1	68.5	33.6	17.0
St Andrews Primary	56.6	27.8	15.2	61.7	31.1	17.1

7.1 Analysis of modelling results

Based on the adjusted model predictions, there are some locations where the NO_2 annual mean objective will be exceeded. Analysis of the NO_2 annual mean contour plot, shown in Figure 7, along with the predicted concentrations at specified receptors has indicated that the annual mean NO_2 objective is currently not being met at the following locations:

- Bearsden Cross;
- Milngavie Road at Canniesburn Toll;
- Drymen Road; and
- Roman Road.

Analysis of the adjusted 2010 PM_{10} modelling results at specified receptors has indicated the annual mean objective is currently not being met at receptors in the following locations:

- Bearsden Cross;
- Canniesburn Toll;
- Drymen Road;
- Milngavie Road at Canniesburn Toll;
- Milngavie Road; and
- Roman Road

Further analysis of the adjusted PM_{10} contour plot shown in Figure 19 indicates that the objective may also not be met at the following locations:

- Stockiemuir Road; and
- Duntocher Road.

It should be noted that the predicted exceedences are as a result of the adjustment of the modelling predictions, which used an adjustment factor based on one kerbside monitoring location. It is considered that having adjusted the model based on a kerbside location a greater increase in the predicted PM_{10} locations at both Roadside and Urban Background sites. This approach provides a worst case estimate of PM_{10}, therefore the predicted exceedences of the 2010 annual mean objective for PM_{10} should be treated with caution. It is recommended that further monitoring should be undertaken before any decision is made to extend the boundary of the AQMA for the PM_{10} annual mean objective.

8.0 POPULATION EXPOSURE

The modelling has indicated that the both the NO_2 and PM_{10} annual mean objectives are being exceeded within the existing AQMA boundary. The modelling has also indicated that the PM_{10} annual mean objective is also being exceeded at a number of residential properties outside the boundary. The Council has provided details of all of the residential properties in a GIS layer to allow for analysis with the adjusted PM_{10} annual mean contour plot and the adjusted NO_2 annual mean contour plot.

Based on national statistics[3] the average Scottish Household has 2.18 householders. From the adjusted PM_{10} and NO_2 annual mean contour plots of ground level concentrations and based on concentrations greater than 18µg/m^3 and 40µg/m^3, respectively, the number of residents exposed to the predicted exceedence have been estimated and are presented in Table 8.1.

Table 8.1: Population Exposure

Road Section	No of residential properties	Population
PM_{10}	226	493
NO_2	33	72
	Total	**565**

9.0 FUTURE SCENARIOS

LAQM TG (09) introduced a new requirement for Further Assessments, that the Local Authority should predict the date of achievement of the air quality objectives were no improvement actions to be taken. The approach to making this prediction can either be based on modelling of future years, or by simply projecting monitoring data forward using the factors outlined in the latest version of Box 2.1 of the guidance[4].

To enable prediction of the likely compliance date for NO_2, the measured concentrations of NO_2 at the worst case receptors outlined above have been used and projected forward using the latest published factors presented in Table 9.1

Table 9.1: Adjustment factor to be applied

Year	Rest of UK
2008	1.000
2009	0.916
2010	0.832
2011	0.783
2012	0.735
2013	0.687
2014	0.639
2015	0.591
2016	0.557
2017	0.523
2018	0.489
2019	0.454
2020	0.420

[3] http://www.gro-scotland.gov.uk/press/news2010/increase-in-households.html

[4] (revised to be used from January 2010)

Table 9.2: Predicted NO_2 concentrations ($\mu g/m^3$) for 2011 to 2015

Year	Receptor							
	Bearsden 7	Bearsden 8	Bearsden 13	Bearsden 14	Bearsden 16	Bearsden 16B	Bearsden 16C	Bearsden 17
2010	46.6	40.4	43.7	43.5	45.5	46	48.3	42.2
2011	43.9	38.0	41.1	40.9	42.8	43.3	45.5	39.7
2012	41.2	35.7	38.6	38.4	40.2	40.6	42.7	37.3
2013	38.5	33.4	36.1	35.9	37.6	38.0	39.9	34.8
2014	35.8	31.0	33.6	33.4	34.9	35.3	37.1	32.4
2015	33.1	28.7	31.0	30.9	32.3	32.7	34.3	30.0

Similarly the measured concentration of PM_{10} at the only monitoring location, Bearsden Cross, has been used and projected forward using published factors and the methodology outlined in Box 2.2 of the guidance to enable prediction of the likely compliance date for PM_{10}.

Table 9.3: Predicted PM_{10} concentrations ($\mu g/m^3$) in 2011 - 20

Year	Bearsden Cross
2010	25
2011	24.2
2012	23.4
2013	22.6
2014	21.8
2015	21.0
2020	18.6

The results indicate that the NO_2 annual mean objective should be met at all sites by 2013. The results indicate that the PM_{10} annual mean objective will remain above the objective beyond 2020. These results are purely indicative and unlike the modelling study they do not take into account any future local conditions such as traffic growth or any changes to fleet composition.

Both studies use published factors which assume reductions in emissions from engines due to improvements in technology. It should be noted that evidence from remote sensing of vehicle exhausts has shown that NOx emissions from newer diesel vehicles (Euro 2 and later cars, LGV, HGV and buses) in urban areas have little changed since Euro 1standard. Therefore the results of this analysis should be treated with caution.

10.0 SOURCE APPORTIONMENT

A source apportionment study has been undertaken in order to investigate which emission sources make the highest contribution to predicted pollutant concentrations in the AQMA. Separate model runs have been conducted in the same manner as described in Section 7 using the “Groups” feature of ADMS-Roads. Different groups were set up to include different sources and the model then predicted pollutant concentrations as a result of emissions from each group. The groups which were included were:

- All sources (road traffic emissions and volume sources);
- All road traffic emissions; and
- Volume sources (local background).

Further source apportionment was carried out to look at the road contribution in more detail where a further model run was carried out with the following groups included:

- Queues (congestion);
- Brake and tyre wear;
- Car emissions;
- Bus emissions;
- LGV emissions; and
- HGV emissions.

Background concentrations were not included in the source apportionment model runs, as the purpose is to calculate the contribution from each local emission source. As such, chemistry is not included, as the chemical reactions within the chemistry scheme act on the total concentration, and cannot act on each individual group's contribution. For this reason, the model was not able to predict NO_2 and has predicted NO_x contributions only. Both PM_{10} and NO_x concentrations are calculated at specified points only. The results of the source apportionment are presented in Tables 10.1 to 10.4 and Charts 5 to 8.

Table 10.1: NOx source apportionment

Receptor	Predicted NO_x concentrations (µg/m^3)			Percentage of total (%)	
	All Sources	Road Traffic	Volume Sources	Road Traffic	Volume Sources
Auto	75.0	40.6	34.4	54%	46%
Bearsden Cross flat	71.5	37.1	34.4	52%	48%
Bearsden Library	43.1	8.7	34.4	20%	80%
Bearsden Primary	49.5	15.2	34.3	31%	69%
pdt 10	32.2	3.1	29.1	10%	90%
pdt 13	51.9	16.3	35.6	31%	69%
pdt 14	71.2	35.2	35.9	50%	50%
pdt 15	48.5	12.6	35.8	26%	74%
pdt 17	72.1	37.7	34.4	52%	48%
pdt 18	70.0	35.6	34.4	51%	49%
pdt 7	69.2	34.8	34.4	50%	50%
pdt 8	63.7	29.2	34.5	46%	54%
Receptor 1	33.1	2.5	30.6	8%	92%
Receptor 2	40.6	9.0	31.6	22%	78%
Receptor 3	39.6	6.7	32.9	17%	83%
Receptor 4	36.3	1.9	34.4	5%	95%
Receptor 5	36.3	0.7	35.6	2%	98%
St Andrews Primary	30.6	2.0	28.6	6%	94%

Table 10.2: Road NOx Source Apportionment

Receptor	Predicted NOx concentrations (µg/m3)						Percentage of total road traffic (%)					
	Bus	Car	LGV	HGV	Congestion	Brake and Tyre Wear	Bus	Car	LGV	HGV	Congestion	Brake and Tyre Wear
Auto	2.6	13.8	2.7	7.8	26.7	N/A	5%	26%	5%	15%	50%	N/A
Bearsden Cross flat	3.1	11.8	3.0	4.7	21.9	N/A	7%	27%	7%	11%	49%	N/A
Bearsden Library	1.9	4.6	1.7	0.4	0.1	N/A	22%	53%	19%	4%	2%	N/A
Bearsden Primary	1.6	5.7	1.5	1.5	7.1	N/A	9%	33%	9%	9%	41%	N/A
pdt 10	0.7	1.4	0.5	0.4	0.1	N/A	22%	46%	15%	13%	4%	N/A
pdt 13	1.4	4.8	2.0	0.4	7.5	N/A	9%	30%	12%	3%	46%	N/A
pdt 14	1.5	4.9	2.1	0.6	22.4	N/A	5%	16%	7%	2%	71%	N/A
pdt 15	0.7	2.5	1.0	0.4	7.1	N/A	6%	22%	8%	3%	61%	N/A
pdt 17	2.9	9.1	2.6	2.7	24.3	N/A	7%	22%	6%	7%	58%	N/A
pdt 18	2.1	12.0	2.2	7.3	24.5	N/A	4%	25%	5%	15%	51%	N/A
pdt 7	2.3	11.5	2.4	6.3	22.8	N/A	5%	25%	5%	14%	50%	N/A
pdt 8	2.2	9.7	2.1	4.5	18.2	N/A	6%	27%	6%	12%	49%	N/A
Receptor 1	0.6	1.5	0.2	0.1	0.0	N/A	23%	61%	9%	6%	1%	N/A
Receptor 2	2.0	4.9	1.7	0.4	0.0	N/A	22%	54%	19%	4%	0%	N/A
Receptor 3	1.3	3.7	1.4	0.3	0.1	N/A	20%	54%	21%	4%	1%	N/A
Receptor 4	0.2	0.8	0.2	0.2	0.8	N/A	10%	35%	10%	9%	37%	N/A
Receptor 5	0.1	0.3	0.1	0.1	0.2	N/A	14%	44%	14%	8%	20%	N/A
St Andrews Primary	0.4	1.1	0.2	0.1	0.0	N/A	23%	60%	10%	6%	1%	N/A

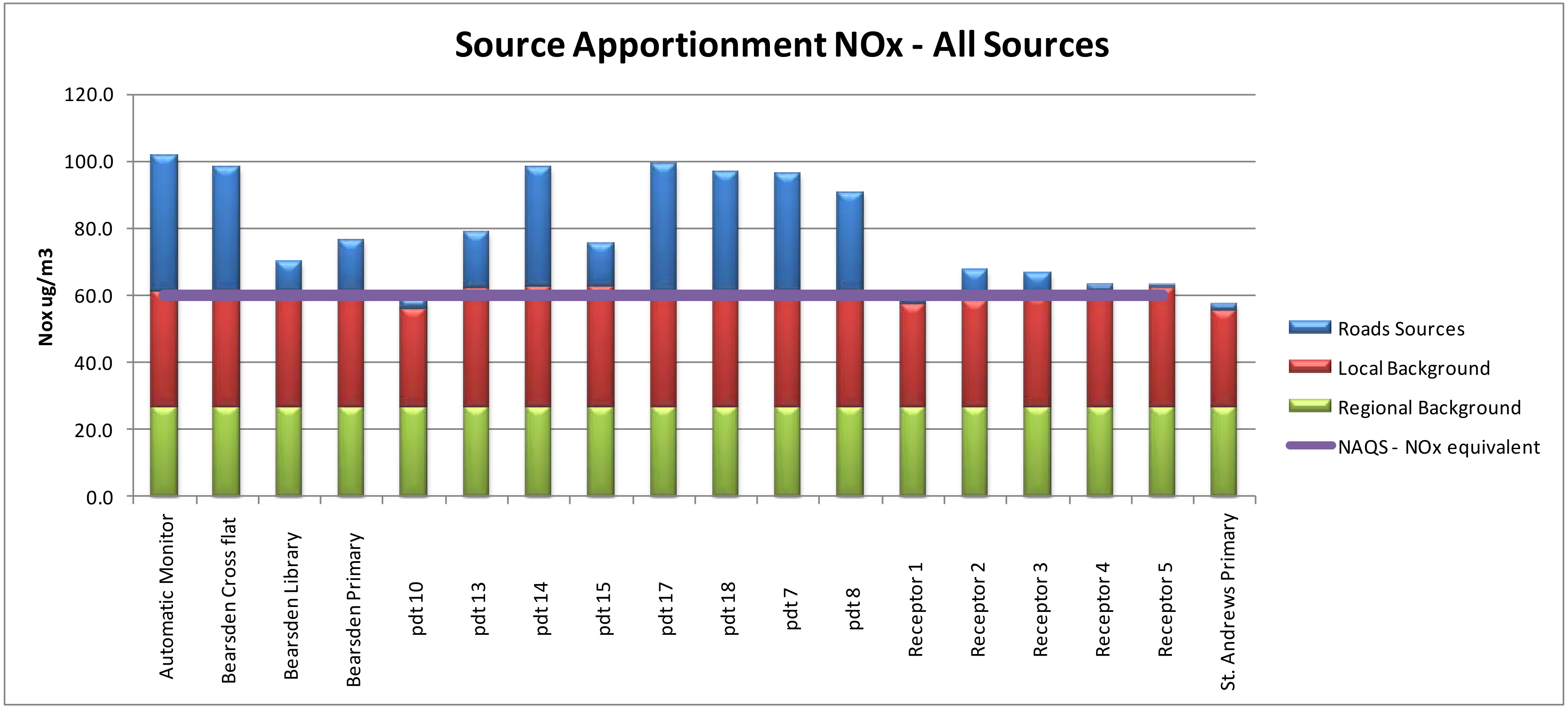


Chart 12.1: Source Apportionment NOx - All Sources

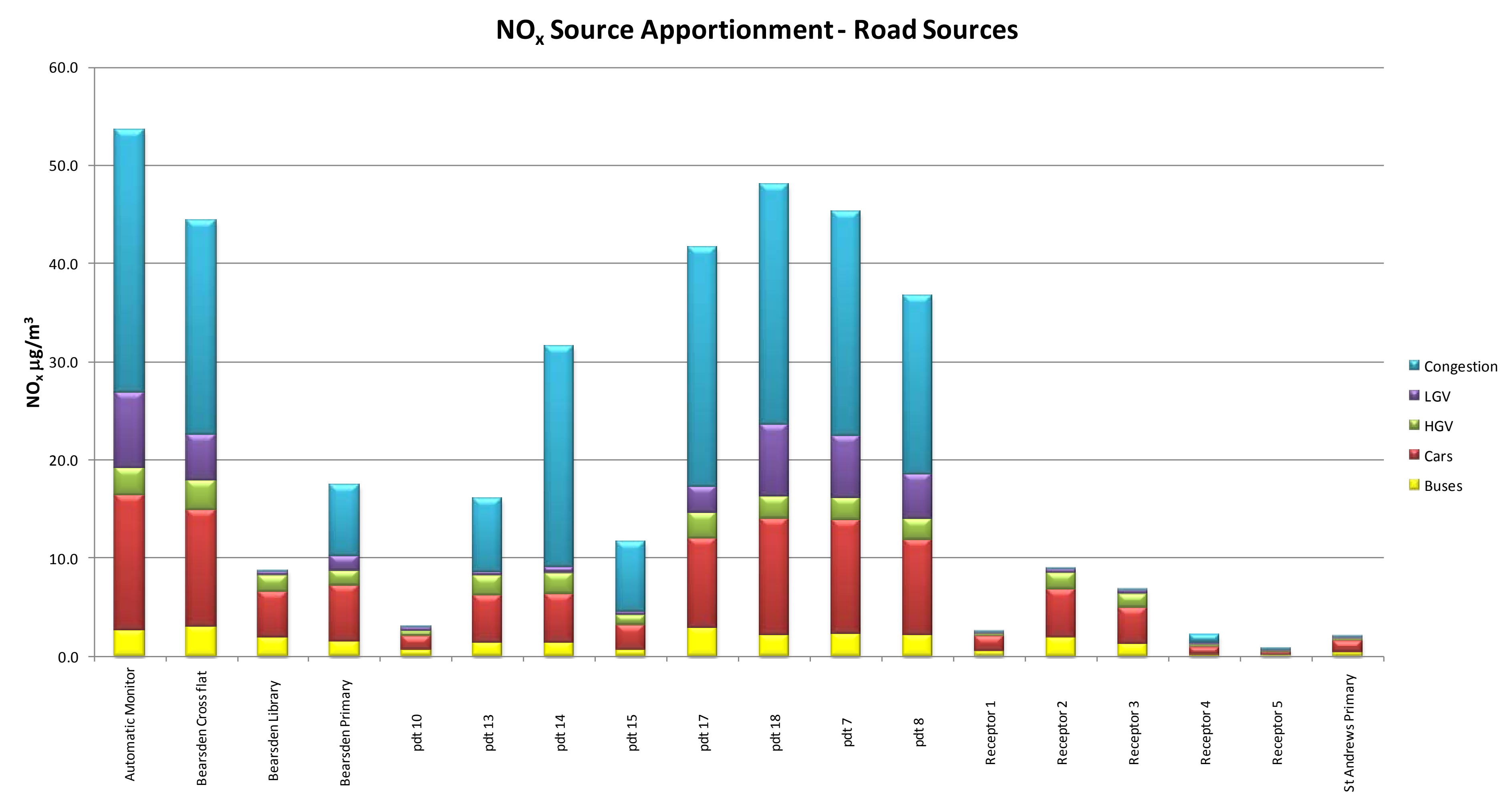


Chart 10.2: NOx Source Apportionment – Road Sources

Table 10.3: PM_{10} Source Apportionment

Receptor	Predicted PM_{10} concentrations (µg/m^3)			Percentage of total (%)	
	All sources	Road Traffic	Volume sources	Road Traffic	Volume sources
Auto	7.0	4.6	2.4	66%	34%
Bearsden Cross flat	6.6	4.2	2.4	64%	36%
Bearsden Library	3.9	1.5	2.4	39%	61%
Bearsden Primary	4.3	2.0	2.4	46%	54%
pdt 10	3.0	0.5	2.6	16%	84%
pdt 13	4.2	1.8	2.4	44%	56%
pdt 14	5.3	2.9	2.4	55%	45%
pdt 15	3.6	1.2	2.4	34%	66%
pdt 17	6.1	3.7	2.4	61%	39%
pdt 18	6.4	4.0	2.4	63%	37%
pdt 7	6.3	3.9	2.4	62%	38%
pdt 8	5.8	3.4	2.4	59%	41%
Receptor 1	2.9	0.5	2.4	17%	83%
Receptor 2	4.0	1.6	2.4	39%	61%
Receptor 3	3.7	1.2	2.4	33%	67%
Receptor 4	2.7	0.3	2.4	10%	90%
Receptor 5	2.5	0.1	2.4	4%	96%
St Andrews Primary	2.6	0.4	2.2	14%	86%

Table 10.4: Road PM_{10} Source Apportionment

Receptor	Predicted PM_{10} concentrations (µg/m3)						Percentage of total road traffic (%)					
	Bus	Car	LGV	HGV	Congestion	Brake and Tyre Wear	Bus	Car	LGV	HGV	Congestion	Brake and Tyre Wear
Auto	0.1	2.0	0.8	0.1	2.1	1.2	1%	32%	2%	13%	33%	19%
Bearsden Cross flat	0.1	1.7	0.5	0.1	1.5	1.2	2%	34%	2%	9%	29%	20%
Bearsden Library	0.1	0.7	0.0	0.1	0.0	0.7	4%	43%	4%	3%	1%	11%
Bearsden Primary	0.0	0.8	0.2	0.1	0.5	0.7	2%	37%	2%	7%	22%	11%
pdt 10	0.0	0.2	0.0	0.0	0.0	0.0	7%	64%	5%	15%	2%	0%
pdt 13	0.0	0.7	0.1	0.1	0.3	0.6	2%	38%	4%	3%	19%	10%
pdt 14	0.0	0.7	0.1	0.1	1.1	0.5	2%	28%	3%	3%	43%	8%
pdt 15	0.0	0.4	0.0	0.0	0.3	0.3	2%	33%	3%	4%	31%	5%
pdt 17	0.1	1.3	0.3	0.1	1.4	1.1	2%	31%	2%	7%	32%	17%
pdt 18	0.1	1.8	0.7	0.1	1.9	0.9	1%	32%	2%	14%	35%	15%
pdt 7	0.1	1.7	0.6	0.1	1.7	1.0	1%	32%	2%	12%	33%	16%
pdt 8	0.1	1.5	0.5	0.1	1.4	0.9	2%	33%	2%	11%	31%	15%
Receptor 1	0.0	0.2	0.0	0.0	0.0	0.2	4%	44%	2%	4%	0%	4%
Receptor 2	0.1	0.7	0.0	0.1	0.0	0.7	4%	44%	4%	3%	0%	12%
Receptor 3	0.0	0.5	0.0	0.0	0.0	0.6	3%	43%	4%	3%	0%	9%
Receptor 4	0.0	0.1	0.0	0.0	0.1	0.1	2%	37%	3%	7%	19%	2%
Receptor 5	0.0	0.0	0.0	0.0	0.0	0.0	3%	40%	3%	6%	9%	1%
St Andrews Primary	0.0	0.2	0.0	0.0	0.0	0.2	4%	44%	2%	4%	0%	3%

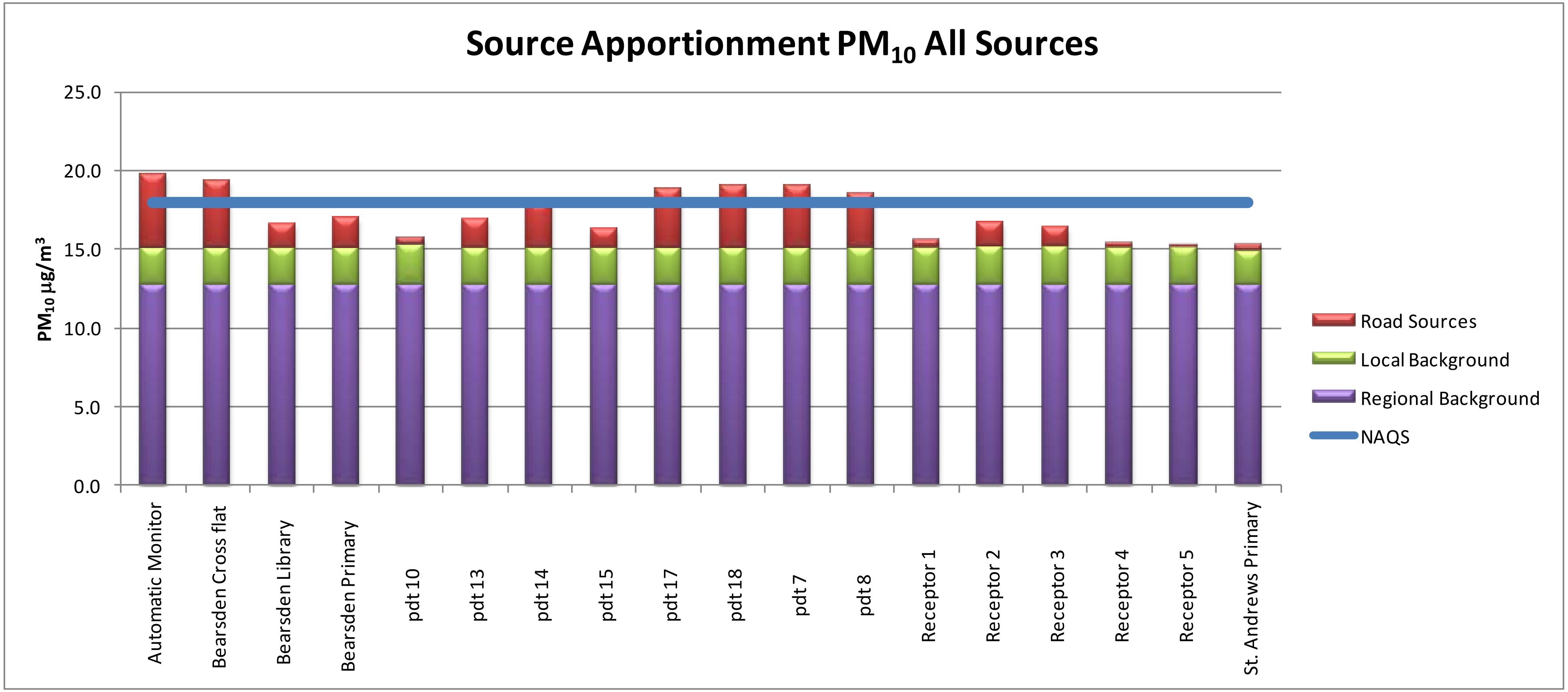


Chart 12.3: Source Apportionment PM_{10} - All Sources

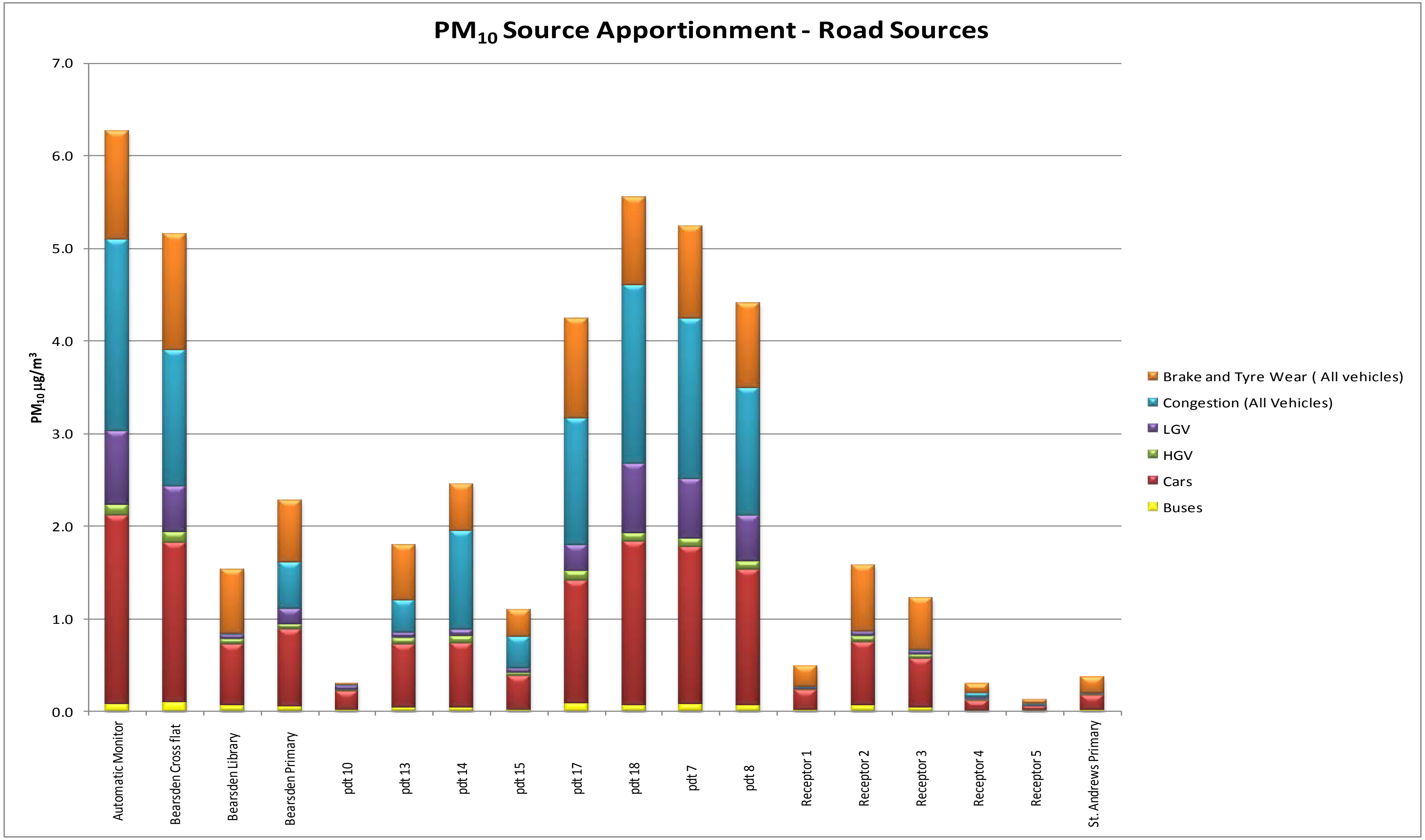


Chart 12.4: Source Apportionment PM_{10} - Road Sources

10.1 NO_x Source Apportionment

Road traffic emissions appear to be the main contributor to NO_x concentrations at locations which are predicted to exceed or are close to the NO_2 annual mean objective. Analysis of the NO_x source apportionment information including the emissions inventory indicates that at road traffic emissions is the largest contributor at locations close to and above the objective. On further analysis of the road traffic component it indicates that emissions from cars and from queuing of all vehicle classes contribute the largest proportions. A reduction in both the volume of traffic and queuing traffic within the AQMA would result in a decrease in the concentrations of NO_2.

Further analysis of the NO_x contribution from road traffic emissions indicates that at the majority of the specified receptors the greatest contribution is from congestion and cars.

10.2 PM_{10} Source Apportionment

The main contributor to ambient PM_{10} concentrations at locations which are predicted to exceed or are close to the annual mean objective is road traffic emissions.

Further analysis was undertaken of the Road Traffic emissions component and this indicated that emissions from Cars, queuing and brake and tyre wear emissions from all vehicles contribute the largest components. A reduction in both the volume of traffic and queuing traffic within the AQMA would result in a decrease in the concentrations of PM_{10}

11.0 REQUIRED REDUCTION IN POLLUTANT EMISSIONS

A requirement of TG (09) is to review the level of reduction required of the current pollutant concentrations to attain the objectives. This allows the Local Authority to judge the scale of the effort required to achieve the relative pollutant objectives. In the case of PM_{10}, a simple calculation of the current measured concentrations compared with the relevant objective will suffice. For NO_2, the ambient reduction required should be expressed in terms of NO_x as this is the primary emission and a non-linear relationship exists between NO_x and NO_2 concentrations.

Both the current road NO_x concentrations and the ambient concentration of road NO_x required to achieve the annual mean objective for NO_2 have been derived using the NO_x to NO_2 calculator. The calculations have been carried out only at locations where the annual mean objectives for each pollutant are currently being exceeded. The results of the NO_2 reduction and PM_{10} reduction calculations are presented in Table 11.1 and Table 11.2 respectively

Table 11.1: Reduction required in NO_2 concentration to meet annual mean objective

Diffusion Tube	Annual mean NO_2 ($\mu g/m^3$)	Total NO_x ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Current Roadside NO_x ($\mu g/m^3$)	Ambient required Road NO_x ($\mu g/m^3$)	Road NOx Ambient Reduction %
Bearsden 7	46.6	108.3	26.8	81.5	59.9	26.5
Bearsden 8	40.4	87.9	26.8	61.1	59.9	2.0
Bearsden 13	43.7	98.4	26.8	71.6	59.9	16.3
Bearsden 14	43.5	97.8	26.8	71.0	59.9	15.6
Bearsden 16	45.5	104.5	26.8	77.7	59.9	22.9
Bearsden 16B	46.0	106.2	26.8	79.4	59.9	24.6
Bearsden 16C	48.3	114.3	26.8	87.5	59.9	31.5
Bearsden 17	42.2	93.6	26.8	66.8	59.9	10.3

Table 11.2: Reduction required in PM_{10} concentration to meet annual mean objective

Receptor	Annual Mean PM_{10} (µg/m^3)	Background PM_{10} (µg/m^3)	Current Roadside PM_{10} (µg/m^3)	Required Road PM_{10} (µg/m^3)	Road PM_{10} Ambient Reduction %
FDMS	25	12.7	12.3	5.3	56.9

The results of the pollution reduction exercise indicate that the level of reduction required is significant at certain sites. The greatest reduction of both road NO_x and PM_{10} is required at the automatic monitoring site which is located at Bearsden Cross. Both NO_x and PM_{10} emissions at this location mainly arise from queuing traffic, therefore any improvement to the traffic flow in this area would be a positive improvement on the road NO_x and PM_{10} contribution.

12.0 CONCLUSIONS

NO_2 and PM_{10} concentrations in and around the Bearsden AQMA have been considered using a combination of new monitoring data and dispersion modelling. The results of this Further Assessment indicate that both the NO_2 and PM_{10} annual mean objectives were exceeded during 2010 in the AQMA.

After model adjustment the area of exceedence of the annual mean objective is within the boundary of the existing AQMA. It is, therefore, concluded that the existing AQMA boundary for the NO_2 annual mean objective is appropriate and it is unlikely that the AQMA boundary will require amendment in the short to medium term. It is recommended that the AQMA should remain in its present form and monitoring should continue.

The predicted area of exceedence of the adjusted PM_{10} annual mean concentrations extends out with the existing AQMA boundary. It should be noted that adjustment of the PM_{10} modelling results were based on an adjustment factor calculated from the comparison from only one Kerbside monitoring site and therefore may now over estimate the annual mean concentrations at receptors located at both Roadside and Urban Background locations. The Council intend to carry out additional monitoring before making the decision whether to amend the existing AQMA boundary.

Source apportionment of both NOx and PM_{10} emissions at a number of locations within the AQMA has also been carried out and the results of this will feed into the Council's developing Action Plan. Analysis of the NO_x source apportionment information, including the emissions inventory, indicates that the group road traffic emissions are the largest contributor at locations close to and above the objective. On further analysis of the road traffic component it indicates that emissions from the Cars and from queuing of all vehicle classes contribute the largest proportions. A reduction in both the volume of traffic and queuing traffic within the AQMA would result in a decrease in NO_2 concentrations.

The analysis of the emissions inventory also indicates that the other major source of NOx appears to be from the commercial, domestic and institutional combustion sector. Therefore the Council should consider measures to address reduction of emissions from this sector in their Action Plan.

Analysis of the PM_{10} emissions inventory and source apportionment indicates that road traffic emissions is the largest contributor. Further analysis was undertaken of the road traffic emissions component and this indicated that emissions from cars, queuing and brake and tyre wear emissions from all vehicles appear to contribute the largest components. A reduction in both the volume of traffic and queuing traffic within the AQMA would result in a decrease in the concentrations of PM_{10}

Report Signature Page

GOLDER ASSOCIATES (UK) LTD

Jennifer Simpson
Air Quality Specialist

Bill Sheridan
Reviewer

JS/BS/te

Date: 4 November 2011

APPENDIX A

Model Adjustment and QA/QC

MODEL VERIFICATION AND ADJUSTMENT

Table 1: Comparison of Monitored NO_2 v's modelled NO_2

Site ID	Monitor type	Site Type	Background NO2 (µg/m³)	Monitored Total NO2 (µg/m³)	Modelled Total NO2 (µg/m³)	% Difference (modelled-monitored)/monitored NO2
Auto	Continuous	K	15.8	47.0	38.5	-18%
pdt 10	Diffusion Tube	R	15.8	35.6	29.3	-18%
pdt 9	Diffusion Tube	R	15.8	33.0	29.1	-12%

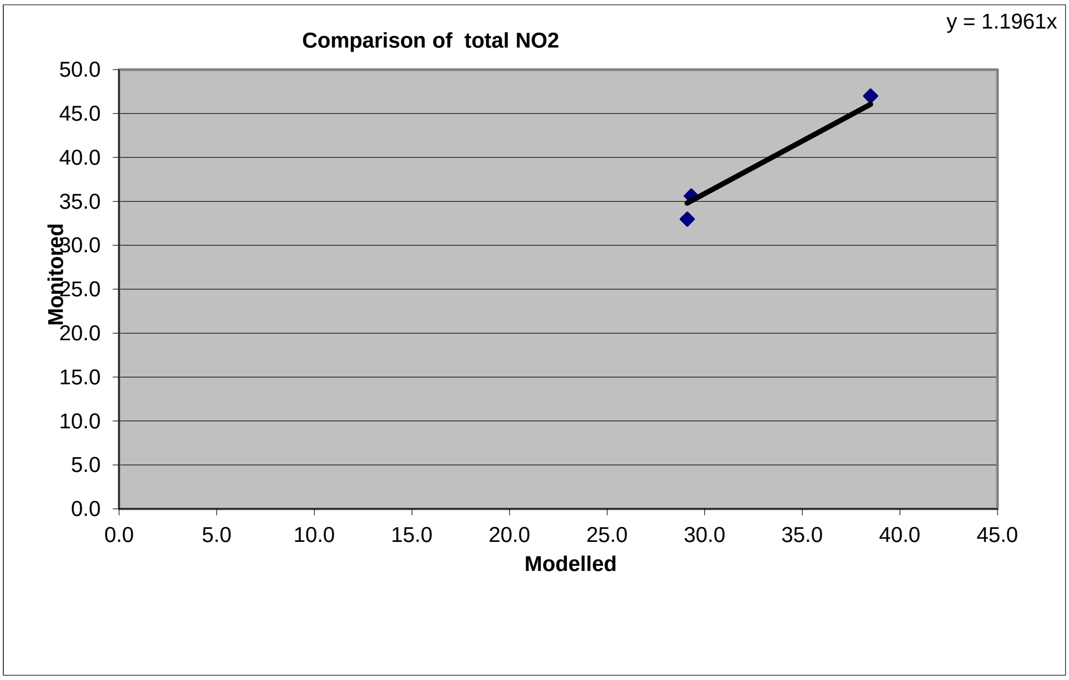


Table 2: Comparison of Monitored NOx v's modelled NOx

Site Id	Monitored NO2	Monitored total Nox (µg/m³)	Background NO2 (µg/m³)	Background NOx (µg/m³)	Monitored road NO2 (total - background) (µg/m³)	Modelled road contribution NOx (µg/m³)	Monitored road contribution NOx (total-background) (µg/m³)	Modelled road contribution NOx (excludes background) (µg/m³)
Auto	47.0	139	15.8	26.8	31.2	101.1	82.86	74.3
pdt 10	35.6	73.88	15.8	26.8	19.8	58.1	47.08	31.3
pdt 9	33.0	66.69	15.8	26.8	17.2	60.9	39.89	34.1

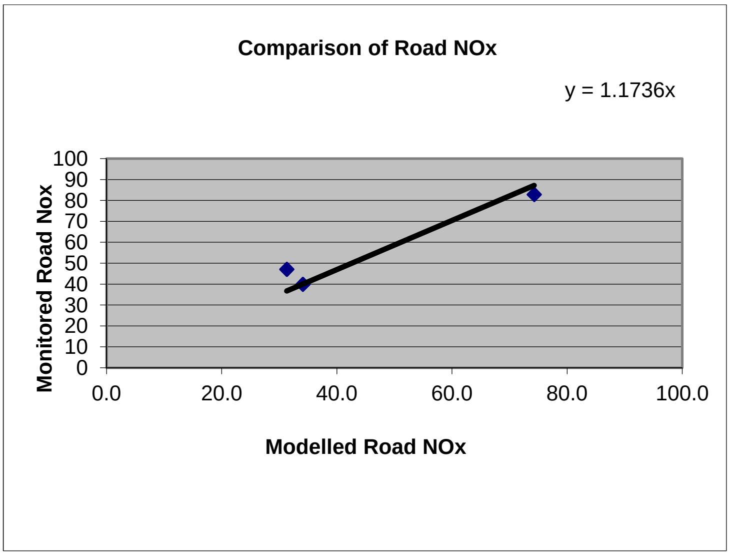
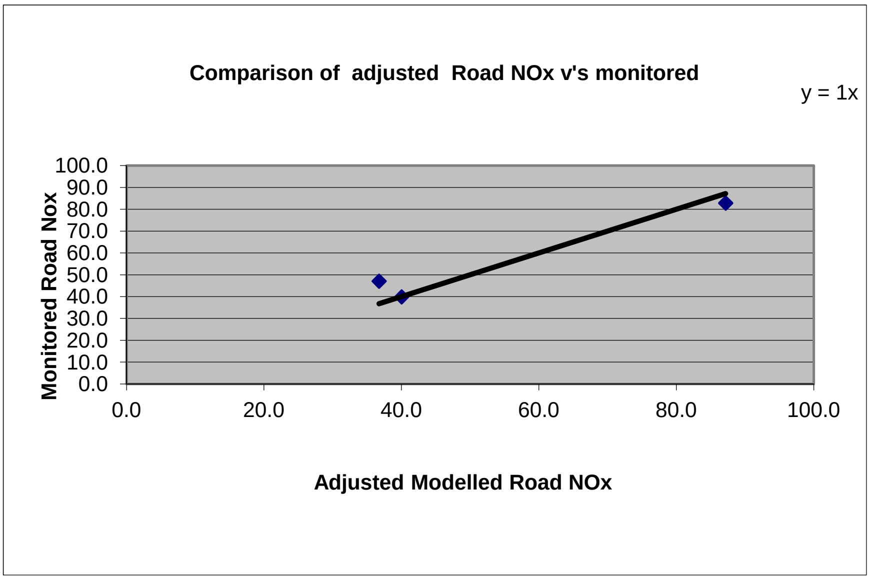
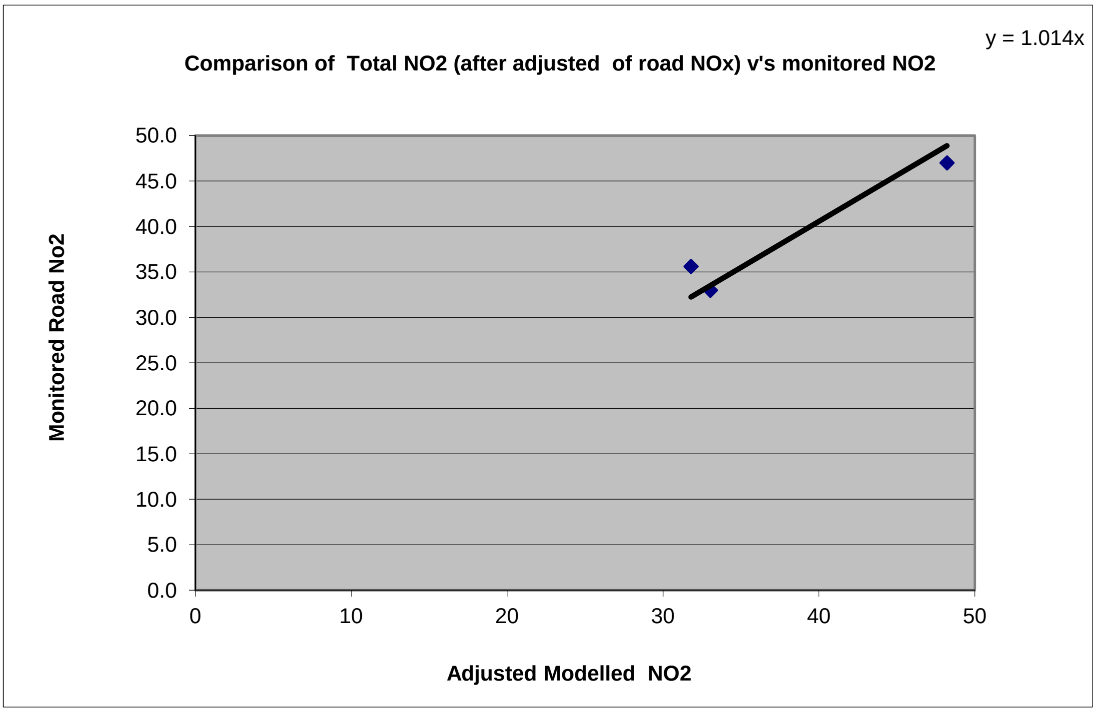


Table 3: Adjustment of Road NOx

Site Id	Ratio of monitored road Nox / modelled NOx	Adjustment factor	Adjusted modelled road contribution	Monitored road contribution Nox (total-background)	Adjusted modelled total Nox (inc background Nox)	Modelled total NO2(based on emperical NOX/NO2 relationship)	Monitored total NO2	% Difference [(modelled-monitored)/monitored]*100
Auto	1.116	**1.1736**	87.2	82.9	114.0	48.21	47.0	2.6%
pdt 10	1.504		36.7	47.1	63.5	31.79	35.6	-10.7%
pdt 9	1.170		40.0	39.9	66.8	33.03	33.0	0.1%





QA/QC

The laboratory analysis of the passive diffusion tubes used by the Council is undertaken by Glasgow Scientific Services. Glasgow Scientific Services is a UKAS accredited laboratory with documented Quality Assurance/Quality Control (QA/QC) procedures for diffusion tube analysis. The laboratory prepares the diffusion tubes using the 20% triethanolamine (TEA) in water method.

Glasgow Scientific Services public analyst participates in the AEA inter-comparison scheme, with bias correction factors calculated and applied annually. The laboratory analyses results from co-location studies at various locations.

The laboratory co-location factors are presented in Table A.1.

Site Name	Study duration	Tube precision	Bias correction factor
Marylebone Road Intercomparison	12	G	**1.10**
Glasgow City Council	9	P	**1.10**
Glasgow City Council	10	P	**0.97**
Glasgow City Council	12	P	**1.12**
Glasgow City Council	11	G	**1.20**
Overall factor from Glasgow Scientific Services co-location studies			**1.1**

Factor from Local Co-location Studies (if available)

The results for the three co-location studies carried out by East Dunbartonshire Council are presented in Table B2.

Site Name	Study duration	Tube precision	Bias correction Factor
Bearsden automatic analyser	11	Good	1.03
Bishopbriggs automatic analyser	10	Poor	0.8
Kirkintilloch automatic analyser	12	Good	1.09
Factor from Bearsden and Kirkintilloch co-location studies			1.06

Due to the Bishopbriggs having a poor precision it was felt more appropriate to only use the results of Bearsden and Kirkintilloch to calculate the local bias correction factor.

Discussion of Choice of Factor to Use

The Council have chosen to use the local bias adjustment factor. The laboratory bias adjustment factor is mainly made up of results from monitoring undertaken by Glasgow City Council. Three of the five co-location studies had poor precisions whilst both of the Council's studies showed good precision. It was felt that using the local adjustment factor would prevent any over-estimate of the NO_2 concentrations within the Council area.

PM Monitoring Adjustment

East Dunbartonshire Council monitor PM_{10} using three types of analyser:

- Beta-attenuation monitor (BAM);
- Tapered Element Oscillating Microbalance (TEOM) with a Filter Dynamics Measurement System(FDMS); and
- Partisol gravimetric analyser

The beta attenuation analysers are maintained by Horiba and undergo regular calibration. The TEOM (FDMS) is maintained by Air Monitors Ltd. The gravimetric analyser was provided by Casella ETI and the filters are analysed by Glasgow Scientific Services which is a UKAS accredited laboratory.

The beta-attenuation monitors (BAMs) used by East Dunbartonshire Council have a heated inlet which has been found to cause evaporation of some semi-volatile particles thereby reducing the measured PM_{10} concentration. All data have been provided ratified and gravimetric equivalent by AEA technology

The TEOM FDMS is equivalent to the European Reference Sampler and the results are therefore fully comparable to the AQS objectives, with no need for adjustment.

Short-term to Long-term Data adjustment

East Dunbartonshire Council has not undertaken any short-term monitoring of pollutants which require adjustment to calculate long-term mean concentrations.

QA/QC of automatic monitoring

Quality Assurance/Quality Control (QA/QC) audits are carried out by AEA Technology Ltd twice a year at all three sites.

FIGURES

LEGEND

Bearsden AQMA

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Project	Bearsden Further Assessment
Title	Bearsden AQMA Boundary
Created by	JS
Project Manager	BS
Reviewer	
Date	Oct 2011
File No.	XXXXX
Project No.	10514880048
Size	
Scale	
Status	Final Issue
Drawing No.	1

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LEGEND

Diffusion Tube Locations

Bearsden Automatic Monitor

Client	sustainable thriving achieving East Dunbartonshire Council www.eastdunbarton.gov.uk		
Project	Bearsden Further Assessment		
Title	Monitoring Locations		
Created by JS	Project Manager BS	Reviewer	Date Oct 2011
File No. XXXXX		Project No. 10514880048	
Size	Scale	Status Final Issue	
Drawing No. 2			

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Receptors

Modelled Domain

Client

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Project	Bearsden Further Assessment		
Title	Modelled Domain and Specified Receptors		
Created by JS	Project Manager BS	Reviewer	Date Oct 2011
File No. XXXXX		Project No. 10514880048	
Size	Scale	Status Final Issue	
Drawing No. 3			

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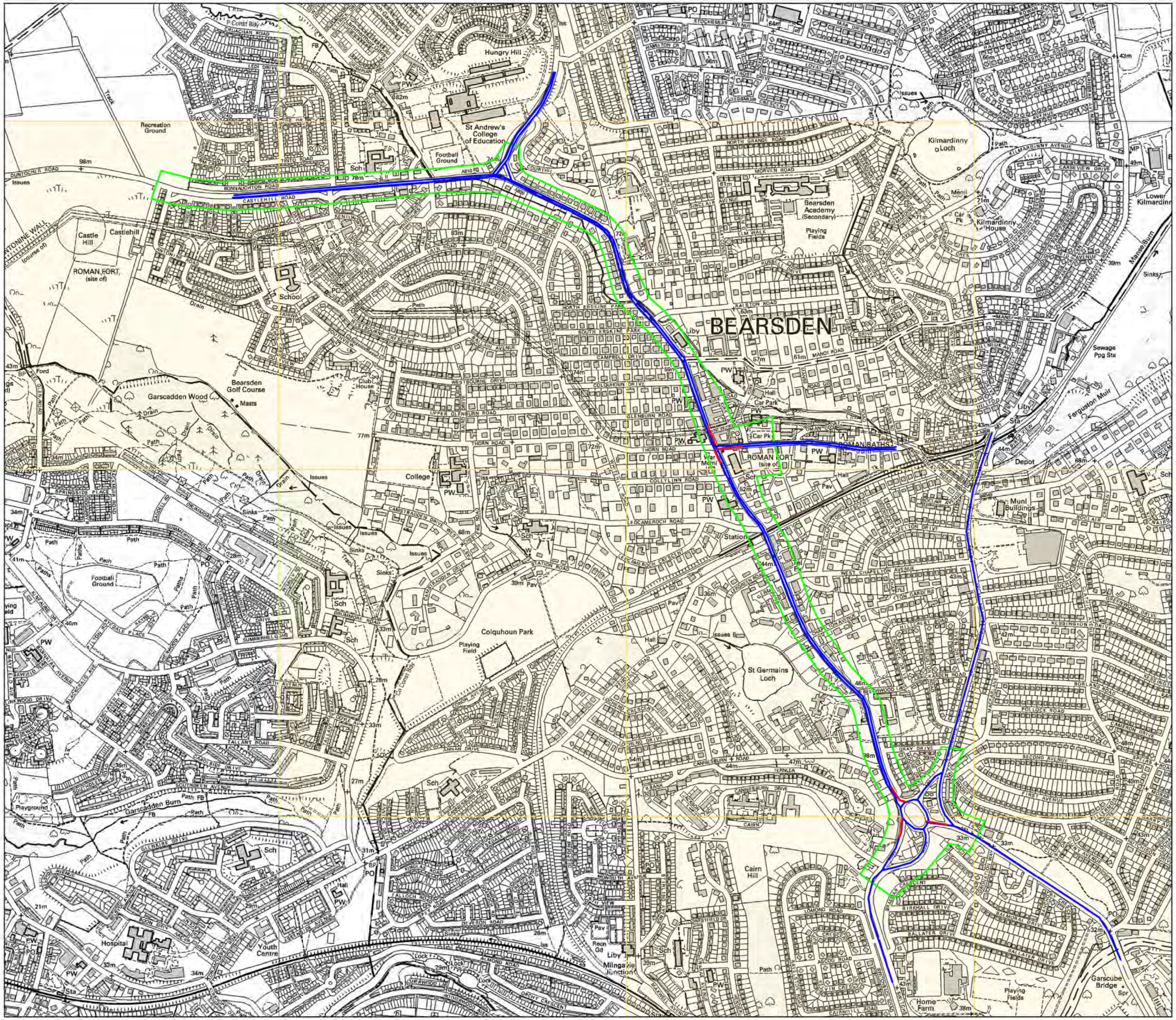

LEGEND

Queues

Modelled Roads

Bearsden AQMA

Volume Sources

Client

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Project
Bearsden
Further Assessment

Title
Modelled Roads and Volume Sources

Created by	Project Manager	Reviewer	Date
JS	BS		Oct 2011

File No.	Project No.
xxxxx	10514880048

Size	Scale	Status
		Final Issue

Drawing No.
4

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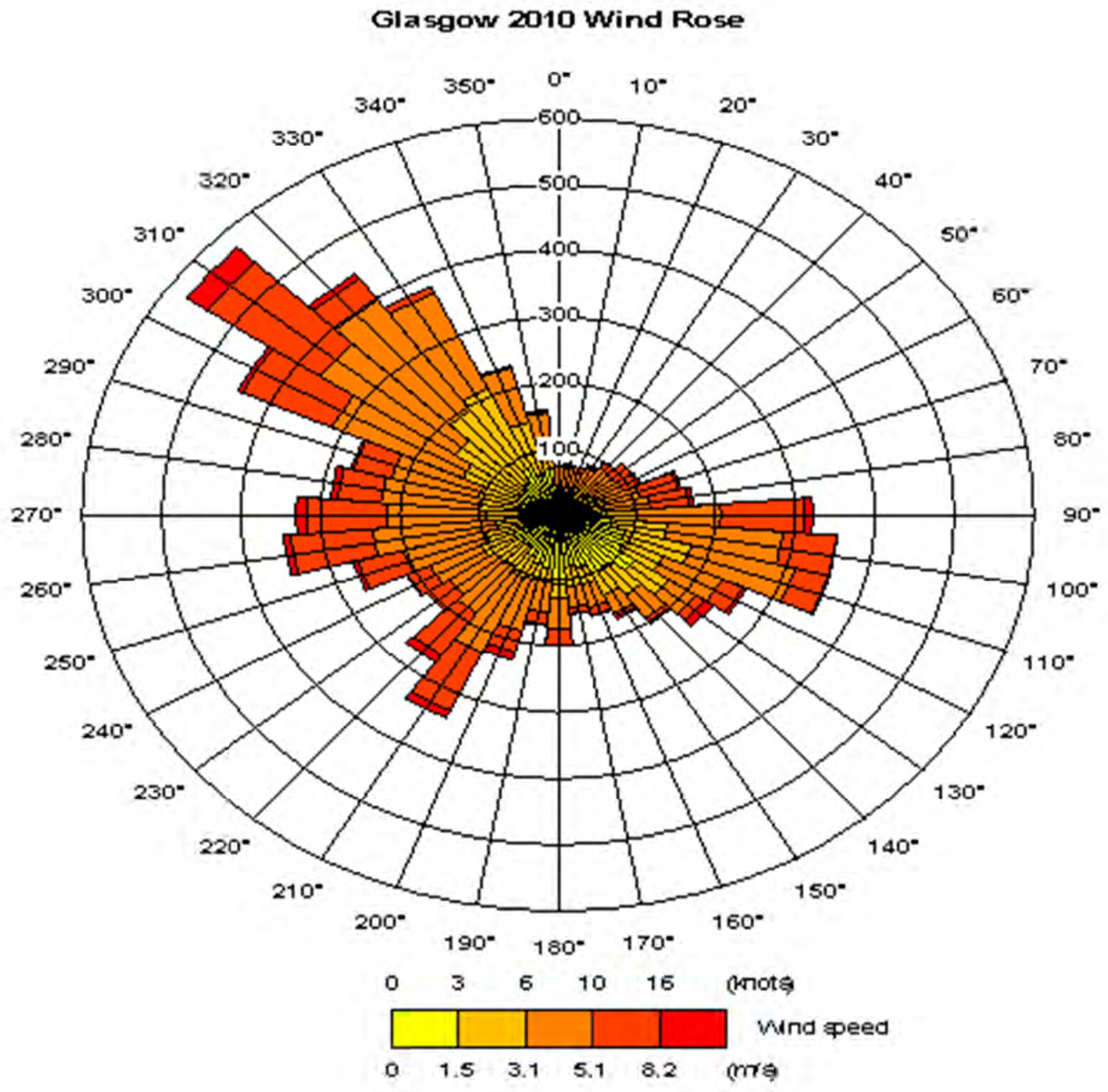

LEGEND

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Project: Bearsden Further Assessment

Title: Glasgow 2010 Windrose

Created by	JS	Project Manager	BS	Reviewer		Date	Oct 2011
File No.	XXXXX			Project No.	10514880048		
Size		Scale		Status	Final Issue		
Drawing No.	5						

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LEGEND

Receptors

Modelled Roads

Bearsden AQMA

Annual Mean NO2
ug/m3

- 64
- 50
- 42
- 40
- 38
- 25
- 17

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Project	Bearsden Further Assessment
Title	Predicted Annual Mean NO2 ug/m3
Created by: JS	Project Manager: BS
Reviewer: SMcG	Date: Oct 2011
File No.: xxxxx	Project No.: 10514880048
Size	Scale
Status	Final Issue
Drawing No.	6

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LEGEND

Specified Receptors

Modelled Roads

Annual Mean NO2
ug/m3

- 77
- 65
- 50
- 40
- 38
- 29
- 16

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Project	Bearsden Further Assessment		
Title	**Adjusted Annual Mean NO2 ug/m3**		
Created by: JS	Project Manager: BS	Reviewer: SMcG	Date: **Oct 2011**
File No.: xxxxx		Project No.: 10514880048	
Size	Scale	Status: Final Issue	
Drawing No.: 7			

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LEGEND

Bearsden AQMA

Specified Roads

Specified Receptors

Annual Mean PM10 ug/m3
ug/m3

- 27
- 24
- 22
- 18
- 17
- 15
- 13

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Project
Bearsden
Further Assessment

Title
Annual Mean PM10 ug/m3

Created by	Project Manager	Reviewer	Date
JS	BS		Oct 2011

File No.	Project No.
	10514880048

Size	Scale	Status
		Final Issue

Drawing No.
8

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LEGEND

Bearsden AQMA

Modelled Roads

Specified Receptors

Annual Mean PM10
ug/m3

- 36
- 32
- 28
- 20
- 18
- 17
- 13

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Project
Bearsden
Further Assessment

Title
Adjusted Annual Mean PM10 ug/m3

Created by	Project Manager	Reviewer	Date
JS	BS		Oct 2011

File No.	Project No. 10514880048
Size / Scale	Status: Final Issue
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