BMT Cordah Limited

ENVIRONMENTAL CONSULTANCY
AND INFORMATION SYSTEMS

Detailed Assessment of Road Traffic Particulate Emissions

A Report for Moray Council

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GLOSSARY

AADT	Annual Average Daily Traffic (Vehicles per Day)
AQMA	Air Quality Management Area
AUN	Automatic Urban (air quality monitoring) Network
AURN	Automatic Urban and Rural (air quality monitoring) Network
CO	Carbon monoxide
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges Screening Model (v1.0g)
EAL	Environmental Assessment Level
EFD (EFDB)	Emissions Factor Database
HDV	Heavy Duty Vehicles (Includes Rigid & Articulated HGVs, Buses and Coaches)
HGV	Heavy Goods Vehicles
LGV	Light Goods Vehicles
Minor Roads	Non- A roads or motorways
NAEI	National Atmospheric Emissions Inventory
NAQS	National Air Quality Strategy
NETCEN	National Environment Technology Centre (AEA Environmental Technology)
NO_2	Nitrogen dioxide
NRTF	National Road Traffic Forecasts
OS	Ordnance Survey
Percentile	The xth percentile is the value at which x percent of the time the measured or modelled pollutant concentration is less than the value.
ppb	parts per billion
ppm	parts per million
PM_{10}	Particulate matter with an (equivalent aerodynamic) diameter of ten microns (10µm) or less
$PM_{2.5}$	Particulate matter with an (equivalent aerodynamic) diameter of two and a half microns (2.5µm) or less
SEPA	Scottish Environment Protection Agency
SO_2	Sulphur dioxide
TEA	Triethanolamine
TEMPRO	Trip End Model PROjections of growth in travel demand, and the underlying car ownership and planning data projections
U&SA	Local Authority Air Quality Management Updating and Screening Assessment

Executive Summary

BMT Cordah has been commissioned by Moray Council to carry out a Detailed Assessment of fine particulates (PM_{10}) from road traffic emissions.

The aim of the study was to determine the risk of any exceedence of the National Air Quality Strategy (NAQS) objectives for PM_{10}, and to advise whether an Air Quality Management Area (AQMA) is required for PM_{10}. The assessment focused on Queen Street Roundabout in Elgin, where the 2003 Updating and Screening Assessment identified a risk of exceedence of the annual mean PM_{10} NAQS objective for 2010.

Monitoring of PM_{10} was carried out at Queen Street Roundabout in Elgin between 4th March and 2nd June 2005. The analyser was located on a traffic island to the east of the roundabout, approximately 5m from the nearest site of relevant public exposure. The period mean was 19.6µg/m^3 and the estimated annual mean for 2004 is 15.0µg/m^3. There was one 24 hour mean exceedence of 50µg/m^3 during the three month period.

Modelled traffic emissions for 2004 indicated that it is unlikely that there would be any exceedences of the 2004 annual mean and 24-hour mean objective for PM_{10}. The modelled traffic emissions for 2010 indicated that there would be no exceedences at relevant locations pf public exposure of the 2010 NAQS objective for PM_{10}. No exceedences of 24-hour mean objective for 2010 were predicted.

The Detailed Assessment of particulates from road traffic emissions concludes that Moray Council are not required to declare an AQMA. Moray Council will continue to follow the requirements of the LAQM framework and will therefore submit an Update and Screening Assessment to the Scottish Executive by 30th April 2006.

CONTENTS

Table Contents List

Figure Contents List

1 INTRODUCTION

BMT Cordah Limited has been commissioned by Moray Council to undertake a Detailed Assessment of road traffic particulate emissions at Queen Street Roundabout in Elgin.

The report aims to assess in greater detail the particulate emissions from road traffic at the Queen Street roundabout where the Updating and Screening Assessment (U&SA) (Reference 1) concluded that there was the potential for exceedence of the 2010 NAQS objective for particulates.

1.1 Review and Assessment Framework

The Environment Act 1995 and subsequent Regulations require local authorities to review and assess air quality in their area to assess compliance with the standards and objectives set out in the National Air Quality Strategy (NAQS) (Reference 2), the Air Quality Scotland Regulations 2000 (Reference 3) and Air Quality Scotland (Amendment) Regulations 2002 (Reference 4).

The framework of local air quality management (LAQM) requires a Review and Assessment of air quality by local authorities on a regular basis. The second round of the Review and Assessment commenced in 2003 and has two phases. The first stage is an U&SA. The U&SA considers any changes that have occurred since the first round of Review and Assessment that may affect air quality.

Where the U&SA identifies that there may be a risk of an exceedence of an air quality objective at a location with relevant public exposure then a Detailed Assessment must be undertaken. A Detailed Assessment will consider any risk of exceedence of an objective to greater depth in order to determine whether it is necessary to declare an air quality management area.

This report is the Detailed Assessment of PM_{10} within Moray and follows the methods set out in the LAQM.TG(03) technical guidance document (Reference 5).

The relevant NAQS objectives for this assessment are presented in Table 1.

Table 1: Relevant NAQS Objectives for PM_{10}

Objective	Concentration (µg/m^3)	Date to be Achieved
Annual mean not to exceed	40	31st December 2004
No more than 35 24-hour mean exceedences of: Or 90.4th percentile of 24-hour means not to exceed:	50	31st December 2004
Annual mean not to exceed	18	31st December 2010
No more than 7 24-hour mean exceedences of: Or 98th percentile of 24-hour means not to exceed:	50	31st December 2010

1.2 Summary of the Review and Assessment by Moray Council

The first round of the Review and Assessment was completed by Moray Council during 2000. It concluded that it was unlikely that there would be any breach of air quality objectives within Moray (Reference 6).

The Moray Council U&SA for the second round of review and assessment was completed in May 2003. The report concluded that it was not necessary to proceed to a detailed assessment for carbon monoxide (CO), benzene, 1, 3-butadiene, lead, nitrogen dioxide (NO_2) or sulphur dioxide (SO_2).

The U&SA included an assessment of road traffic emissions using the Design Manual for Roads and Bridges (DMRB) screening model (Reference 7). The screening model identified one busy junction, namely Queen Street Roundabout, as having the potential to exceed 2010 NAQS PM_{10} objective levels at locations of relevant public exposure. It was recommended that a Detailed Assessment of PM_{10} be carried out with respect to traffic emissions at the roundabout of Queen Street, Greyfairs Street, South College Street (A96) and Alexandra Road (A96).

1.3 Moray Council Area

The Moray Council area is situated in the north east of Scotland, south of the Moray Firth. The Council area is neighboured by Highland Council to the south and west, by the Moray Firth to the north, and by Aberdeenshire to the east.

Moray has a relatively low population density with approximately 86,940 people living in the area, a large proportion of whom live in Elgin.

The area varies topographically from estuarine waters in the north to mountainous areas in the south reaching altitudes greater than 800m above sea level. A large proportion of Moray is forested. The three most prominent rivers in the Moray area are the Rivers Spey, Lossie, and Findhorn. The Spynie Canal drains the lower part of Moray.

There are no motorways within the district although there are several major roads: A96, A95, A98, A920, A941, A940, and the A942. There is one mainline railway which operates in Moray. Several small ports and harbours are operational along the Moray Firth at Cullen, Portknockie, Buckie, Hopeman, Burghead, Lossiemouth, Findochty and Findhorn. No commercial airports are found within the Moray area but there are two RAF airfields in operation at Lossiemouth and Kinloss.

The traffic flows around Moray are generally low with a significant proportion of the traffic comprising farm vehicles and lorries. The main arterial route through Moray is the A96(T) which passes east west from Aberdeen to Inverness. The road comprises a single carriageway in either direction and passes through several of the larger towns in Moray Council including Elgin. Queen Street Roundabout is situated to the east of Elgin town centre on the A96(T). The roundabout is surrounded by residential properties to the north, east and south and by a supermarket car park to the west.

A map of the Moray area is included in Figure 1 of Appendix 1. The area of assessment is shown in Figure 2.

2 MONITORING DATA

Monitoring of PM_{10} was undertaken to provide an accurate measure of particulate concentrations at the site of potential exceedence. The monitoring data is also used to verify concentrations predicted in the modelling study of road traffic emissions.

2.1 Background Concentration

In addition to emissions from road traffic sources there will be other emission sources impacting on air quality at the roundabout considered including domestic, industrial and transboundary sources. To include for all these other pollutant sources when assessing the predicted pollutant concentrations against the NAQS objectives a background concentration is added to the model output concentrations. A background concentration for PM_{10} was obtained from the NETCEN background concentration maps (Reference 8).

NETCEN has mapped estimated annual mean background concentrations for primary PM_{10} concentrations during 2001, 2004 and 2010 and secondary PM_{10} concentrations for 2001. The factors provided in Box 8.7 of the LAQM.TG(03) technical guidance were used to calculate the secondary PM_{10} concentrations for 2004 and 2010.

The total background concentration is therefore predicted to be below 18µg/m^3 in both 2004 and 2010. The predicted background concentration is typical throughout the council area.

The background concentrations at the location of the Queen Street Roundabout in Elgin are calculated as an average of the PM_{10} concentrations for the grid squares surrounding those containing the Queen Street Roundabout. The background concentration is not taken from the grid square containing the Queen Street Roundabout as this concentration will contain contributions from road traffic on the roundabout and therefore result in duplication of emissions if added to the traffic emissions calculated using the model. A background concentration derived from grid squares surrounding the Queen Street Roundabout accounts for all other local sources of PM_{10} including traffic emissions from minor roads in the vicinity of the junction. The assumed background concentrations for PM_{10} are summarised in Table 2.

Table 2: Background PM_{10} concentrations for Queen Street Roundabout, Elgin

Averaging Period	Concentration (µg/m^3)
Annual mean PM_{10} concentration for 2004	13.4
Annual mean PM_{10} concentration for 2010	12.8

2.2 Moray Council Monitoring Data

Following the results of the U&SA Moray Council installed a partisol monitor close to the Queen Street roundabout between the east and west bound carriageways of the A96(T). The partisol was set up on the traffic island to the east of the roundabout at National Grid reference (NJ 22058 62847), where the electrical supply was provided by a spur from a mains cable installed for the purpose. The location of the monitor represents a worst case scenario as it is situated on a traffic island and not at the nearest sensitive receptor.

The location of the PM_{10} monitor is shown in Figure 2 in Appendix 1. The partisol filters were prepared and analysed by a UKAS accredited laboratory. Monitoring commenced in March 2005 and it was agreed with SEPA and the Scottish Executive that an initial period of monitoring would be conducted over three months to provide an indication of PM_{10} concentrations.

2.3 Particulate Monitoring Results

Ideally, monitoring would have been carried out over the period of a year, although a shorter period may be sufficient to demonstrate that the risk of an exceedence of the objectives is negligible. It is possible to estimate the annual mean concentration by introducing suitable adjustment to the period mean concentration of PM_{10}. The adjustment assumes that patterns in pollutant concentrations usually affect a wide region. The annual mean concentration has therefore been estimated using the techniques contained within LAQM.TG(03) technical guidance. The method for the projection is summarised in Equation 1.

To obtain an estimate of the average annual concentration for 2004 in Elgin, data from the two nearest long term monitoring sites, Inverness and Aberdeen, was analysed. Ideally the period mean to annual mean factor would be calculated from a nearby site. There is considerable distance between Aberdeen and Inverness and the Elgin monitoring location (approximately 60km and 30km respectively). However, the data from both can be assumed to be typical of an urban background location within north Scotland where there is an absence of industrial PM_{10} emissions. An average period mean to annual mean ratio was calculated using monitoring data from Inverness and Aberdeen and is presented in Table 3.

Table 3: Inverness and Aberdeen measured PM_{10} concentrations (µg/m^3)

Long term site	2004 Annual mean (Am)	Period mean (4^{th} Mar- 31^{st} May) (Pm)	Ratio (Am/Pm)
Aberdeen	19	21.6	0.88
Inverness	15	20.8	0.65
		Average (Ra)	**0.77**

The best estimate for the annual mean for the site in 2004 is given by the following:

Equation 1

Annual mean for 2004 = period mean x Average (Ra)

= 19.6 x 0.77

= 15.0µg/m^3

The annual average concentration is below the NAQS 2004 objective concentration of 40ug/m^3. The estimated annual mean concentration does not exceed the 2010 annual mean objective level of 18µg/m^3. It is expected that the improvements in emission reduction techniques and motor efficiencies will result in an improvement in local air quality. The annual mean concentration has been projected forward to 2010 using the techniques contained within LAQM.TG(03) technical guidance. The factors supplied in the LAQM.TG(03) technical guidance are:

- for converting the 2001 secondary PM_{10} concentration to 2004 secondary PM_{10}: **0.932**
- for converting the 2001 secondary PM_{10} concentration to 2010 secondary PM_{10}: **0.795**
- for converting the 2001 primary PM_{10} concentration to 2004 primary PM_{10}: **0.954**
- for converting the 2001 primary PM_{10} concentration to 2010 primary PM_{10}: **0.795**

The method used for the projection is summarised in Equation 2.

Equation 2	
Monitored Annual mean concentration in 2004	= 15.0 µg/m^3
Secondary Concentration 2001 (form maps)	= 2.85 µg/m^3
Coarse PM_{10} fraction (from LAQM.TG(03))	= 10.5 µg/m^3
Secondary Concentration 2004	= 2.85 µg/m^3 x 0.932 = 2.66µg/m^3
Secondary Concentration in 2010	= 2.85 x 0.795 = 2.27 µg/m^3
Primary concentration in 2004	= 15.0 – 10.5 – 2.66 = 1.84 µg/m^3
Primary Concentration in 2010	= 1.84 x (0.795/0.954) = 1.53 µg/m^3
Total PM_{10} concentration in 2010	= 1.53 + 2.27 + 10.5 = 14.30 µg/m^3

The total projected PM_{10} concentration in 2010 is not therefore predicted to exceed the 2010 annual mean NAQS objective of 18µg/m^3.

One exceedence of the 24-hour mean objective of 50µg/m^3 was recorded in the 3 month period from 4th March 2005 to 2nd June 2005. The exceedence of the 24-hour mean objective occurred during a dry period in which it was noted that sand and soil dust from nearby agricultural and coastal land was re-suspended due to strong winds. This is often the case in Moray where there is a large amount of coastal and agricultural dust evident in the atmosphere during dry spells, particularly during late spring and summer.

Thirty-five exceedences of the 24-hour mean objective are permitted by the NAQS objectives in 2004 but only seven exceedences are permitted in 2010. The number of 24-hour mean exceedences of 50µg/m^3 recorded during the 3-month monitoring period does not exceed the 2004 or 2010 24-hour mean objectives.

The number of exceedences of the 24-hour mean objective cannot be directly projected forward to future years. However, the LAQM.TG(03) technical guidance provides a method for estimating the number of 24-hour exceedences of 50µg/m^3 based on the annual mean. The method used for the projection is summarised in Equation 3.

Equation 3

No. of Exceedences = -18.5 + 0.00145 * (annual mean)^3 + (206 / annual mean)

For 2004
No. of exceedences = -18.5 + 0.00145 * 15.0^3 + (206 /15.0)
= -18.5 + 5.40 + 13.29
= 0.1 exceedences
For 2010
No. of exceedences = -18.5 + 0.00145 * 14.3^3 + (206 /14.3)
= -18.5 + 4.61 + 14.01
= 0.1 exceedences

The number of exceedences of the 24-hour mean objective of 50µg/m^3 estimated for 2004 and 2010 at Elgin is less than one. This is below the respective thirty five and seven permitted exceedences within a year for 2004 and 2010. It is therefore predicted that the 24-hour mean PM_{10} objective for 2010 will not be exceeded at Queen Street Roundabout, Elgin. A summary of predicted PM_{10} Concentrations is presented in Table 4 and the daily mean concentrations between 4th March and 2nd June 2005 are shown in Figure 5.

Table 4: Monitoring Results for Queen Street Roundabout

Period mean concentration (µg/m^3)	Predicted annual mean concentration for 2004 (µg/m^3)	Projected annual mean concentration for 2010 (µg/m^3)	Number of 24-hour mean exceedences of 50µg/m^3 during monitoring period	Predicted Number of 24-hour mean exceedences of 50µg/m^3 in 2004	Predicted Number of 24-hour mean exceedences of 50µg/m^3 in 2010
19.6	15.0	14.3	1	<1	< 1

3 MODELLING ASSESSMENT OF ROAD TRAFFIC EMISSIONS

Moray Council's U&SA identified the potential for exceedence of the 2010 NAQS objectives for PM_{10} at one location as a result of road traffic emissions. The exceedences were identified through DMRB assessment of road traffic emissions and local monitoring data. In order to ascertain the extent of any potential exceedence and to predict future PM_{10} concentrations a dispersion modelling study was undertaken on road traffic emissions at the road junction.

The modelling study considered two emission scenarios for the road junction:

- base year emissions based on measured 2004 traffic flows for comparison with local monitoring data using both 2002 and 2003 meteorological data to provide a sensitivity analysis; and

- traffic emissions for 2010 based on projected traffic flows and future emissions factors using the worst case scenario meteorological data.

A description of the model used is provided in Section 3.1 whilst the data input to the model is discussed in Sections 3.3 to 3.7. The results of the modelling study and model verification procedures are discussed in Section 4.

3.1 Model Description

The modelling study utilised ADMS Roads, an advanced Gaussian dispersion model which is approved for use in Detailed Assessments. The model has been subject to extensive validation and inter-model comparison studies.

References to the validation studies and other technical details of the dispersion model are reported on the developer's website and user guide (Reference 9).

3.2 Area Description

Dispersion modelling was undertaken on road traffic emissions at one junction:

- Junction of Queen Street, Greyfriars Street, South College Street (A96), Alexandra Road (A96).

The road junction incorporates four roads and a roundabout. To the north and south of the roundabout lie residential areas. A school is also located 50m south west of the roundabout. To the east of the junction along the A96 there are several industrial and retail areas including the Tyock, Linkwood and Chanonry industrial estates. Cooper Park is a larger open space adjoining the River Lossie and is located to the north west of the junction along Alexandra Road. The main town centre of Elgin is located to the south west and west of the Queen Street Roundabout and contains a mixture of residential, commercial and office buildings. The location of the modelled roundabout junction is presented in Figure 2 in Appendix 1.

3.3 Review of Topographical Data

The ADMS suite of models has an in-built module for the assessment of local terrain on pollutant dispersion. A gradient rise of 1 in 10 metres would normally be necessary to cause significant changes in flow field and hence influence dispersion of emissions.

Local topographical contour data derived from OS 1:50,000 scale map data provided by Moray Council allowed a basic analysis of gradients to be carried out. The area of assessment had a gradient of less than 1 in 10. It was therefore concluded that the of terrain modelling would not be required as the effect of local topography would be insignificant in comparison to other influences such as traffic count data, vehicle emissions data, surface roughness and meteorological parameters.

3.4 Review of Local Meteorological Data

A review of available and suitable meteorological data was undertaken to determine the most suitable data for use in the modelling study. The nearest meteorological station to Elgin recording a full suite of meteorological parameters is the meteorological station at RAF Kinloss. The site at Kinloss is located 2km from the coast of the Moray Firth and 15km west of Elgin. Elgin is situated 8km from the coast on a flat coastal plain with mountainous and forested areas to the south similar to the RAF Kinloss meteorological station. The meteorological data from RAF Kinloss is therefore representative of the meteorological conditions found at the road junction in Elgin.

The meteorological dataset for Kinloss include all the meteorological parameters required by the model comprising hourly sequential recordings of surface temperature, precipitation, wind speed, wind direction, relative humidity and cloud cover. Meteorological data for both 2002 and 2003 was used in the modelling study as the most recently available data.

A wind rose for each year's data is provided in Figures 3 and 4. Dispersion modelling was undertaken for each year of meteorological data and the worst case year used for modelling future concentrations. The prevailing wind direction is typically south-westerly with a typical wind speed of 3-5 m/s for both 2002 and 2003.

Modelling runs were conducted for 2004 base line traffic flows for each year of meteorological data available to identify the year which would produce the highest pollutant concentrations. Modelling runs for 2010 were undertaken using the meteorological year producing the highest pollutant concentrations to present the worst case scenario.

Further advanced meteorological parameters used in the model are detailed in Appendix 2.

3.5 Surface Roughness

A surface roughness length is used in the dispersion modelling study to characterise the land use of the surrounding area in terms of the frictional effect that will occur due to the interaction of the wind with the surface. This is a key component in the generation of atmospheric turbulence, which influences dispersion.

The road junction assessed in the dispersion modelling study is within a small urbanised area on flat terrain. An area of parkland is located 200m to the north west of the junction with dispersed industrial buildings located to the east of the junction along the A96(T). An appropriate surface roughness length for open suburbia, parkland and industrial land uses of 0.5m was therefore applied in the model.

3.6 Traffic Flow Data

The road traffic flow data for the Queen Street Roundabout was from a week long traffic count commissioned by the Council for the assessed roads during June 2004.

The traffic flows on four roads approaching the roundabout under consideration were obtained through a series of automatic traffic counts. The base year for assessment was set at 2004.

The automatic counts were undertaken using sensors known as traffic loops which are laid across the roads. The traffic loop consists of two rubber tubes stretched parallel across each lane of the road which are attached to sensors on an electronic logger. As vehicles pass over the sensors the pressure of the vehicle tyres generates a pulse of air that travels along the tube to the kerbside receiver. The receiver registers the pulse and 'counts' the vehicle. In addition to counting the vehicle the receiver can determine traffic speed by the speed at which the air pulse is received and can determine the vehicle type by the time delay from the pulse received as the front tyres pass over the sensors until the pulse is received from the rear tyres passing over the sensors. The pressure on the sensors required to generate the air pulses means that the counters have to be placed on stretches of road with free-flowing traffic. In areas of congested, and therefore slow moving, traffic the pressure air pulses generated by the sensors will be weak and slow moving. The sensors may not properly register the vehicles in this situation.

The automatic counters were *in situ* for a full week during school term time. The data obtained can therefore be used to determine the annual average daily traffic flow (AADT) and the diurnal variation in flow. The week over which the traffic flow is measured is assumed to be a 'typical week' and therefore the average hourly traffic flow over the week is assumed to be equivalent of an AADT flow. Due to the one week duration of the traffic count no seasonal variation in traffic flow was determined. The vehicle count was split into five categories, these were: cars; light goods vehicles (LGVs); heavy goods vehicles (HGVs); buses and motorcycles.

Loops were laid across each road approaching the Queen Street Roundabout junction. The loops had to be placed away from the junction due to the slow traffic speed close to the junction. An estimation of traffic speed closer to the junction was therefore made based on local knowledge.

3.6.1 Variations to the Annual Average Daily Traffic (AADT) Flow

In addition to the AADT flow the model allows the insertion of a diurnal variation factor. The diurnal variation factor allows the model to assess peak hour traffic flows and emissions in order to evaluate the predicted ground level concentrations against hourly air quality objectives. The diurnal variation of traffic flow is calculated for weekdays, Saturdays and Sundays. A diurnal flow variation was calculated for the roundabout by the averaging the diurnal variation available for each contributing road at the roundabout. The diurnal variation factors are used to represent the changes in traffic flow throughout the day within the model. The factors are calculated as the ratio between the proportion of traffic in a particular hour compared to the average hourly traffic flow. The diurnal variation factors are summarised in Table 5.

Table 5: Diurnal Variation in Traffic Flow for Queen Street Roundabout

Hour	Average Saturday Factor	Average Sunday Factor	Average Weekday Factor
1	0.35	0.24	0.10
2	0.34	0.18	0.05
3	0.09	0.13	0.03
4	0.06	0.11	0.04
5	0.03	0.04	0.07
6	0.06	0.04	0.14
7	0.18	0.11	0.45
8	0.52	0.28	1.10
9	0.86	0.28	2.30
10	1.32	0.54	1.65
11	1.81	0.92	1.66
12	2.23	1.06	1.88
13	2.00	1.47	1.94
14	1.92	1.29	2.08
15	2.04	1.51	2.34
16	2.01	1.42	2.31
17	1.66	1.41	2.02
18	1.58	1.16	1.82
19	1.21	1.09	1.34
20	1.05	0.82	1.14
21	0.66	0.68	0.85
22	0.61	0.61	0.67
23	0.43	0.34	0.40
24	0.38	0.15	0.23

3.6.2 Vehicle Flow Composition

The measured traffic flow on each road is broken down into five vehicle categories. These are:

- cars;
- light goods vehicles (LGVs);
- heavy goods vehicles (HGVs);
- buses; and
- motorcycles.

The model requires simply an hourly average traffic flow for two vehicle categories: Heavy duty vehicles (HDVs) including all HGVs, buses and coaches; and LGVs, which includes all LGVs, cars and motorcycles.

3.6.3 Traffic Speed

Traffic speed data were available for the roads from the automatic monitoring stations as speeds recorded at each of the roads approaching the roundabout at times of peak am and pm traffic flow.

Consideration was given to the speed of vehicles slowing on approach to the roundabout and an increase in speed leaving the roundabout.

The average traffic speeds on each section of the road included within the modelling study are displayed in Table 6.

3.6.4 Road widths and Canyon Heights

The road widths used in the modelling study were estimated from OS 1:10,000 map data and a site visit from BMT Cordah staff.

The roads attached to the roundabout were assessed for potential street canyon effects. A street canyon is generally defined as a street where the height of the lowest building is higher than the distance between the buildings on either side of the road. The nature of the suburban residential buildings along assessed routes means that no roads were identified as potential street canyons.

The road widths included in the study are summarised in Table 6.

3.6.5 Traffic Growth

Predicted traffic growth was not available as a regional estimate therefore the central National Traffic Growth factors were used to estimate traffic growth between 2004 and 2010 (Reference 10). The central National growth estimate for total traffic of 1.095 was applied to each traffic flow for 2004 to estimate traffic flows for 2010. The projected flows for 2010 are shown in Table 6.

3.6.6 Emissions Factors

The ADMS Roads model has an in-built database of traffic emissions factors. The modelling study utilised the DMRB emission factor dataset for 2003. The dataset is consistent with the emission factor toolkit dataset discussed in LAQM.TG(03) technical guidance. The emission factors provide an average pollutant emission rate per vehicle type, at a set speed for the distance travelled. The model automatically calculates a linear emission for the stretch of road based on the traffic flow data input.

The model has inbuilt fleet sub-categories of composition based on the DMRB 2003 categories. The sub-categories are determined by engine type and emissions. For the initial model runs the traffic flow input to the model was determined as a total flow of cars/LGVs and HGVs/buses. The allowed the emissions to be calculated based on DMRB Urban 2003 vehicle composition emission factors

Emission factor datasets are available for future years including 2010. Predictive modelling was undertaken for 2010 utilising this dataset and future traffic flow data.

Table 6: Road Traffic Data used in Modelling Study

Road Section	Average Speed (km/hr)		Vehicle Count 2004		Projected Vehicle Flow 2010		Road Width (m)
	LGV	HGV	LGV	HGV	LGV	HGV	
Alexandra East 1	20	20	336	13	336	13	5
Alexandra West 1	25	25	410	14	410	14	5
Alexandra West 2	35	35	410	14	410	14	4
Alexandra East 2	40	40	336	13	336	13	4
Greyfriars North-East 1	20	20	170	3	170	3	5
Greyfriars South-West 1	25	25	147	1	147	1	5
Greyfriars North-East 2	35	35	170	3	170	3	4
Greyfriars South-West 2	40	40	147	1	147	1	4
Queen Street North 1	15	15	17	0	17	0	3
Queen Street South 1	20	20	21	0	21	0	3
Queen Street North 2	25	25	17	0	17	0	3
Queen Street South 2	25	25	21	0	21	0	3
South College East 1	25	25	336	17	336	17	5
South College West 1	20	20	340	16	340	16	5
South College East 2	45	45	336	17	336	17	4
South College West 2	45	45	340	16	340	16	4
Queen Street Roundabout	20	20	444	16	444	16	5

3.6.7 Output Parameters

The model output is specified as a grid of predicted concentrations. The model calculation grid covers a 4km^2 area encompassing the roundabout and surroundings. The calculation grid was set to a resolution of 25m with regular spacing. The grid covered the area from 321000 323000 east west and 861850 to 863850 north south.

The model also has the capability to model concentrations for specified points identified as sensitive receptors. The closest sensitive receptors to the junction considered in the modelling assessment include residential, school and office properties. Model runs were therefore undertaken to predict pollutant concentrations at sensitive receptors at ground level where relevant public exposure could occur. The sensitive receptors identified for the modelling assessment are presented in Table 7 and illustrated in Figure 6.

Table 7: Location of Sensitive Receptors

Sensitive Receptor	Easting	Northing	Distance from centre of roundabout (m)	Distance from nearest assessed road (m)
Supermarket, High Street	321902	862844	130	70
House on junction A96 north	322038	862886	30	2
Church, Greyfriars Road	321941	862759	130	3
Offices / tenements, High Street	321966	862863	70	20
School, Institution Street	322170	862863	220	110
Museum, North College Street	321917	862686	120	30
School, Abbey Street	321930	862869	190	80
Monitoring Site	322015	862875	20	0
House, Queen Street south of junction	322027	862820	30	2
House South College Street, east of junction	322112	862836	80	2

4 MODELLING RESULTS

The model predicted ground level PM_{10} concentrations for the base year, namely 2004 and for 2010 for comparison with the NAQS objectives.

The modelling predictions were verified against local monitoring data where possible. The model verification procedures are discussed in Section 4.2 whilst the predicted pollutant concentrations are discussed in Sections 4.3 and 4.4.

4.1 Meteorological Analysis

The sensitivity analysis for meteorological parameters features meteorological data for 2002 and 2003. The base year traffic flows for 2004 were modelled for each year of meteorological year for future model runs. Results of the meteorological analysis are shown in Table 8.

Table 8: Modelled Traffic Emissions Comparison for 2002 and 2003 Meteorological Data

NAQS Objective	2002 Concentration (µg/m^3)	2003 Concentration (µg/m^3)	Percentage Difference (%)
Maximum PM_{10} Annual Mean	0.76	0.81	6.0%
Maximum PM_{10} 90.4th Percentile of 24-hour means	1.52	1.54	4.1%
Maximum PM_{10} 98th Percentile of 24-hour means	2.26	2.35	1.5%

The difference between the maximum predicted pollutant concentrations for each year was less than 6.0%. The majority of highest pollutant concentrations were predicted to occur using 2002 meteorological data. The highest pollutant concentrations represent the worst case scenarios and so the 2002 meteorological data was used for future predictions for 2010.

4.2 Model Verification

Dispersion modelling studies include a number of uncertainties notwithstanding model input. The ADMS roads model has been extensively validated by the developers of CERC over a number of scenarios. These validation studies are discussed and referenced in the ADMS manual and CERC website (Reference 9).

The main uncertainty in modelling studies is often the model input data. In this study the road traffic flow and subsequent emissions and the influence if meteorology will have significant effect on the predicted ground level concentrations.

In order to verify the ground level concentrations predicted by the model comparisons was made between the modelled predictions and available PM_{10} monitoring data. Verification of the model is shown in Table 9.

Table 9: Modelled versus Monitored Annual Mean PM_{10} Concentrations for 2004

Period	Monitored Concentration (µg/m^3)	Modelled Concentration (µg/m^3)	Background Concentration (µg/m^3)	Total Modelled Concentration (µg/m^3)	Percentage Difference (%)
Annual mean	15.0	0.7	13.4	14.1	-6

The performance of the model against monitoring data is good (<10% difference). The model under-predicted the annual mean at the partisol analyser by 6%, however as there is only one monitoring site from which comparisons can made no correction factor has been applied to the model predictions.

4.3 Predicted Modelling Results

The maximum PM_{10} concentrations predicted by the model at the roundabout is presented in Table 10. The results include the respective annual mean concentrations for NAQS objective years and short term concentrations comparable with the NAQS objectives. No adjustment of predicted concentrations has been made as a result of the model verification.

The concentration contours for PM_{10} provide a pictorial representation of the extent of peak pollutant concentrations with respect to areas of relevant public exposure. Concentration plots are provided for comparison with NAQS objectives in Figures 7 to 10.

Table 10: Maximum Predicted Pollutant Concentrations for Queen Street Roundabout Elgin

Criteria	Year	Maximum Predicted Concentration (µg/m^3)	Background Concentration (µg/m^3)	Total Concentration (µg/m^3)
Annual Mean	2004	0.8	13.4	14.2
	2010	0.5	12.8	13.3
90.4th Percentile of Hourly Means	2004	1.5	13.4	14.9
98th Percentile of Hourly Means	2010	1.4	12.8	14.2

4.4 Sensitive Receptors

There are a number of sensitive receptors in the area surrounding the road junction under consideration in this modelling study. The ground level concentrations at nearby sensitive receptors have been predicted by the model and the results are displayed in Table 11.

Table 11: Predicted PM_{10} Concentrations at Sensitive Receptors (µg/m^3)

Sensitive Receptor	2004 annual mean concentration	90.4th percentile of 24-hour mean concentration 2004	2010 annual mean concentration	98th percentile of 24-hour mean concentration 2010
Supermarket, High Street	13.5	13.5	12.8	13.0
House on junction A96 north	13.9	14.3	13.1	13.7
Church, Greyfriars Road	13.5	13.6	12.8	13.0
Offices / tenements, High Street	13.6	13.8	12.9	13.1
School, Institution Street	13.4	13.5	12.8	12.9
Museum, North College Street	13.5	13.7	12.9	13.0
School, Abbey Street	13.4	13.5	12.8	12.9
Monitoring Site	14.1	14.7	13.2	13.9
House, Queen Street south of junction	13.6	14.0	13.0	13.3
House South College Street, east of junction	13.8	14.2	13.1	13.5

In analysing the results of the dispersion modelling assessment the predicted ground level concentrations have been categorised into terms of likelihood of potential exceedence of the NAQS objectives. The categories are defined by pollutant bandings and their definitions for predicted PM_{10} concentrations which are represented in Table 12. The likelihood of exceedence has been adapted from the method given in the LAQM.TG(03) technical guidance to reflect the specific scenarios and the model used by BMT Cordah Ltd.

Table 12: Predicted Ground level PM_{10} Concentration Categories

Category	Predicted Annual Mean PM_{10} Concentration (µg/m^3) for 2004 (2010)	Definition
Unlikely	< 36 (<16)	Low ground level concentration predicted. Exceedence of NAQS annual mean objective for PM_{10} unlikely.
Possible	36 – 40 (16 – 18)	Predicted PM_{10} ground level concentrations below NAQS annual mean objective but within 10%. Some potential for Exceedence therefore exists.
Probable	40 – 44 (18 – 20)	Predicted PM_{10} ground level concentrations above NAQS annual mean objective by up to 10%. It is considered likely that the NAQS objective will be exceeded.
Likely	> 44 (>20)	Predicted PM_{10} ground level concentrations above NAQS annual mean objective by greater than 10%. It is considered very likely that the NAQS objective will be exceeded.

The analysis of the potential for PM_{10} exceedences has been carried out using the above classification.

Model predictions indicated that there were no exceedences of the 2004 annual mean or 24-hour mean objectives in the area surrounding the junction under consideration in this modelling study.

The model predicted that it is unlikely that there will be any exceedences of the 2010 annual mean NAQS objectives and all predicted PM_{10} concentrations around the Queen Street Roundabout were below 16 $\mu g/m^3$.

5 CONCLUSIONS

Moray Council conducted monitoring of PM_{10} at Queen Street Roundabout in Elgin, between 4th March and 2nd June 2005 using a partisol analyser. The measured concentration mean was 19.6 µg/m^3 and there was one exceedence of the 24 hour mean objective of 50 µg/m^3. Due to the short period of monitoring, data from nearby PM_{10} analysers was used to estimate a representative annual mean concentration using techniques detailed in the LAQM.TG(03) technical guidance. The estimated annual mean PM_{10} concentration at Queen Street roundabout for 2004 was 15.0 µg/m^3 and the estimated annual mean PM_{10} concentration at Queen Street roundabout for 2010 was 14.3 µg/m^3.

A traffic survey was conducted at the Queen Street Roundabout during July 2004, results of which were used to model the traffic emissions at the junction using the ADMS ROADS model. The model predicted that PM_{10} concentrations would not exceed the PM_{10} annual mean or 24-hour mean objectives in 2010.

The analysis of the PM_{10} concentrations predicted by the model showed a good model performance compared to monitored results showing a 6% difference between modelled and monitored concentrations. It is therefore considered unlikely that the annual mean or 24-hour mean PM_{10} objectives will be excceded at Queen Street Roundabout in Elgin in 2010.

The Detailed Assessment of particulates from road traffic emissions concludes that Moray Council are not required to declare an AQMA. Moray Council will continue to follow the requirements of the LAQM framework and will therefore submit an Update and Screening Assessment to the Scottish Executive by 30th April 2006.

6 REFERENCES

Reference 1	Moray Council Air Quality Updating and Screening Assessment 2003. BMT Cordah Limited report no: MOR.005, May 2003.
	Moray Council Supplementary Report to the Air Quality Updating and Screening Assessment 2003. BMT Cordah Limited report no: MOR.008, January 2004.
Reference 2	National Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2000
Reference 3	The Air Quality (Scotland) Regulations 2000 SSI No. 97, HMSO, March 2000
Reference 4	The Air Quality (Scotland) Amendment Regulations 2002 SSI No 297, HMSO, June 2002
Reference 5	Part IV of the Environmental Act 1995 Local Air Quality Management, Technical Guidance, LAQM.TG(03), DEFRA, 2003,
Reference 6	First Stage Review and Assessment, BMT Cordah Limited report no: MOR.001, 2000
	Supplementary Air Quality Report, First Stage Review and Assessment, BMT Cordah Limited report no: MOR.002, 2000
Reference 7	Design Manual for Roads and Bridges, Volume 11, Section 3 Part 1, Air Quality Supplement1, Stationery Office, 2000, DMRB Assessment v.1.02 (November 2003)
Reference 8	The Air Quality Archive, Background Concentration Maps, AEA Technology, National Emissions Technology Centre NETCEN website: www.airquality.co.uk/archive/laqm/tools
Reference 9	CERC, ADMS-Roads An Air Quality Management System, User Guide Version 2.0, July 2003
Reference 10	Transport Statistics Bulletin, Road Traffic Statistics for Great Britain: 2002, Statistics Report SB (03)26, Department for Transport, July 2003

APPENDIX 1: FIGURES

Moray Council
Detailed Assessment of Particulates

Figure 1: Moray Council Area and locations of Queens Street Roundabout, Elgin and Kinloss Meteorological Station

0 10 Kilometers

Legend

- Queen Street Roundabout
- Kinloss Met Station
- Moray Council Boundary

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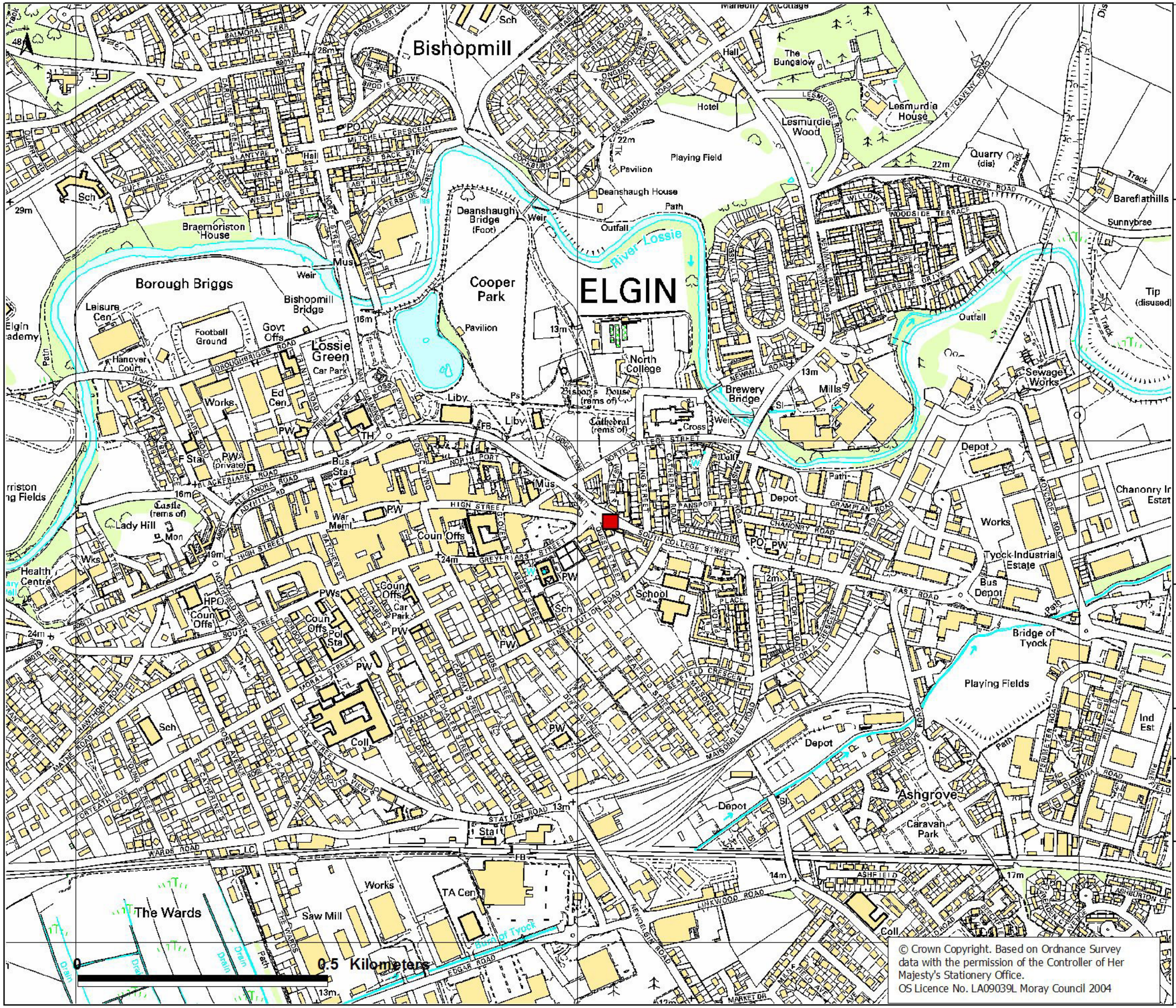

Client:

Moray Council

Project Title:

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Project Number:

MOR-009

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Partisol Monitoring Location

Drawing Title:

Figure 2: Location of Partisol Analyser at Queen Street Roundabout

Drawing Ref: MOR.009/Figure2

Drawing By:	REC	29/06/2005
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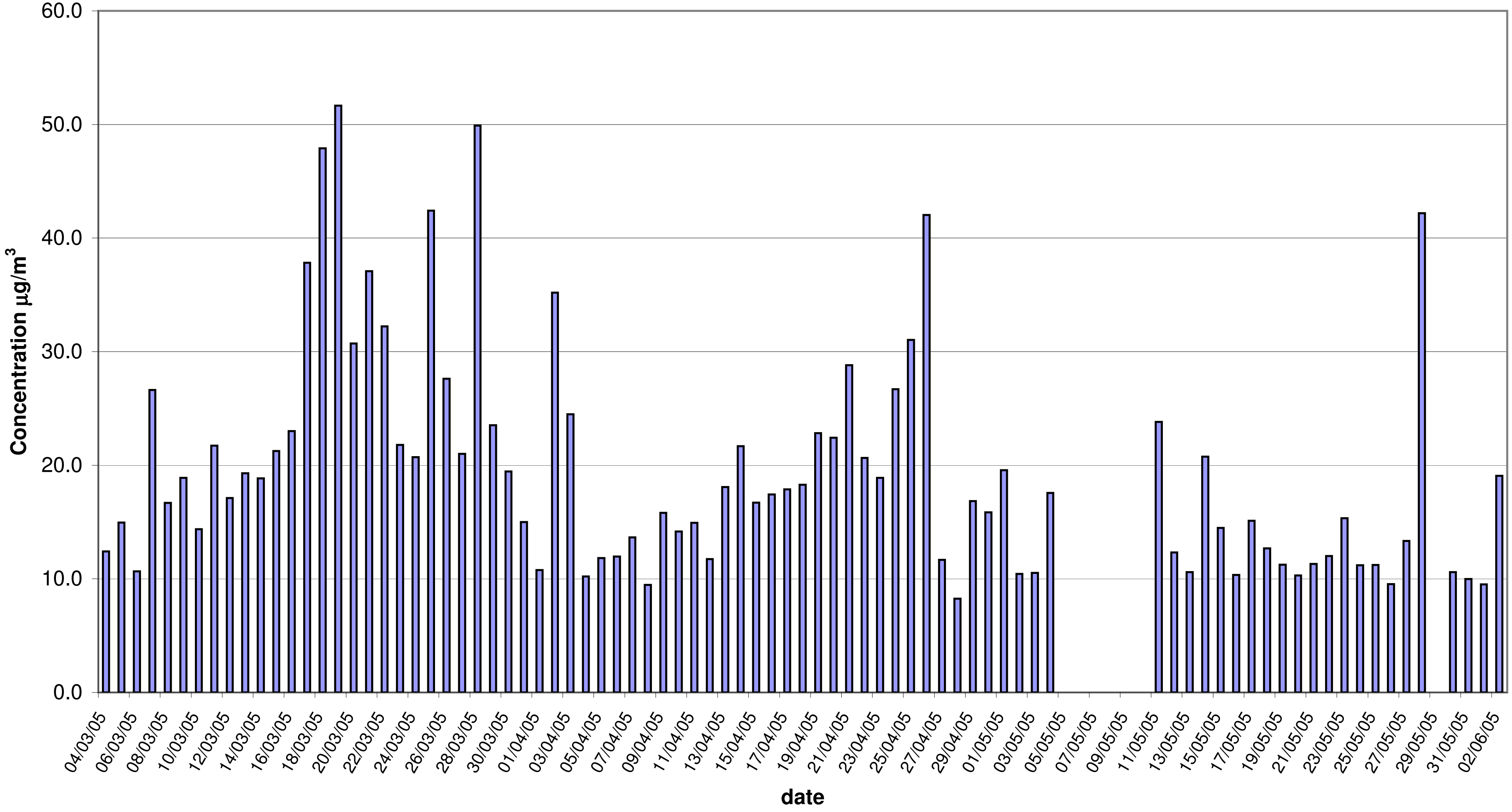
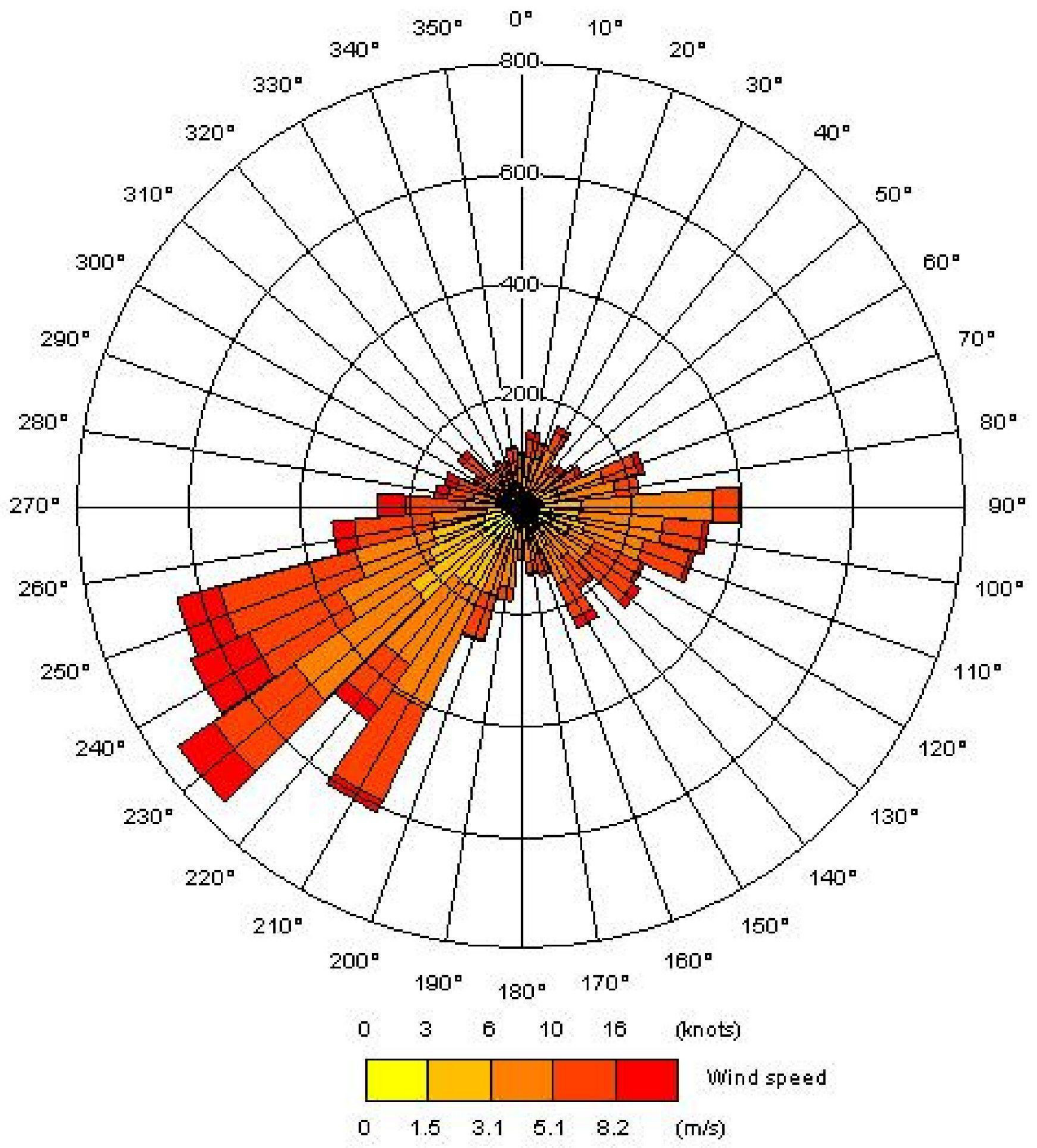
Figure 3: Daily Mean PM_{10} Concentrations at Queens Street Roundabout, Elgin





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Drawing Title:

Figure 4: 2002 wind rose for Kinloss

Drawing Ref: MOR.009/Figure 4

Drawing By:	REC	12/10/2004
Authorised By:	DS	12/10/2004

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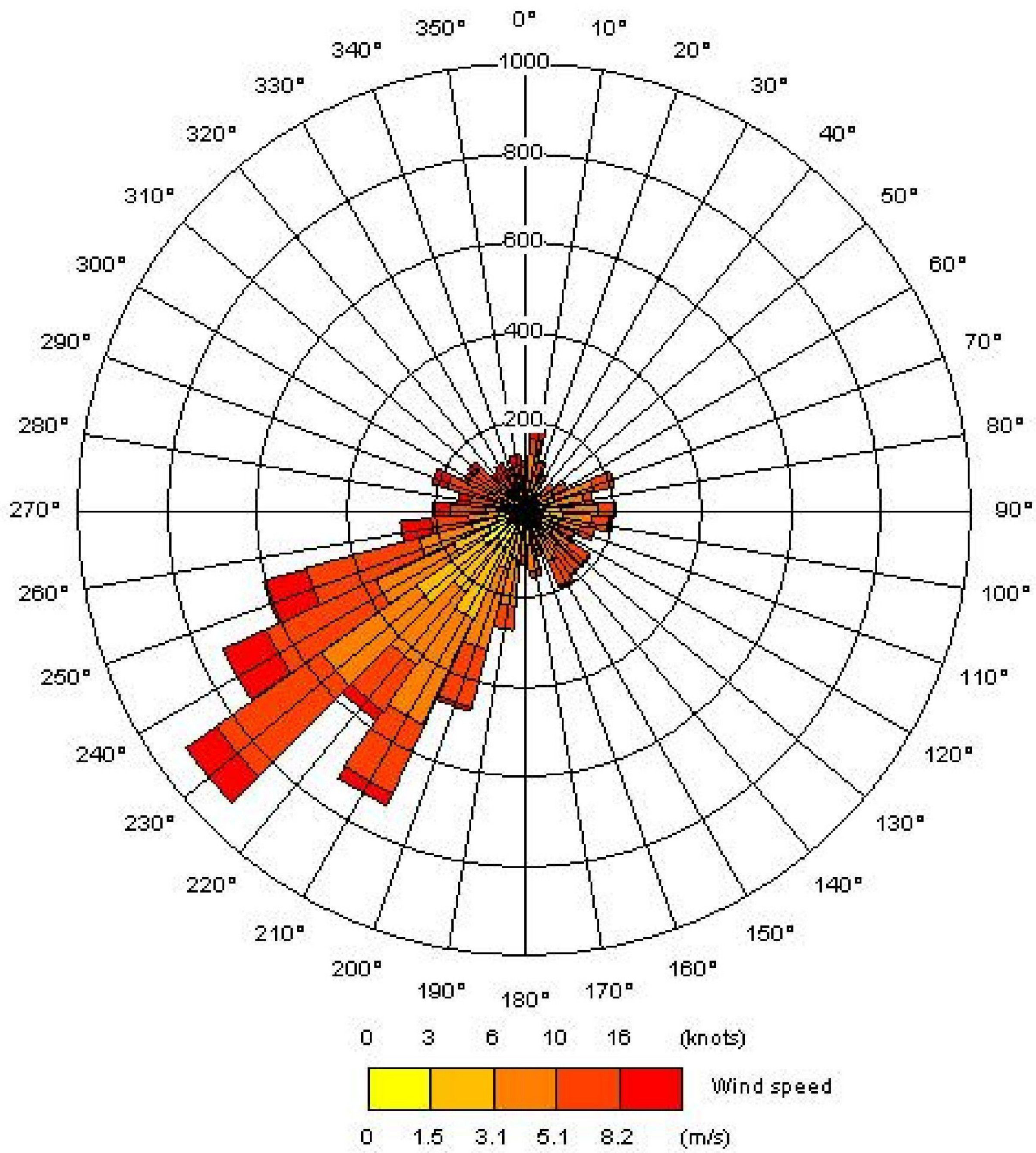

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Project Title:

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Project Number:

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Drawing Title:

Figure 5: 2003 wind rose for Kinloss

Drawing Ref: MOR.009/Figure5

Drawing By:	REC	12/10/2004
Authorised By:	DS	12/10/2004

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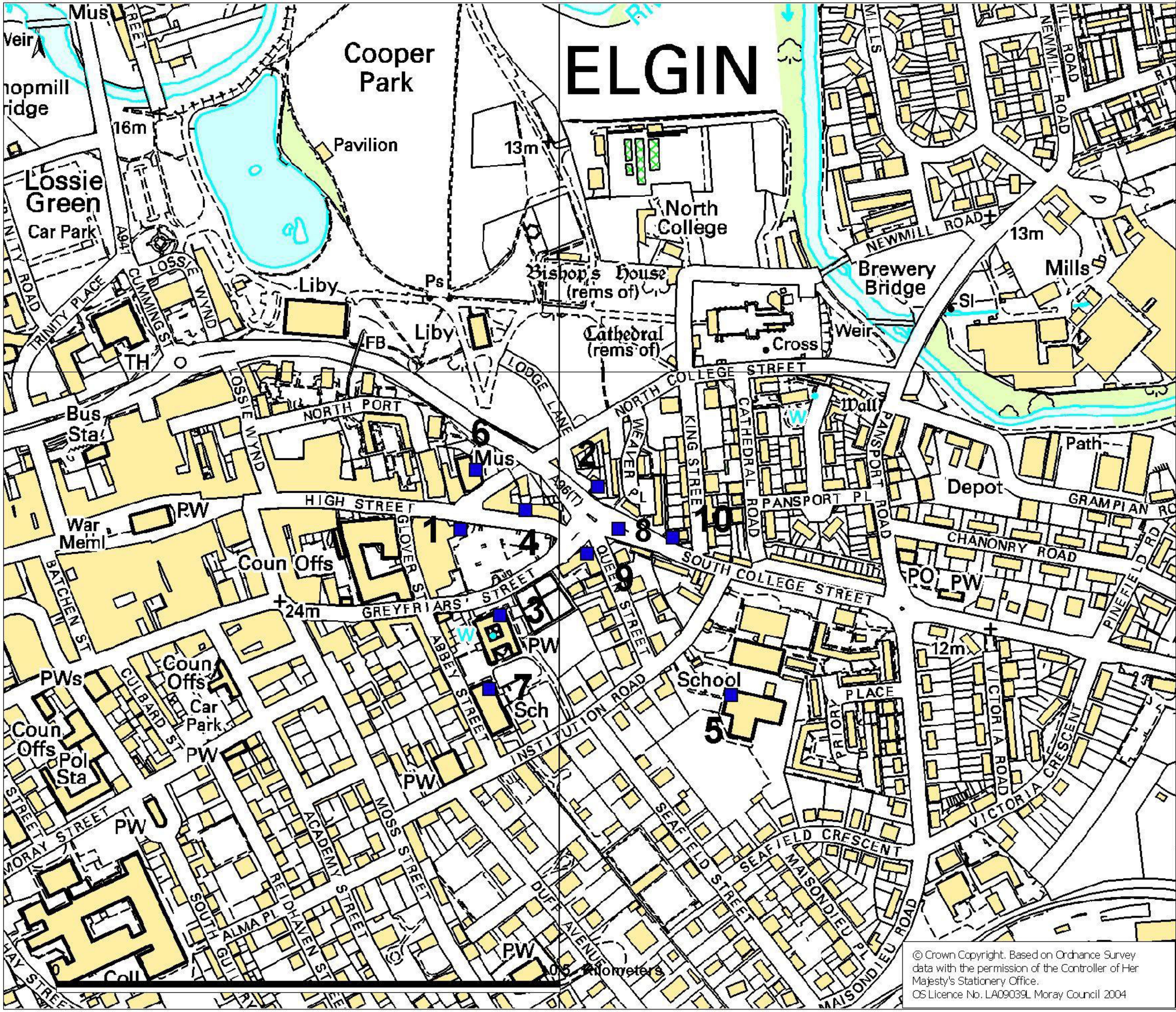

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Legend

Sensitive Receptors

1. Supermarket
2. House north of RBT
3. Church, Greyfriars Rd
4. Tennements, High St
5. School, Institution St
6. Museum, N. College St
7. School, Abbey Rd
8. Monitoring Site
9. House, south of RBT
10. House, S. College St

Drawing Title:

Figure6: Location of sensitive receptors at Queen Street Roundabout

Drawing Ref: MOR.009/Figure6

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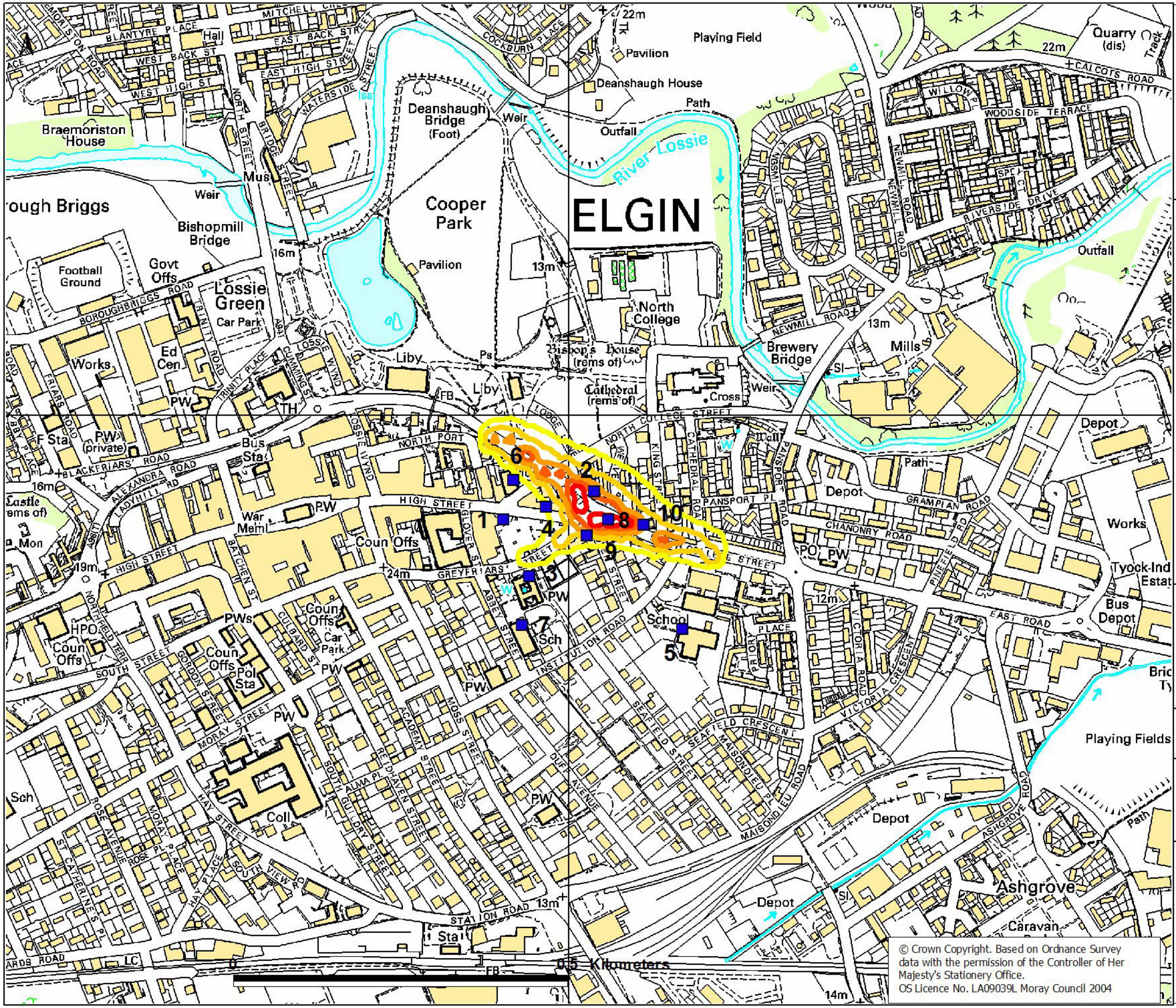

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Sensitive Receptors

Annual Mean PM10 concentration for 2004 (ug/m³)

13.55
13.65
13.8
13.9
14.05

1. Supermarket
2. House north of RBT
3. Church, Greyfriars Rd
4. Tennements, High St
5. School, Institution St
6. Museum, N. College St
7. School, Abbey Rd
8. Monitoring Site
9. House, south of RBT
10. House, S. College St

Drawing Title:

Figure 7: Predicted annual mean PM10 concentrations for 2004

Drawing Ref: MOR.009/Figure7

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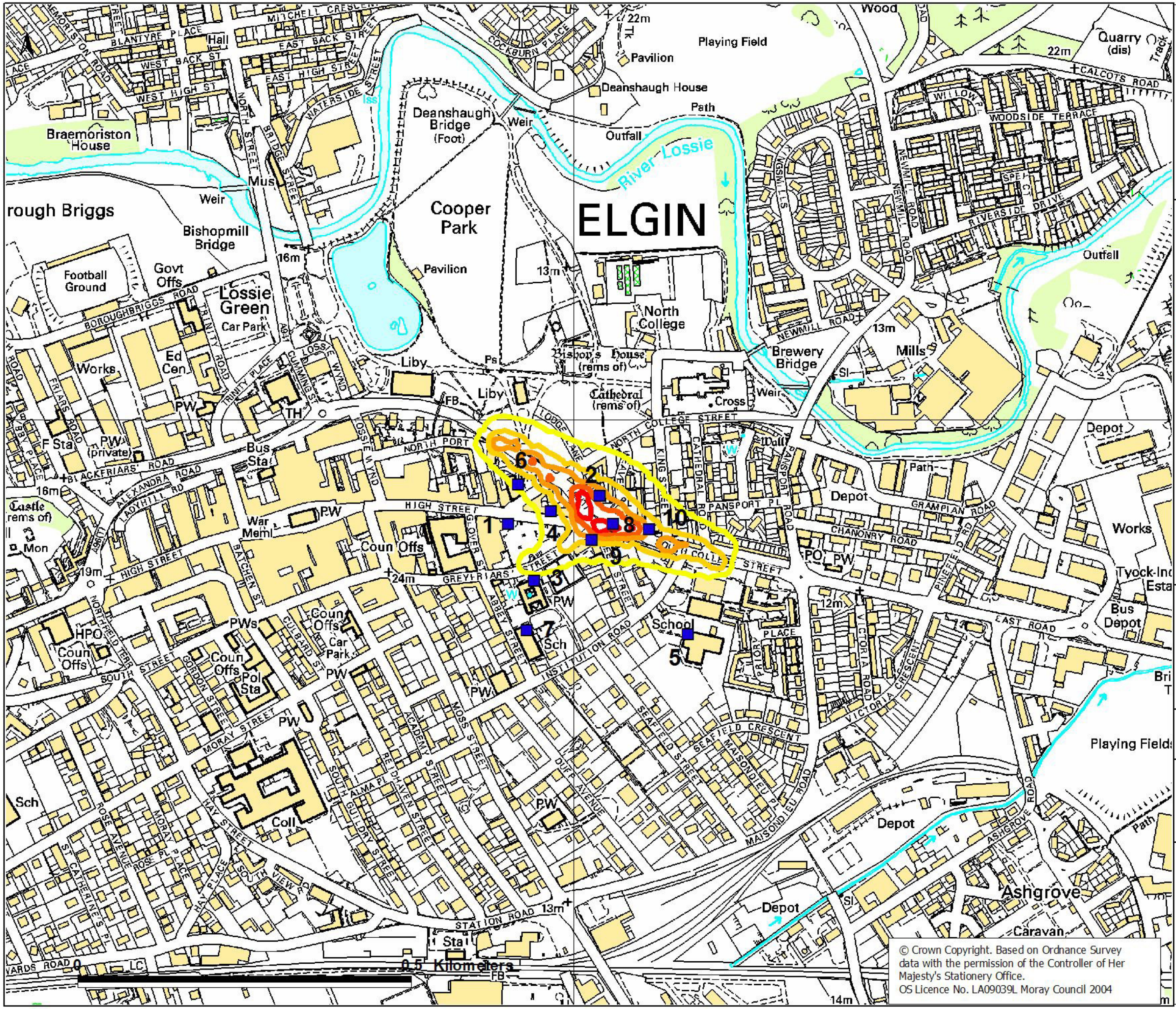

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Legend

Sensitive Receptors

90.4th percentile of 24-hour mean PM10 concentrations (ug/m³)

13.65
13.9
14.15
14.4
14.65

1. Supermarket
2. House north of RBT
3. Church, Greyfriars Rd
4. Tennements, High St
5. School, Institution St
6. Museum, N. College St
7. School, Abbey Rd
8. Monitoring Site
9. House, south of RBT
10. House, S. College St

Drawing Title:

Figure 8: Predicted 90.4th percentile of 24-hour mean PM10 concentrations for 2004

Drawing Ref: MOR.009/Figure8

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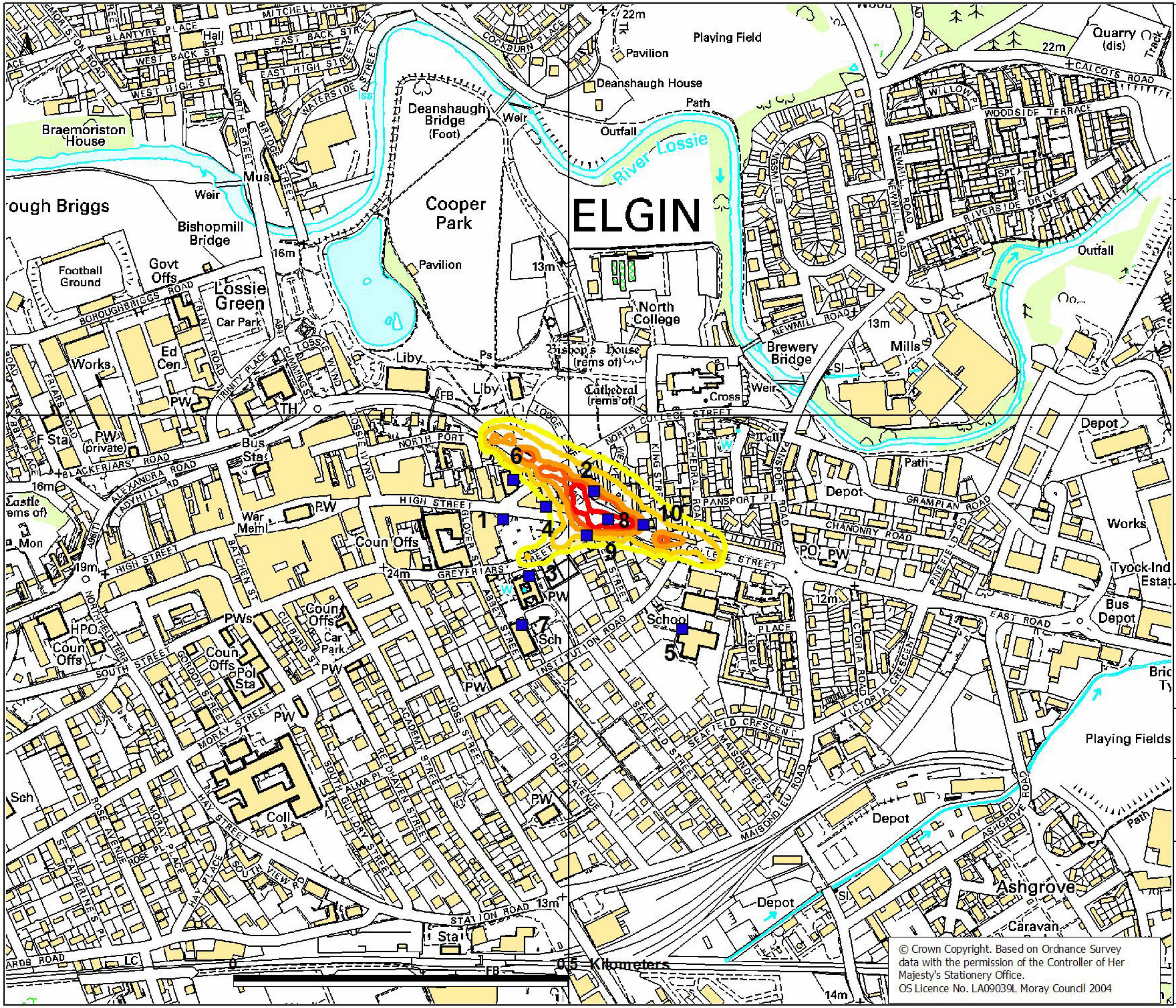

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Project Number:

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Sensitive Receptors

Annual Mean PM10 concentrations for 2010 (ug/m³)

12.9
12.95
13.05
13.1
13.2

1. Supermarket
2. House north of RBT
3. Church, Greyfriars Rd
4. Tennements, High St
5. School, Institution St
6. Museum, N. College St
7. School, Abbey Rd
8. Monitoring Site
9. House, south of RBT
10. House, S. College St

Drawing Title:

Figure 9: Predicted annual mean PM10 concentrations for 2010

Drawing Ref: MOR.009/Figure9

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Sensitive Receptors

98th percentile of 24-hour mean PM10 concentrations (ug/m³)

- 13.05
- 13.3
- 13.55
- 13.8
- 14.0

1. Supermarket
2. House north of RBT
3. Church, Greyfriars Rd
4. Tennements, High St
5. School, Institution St
6. Museum, N. College St
7. School, Abbey Rd
8. Monitoring Site
9. House, south of RBT
10. House, S. College St

Drawing Title:

Figure 10: Predicted 98th percentile of 24-hour mean PM10 concentrations for 2010

Drawing Ref: MOR.009/Figure10

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APPENDIX 2: MODEL PARAMETERS

Advanced meteorological settings

The Monin-Obukhov length provides a measure of the atmospheric stability being modelled. For unstable conditions the Monin-Obukhov length is negative and represents the height at which convective turbulence is more important than mechanical turbulence caused by friction at the earth's surface. For stable conditions the Monin-Obukhov length is positive and represents the height above which vertical turbulent motion is inhibited by the stable stratification of the atmosphere. For small towns and rural areas a typical monin-Obukhov length would be 10m, for industrial, mixed urban and larger towns a typical length would be 30m. Due to the mixture of land uses (industrial, parkland and residential) within the assessment area a Monin-Obukhov length of 30m was used in the model.