

Calculation of Projected Roadside NO₂ Concentrations in Northern Ireland

A report produced for Department of the Environment
Transport and the Regions, The Scottish Executive,
The National Assembly for Wales and Department of
Environment for Northern Ireland

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Introduction

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS, 2000) sets air quality objectives for a total of eight pollutants and specifies a date by which certain concentrations should not be exceeded. Analysis of both current and projected concentrations indicates that the annual mean objective for nitrogen dioxide (NO₂) not to exceed 40 µgm⁻³ by the end 2005 is one of the most stringent objectives. Road traffic is currently the dominant source of NO₂ in most locations and an examination of annual mean NO₂ concentrations at the roadside is therefore a valuable indicator of the impact of traffic on air pollutant concentrations.

National modelling of roadside NO₂ concentrations in 2005 has been presented in the AQS (2000) for a scenario that included the impact of current national and international policies. The results indicated that about 10% of built-up major road links in the UK could be at risk of exceeding 40 µgm⁻³ at the end 2005. The first EC Air Quality Daughter Directive also sets an annual mean limit value of 40µgm⁻³, to be achieved by 1 January 2010. The analysis presented in the AQS indicated that NO₂ concentrations are expected to be even lower by 2010, with only about 2% of built-up major roads at risk of exceeding 40µgm⁻³. This analysis was based on air emission maps calculated for 1996. New estimates of roadside NO₂ concentrations in Northern Ireland have been calculated for this current study based on maps of air emissions for 1998, which incorporate significant improvements in the use of digital map data.

New transport emissions methodology

A new method for mapping road transport emissions has been developed for the 1997 and 1998 emissions maps. New maps of road links have been obtained and new traffic count data has been included.

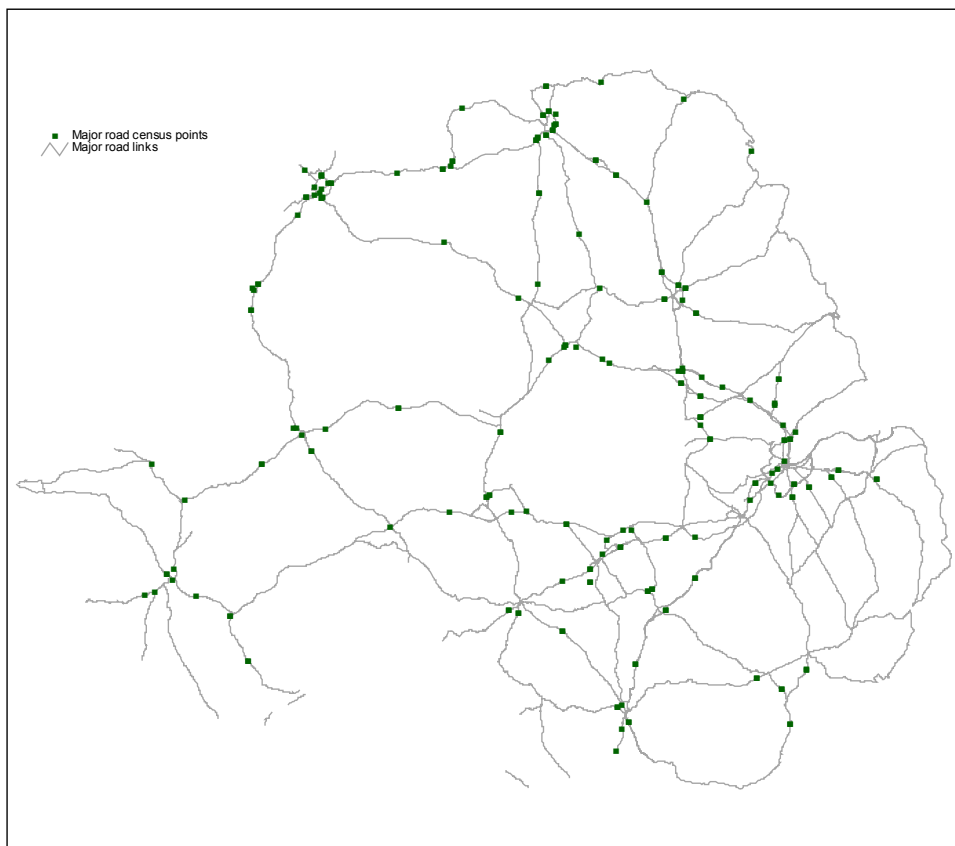
MAJOR ROADS

The Northern Ireland road map was provided by the Department of Environment Northern Ireland. This was converted to the GB OS National Grid and consistent road names were assigned to the major roads so that the flow data could be assigned to the major A-roads and Motorways. Figure 1 shows the locations of the major road traffic count points.

Traffic flow data, as published in the Annual Traffic Census Report 1998 (Roads Service, 2000) and Vehicle Kilometres of Travel (VKT) Survey of Northern Ireland 1998, were obtained from the Roads Service (data from 1998 VKT report were obtained in digital form prior to publication of the report). These data were used to populate the major road links. The basic vehicle mix for some count points were also available in the Vehicle Kilometres of Travel Survey report. For roads without data, a generic vehicle flow and average vehicle split was applied.

For the mapping of the road traffic flow, calculated emissions and roadside concentrations, each road link is defined as the length of road to which an individual traffic count has been applied. The count points are assigned to the closest sections of the relevant road to that point. As a result of a fairly sparse coverage of traffic count points, some road links are quite long. This may result in some inaccuracy in the result because traffic flow does in fact vary along the length of these links. However it is the best that can be achieved with the current data. Future improvements in traffic count coverage will be used to improve the mapping of traffic flow.

Figure 1 Major road traffic count point locations in Northern Ireland



Neither the Northern Ireland Ordnance Survey data or the traffic census data provides information on road attributes, such as speed limit or number of carriageways. In order to assign appropriate speeds to the road links, they were classified into urban and rural roads. A land use map at 1km spatial resolution was used to classify the major roads as built up or non-built up. Roads that intersect with a grid square containing greater than 50% urban land were classified as a 'built up' and assigned average speeds appropriately. It is recognised that this results in an overestimate of urban links because of the length of some links extending into non-built up grid squares.

Average road speed classes were assigned to each road based on two attributes: road type and road setting (built up or non-built up). A vehicle speed profile defines the percentage of vehicles of a particular type (cars, buses and HGV etc) travelling at a particular speed within a defined range on each road link. This profile was generated using the Transport Statistics of

Great Britain (TSGB) tables on Road transport speeds. Emissions in kg per m per year were calculated using speed related emission factors for each link and vehicle type.

MINOR ROADS

Emissions from minor roads are modelled as an element of background emissions rather than along specific road links. These background emissions are used in the calculation of background NO₂ concentrations. The method of mapping these emissions has also been greatly improved in comparison with the method used for the 1996 maps.

The OS Northern Ireland road maps are used as the basis for the minor road distribution. The total length of each type of minor road within each 1x1km grid square is calculated. A Northern Ireland average traffic flow, provided by the 1997 VKT report (Roads Service, 1997), is applied to this total length per cell to estimate the total vehicle kilometres per cell. Vehicle kilometre grids are calculated in this way for each of the minor road classes (B, C and U) for urban (U) and rural (R) areas.

The vehicle kilometre grid maps for each minor road class are then used to generate grids of fuel use for petrol and diesel road transport assuming uniform vehicle mix for each BU, BR, CU, CR, UU and UR road type.

Revised method for estimating roadside NO₂ concentrations

The method used to estimate roadside NO₂ for the AQS (2000) has been described in detail by Stedman *et al* (1998). The same general approach has been adopted here but we have made use of updated parameters, which incorporate the latest air monitoring results and emission inventory information. A comparison has shown good agreement between these new estimates for Northern Ireland and those calculated using the previous method. The approach based on the 1998 emission maps is preferred here, due to the improved geographical representation of the emissions.

Roadside NO₂ concentration in 1998 are calculated as the sum of two components:

$$\text{roadside concentration} = \text{background concentration} + \text{roadside increment}$$

The roadside increment is derived from NO_x emissions along the relevant road link. The background concentration is determined from a modelled concentration map that includes all sources of NO_x. The total roadside concentration is then converted to an NO₂ concentration using an empirically derived relationship.

Concentrations in 1998 have been projected forwards to 2005 and 2010 based on our understanding of the likely impact of current national and international policies on NO_x emissions. Traffic projections specific to Northern Ireland have been used. Road traffic emission of NO_x in urban areas of the GB are expected to reduce to approximately 59 % of

1998 levels by 2005 as a result of European directives, which set tighter standards for the emission from new vehicles and improvements in fuel quality. In comparison the traffic emissions in Northern Ireland are expected to be 65% of 1998 levels in 2005 and 46% by 2010. These figures include the assumption of 40% vehicle kilometres growth between 1997 and 2010 as stated in the 1997 VKT report (Roads Service, 1997). UK NO_x emissions from non-traffic sources are expected to remain at approximately 1998 levels.

Calculated roadside concentrations

The results of this analysis are shown in Figures 2, 3 and 4 and summarised in Table 1. 13 built-up road links have exceedances (>40 ug^m⁻³) in 1998, 2 in 2005 and 1 in 2010 (shown in bold). Road links with exceedances are shown in shades of red on the maps in Figures 2, 3 and 4. Both the AQS objective for 2005 and the EC Daughter Directive limit value in 2010 are an annual mean value of 40 ug^m⁻³.

Table 1 Details of built-up road links with predicted exceedances in 1998, 2005 and 2010

Road Name	Count point reference	Road class ¹	Length (km)	1998 Roadside NO ₂ (ug/m ³)	2005 Roadside NO ₂ (ug/m ³)	2010 Roadside NO ₂ (ug/m ³)
A12	902213	PB	2.3	71.4	56.2	46.7
A55	902221	PB	8.2	53.1	42.1	35.3
A24	902219	PB	13.2	48.7	38.6	32.4
A12	902290	PB	2.6	48.4	38.8	32.9
A2	902350	PB	6.5	45.2	35.4	29.3
A20	902216	PB	12.7	44.2	34.9	29.2
A55	902220	PB	6.4	43.8	34.8	29.2
Central Belfast ²	902901	PB	15.2	42.9	34.5	29.4
A6	902363	PB	1.2	42.4	33.1	27.5
A3	902401	PB	4.9	41.6	32.7	27.2
A55	902222	PB	6.8	40.9	32.7	27.6
A515	902353	PB	2.4	40.5	31.5	26.0
A2	902356	PB	3.9	40.3	31.7	26.3

Notes:

1. PB: Primary built-up.
2. Traffic flow data were not available for individual links in Central Belfast, and therefore flows have been estimated. These roads are therefore classed as one link.

Considering the roads with predicted exceedances in 1998, 2005 and 2010 as outlined above, it is worthwhile assigning the roads their 'common names'. Of those highlighted, a significant proportion is part of the greater Belfast road network (Table 2).

Table 2 Common names and locations of links in Belfast

Road Name	Count point reference	Common Name and Location	Annual Average Daily Traffic Flow (1998)
A12	902213	Westlink in Belfast, south of Roden Street.	58150

A55	902221	Upper Knockbreda Road, Belfast.	37020
A24	902219	Belfast to Carryduff road at the Ivanhoe Inn.	28190
A12	902290	Westlink at Clifton Street towards the M2	25088
A55	902220	Shaw's Bridge, Belfast	29460
A55	902222	Parkway, Belmont - Holywood Rd, Belfast	18980

Figure 2 Roadside NO₂ in 1998 on built-up road links in Northern Ireland

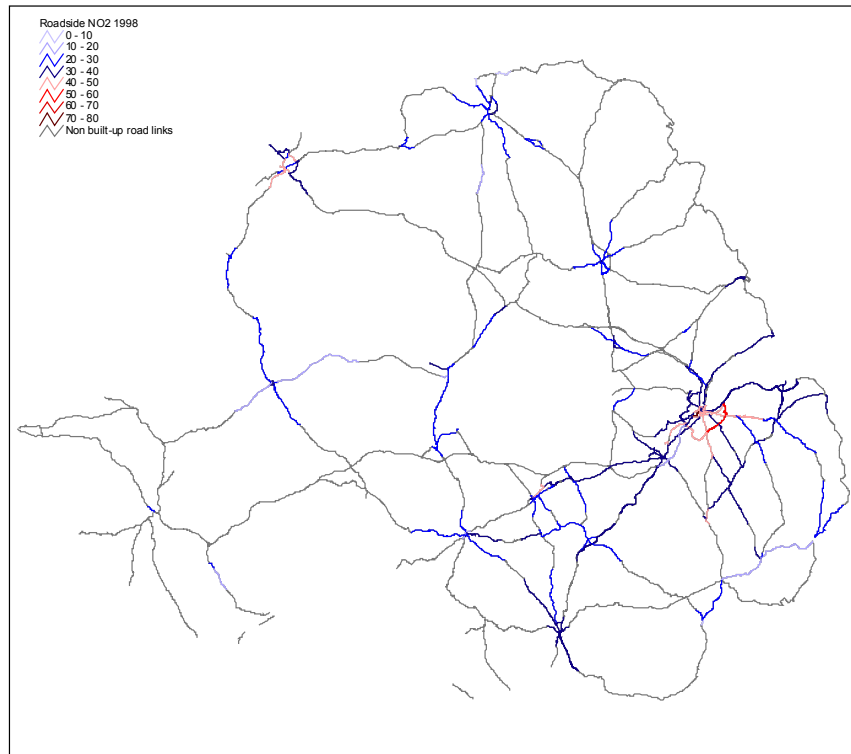


Figure 3 Roadside NO₂ in 2005 on built-up road links in Northern Ireland

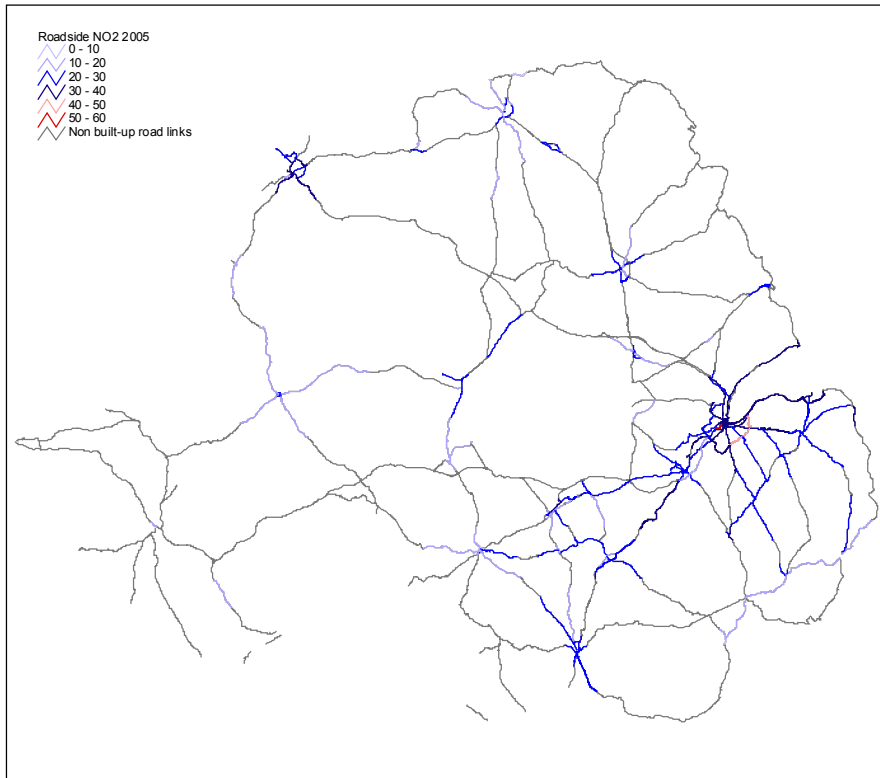
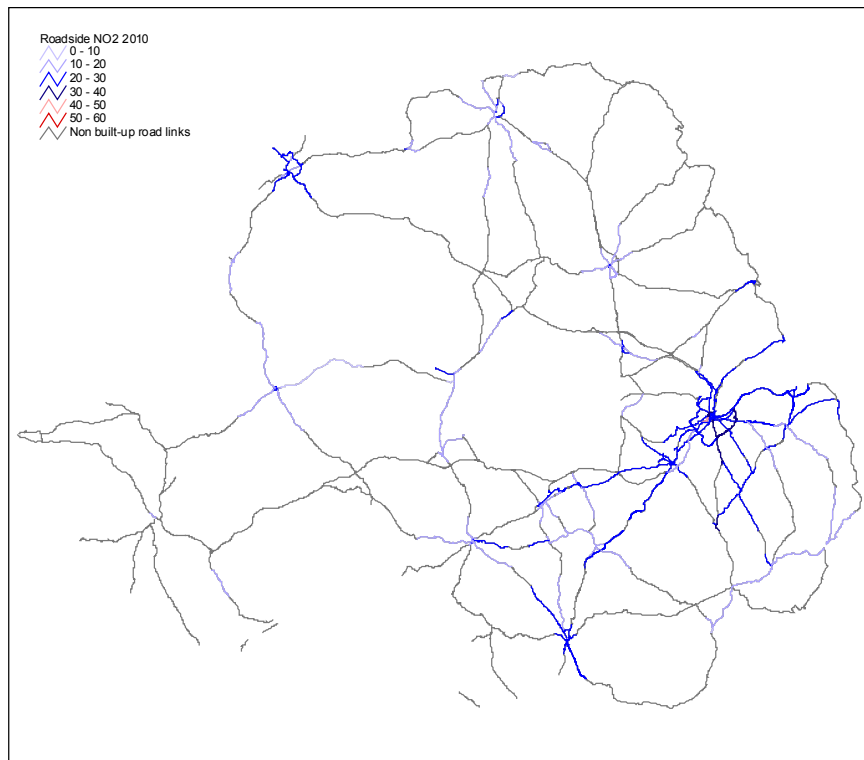


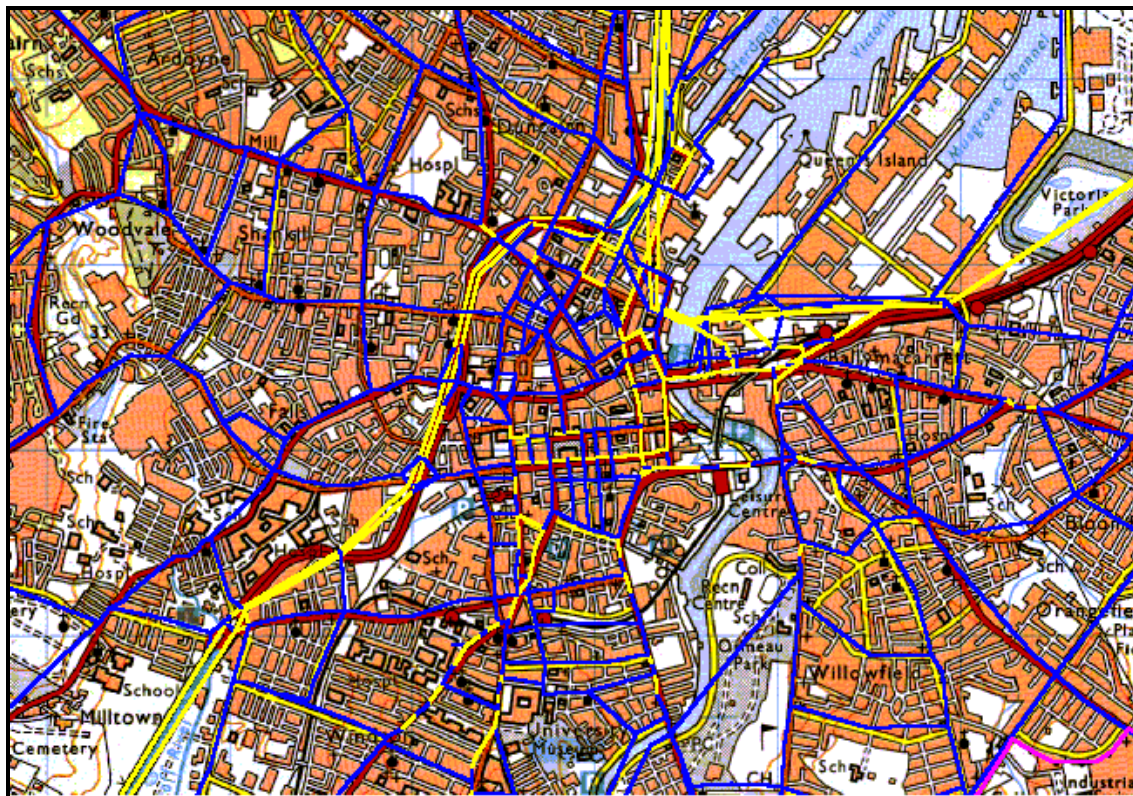
Figure 4 Roadside NO₂ in 2010 on built-up road links in Northern Ireland



Comparison with modelled traffic flow data

Belfast City Council has modelled road traffic flow in Belfast as a screening exercise part of the First Stage Review of air quality. Highlighted (yellow) roads, with annual flows in excess of 20,000 vehicles, have been identified as requiring further investigation. These data have not been used in the roadside NO₂ analysis reported here because they were not available at the time of the calculations and previously problems have been encountered when matching modelled and measured flow data sets. However, Figure 5 shows the model data could provide a more detailed picture of flows across Belfast, and may be used in future work of this kind.

Figure 5 Modelled traffic flows in Belfast (Yellow highlighted roads have AADF > 20,000)



Map provided by Belfast City Council

NO₂ monitoring data in Ireland

Figure 6 and Figure 7 show the time series of NO₂ diffusion tube data collected at kerbside and the background sites respectively. We have included only those sites with a continuous set of data for the last 5 years. The data shows general decline in concentrations both at background and roadside sites. The Belfast sites show a dip in 1997 but subsequent rise in 1998. One roadside site (Londonderry) has shown an increase. Figure 8 shows the locations of the kerbside monitoring sites for which data are shown here.

Figure 6 Kerbside NO₂ concentrations 1994 – 1998

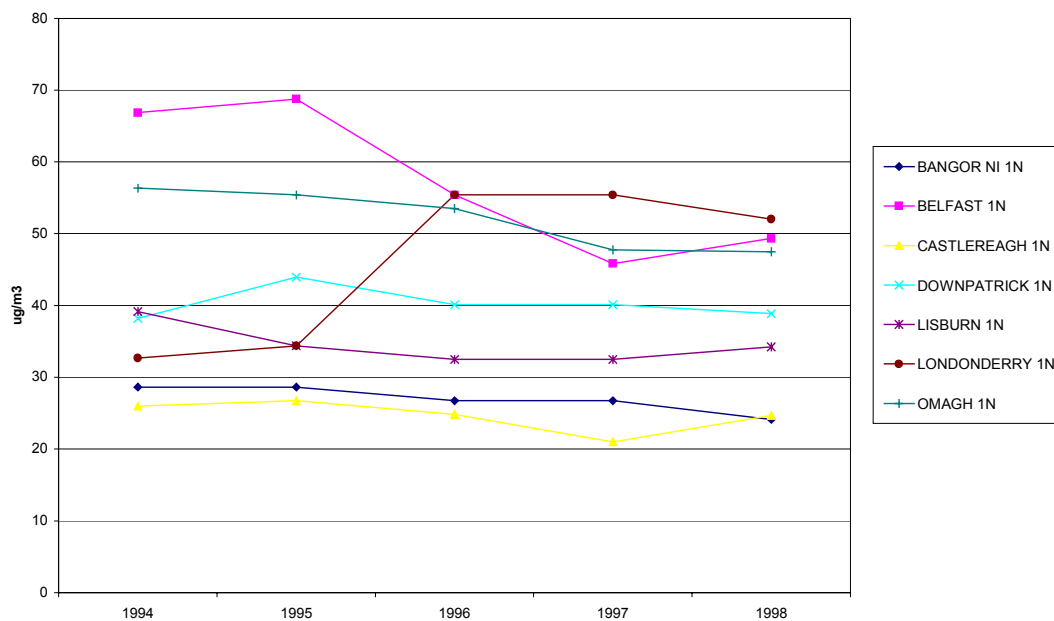


Figure 7 Background NO₂ concentrations 1994 – 1998

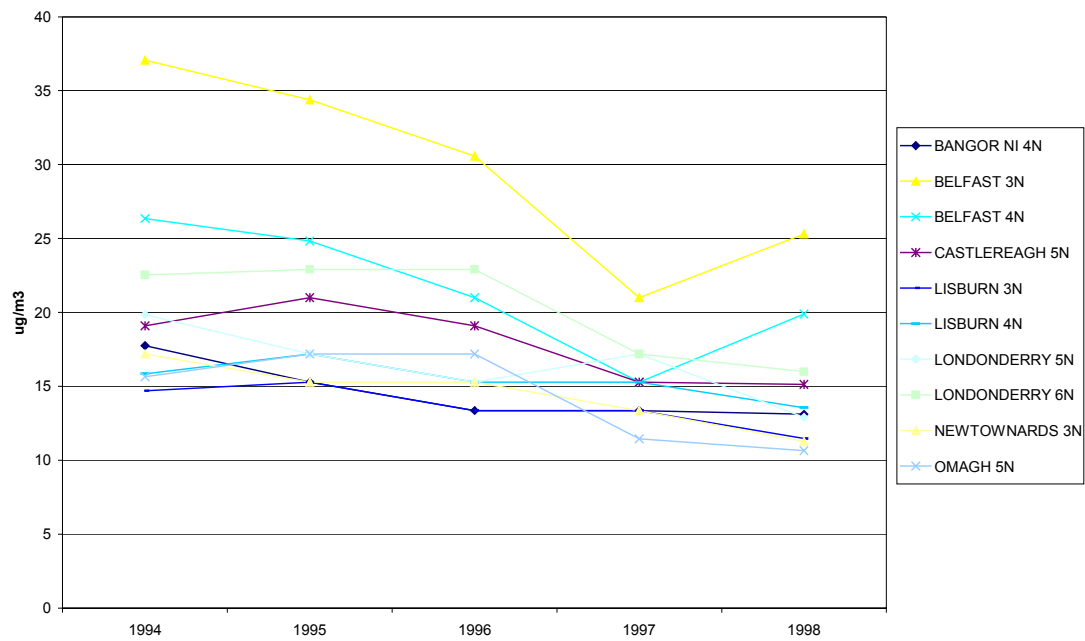
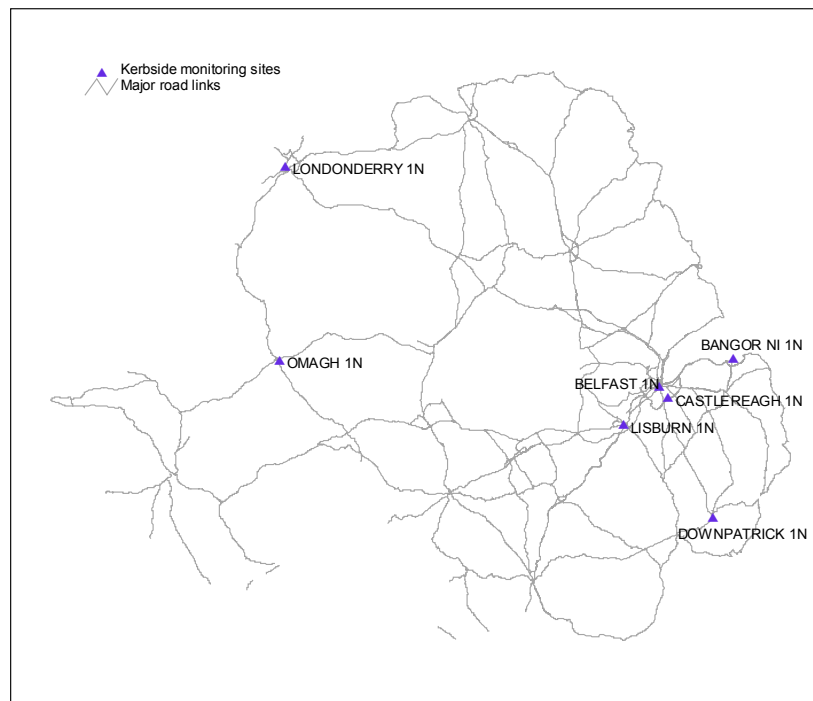


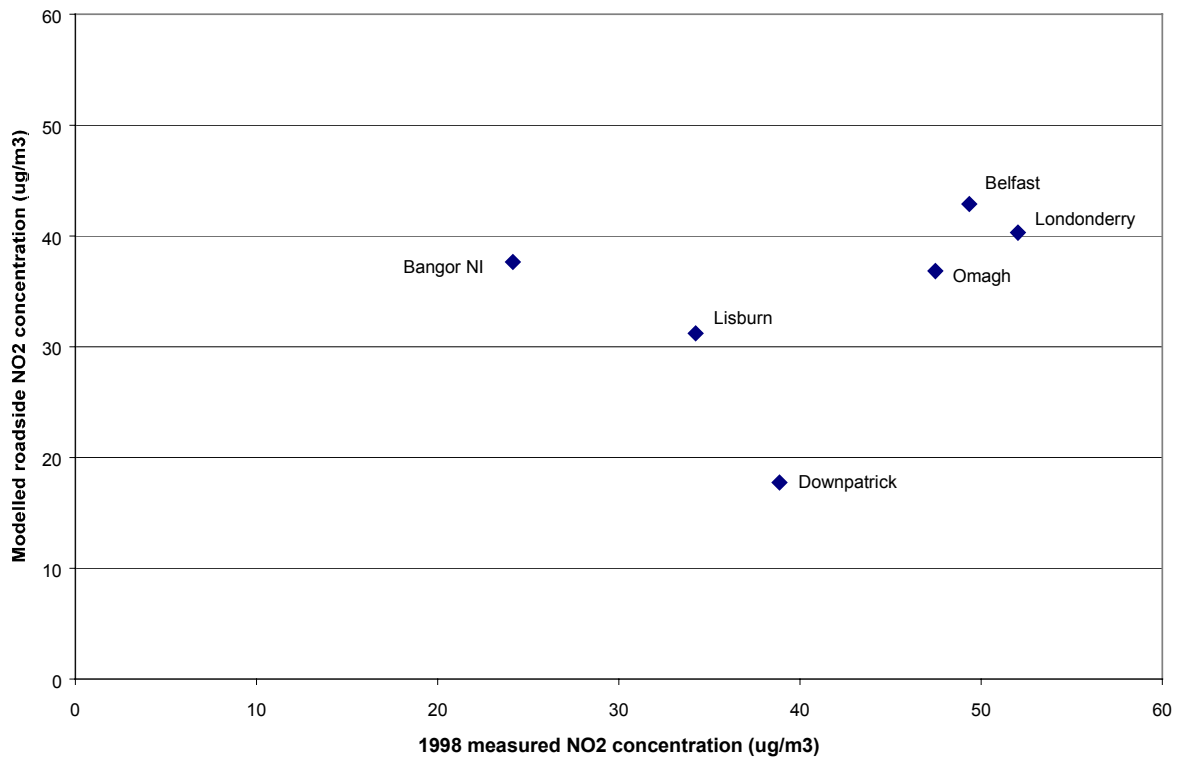
Figure 8 Locations of the kerbside sites in the NO₂ diffusion tube survey that have been analysed in this study



Comparison of modelled and measured data

A comparison can be made between the NO₂ concentrations measured at kerbside sites, as shown in Figure 8, and the model estimates shown in the maps above. This comparison can be made for all sites other than Castlereagh, which is not on a major road link. The results are shown in Figure 9. There is reasonably good agreement between the two data sets except for Downpatrick where the model underestimates and Bangor where there is an over estimate. Some discrepancies are, however, to be expected because we have compared the results of a national modelling exercise with measurements carried out using an indicative monitoring method.

Figure 9 Comparison between measured NO₂ with modelled roadside concentrations



Conclusions

This study has shown that although there are significant exceedances of the $40\mu\text{g}\text{m}^{-3}$ limit in 1998, by 2005 there are only 2 road links with predicted roadside concentrations above this level and in 2010 only 1 link.

The results presented here are derived from a UK-wide strategic model of roadside NO_2 concentrations. We anticipate that the overall conclusions should be consistent with more detailed modelling or monitoring exercises, such as might be carried out within the formal framework for local air quality review and assessment. A UK-wide model cannot, however, provide the level of detail that would be provided by specific local studies.

This work is part of an ongoing policy support contract therefore the modelling will be updated as methods develop and new data become available.

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