Specialist Professional and Technical Services (SPATS) Framework

Task 61
Air Quality Geographic Pilot Study – A38 Derby

May 2018

Final report

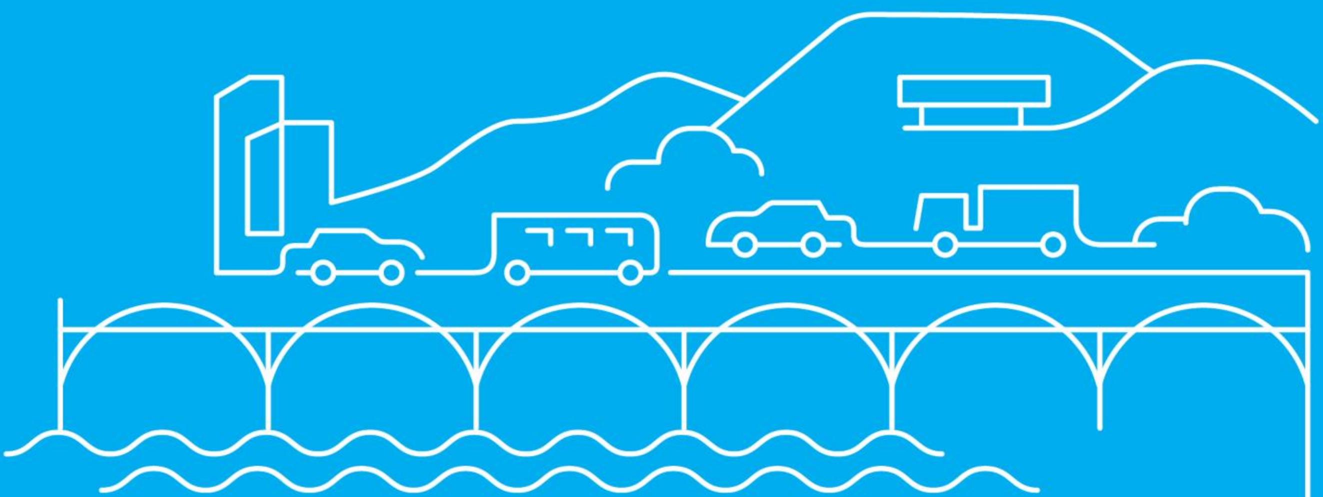

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Table of Contents

APPENDICES

1. Introduction

Context

Atkins CH2M Joint Venture (ACJV) has been commissioned by Highways England to investigate the reasons for the poor air quality in and around the A38 near Derby. The focus has been on concentrations of nitrogen dioxide (NO_2), since this is the pollutant of principal concern with respect to exceeding the UK Government's air quality objectives and European Limit Values.

This report provides a description of the air quality alongside the A38 and its adjoining arterial roads. More importantly, it demonstrates an understanding of the root causes of high NO_2 concentrations in this area and indicates whether anything can be done to improve specific air quality issues related to the A38 near Derby. As such, the study, through a combination of detailed traffic journey, vehicle emission and pollutant drop off analyses goes well beyond the level of assessment typically found in an air quality assessment (e.g. an air quality impact assessment in accordance with the Design Manual for Roads and Bridges).

Where possible, the findings of the study have been used to provide a direction for the development of mitigation strategies to improve air quality; but identifying mitigation measures has not been the focus of the study. The approach taken has been guided by Highways England. Despite this study providing a more rigorous level of analysis than would be found in a typical air quality assessment, it should be recognised that it is not possible to provide results with certainty. All results presented in this report should thus be interpreted as indicative. The interpretation of the findings presented here should consider the uncertainty associated with the information and tools used to produce them.

Outline to the Study

The A38 is a major (non-motorway) north-south route that is included as part of the UK Government Strategic Road Network between Birmingham and the Nottingham-Derby area. At its northern and southern extent the road connects the M1 and M6 motorways. Where the A38 passes through the western and northern parts of Derby, local intra-urban trips cross the A38 on roads into the city or use the A38 to travel around Derby.

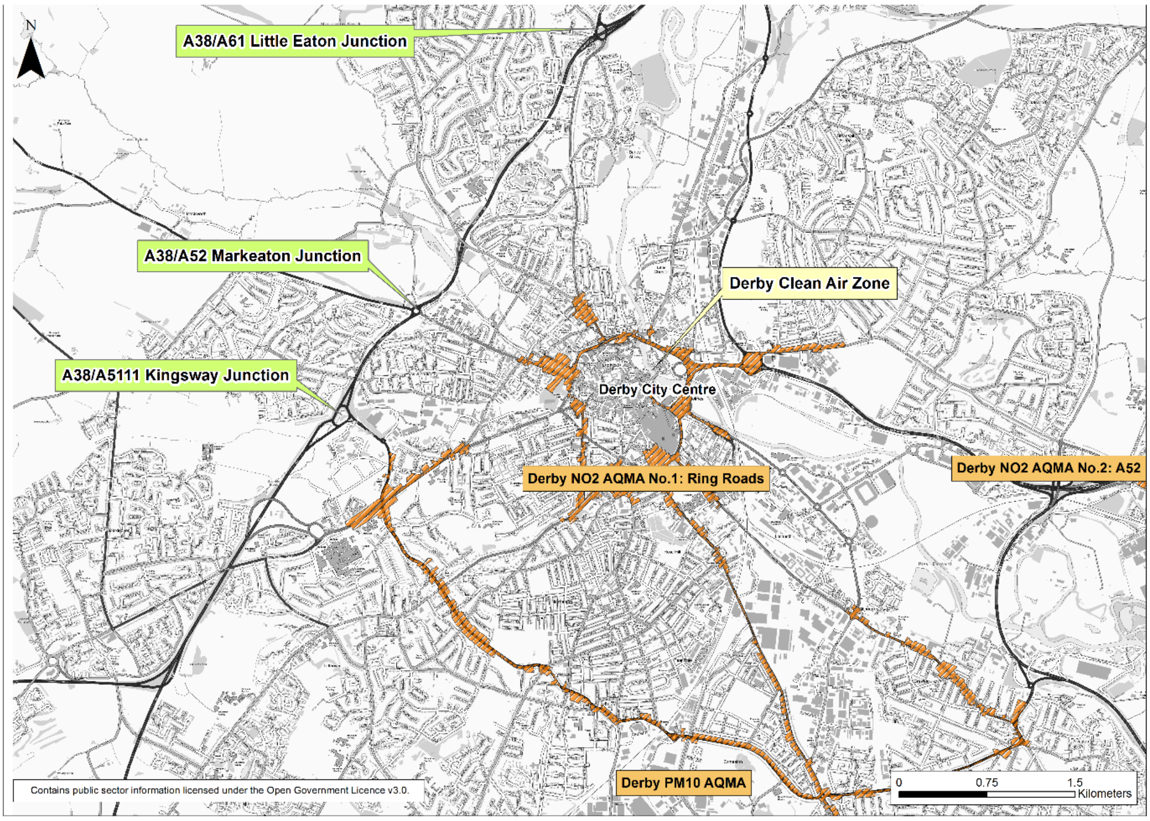


Figure 1: A38 Derby area including the Derby AQMAs and A38 Derby Junctions

The interaction between strategic and local trips results in delays at the three roundabout junctions on the A38, namely the A38/A5111 Kingsway junction and the A38/A52 Markeaton junction to the west of Derby City centre, and the A38/A61 Little Eaton junction to the north of Derby City centre (shown in **Figure 1**). This is the extent of the A38 considered in our study area.

Derby and its immediate surrounding area are expected to accommodate significant housing and employment growth in future years. This is expected to increase traffic demands on the A38 through Derby, which are expected to grow more quickly than the national average. The Highways England A38 Derby Junctions scheme aims to accommodate future traffic growth with local junction and mainline improvements through increasing capacity. The scheme also aims to reduce congestion through specific Junction improvements at the A38/A5111 Kingsway junction, A38/A52 Markeaton junction and A38/A61 Little Eaton junction.

Derby is also one of the five cities outside of London required to implement a Clean Air Zone in their city by 2020. Derby's commitment to implement a Clean Air Zone is likely to impact on the diesel portion of the fleet within Derby. Derby City Council's current provisional options being explored are based on a phased approach:

- "Phase 1 - the introduction of a class B (Buses, coaches, taxis and HGVs) chargeable access restriction within the area bounded by the inner ring road (but not including the inner ring road and the bus station) by 2020.
- Phase 2 - the introduction of an extended class B chargeable access restriction within the area bounded by the outer ring road by 2025." (shown in **Figure 2**).

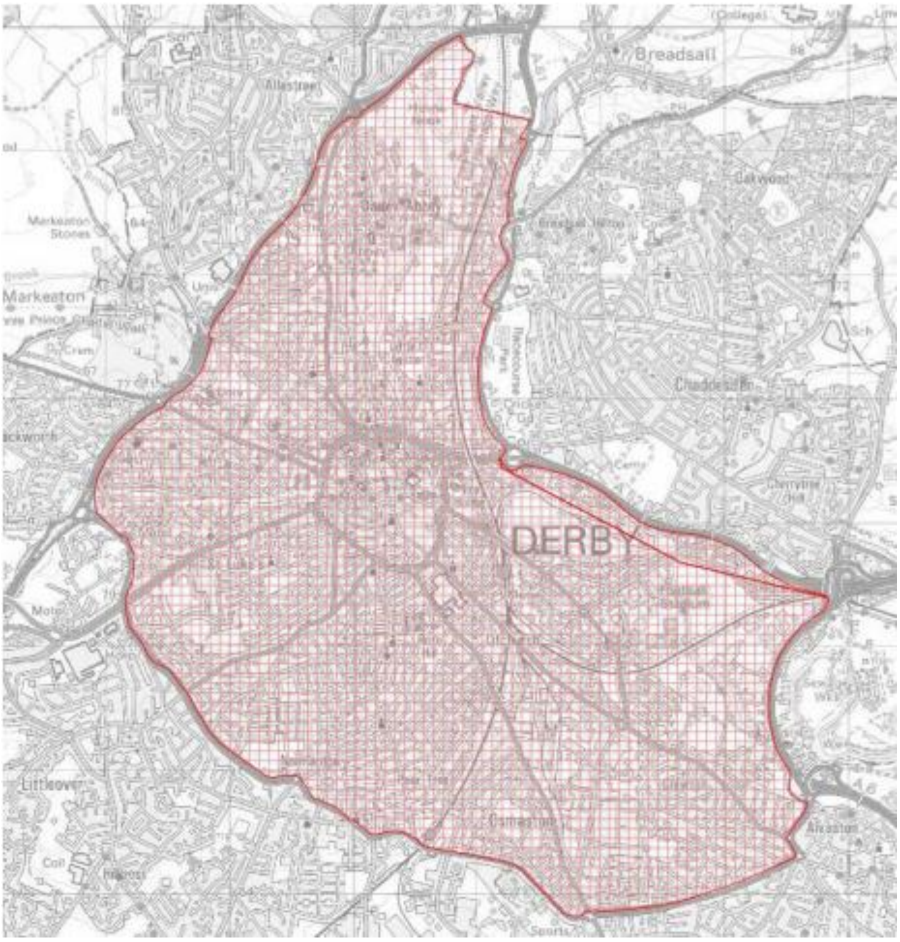


Figure 2: Outer Derby Ring Road Clean Air Zone (Working Option)

Knock-on effects of the CAZ (both positive and negative) are therefore possible along the A38 in Derby and along arterial roads linking the A38 to Derby city centre. The classes of vehicles proposed to be affected by the CAZ are considered unlikely to have much opportunity to alter their origin and destination, so it would not be expected that traffic re-routing following the introduction of the CAZ would significantly affect the A38. Vehicles affected by the CAZ are however likely to travel along the A38, which may result in an associated improvement in air quality adjacent to the A38.

This study therefore focusses on current air quality and traffic conditions along the A38 near Derby and its adjoining arterial roads. More importantly, it aims to provide an understanding of the root causes of high NO_2 concentrations and whether anything can be done to improve specific air quality issues related to the A38 near Derby prior to the implementation of the CAZ and the Derby Junctions scheme.

Purpose and Approach

The approach has been to rely largely on empirical evidence, rather than resting on pre-conceived ideas or published models, which can often disguise the level of uncertainty associated with their results. Spatial and temporal patterns in measurements have been studied; with these measurements relating both to air quality concentrations and traffic flows on the A38 and adjoining arterial roads.

The purpose of this study was to develop a deep understanding of the causes of local air quality problems on the A38 Derby, including its adjoining arterial roads into Derby. The A38 in Derby could influence air quality by:

1) Direct emissions from the volume of traffic on the A38;

2) Direct emissions due to congestion around junctions of the A38 with adjoining arterial roads; and

3) Increased traffic on local A-roads caused by vehicles accessing the A38.

The availability of air quality monitoring data was a limiting factor in this study, given the absence of any reliable continuous monitoring stations within the area. Passive diffusion tube monitoring data from both Derby City Council and Highways England were available and used to understand NO_2 concentrations spatially and by source contribution. To make best use of the data available and to explore the air quality problem further, the focus of this study was obtaining a deeper understanding of the air quality problems through detailed traffic data analysis.

Origins and Destinations of vehicle movements were investigated using a traffic model to improve our understanding of the routing of traffic journeys in the study area and to make use of this evidence to better understand the air quality problems within Derby. A Select Link Analysis approach was used making full use of the available Highways England scheme base traffic model. This investigation is a crucial component of the understanding of the air quality problems but its accuracy relies on the transport modelling validation and semi-theoretical approach and assumptions used therein.

Report Structure

The report is structured in a series of Chapters as follows:

- Chapter 2 sets the scene for the analysis and style of reporting and structure.
- Chapter 3 focuses on road traffic. This chapter includes an investigation of traffic flows, speeds and composition to explain how traffic on various parts of the road network affects air quality. A strong focus of this chapter is the understanding of local journeys and origins and destinations of vehicle movements along the A38 and its adjoining arterial roads into Derby, and the implications on elevated NO_2 concentrations in Derby.
- Chapter 4 gives an overview of mapped background concentrations and air quality monitoring data. This chapter also provides an outline summary of the source apportionment of the NO_2 contributions for different areas and roads.
- Chapter 5 draws out the key findings from this analysis and comments on the implications for managing local air quality near the A38 Derby and presents the key evidence which improves understanding of the causes of local air quality problems derived from this work.
- Chapter 6 comments on the key procedural lessons learnt from the study that could be of use in future work and any measures that could be explored.

2. Setting the Scene

Introduction to Chapter

This Chapter focuses on providing an outline of the current air quality and traffic conditions that might affect area-wide air quality over the whole study area. It considers meteorological conditions, regional and local background concentrations and air quality monitoring data and briefly introduces current traffic conditions in and around the A38 near Derby.

Meteorological conditions

Based on meteorological data from East Midlands Airport between 2014 and 2016, the dominant wind direction is west-south-westerly, as shown in **Figure 3**. This was the nearest meteorological station available to the A38 near Derby, and is located approximately 16 km southeast of Derby.

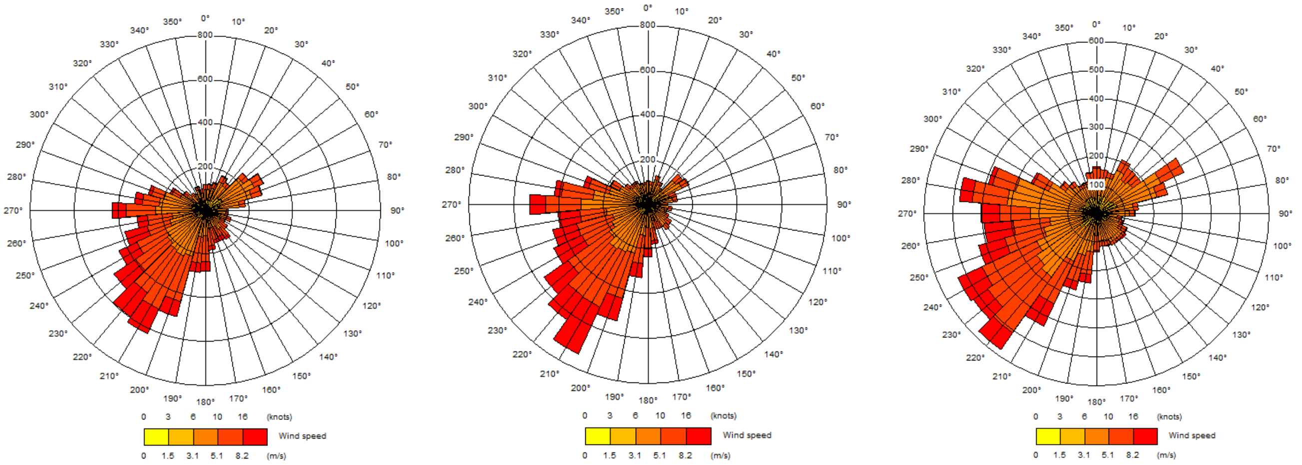


Figure 3: 2014 - 2016 East Midland Airport Windroses showing the dominant wind direction and speed.

Background Concentrations

For the purposes of source apportionment, total background pollutant concentrations consist of a regional and local component. Defra background mapping have been reviewed and are detailed in **Appendix 2**.

The regional background is generally considered to be made up of emissions from long-range sources, including traffic emissions from the whole of the UK and Europe, as well as emissions from many other sectors. It is regarded as the component of the background which is difficult to influence change over. National and international policy is attempting to reduce regional background concentrations, but there are no local measures which could exert a material effect on these background concentrations.

The local background concentration has been defined first by determining the 'total background' concentration and then subtracting the regional background concentration. It comes from much shorter-range sources and unlike the regional component, local measures can exert an effect.

Defra's maps of background annual mean NOx and NO_2 concentrations, which are derived using its Pollution Climate Mapping (PCM) model, have been used to define the sources contributing to the background in the A38 Derby area. These are detailed in **Appendix 2**.

In summary contributions from regional background sources are largely rural (which amount to the largest proportion of the total background) while local background contributions are predominantly attributable to road traffic emissions, with some influence from point source (industrial) emissions in some areas of Derby.

Focus Areas

A number of distinct 'focus areas' were defined within the pilot study area based upon the results of air quality monitoring and potentially related traffic issues. These focus areas, which are referred to throughout this report and within which more detailed analysis has been undertaken, are described in detail in **Appendix 1** and illustrated in **Figure 4**.

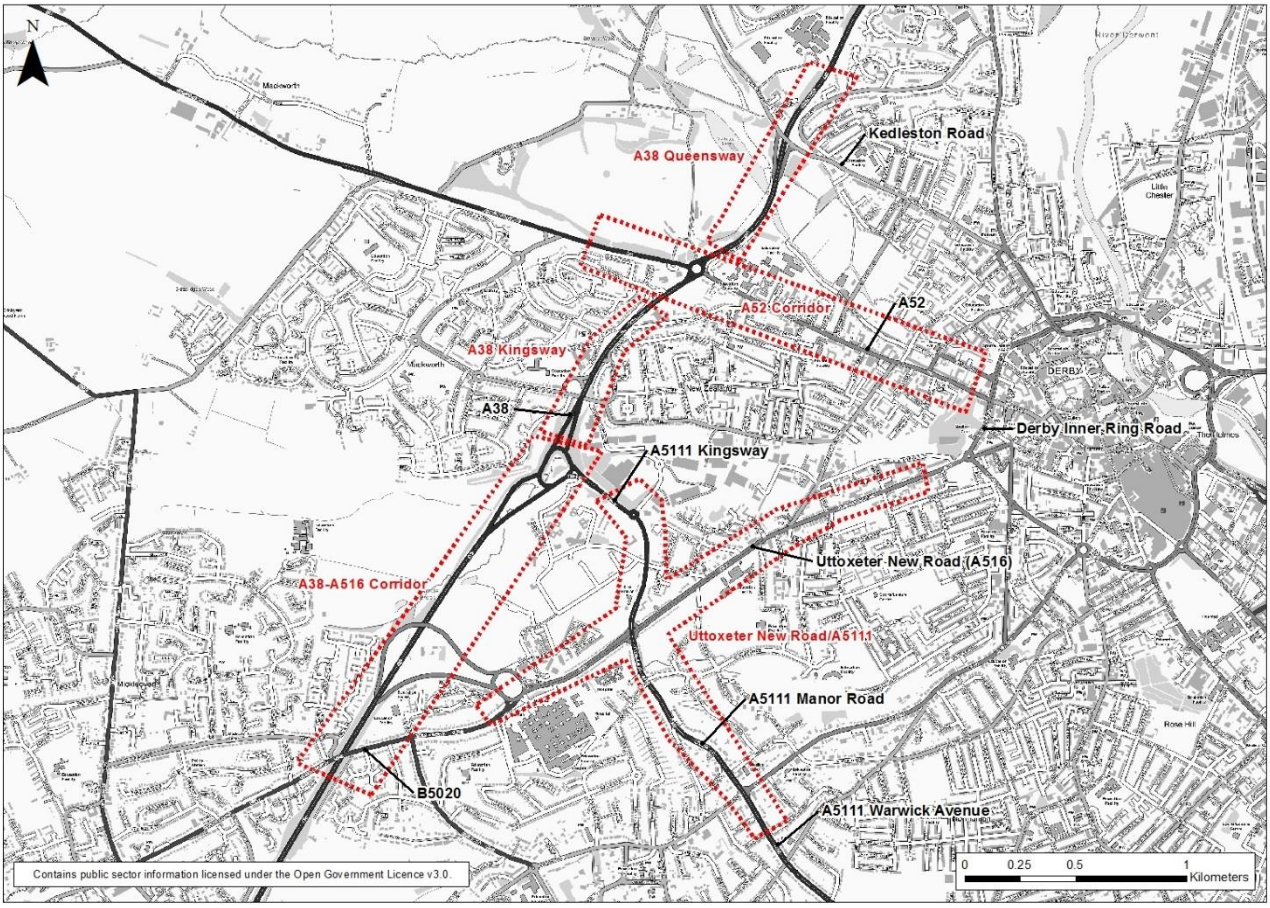


Figure 4: Map of the A38 Derby Pilot Study focus areas and relevant road names

Current Air Quality Conditions

Air quality data availability in the study area was limited to NO_2 diffusion tube data from Highways England and Derby City Council (DCC) monitoring. The data sources and the quality assurance methods applied to these data are summarised in **Appendix 3**. The monitoring data used in this study, split by focus area, are presented in **Appendix 4**, which provides a summary of the locations where national air quality objectives are exceeded ("hot spots") in and around the A38 Derby.

As is shown in **Figure 5**, between 2012 and 2015 only three monitoring sites have consistently measured exceedances of the annual mean NO_2 air quality objective (40 µg m^{-3}) adjacent to the A38. All these monitors are located close to the road and at a distance (>10m) from the nearest site of relevant exposure, which is where air quality objectives are applicable.

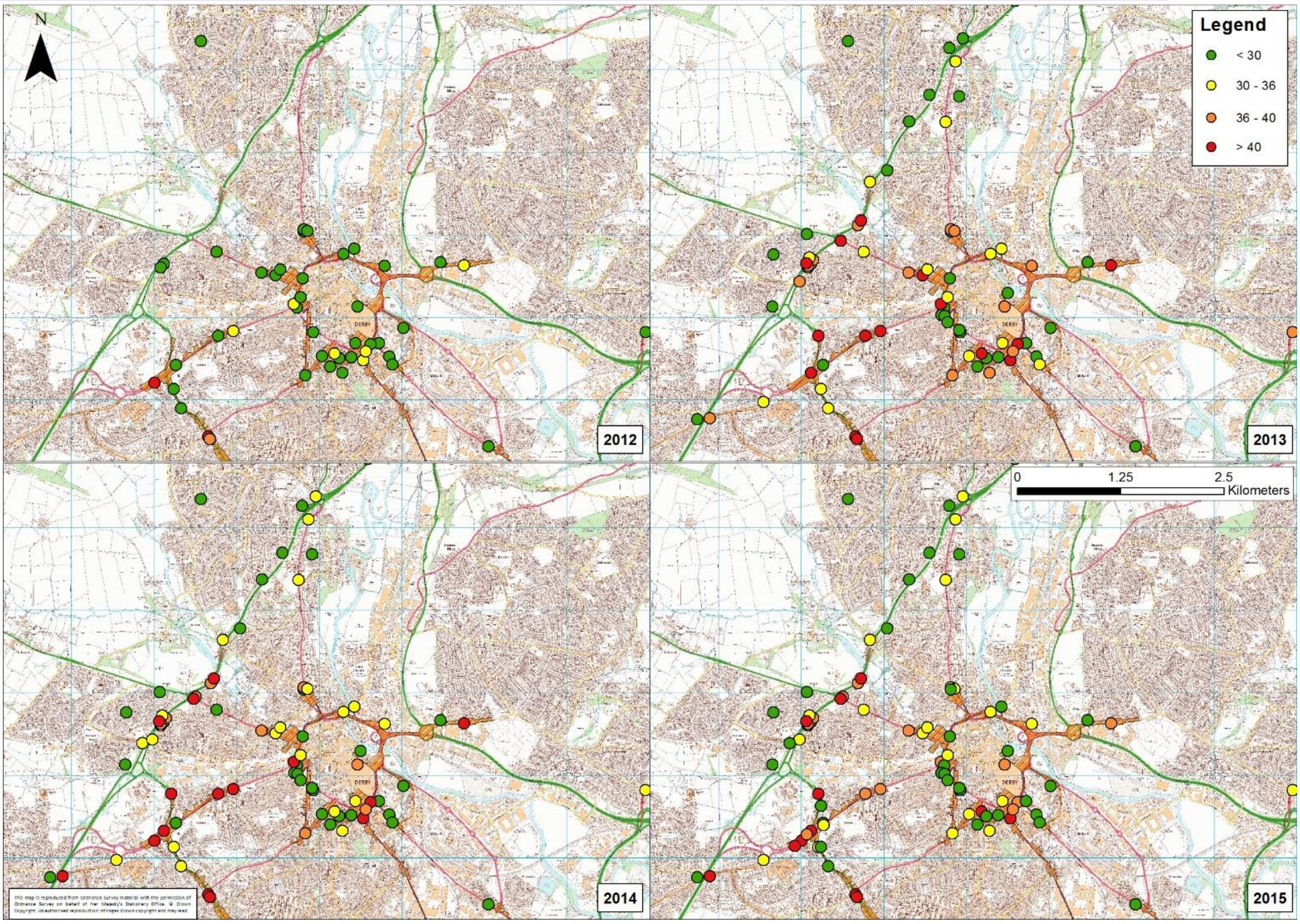


Figure 5: Annual mean NO_2 in the A38 Derby area for 2012 – 2015 (Includes data from both Derby City Council and Highways England)

As locations of relevant exposure are generally set back from the A38 Derby main carriageway, it is considered that in general, air quality monitoring at locations of relevant exposure within this study area are predominantly located away from the A38 and closer to its adjoining arterial roads. In fact, it is the inner roads of Derby leading to its ring roads that are declared as an Air Quality Management Area (AQMA), and where more exceedances of the annual mean objective at locations of relevant exposure are recorded. These are what are considered to be the problem areas for air quality and are investigated later on in this report.

The two main Derby AQMAs (AQMA no.1 and no.2, both declared due to exceedances of the annual mean NO_2 objective) encompass the Inner and Outer Ring Roads in the city as well as some sections of radial roads and the entire length of Osmaston Road.

Further investigation on the likely localised sources contributing to these elevated measured NO_2 concentrations is provided in Chapter 4. This was carried out utilising the calculated road-NOx concentration at each monitoring site and its distance from the nearest road to compare with the Design Manual for Roads and Bridges (DMRB) normalised drop-off curve. This comparison assumed freely flowing traffic, therefore any deviations from the curve are useful indicators of other key influences, including congestion, road gradient, meteorology, as well as other factors that could explain the observed concentrations. The available evidence suggests that local influences appear to be the cause of the hot spot areas where NO_2 is in exceedance of the annual mean air quality objective.

Current Traffic Conditions

There are several employment areas near the A38 Derby Junctions (the A516, Kingsway and Markeaton junctions) that may influence traffic flows during weekday peak periods. Traffic growth is also an issue in Derby, which is a driving factor for the Highways England scheme.

Traffic flows and speeds along the A38 main carriageway and its adjoining arterial roads are regarded as crucial in understanding the air quality problems in and around the A38 Derby. This section covers the current traffic flows, journeys and congestion patterns at the junctions and relates these to the air quality problems in the defined focus areas and knock on effects in Derby city centre.

Table 1 presents the typical traffic flows and speeds in each direction for the A38 main carriageway and a few key adjoining arterial roads. Speed information was taken from the Trafficmaster service. Trafficmaster data is collected by polling the GPS locations of affiliated vehicles. The vehicles tend to predominantly be those operated as part of commercial fleets. Although only certain modern vehicle fleets incorporate such technology, and data capture in terms of the overall vehicle fleet is therefore relatively low, because the data have been averaged to weekday hourly speeds there is reasonable confidence that the speeds derived are representative of traffic conditions.

Road	Direction	Annual Mean NO_2 ($\mu g\ m^{-3}$)	Traffic Flow (AADT)	TM AM Peak Speed kph	TM Inter Peak Speed kph	TM PM Peak Speed kph	TM Off Peak Speed kph
A52 Ashbourne Road	Eastbound	51.9	10,000	58.6	58.7	59.2	64.9
	Westbound		10,000	34.5	34.1	32.6	38.0
A38 Queensway	Northbound	54.4	23,000	58.6	58.9	59.2	64.9
	Southbound		22,000	22.1	39.0	36.7	48.2
A516 (Uttoxeter New Road)[1]	Eastbound	42.6	9,600	27.9	44.8	33.4	55.9
	Westbound		9,200	34.3	37.6	34.2	45.7
A5111 (Manor Road)	Northbound	51.7	17,400	31.1	29.7	29.3	28.9
	Southbound		17,500	48.9	50.9	46.8	57.8

Table 1: Annual Average Daily Traffic (AADT) Flows and Average Period Speeds (AM, IP, PM, OP) along the A38 and adjoining arterial roads in Derby ([1] assumed East of A5111 Junction speeds)

The A38 has approximately 45,000 AADT, which is more than double the volume experienced on the adjoining arterial roads into Derby (i.e. the A516 Uttoxeter New Road and the A52 Ashbourne Road). The A5111 is in between these, with annual average daily traffic volumes reaching 35,000 vehicles per day.

Trafficmaster speeds have been presented in **Table 1**. These will be presented and discussed in more detail in the following Chapter. Observed speeds along the A38 northbound are higher as traffic is more free flowing during different times of day while the southbound traffic is generally slower moving, which is likely to be a consequence of queuing traffic during peak and inter-peak periods. These observed speeds are applicable to the A38 along Kingsway between the Markeaton Junction and the Kingsway Junction. From a more detailed analysis of other sections of the A38, the traffic queuing up to junctions, and the interaction with adjoining arterial roads into and out of Derby, is expected to be a contributing factor to the lower observed speeds along the A38 southbound.

The A52 Eastbound is largely free flow in nature away from the Markeaton Junction with the A38, while the observed speeds are lower in the westbound direction approaching the Junction.

The A516 Uttoxeter New Road experiences low observed speeds throughout peak and off-peak times of the day, with the lowest speeds experienced eastbound going into Derby city centre, almost half the speed limit on this road (48kph). The A5111 only experiences light congestion during peak hours of traffic in the northbound direction, which lead up to the A38 Kingsway and A516 Junction near the Royal Derby Hospital. Traffic going southbound is generally free flowing.

Summary

As previously described, there are known delays in the network where the A38 intersects with its adjoining arterial roads (the A5111 Kingsway, A52 Markeaton and A61 Little Eaton) which consequentially would be expected to lead to higher NO_2 concentrations in these areas.

There are exceedances of the annual objective for NO_2 along the A38 in Derby, shown in **Figure 2**, however these are all in areas where sensitive receptors are set back from the road, so there is no (or limited) public exposure to these elevated concentrations, suggesting that road traffic emissions from the A38 do not result in significant air quality problems.

The air quality problems in Derby are likely to be positively and negatively affected by the following future activities:

1) Highways England A38 Derby Junctions scheme – improvement of the three existing roundabout junctions at A38/A5111 Kingsway, A38/A52 Markeaton and A38/A61 Little Eaton
2) Future growth and development in Derby
3) Derby Clean Air Zone

While the Highways England scheme would be expected to lead to improvements in air quality in some areas and may counter some of the effects from future growth in Derby, the impact of the Derby Clean Air Zone (CAZ) is at this stage undetermined.

The CAZ is likely to influence air quality in the study area by improving problem areas in the centre of Derby, but may lead to traffic redistribution that could have an impact on the wider area of Derby. All these future possibilities are discussed in the following sections together with the findings from road traffic and air quality investigations to predict the likely implications these may have on air quality problem areas in and around the A38 in Derby.

3. Road Traffic

Introduction to Chapter

This Chapter considers how road traffic emissions are affecting local air quality in the study area. It draws on the traffic flows, journeys and congestions patterns on the A38, adjoining arterial roads and their intersecting junctions, and relates these to the air quality problems and knock on effects within Derby.

In terms of its characteristics, the A38 is thought to be somewhere between a motorway and an urban road. There are comparisons throughout this chapter which outline the characteristics that the A38 shares with a motorway, and the differences in these characteristics to its adjoining arterial roads.

Traffic flows and Speeds

Automatic Number Plate Recognition (ANPR) data were collected for the purposes of this pilot study using cameras which record the number plate of all vehicles passing the camera to identify the vehicle type and emission class. Traffic information from traffic counts, supplemented with modelled data from local scheme assessments where necessary, were collated.

Traffic data were processed into average hourly flows, %HDV and speed (kph) for an average weekday, Saturday and Sunday, for use in emissions calculations. The traffic count data consisted of Highways Agency Traffic Information (HATRIS) count data which were adjusted to the assessment year (2015). Where there were gaps in the HATRIS data, DfT average daily count data were obtained and converted to hourly flows using an average diurnal profile determined from HATRIS data. Where traffic count data were not available, modelled data were used from the Highways England A38 Derby Junctions scheme assessment. ANPR data were only available for 10 locations within the study area and HATRIS data were only available for certain locations along the A38 main carriageway.

In addition to traffic flow and composition data, Trafficmaster observed speed data were also obtained and used to determine how traffic speeds on various parts of the road network affect the focus areas shown in **Figure 4**. Despite the low data capture attributed to this technology (only incorporated into certain modern vehicle fleets), these data had been averaged to weekday hourly speeds and therefore there is reasonable confidence that speeds derived are representative of traffic conditions in general.

Traffic Flow Profiles

A comparison of the A38 to a motorway (the M1) and local A-roads (A52 and A5111) was thought useful to understand better the A38's traffic characteristics. **Figure 6** shows the weekday profile for each of these sites, which demonstrates that the A5111 and A52 have proportionately more traffic during peak periods (as demonstrated by the higher peaks during the AM and PM), whereas the M1 has the lowest proportion of traffic occurring during these periods. The A38 demonstrates a very similar profile to the M1 during the AM and inter-peak, but has a similar level of traffic (percentage-wise) in the PM peak to the A52. This indicates that the A38 is likely to serve both a strategic and local purpose as it is similar to the M1 but includes a greater proportion of local traffic during the PM peak.

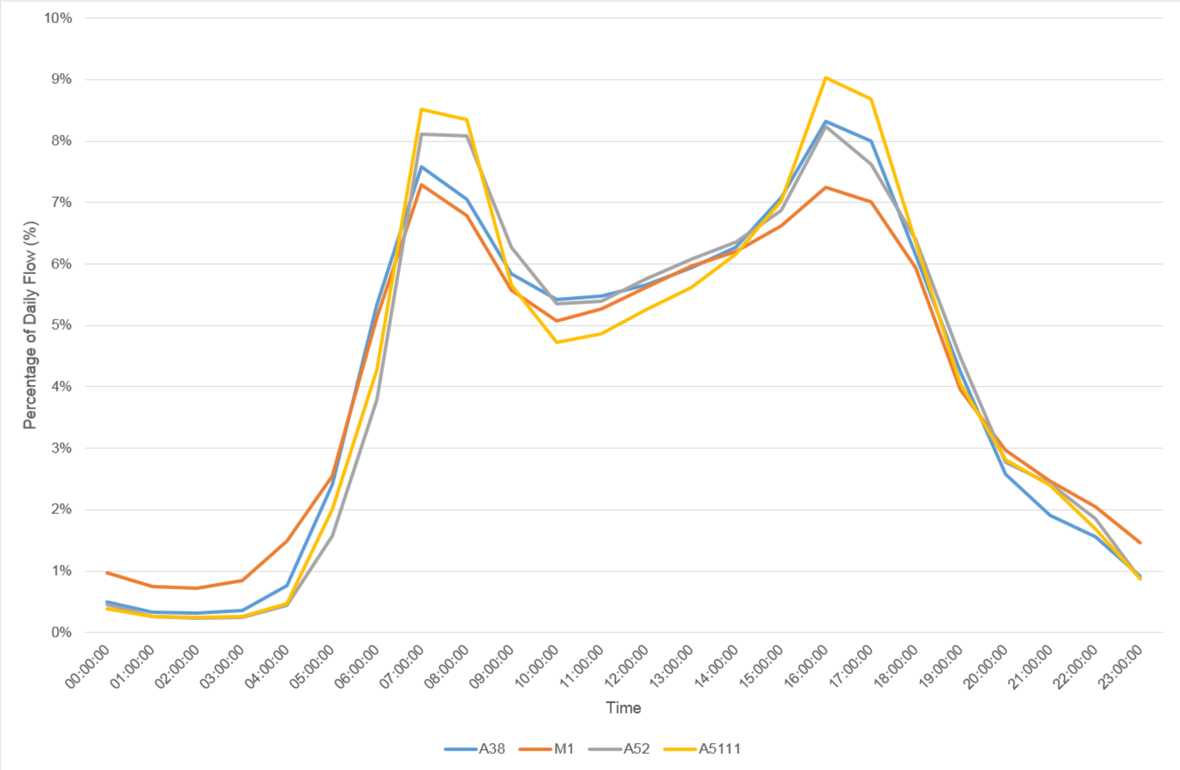


Figure 6: Hourly Traffic flow profiles as percentage of total daily flows on the A38, M1, A52 and A5111

Figure 7 below compares the proportion of HGVs over the day for the different roads. The M1 has the highest proportion of HGVs and the A52 and A5111 typically have the lowest proportion of HGVs. The proportion of HGVs on the A38 lies between the two, which is a potential indication that the corridor could serve both strategic and local traffic. This was considered further using a Select Link Analysis approach, discussed later in this chapter.

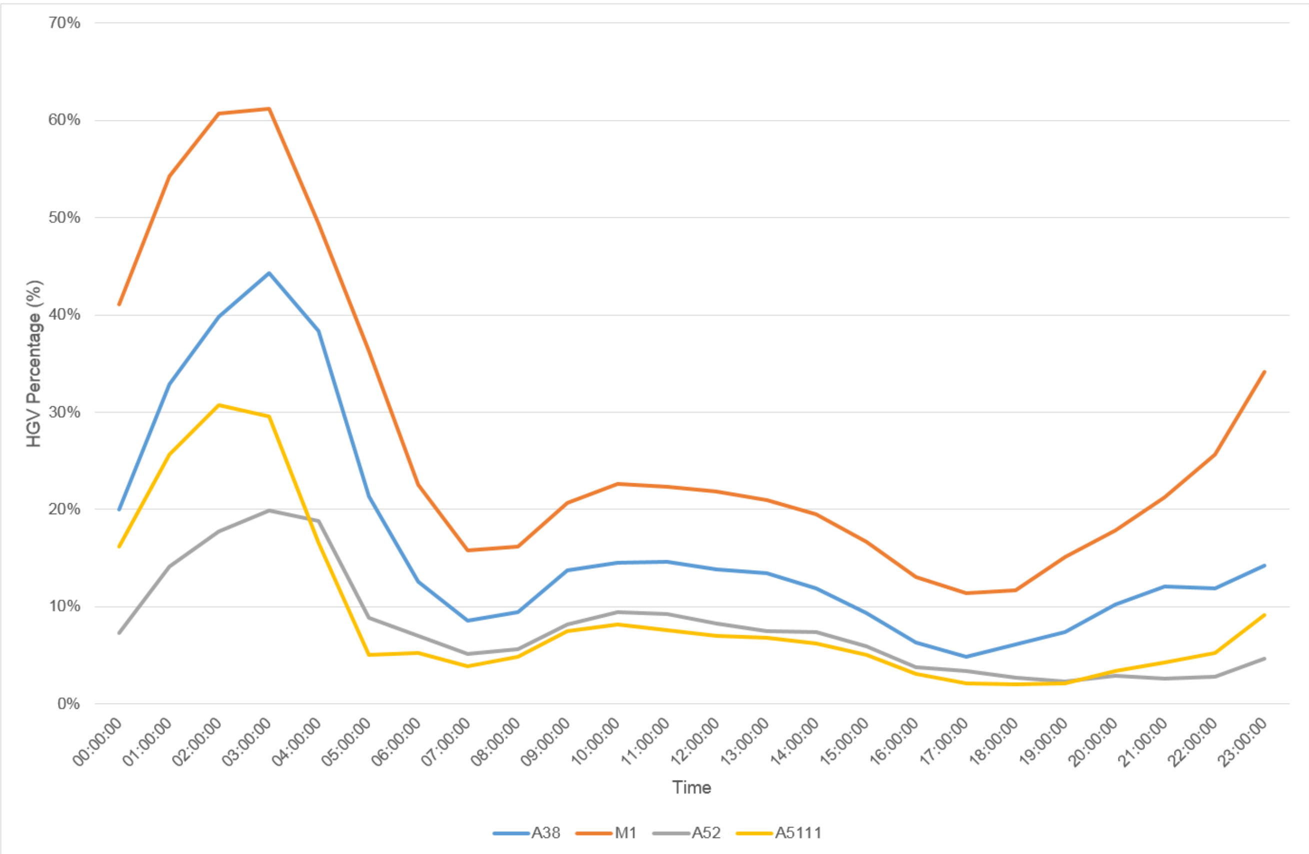


Figure 7: HGV percentage profile

Traffic Speeds

Observed journey time information obtained from the Trafficmaster database was used to evaluate traffic speeds over four different time periods: AM Peak, Inter Peak, PM Peak and Off-Peak, for the A38 Derby area. The definitions shown in **Table 2** from the Speed Banding Interim Advice Note 185/15 (Highways England, 2015) for an urban/rural (non-motorway) road were used to categorise traffic conditions based on vehicle speed.

Speed Band	Speed Range	General Description	Legend Colour
Heavy Congestion	<20 kph	Traffic with a high degree of congestion. Within a 100m radius of road junction with a high degree of congestion.	Red
Light Congestion	20 – 45 kph	Typical urban traffic with a reasonable degree of congestion. Within a 100m radius of road junction.	Orange
Free Flow	45 – 80 kph	Typical urban traffic with limited or no congestion.	Light Green
High Speed	>80 kph	High speed urban single or dual carriageway	Dark Green

Table 2: IAN 185/15 Speed Banding ranges for an urban/rural (non-motorway) road

The key outputs from the Trafficmaster speed dataset are illustrated in **Figure 8** and summarised in the following sections by road (the locations of which are shown in Figure 4).

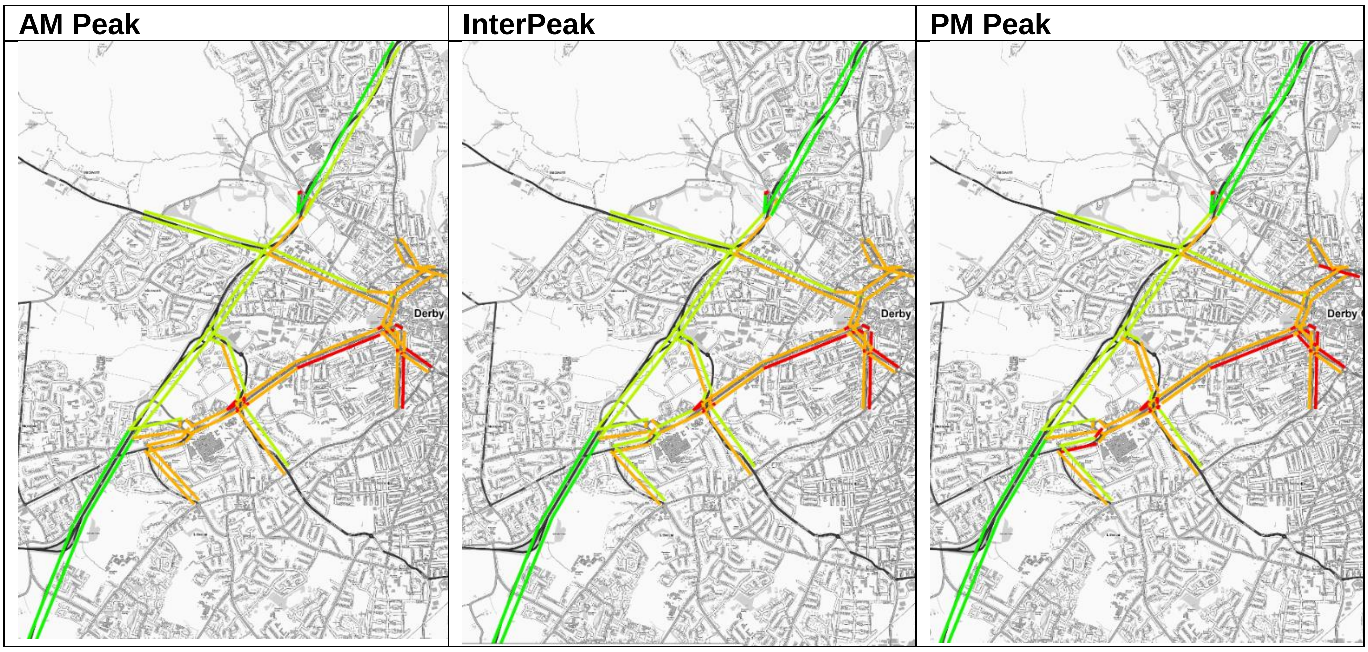


Figure 8: Trafficmaster speeds during the AM, IP and PM peak times in the A38 Derby area

A38 (Kingsway and Queensway)

Based on observed speeds, the northbound A38 mainline is predominantly free flow during all traffic periods shown in **Figure 8**. The speeds are lower along the A38 Kingsway and Queensway sections at the junction approaches, which is possibly also due to the speed limit of 40mph enforced along the A38 Kingsway between the Kingsway and Markeaton Junctions, however speeds are still classified as free flow. The southbound A38 speeds are also largely free flow with the only section of the A38 experiencing congestion being the approach to the Markeaton Junction, where light congestion occurs during peak and interpeak hours. The observed speeds are considerably lower than the allowed speed limit (113 kph) along the A38 Kingsway and Queensway, which is indicative of queuing and slower moving traffic approaching the Derby junctions.

The Highways England scheme is expected to lead to improved journey times along the A38 and therefore reduce congestion at these junctions. This is expected to lead to air quality benefits along the A38 Derby main carriageway where congestion occurs however these improvements may be countered by other effects. For example, the scheme may bring traffic closer to sensitive receptors as a result of highway widening and/or an increase in traffic flows on the A38 as a result of the scheme, along with future traffic growth in Derby.

Further north from the A38 Queensway, average speed data have not been presented as data were not provided. Modelled traffic speeds were reviewed for the A38 up to the Junction with the A61 and modelled speeds are higher away from the Derby junctions shown in **Figure 8**.

A52 Ashbourne Road

The observed speeds along the A52 are restricted by lower speed limits than along the A38 which is 70mph (112 kph), except for the A38 Kingsway section which is a 40mph zone. To the west of the Markeaton Junction the speed limit is 40 mph (64 kph) whilst it is 30 mph (48 kph) to the east of the junction into and out of the Derby centre. Observed speeds along the A52 indicate that westbound traffic is queued up on the approach to the Markeaton Junction, with light congestion that stretches back to the Derby inner ring road. The inner ring road itself also suffers from light congestion during peak and interpeak hours, with heavy congestion also observed during the PM peak to the north of the Derby inner ring road. Eastbound A52 observed speeds are predominantly free flow with some light congestion links observed on the approach to the Derby inner ring road around the intersection of the A6/A601.

Given the A38 Queensway linking up with A52 Ashbourne Road at the Markeaton Junction suffers from slow moving traffic, it is expected any vehicles merging from here onto the A52 would be accelerating along the first section of road off the Markeaton Junction. This is likely to increase vehicle emissions and in turn contribute to the air quality problems witnessed along the A52 Ashbourne Road. Local trips and origin destinations are explored later in this chapter to understand the car, LGV and HGV movements in and around the A38 Derby.

Similarly, the queuing traffic leading up to the Markeaton Junction is slower moving and likely to be more stop-start traffic which would also result in elevated emissions and higher NO_2 concentrations at nearby receptors.

A5111 Kingsway and A5111 Manor Road

The A5111 Kingsway is free flow during the AM and interpeak away from the Kingsway Junction, and lightly congested on the approach to the Junction. PM peak traffic is congested in both directions, which might be attributed to the numerous employment and residential areas adjoining this stretch of road. There are few receptors sensitive to air pollution within close proximity of the A5111 Kingsway, however this road is linked to other key roads into Derby with nearby residential receptors including the A5111 Manor Road and the A516 Uttoxeter New Road, traffic conditions along which are likely to be affected by any queuing traffic along this road.

Further south along the A5111 Manor Road southbound, traffic is free flowing and as it is downhill in parts there are more high speed movements. This is in contrast with the northbound traffic on the A5111 Manor which is light congestion during peak and interpeak periods. Similarly to the A52 Ashbourrne Road, there is the likelihood of there being acceleration along the southbound direction traffic away from the Junction with the A516 Uttoxeter New Road, and queuing traffic and stop-start conditions northbound at an incline, which could both result in increased road traffic emissions and in turn contribute to the air quality problems at receptors along this road. These issues will be explored separately in more detail in the following chapter.

A516 Uttoxeter New Road

A review of the locations of exceedances of the annual mean NO_2 objective and exposed sensitive receptors in the study area, described in **Appendix 4**, found that annual mean NO_2 concentrations are of particular concern adjacent to this road. A key hot-spot area based on the air quality monitoring data was identified around the Junction of the A516 with the A5111. As the flows along the A516 Uttoxeter New Road are small in comparison to the A38 and A5111, it is not unreasonable to assume that the air quality problems in this area primarily originate from increased emissions caused by congestion along this road.

The areas adjacent to the A516 Uttoxeter New Road are predominantly residential, with some employment areas, notably the Royal Derby Hospital to the east of the Junction with the A5111. The observed speeds on this road are shown to be similar during both peak and interpeak periods, with light congestion occurring along the full length of the A516 Uttoxeter New Road in both directions, with heavy congestion leading up to the Junction with the A5111 from all directions.

The westbound traffic out of Derby is more congested near to the inner ring road than the eastbound traffic, with heavy congestion also seen during the PM peak near to the Royal Derby Hospital on the B5020. This road may not cope well with the volumes of local traffic most likely travelling to and from the Royal Derby Hospital and possibly retail and residential areas, which encompasses this A516 Uttoxeter New Road area. The proximity of sensitive receptors to road traffic emission sources is also a factor that influences the air quality problems in this area.

The signalled junction with the A5111 leads to further congestion which results in stop-start traffic, frequent heavy acceleration away from the junction and idling emissions, all of which result in increased emissions and contribute to the elevated NO_2 concentrations at nearby receptors.

Vehicle Fleet Composition

Introduction

ANPR surveys were undertaken at 10 different sites in the A38 Derby study area between 22/04/16 and 28/04/16, the data from which were used to determine local fleet composition for road links in the study area. The locations of where the data were collected are shown in **Figure 9**.

The data have been analysed to determine the proportions of different vehicle types by hour of day and the average proportions of vehicle types by Euro standard[1].

The small number of vehicles that were unable to be classified were removed from subsequent calculations. The percentage breakdown of the remaining vehicles at each count site by hour of day was then calculated, which was then used to determine an average hourly fleet composition for an average weekday and weekend day at each survey site. Averages were also derived for ‘urban roads’ which were subsequently used to disaggregate measured / modelled Heavy Duty Vehicle (HDV) and Light Duty Vehicle (LDV) flows for those road links for which ANPR survey data were unavailable (i.e. the A5111 Manor Road and A516 Uttoxeter New Road).

[1] Vehicles are classified according to their European type-approval emissions standard (Euro standard), with more modern vehicles having to meet more stringent emission standards

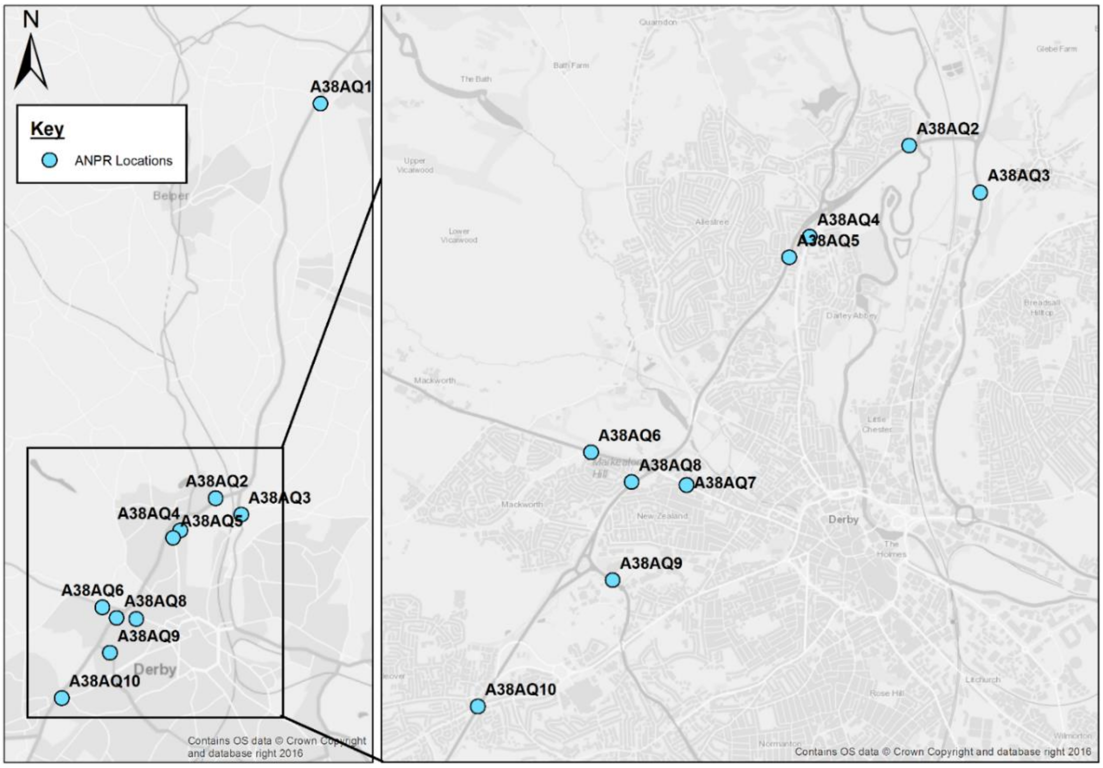


Figure 9: Links where ANPR Data were Collected

Comparison of Vehicle Fleet Proportions with National Projections

A detailed comparison has been made between the vehicle composition data derived from the ANPR surveys with the corresponding values projected by the Department for Transport and used by Defra in its Emissions Factors Toolkit (EFT v7.0). These projected vehicle fleet composition data also underpin the 2013 version of the Defra PCM model and were the most recently available at the time of this study.

Table 3 presents a comparison of measured vehicle fleet composition at different locations of interest in and around the A38 Derby with national fleet composition projections. ANPR sites A38AQ5 - A38AQ10 were used in this analysis as these are the nearest to the air quality focus areas discussed in this report, and a review of air quality monitoring data suggests that exceedances of the annual mean air quality objectives are unlikely to occur north of the A38 Queensway.

Vehicle Type	Motorway (Not London)	Urban (Not London)	A38 Queensway	A52 West	A52 East	A38 Kingsway	A5111 Kingsway	A38 (South of A516)
	EFT National Fleet Composition		A38AQ5	A38AQ6	A38AQ7	A38AQ8	A38AQ9	A38AQ10
Electric car	0%	0%	0%	0%	0%	0%	0%	0%
Petrol car[1]	28%	43%	33%	42%	44%	36%	45%	35%
Diesel car[1]	47%	39%	44%	42%	42%	42%	45%	45%
Petrol LGV	0%	0%	0%	0%	0%	0%	0%	0%
Diesel LGV	13%	13%	14%	12%	12%	12%	8%	13%
Rigid	5%	2%	3%	2%	1%	3%	1%	3%
Artic	7%	0%	6%	1%	0%	6%	1%	5%
PSV	0%	1%	0%	1%	1%	0%	0%	0%
Motorcycle	0%	1%	0%	0%	0%	0%	0%	0%

Table 3: Comparison of national fleet composition projections against ANPR survey results on the A38 main carriageway, A52 and A5111 ([1] proportions include hybrids)

A comparison of the A38 vehicle fleet composition derived from the ANPR survey with values projected by DfT and used by Defra in its Emission Factor Toolkit (EFT) shows that:

- At all sites along the A38 (ANPR sites AQ5, AQ8 and AQ10), the measured proportion of petrol cars makes up a smaller proportion of the vehicle fleet than that projected for an urban road within the EFT, but a larger proportion of the fleet than projected within the EFT for a motorway; (this includes ANPR sites 1 and 2 not included in **Table 3**)
- The measured proportions of diesel cars at all sites along the A38 are lower than projected within the EFT for a motorway but higher than projected within the EFT for an urban road;
- All A38 sites have a comparable proportion of articulated HGVs to that projected within the EFT for a typical motorway, whereas the proportions of rigid HGVs along the A38 are slightly smaller compared to the EFT projections for a motorway;
- Public Service Vehicles (PSVs) make up a small proportion of the total vehicle fleet for all A38 sites, with the measured proportions of buses and coaches similar to the EFT projections for motorways;
- at all sites, the measured proportions of motorcycles appear to be considerably lower than EFT projections, possibly due to lower capture rates for motorcycles as they generally tend to have smaller number plates which may be more difficult to capture using ANPR; and
- LGVs appear to make up a similar proportion of the vehicle fleet compared to EFT projections.

The ANPR data therefore suggests that the composition of the vehicle fleet on the A38 is more similar to a motorway and therefore the A38 serves a more strategic purpose than other local roads. This is investigated further in the following section on Select Link Analysis to understand better the true nature of the journeys and origin destinations in and around Derby.

For the A38's adjoining arterial roads (the A52 and A5111), the fleet composition is different to that of the A38 and the comparison of the fleet composition on these roads against EFT projections shows that:

- the average measured proportion of petrol cars is slightly lower than that projected within the EFT and the average measured proportion of diesel cars is slightly higher than that projected within the EFT;
- the average proportions of Rigid and Artic HGVs on arterial roads into Derby are consistent with the EFT projections for an urban road, while for the A52 west of the A38 the measured proportions of HGVs are slightly higher compared to the EFT projections for an urban road;
- Measured proportions of PSVs are slightly lower than projected with the EFT, with no buses measured along the A5111 Kingsway whatsoever, which is not unreasonable given there are no bus stops along this section of the A5111;
- the measured proportion of motorcycles is significantly lower than that projected within the EFT, which as previously mentioned, could be due to lower data captures for motorcycles; and
- LGVs appear to make up a similar proportion of the vehicle fleet compared to EFT projections, except for the A5111 Kingsway which has lower proportions of LGVs. This is quite an unexpected finding given the proximity of this site to the Kingsway retail park.

Whilst the A38 appears more similar to a motorway and therefore possibly more strategic in nature, the adjoining arterial roads are more similar to the fleet composition projections within the EFT for an urban road.

Comparison of Vehicle Type Euro Proportions with National Projections

In addition to vehicle type, ANPR survey data can also be used to determine the Euro emission standard of each captured vehicle, the proportions of which will influence road traffic emissions as more modern vehicles, which meet more recent Euro emission standards, have lower emissions. The average Euro standard proportions for the ANPR sites on the A38 Derby, A52 Ashbourne Road and A5111 Kingsway are presented in **Table 4** for Diesel cars, LGVs, HGVs and Buses and coaches. In terms of Euro standard, and in comparison to national projections, the analysis showed that:

- The measured proportions of Euro 5 and Euro 6 petrol cars are lower than those projected in the EFT while proportions of Euro 3 and Euro 4 vehicles are higher than EFT projections;
- the measured proportions of Euro 6 diesel cars are lower than the EFT projections, with the proportions of Euro 3, 4 and 5 vehicles being consequently slightly higher;
- The proportion of Euro 6 Diesel LGVs in the EFT (17%) is substantially higher than measured at all sites across Derby (1% on average). This difference is primarily related to a delay between approval and first registration of Euro 6 LGVs in the UK. Measured proportions of Euro 3 and Euro 4 Diesel LGVs are therefore much higher (16% and 29% on average) than projected within the EFT;

- Measured proportions of Euro VI Rigid and Artic HGVs are substantially lower than projected in the EFT, with higher measured proportions of Euro III, IV and V as a result; and
- Measured proportions of Euro VI PSVs for are significantly lower than projected within the EFT, with greater measured proportions of Euro I to IV PSVs on all roads.

The ANPR survey data suggests that the local A38 and Derby fleet is older than suggested by national projections, which are likely to have assumed a much quicker rate of renewal of the vehicle fleet than appears to have been the case.

Euro Class	National Projection	A38	A52	A5111
Diesel Cars				
Pre-Euro 1	0%	0%	0%	0%
Euro 1	0%	0%	0%	0%
Euro 2	0%	0%	1%	1%
Euro 3	8%	8%	10%	10%
Euro 4	23%	26%	29%	29%
Euro 5	44%	48%	45%	47%
Euro 6	24%	17%	15%	13%
Articulated and Rigid HGVs				
Pre-Euro I	0%	0%	0%	0%
Euro I	0%	0%	0%	0%
Euro II	0%	1%	2%	0%
Euro III	6%	8%	12%	9%
Euro IV	7%	16%	22%	18%
Euro V	32%	43%	39%	49%
Euro VI	54%	32%	25%	24%
Diesel LGVs				
Pre-Euro 1	0%	0%	0%	0%
Euro 1	0%	0%	1%	1%
Euro 2	0%	1%	2%	1%
Euro 3	4%	12%	17%	17%
Euro 4	20%	27%	30%	30%
Euro 5	58%	58%	50%	48%
Euro 6	17%	1%	1%	3%
Buses and Coaches (PSVs)				
Pre-Euro I	0%	0%	0%	0%
Euro I	0%	3%	3%	10%
Euro II	4%	13%	11%	21%

Euro Class	National Projection	A38	A52	A5111
Euro III	17%	24%	9%	35%
Euro IV	13%	21%	16%	22%
Euro V	35%	34%	61%	6%
Euro VI	31%	5%	1%	6%

Table 4: Comparison of Defra EFT Euro compositions against average ANPR survey results on the A38 main carriageway, A52 and A5111 for Diesel cars, Diesel LGVs, HGVs, and PSVs.

Select Link Analysis

Origin and destination information has been taken from the Derby Junctions base year traffic model. The results of this analysis, which are presented in detail in **Appendix 8**, indicate that vehicles travel predominantly on a north to south route along the A38 Derby during the morning peak hour, bypassing Derby, and vice versa during the evening peak hour, with some local traffic travelling in to Derby via the A516.

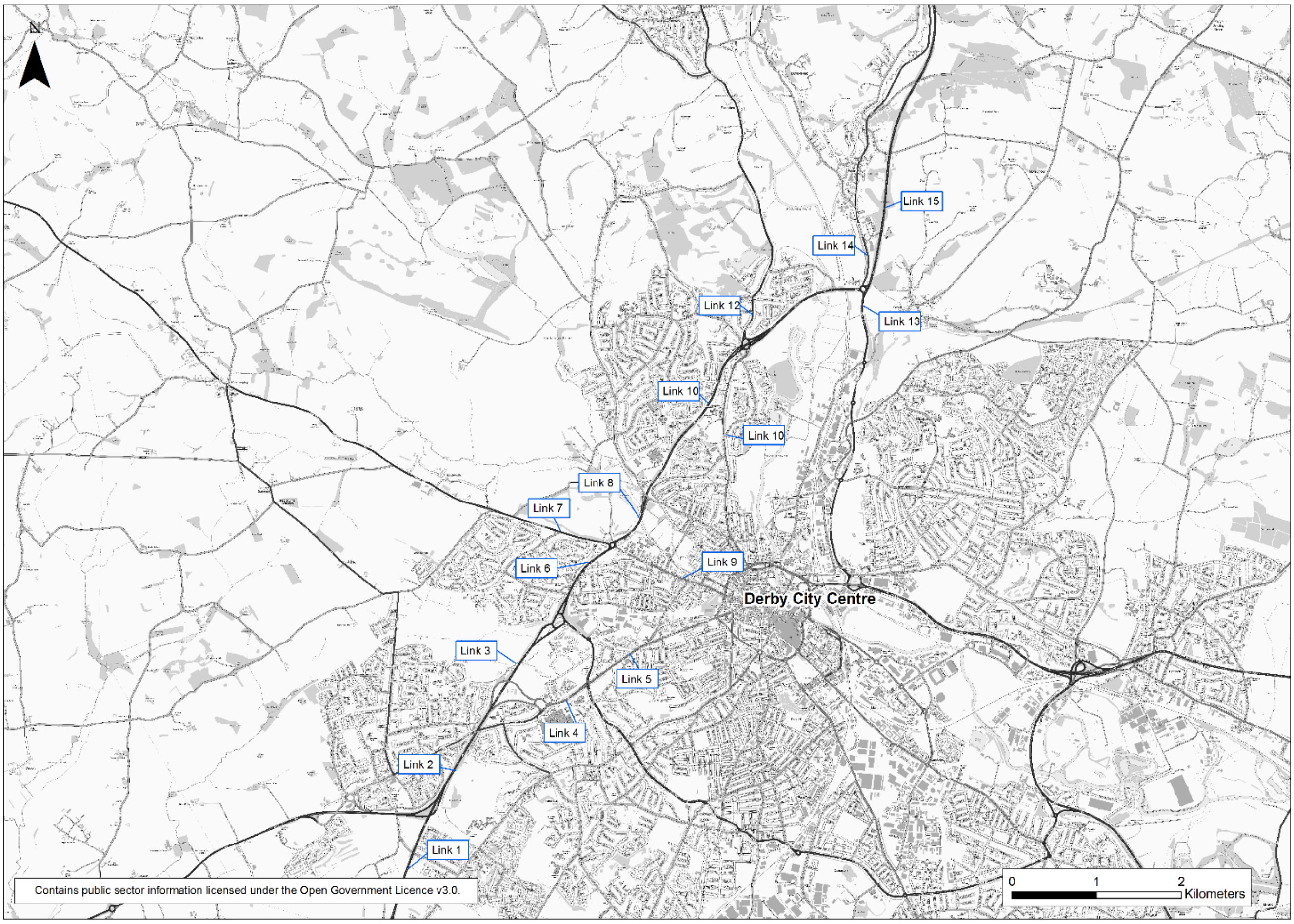


Figure 10: Location of Select Links from Derby Junctions transport model

The traffic analysis contributes to the air quality exercise by indicating whether the air quality issues on the A38 and in the Derby area are a result of long distance traffic, local traffic or a combination of the two. **Figure 10** shows the Select Links that have been analysed using bandwidths[2] to understand the local movements taking place and in matrix format to understand the overall origin and destinations of these movements.

[2] Information representing the loaded volumes of trips in between starting and ending points within the transport network.

The results discussed here consider six out of the 15 Select Link locations in detail, namely:

- The A38 at the northern and southern extents of the study area (Select Links 1 and 15);
- Uttoxeter New Road, north and south of Manor Road (Select Links 4 and 5); and
- The A52 to the west and east of the A38 (Select Links 7 and 9).

Summaries of the other locations can be found in **Appendix 8**. The detailed analysis considers whether traffic using the selected locations are routing via local or strategic roads. This analysis has been undertaken by vehicle type (car, LGV and HGV). It should be noted that the figures presented to support this analysis have different scales in the key, this is to allow the routing of traffic to be clearly visible in each figure.

A38 (Select Link 1 – A38 South of study area)

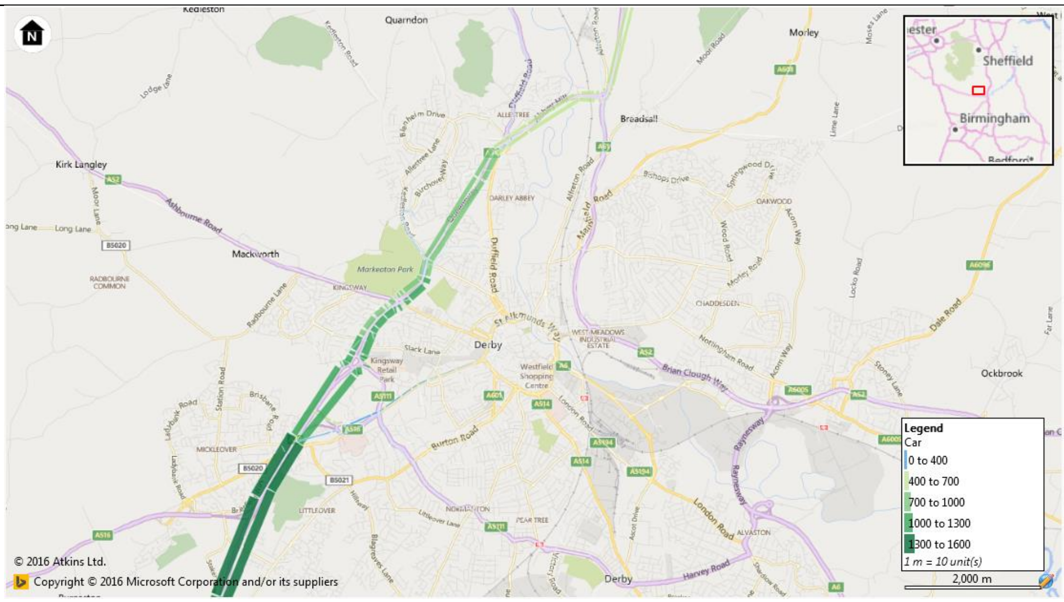
This Select Link is located along the main A38 carriageway between the roundabout joining the A38 with Rykneld road and Staker lane and the junction with the A516. The Select Link Analysis shows similar routing in the AM and PM peak periods, therefore figures are only provided here for the AM peak.

HGV traffic comes from/goes to the A38 north and south of the Select Link, with minimal trips onto local routes. This indicates that the majority of HGVs on the A38 at this point are making longer distance, strategic journeys, rather than travelling to and from Derby.

A similar pattern can be seen for LGVs, although the lighter bandwidths to the north of the Select Link indicate that some northbound LGV trips in the AM peak are travelling to the local area.

In contrast, car journeys on this link appear to be more heavy associated with local trips and in particular trips along the A516 and Uttoxeter New Road/A5111, and to a lesser extent from the B5008 leading to Willington, which suggests commuting from the south into and out of Derby via this route. These are likely to be attributed to the hospital or residents around the area preferring this route to either get to the M1 (via the A50) or commute to Burton-upon-Trent.

A38 Derby AM Peak Hour **Car Journeys**



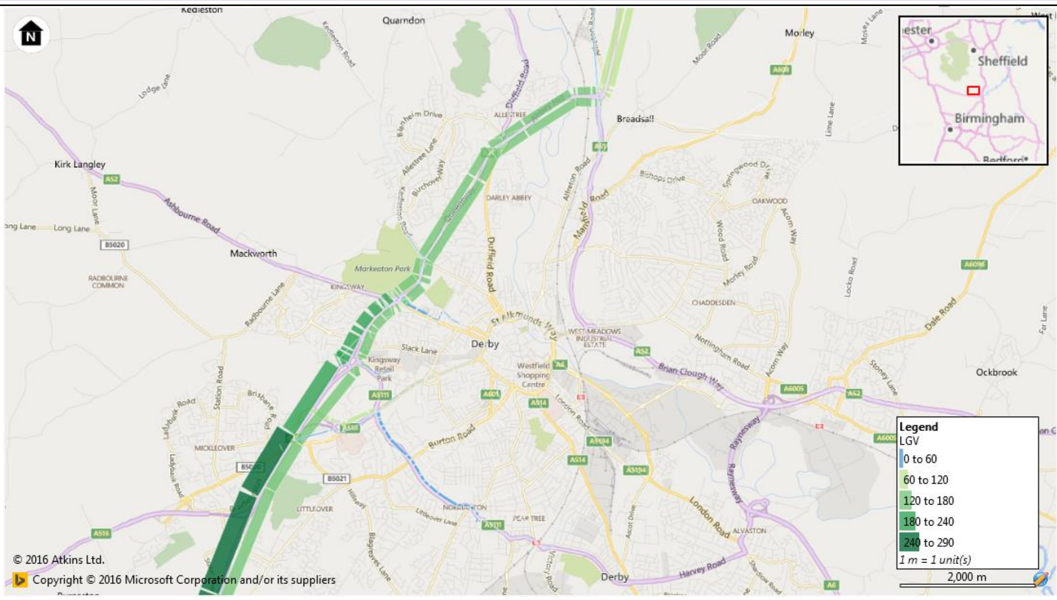
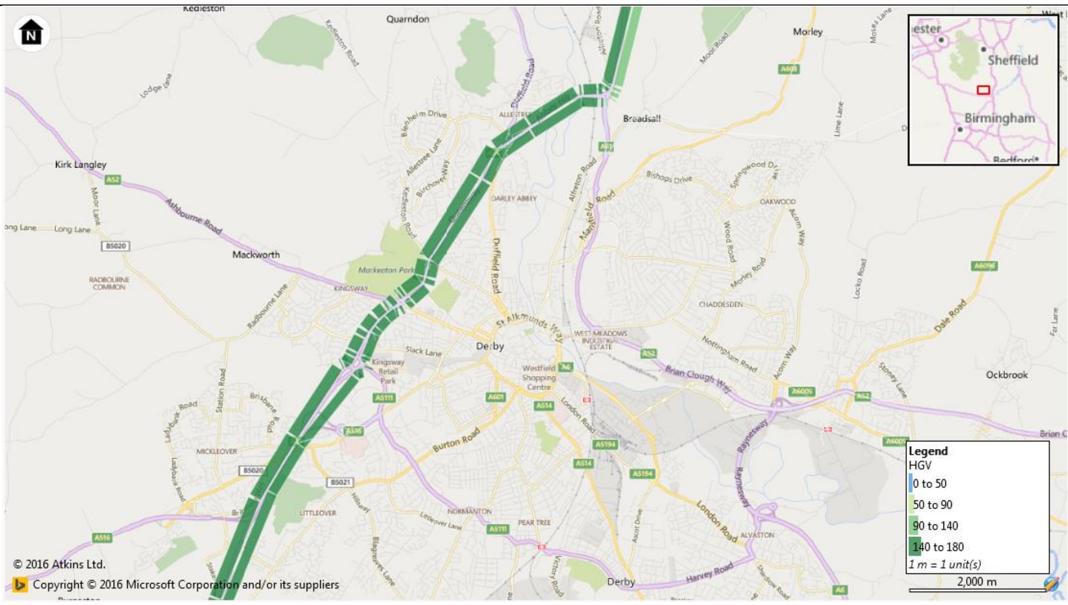
A38 Derby AM Peak Hour **LGV Journeys**	
A38 Derby AM Peak Hour **HGV Journeys**	

Figure 11: Select Link South of A516 Junction with A38 during the AM peak and for cars, LGV and HGV journeys

A38 (Select Link 15 North of study area)

Select Link 15 is located on the A38 between Little Eaton Island in the south and the junction leading onto the B6179 in the north. There are large flows of car, LGV and HGV traffic from the A38 (north) and A38 (west) on this link. It is also noteworthy that there is a significant amount of car traffic travelling to and from the A61 (south).

Similar distributions of trips can be seen in the AM and PM peak, though the absolute numbers of trips are themselves of course different.

A52 Ashbourne Road (Select Link 9 East of A38)

Select Link 9 is located on the A52 (Ashbourne Road) between the A38 Kingsway / Queensway in the west and Ford Street in the east. Car movements along this link are dominated by movements via the A52. There is little influence from the A38, with less than 10% of the total car traffic routing via the A38 Kingsway northbound on this link. A similar pattern is seen for both HGV and LGV movements along this link, albeit that a number of LGV movements are associated with the northbound A38 to the south.

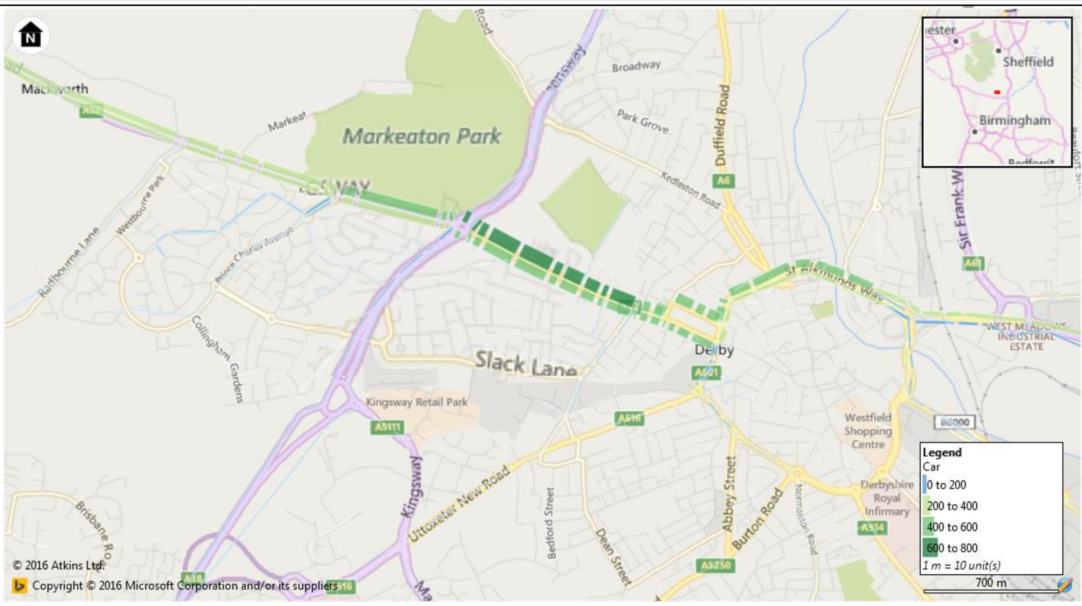
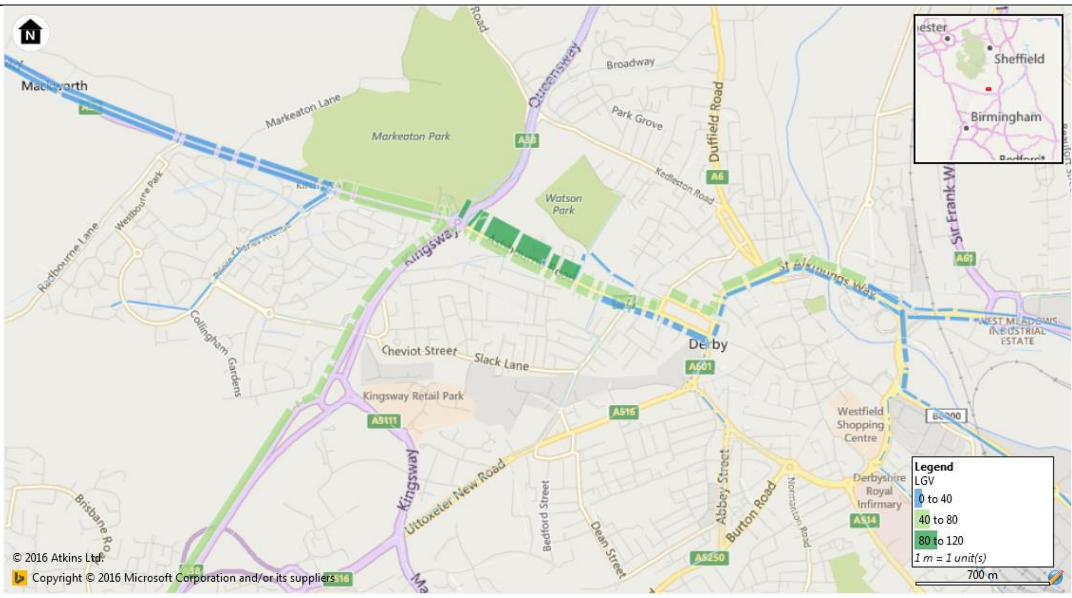
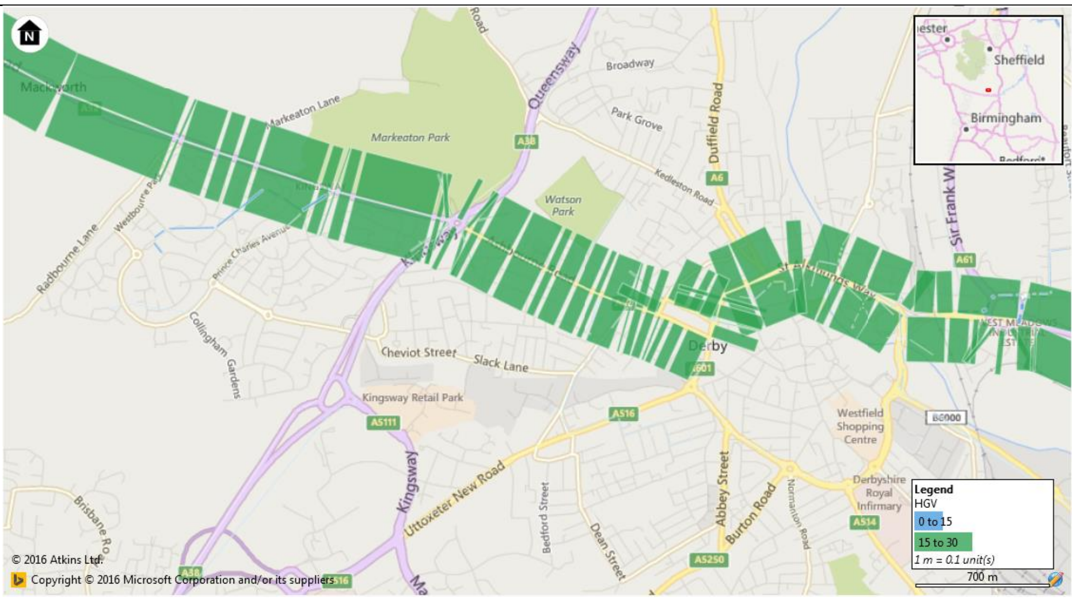
A52 Ashbourne Road AM Peak Hour **Car** **Journeys** from SLA east of A38	
A52 Ashbourne Road AM Peak Hour **LGV** **Journeys** from SLA east of A38	
A52 Ashbourne Road AM Peak Hour **HGV** **Journeys** from SLA east of A38	

Figure 12: Select Link on A52 Ashbourne Road during the AM peak for cars, LGV and HGV journeys

A52 Ashbourne Road (Select Link 7 West of A38)

This link is located on the A52 (Ashbourne road) between a roundabout linking the Kingsway and Queensway to the east and the junction with Markeaton Lane to the west. The majority of car traffic routing along Select Link 7 travels in a West-East direction through to the A52 east of Derby via the Derby Inner Ring Road, with some routing on to the A5111 via the A38 Kingsway northbound (15%).

LGVs follow similar routing to cars with the exception that there are some movements along the A38 Queensway. The majority of HGV movements are in a West-East direction, with minimal trips routing to/from the A38 in both the AM and PM peaks. This supports the results of the analysis of the A38 Select Links, in that HGV traffic on the A38 appears to be largely strategic and routes through the study area.

A516 Uttoxeter New Road (Select Link 4 South of Manor Road)

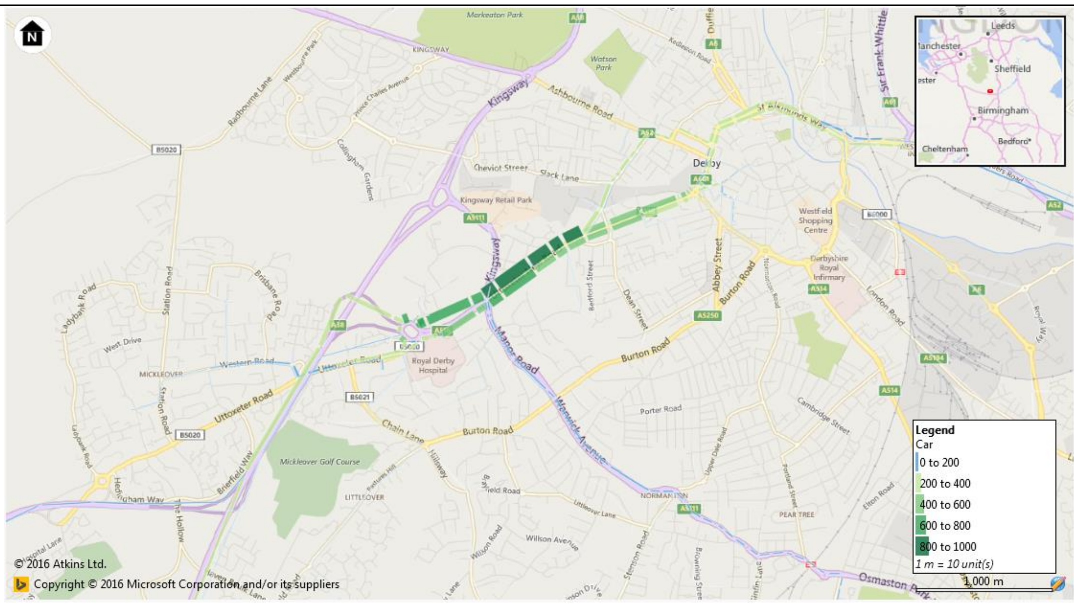
Select Link 4 is located on the A516 (Uttoxeter New Road) between the roundabout with the B5020 and the cross roads with Manor Road / Kingsway. The traffic along this link is largely dominated by cars, with lower volumes of LGVs and fewer HGVs. The distribution of cars and LGV journeys is similar, with the majority originating from the A516 Uttoxeter New Road and A5111 Manor Road, with the B5020 and A38/A516 Northbound Junction also being a significant route.

More than half of the Eastbound A516 car traffic travels via the Ring Road to the A601. Westbound A516 traffic from Manor Road and Uttoxeter New Road travels either via the B5020 (c.35%) or along the A516 Southbound (65%). The largest flows are from the A5111 Manor Road and the A516 via the A38.

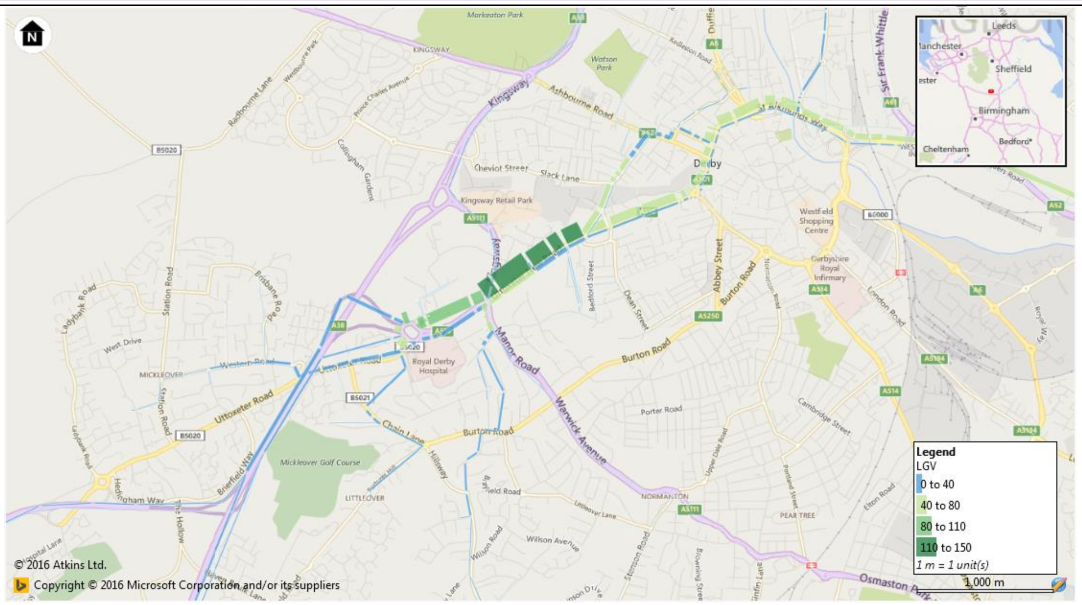
A516 Uttoxeter New Road (Select Link 5 North of Manor Road)

Select Link 5 is located along the A516 (Uttoxeter New Road) between the crossroads with Manor road and the roundabout with the A601 (Mercian way / Derby ring road). The majority of car movements on this link (75%) originate from local roads adjacent to the Uttoxeter New Road/A516 up to the inner ring road and B5020, with some influence from the A516 merging with the A38 or continuing on the A516 (<25%). HGV and LGV movements are fed from the B5020 and the Derby Inner Ring Road, with little contribution from other directions. The A5111 is a minor contributor to all vehicle type movements along this link.

A516 Uttoxeter New Road AM Peak Hour
Car Journeys from SLA east of A5111



A516 Uttoxeter New Road AM Peak Hour
LGV Journeys from SLA east of A5111



A516 Uttoxeter New Road AM Peak Hour
HGV Journeys from SLA east of A5111

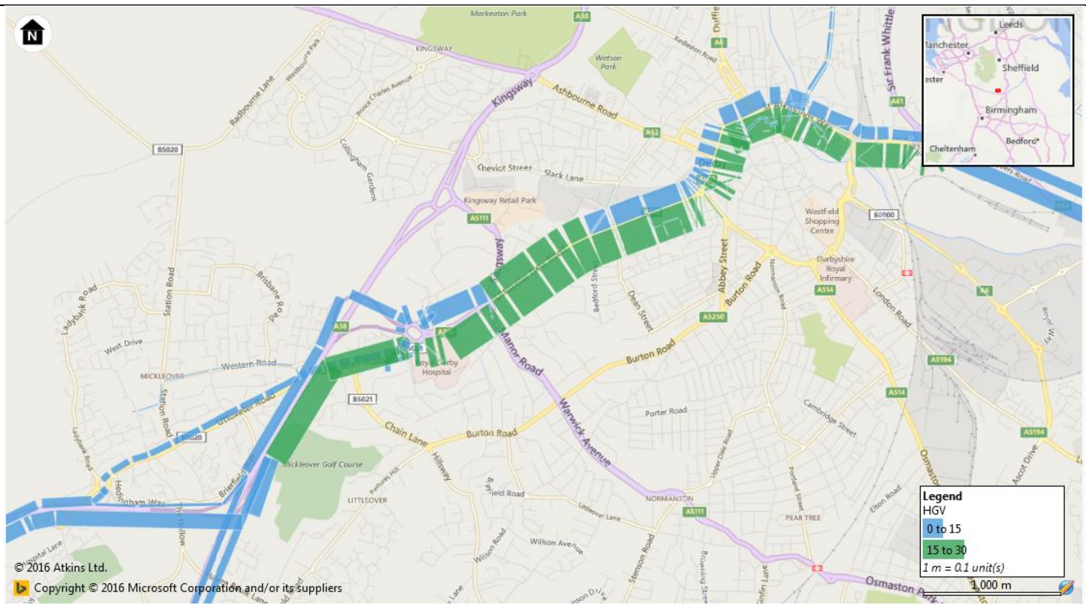


Figure 13: Select Link on A516 Uttoxeter New Road East of the Junction with A5111 during the AM peak and for cars, LGV and HGV journeys

Origin Destination Analysis

The select link analyses discussed above consider the routing of traffic either side of the selected link. It is however also useful to consider the ultimate origin and destination of these trips, as this could potentially inform mitigation measures. This analysis requires exporting the data from the traffic model in a slightly different format, allowing the number of trips traversing the selected link to be viewed as a thematic map by origin and destination, rather than the number of trips on a particular link. **Figure 14** below shows this analysis for the A38 for Select Link 15 for total traffic in the AM peak.

The purpose of this analysis is to support the hypothesis that the ultimate origins/destinations of trips on the A38 are generally longer distance, rather than within Derby itself. The bandwidth Select Link Analysis figures discussed above do not readily show the ultimate origin/destination of trips. Only Origin/Destination analysis for the A38 during the morning time period is presented here. Other Select Links and time periods were explored and included and discussed further in **Appendix 8**.

This origin and destination analysis, as shown for the A38 north of the study area in **Figure 14** and **Figure 15**, indicates that the majority of vehicles travel from the Midlands and South West to South Yorkshire and Nottingham/Derby during the AM peak. This evidence emphasises the important strategic purpose of the A38 Derby.

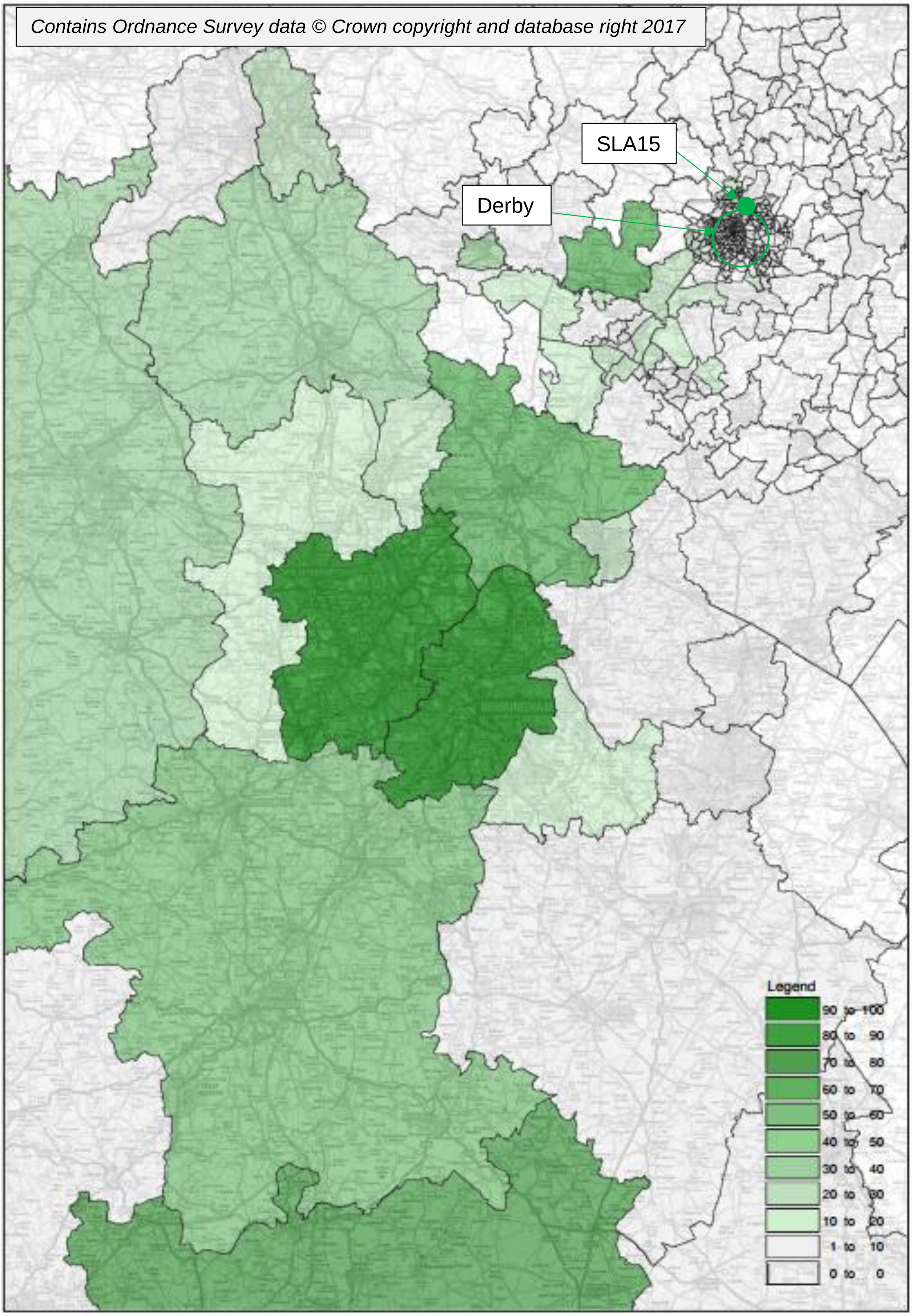


Figure 14: AM Peak Hour A38 north of study area, northbound SLA origins (Number of trips)

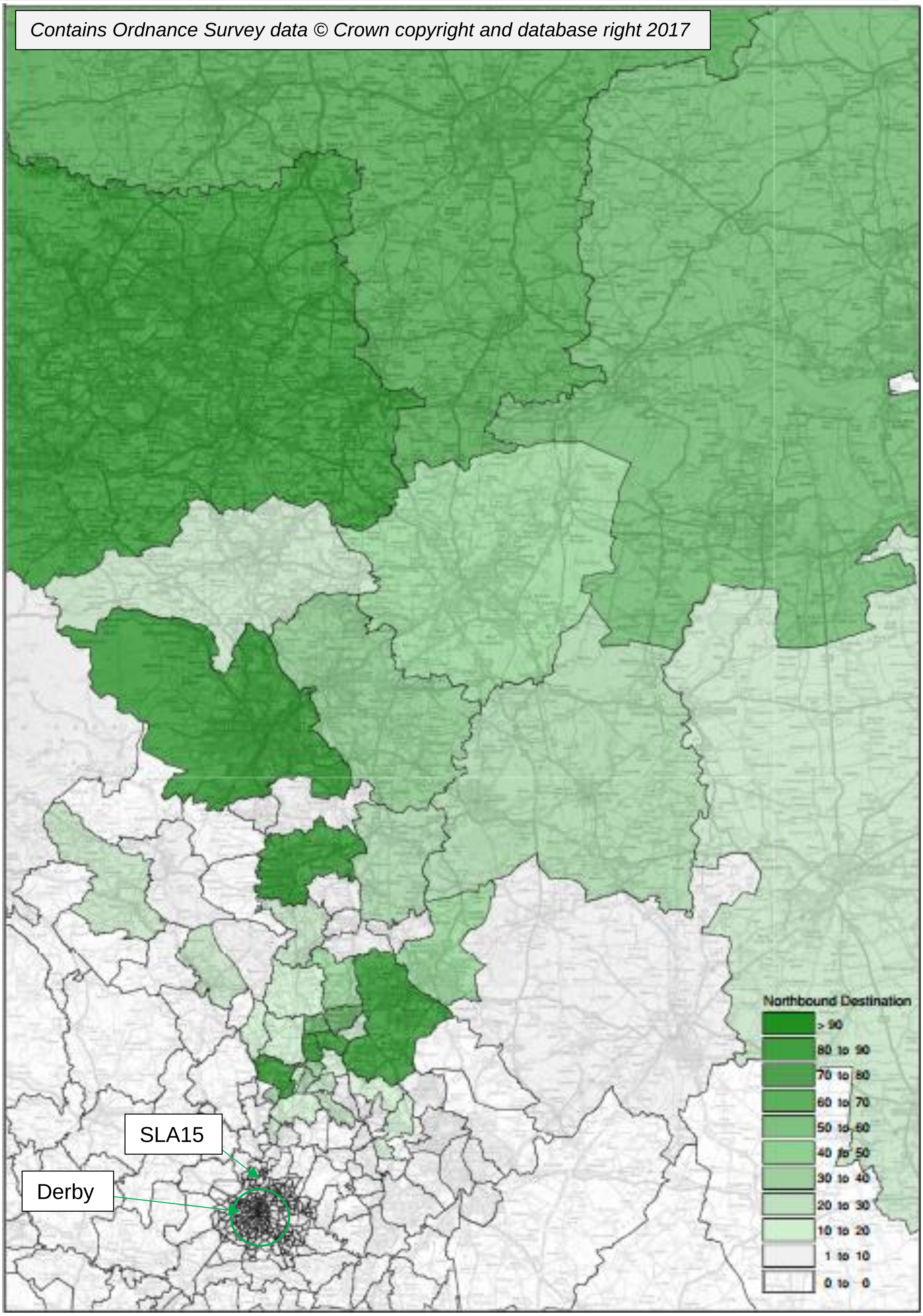


Figure 15: AM Peak Hour A38 north of study area, northbound SLA destination (Number of trips)

4. Air Quality

Introduction to Chapter

This Chapter considers how road traffic emissions affect local annual mean NO_2 concentrations in the study area. It draws on the rural and local background NO_2 component and annual mean concentrations of NO_2 measured using passive diffusion tubes at numerous roadside sites across the A38 Derby area. The A38 in Derby could influence air quality by:

1) Direct emissions from the volume and composition of traffic on the A38;
2) Direct emissions due to congestion around the junctions of the A38 with adjoining A-roads; and
3) Increased traffic on local A-roads caused by vehicles accessing the A38.

This chapter aims to explain the likely causes of the air quality problems in Derby.

Mapped Background Concentrations

Defra Background NO_2 and NOx mapped concentrations are discussed in **Appendix 2**, which provides a review of the Defra background mapping data for NO_2 and NOx for the A38 Derby pilot study area. The 2013 Defra base year background maps were used to project 2015 data. Pollutant concentrations are provided on 1 km^2 grids over the Derby City Council authority area. Concentrations were compared to the annual mean UK AQS objective for NO_2 (40 µg m^{-3}). There is not an equivalent UK AQS objective for NOx, as this comprises all oxides of nitrogen (i.e. NO and NO_2), and NO is not a human health issue. Instead, grid squares with elevated NOx concentrations have been identified to understand source contributions to NO_2. Defra background mapping provides individual source contributions, for road and non-road sources, to NOx. Hot spot locations were identified as grid squares where the NO_2 concentration was at least 75% of the AQS objective (i.e. ≥30 µg m^{-3}), none of which were located close to the A38 Derby mainline or adjoining arterial roads.

The largest in-square contribution to NOx close to the A38 Derby is the Kingsway Hospital Site (a 1,000 kW biomass Combined Heat and Power Energy facility) that contributes 1.7 µg/m^3. Hot spot locations for NO_2 and NOx are located east and southeast of Derby city centre. The majority of the background contributions in the hot-spot locations identified is from non-road sources. Excluding the regional rural contribution, most NOx emissions are from industrial, domestic, rail and other (off-road) sources. Other point source contributions are less significant.

The highest NO_2 concentrations (i.e. >50% of the annual mean AQS objective) are centred on the primarily industrial area southeast of Derby city centre. Higher concentrations also follow major traffic routes, including the A52 east towards Nottingham, the A38/A61 north, the A5111 through southern sections of the city, and a railway line extending to the southwest towards the A38/A50 junction.

There are higher NO_2 and NOx concentrations on the eastern side of Derby than the western side. This is consistent with the dominant wind direction for the area, indicated by the meteorological data obtained for East Midlands airport between in 2014 – 2016 shown in **Figure 3**.

The maximum mapped background NO_2 concentration (34.1 µg m^{-3}) and NOx concentration (60.3 µg m^{-3}) are located in the same grid square (437500, 334500) southeast of Derby city centre. The grid square with the maximum concentration is in the vicinity of many active industrial facilities, including the Bombardier UK manufacturing facilities, the Etches Park train depot, Rolls Royce and Balfour Beatty industrial sites, waste treatment facilities and other industrial units including distribution facilities.

Background mapping along the A38 Derby suggests there are no significant individual in-square NO_x contributions, with the exception of the Royal Derby Hospital. Background NO_2 concentrations are also low (less than 30 µg m^{-3}) with a large rural (regional background) accounting for the majority of this contribution.

Passive Diffusion Tube Analysis

Air quality monitoring data availability was limited to nitrogen dioxide (NO_2) passive diffusion tube monitoring, as no reliable continuous monitoring data were available. The data sources used and the quality assurance methods applied are summarised in **Appendix 3.**

The monitoring data used in this study are presented in **Appendix 4**, which highlight some “hotspot” areas along major routes where NO_2 concentrations exceeded, or were close to exceeding, the annual mean AQS objective (40 µg/m^3). Within these areas, a small number of monitoring sites were identified (i.e. “shortlisted”) to be included in the source apportionment analysis (see **Appendix 6**). The monitored concentrations at these sites are discussed in detail in this section along with observations at other monitoring sites. **Table 5** presents the shortlisted monitoring sites discussed, the locations of which are shown in .

Shortlisted Site IDs	Source IDs	Description
R1	DCC 29	Warwick Avenue
R2	DCC 40	179 Uttoxeter New Road
R3	DCC 78	Friar Gate-Brick Street
R4	HE DJ_003_0813	Uttoxeter Road South (B5020)
R5	HE DJ_006_0813	A516/A5111 Junction
R6	HE DJ_007_0813	A5111 Kingsway
R7	HE DJ_014_0813	Ashbourne Road (A52)
R8	HE DJ_029_0813	Queensway (CMP2)
R9	HE DJ_032_0813	Kingsway (CMP4)

Table 5: Shortlisted NO_2 monitoring sites used in source apportionment analysis

The interpretation of these data was limited to the spatial analysis of measured NO_2 concentrations. The diffusion tube monitoring available along the A38 is mostly from Highways England diffusion tube surveys undertaken between 2013 and 2015. Diffusion tubes along the adjoining arterial roads are a combination of Highways England and Derby City Council monitoring sites.

The most recent measured NO_2 concentrations available (2015) were analysed as they provide us with the most recent baseline for air quality and are the most complete year in terms of data coverage from available data sources (Highways England and Derby City Council). This year is also the same as the traffic data that have been discussed in the previous section and the closest year of monitoring data available to the ANPR survey data collected in 2016 and utilised to inform the NO_2 source apportionment, which will be discussed further on in this chapter.

An explanation of likely localised sources contributing to elevated measured NO_2 concentrations is presented in **Appendix 5**. This was carried out by plotting the measured NO_2 concentration and its distance from the nearest road and comparing this contribution with that estimated by the DMRB normalised drop-off curve. This analysis assumes free flow traffic conditions and therefore any deviations from the idealised curve can potentially indicate other key influences, including congestion, road gradient, meteorology, as well as other factors.

Measured 2015 annual mean NO_2 concentrations were used to determine the annual mean road-NOx concentration at each monitor using Defra’s NOx to NO_2 Calculator (v5.1, June 2016). The resultant NOx concentrations were then normalised to a distance of 10 m, using the fall-off with distance curve produced by Air Quality Consultants (AQC) for the DMRB Air Quality Model (2013 iteration).

These values were then averaged where there were multiple monitoring sites adjacent to the same road, with the resultant average concentration used to extrapolate concentrations using the DMRB fall-off curve from the kerb to as far as 100 m away. Close correlation between the idealised curve and the measured values indicate that the source of the NOx emissions being described by the curve is driving the measured concentrations. In other words, the curve has its origin at the edge of the road, so the idealised curve shows how concentrations would be expected to behave if emissions from that road were solely responsible for the difference between measured and background concentrations. The curve assumes free flow conditions along the road of interest, and does not account for local meteorology or dispersion.

This approach was considered a useful way to determine the contribution that road traffic emissions make to annual mean NOx and therefore NO_2 concentrations, using the results from passive diffusion tubes. This approach only made use of NO_2 monitors not near to other road emission sources, or for which the contribution from other road sources can be readily quantified. The NO_2 monitors along the A38, A52 and A516 Uttoxeter New Road lend themselves to such an analysis.

A38 Diffusion Tubes

Most NO_2 monitors along the A38 are located close to the road and at a distance (>10m) from the nearest location of relevant exposure (i.e. sensitive receptors such as residential properties where the AQS objectives apply). The locations of these monitoring sites are shown in **Figure 16**.

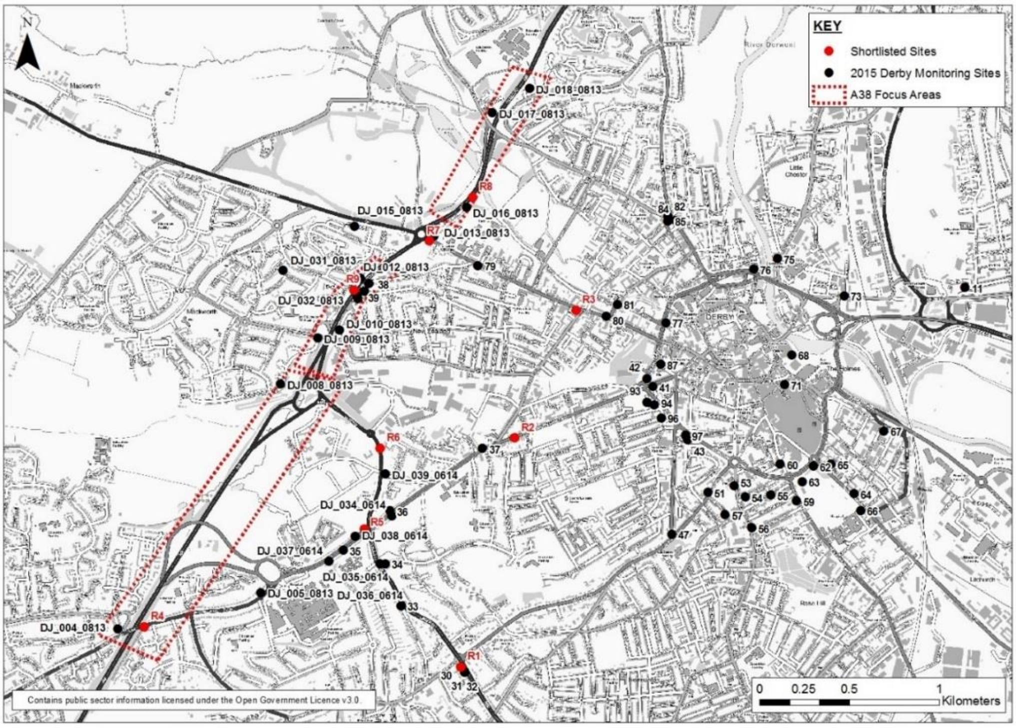


Figure 16: NO_2 Monitors (with shortlisted source apportionment monitors in red) along the A38 areas

Measured annual mean NO_2 concentrations north of the A38 Queensway Markeaton Junction are all consistently below the AQS objective indicating air quality is not a problem in this area. For this reason, only monitors located between the A516 intersection with the A38 and the A38 Queensway have been investigated further to understand the contribution road traffic emissions from the A38 main carriageway make to measured NO_2 concentrations. There are three monitoring sites that have measured exceedances of the annual mean NO_2 adjacent to the A38.

Figure 17 shows the road-NOx calculated for diffusion tube sites along the A38 plotted as a function of distance from the edge of the road, with the idealised curve from the DMRB model fitted through the average of all the measurements. The A38 main carriageway diffusion tube monitoring sites which measured annual mean NO_2 concentrations in 2015 (see **Appendix 4**) were used in this analysis.

As the A38 has a North-East to South-West alignment near Derby it may be that the prevailing wind direction (south-westerly) may have an influence on the dispersion of road traffic emissions in the area. For this reason, monitoring results were split between those west of the A38 and those east of the A38, to account for the influence of meteorological effects on these measurements. All the measurements follow the idealised curve reasonably well, both the east and west of the A38, except for R4 which is located approximately 30m from the A38.

The measured NO_2 concentration at R4 (41.4 $\mu g/m^3$) is higher than predicted at 30 m from the A38, using the idealised drop-off curve, by about 12 $\mu g/m^3$. The site is within 3 m of the B5020, so it is likely that the contribution of road traffic emissions on that road explains this difference. This hypothesis was tested when the analysis was repeated for the B5020. The 2015 measured NO_2 concentration at R4 is higher than expected based on its distance from the B5020 by about 6 $\mu g/m^3$, indicating some likely influence from the A38. When the normalised road-NOx contributions from both the A38 and the B5020 at site R4 were combined, the resultant NO_2 concentration derived from the Defra NOx to NO_2 calculator was within 0.2 $\mu g/m^3$ of the measured concentration. Therefore, it is thought the combined influence from road traffic on the A38 and the B5020 explain the 2015 annual mean NO_2 concentration at site R4 well.

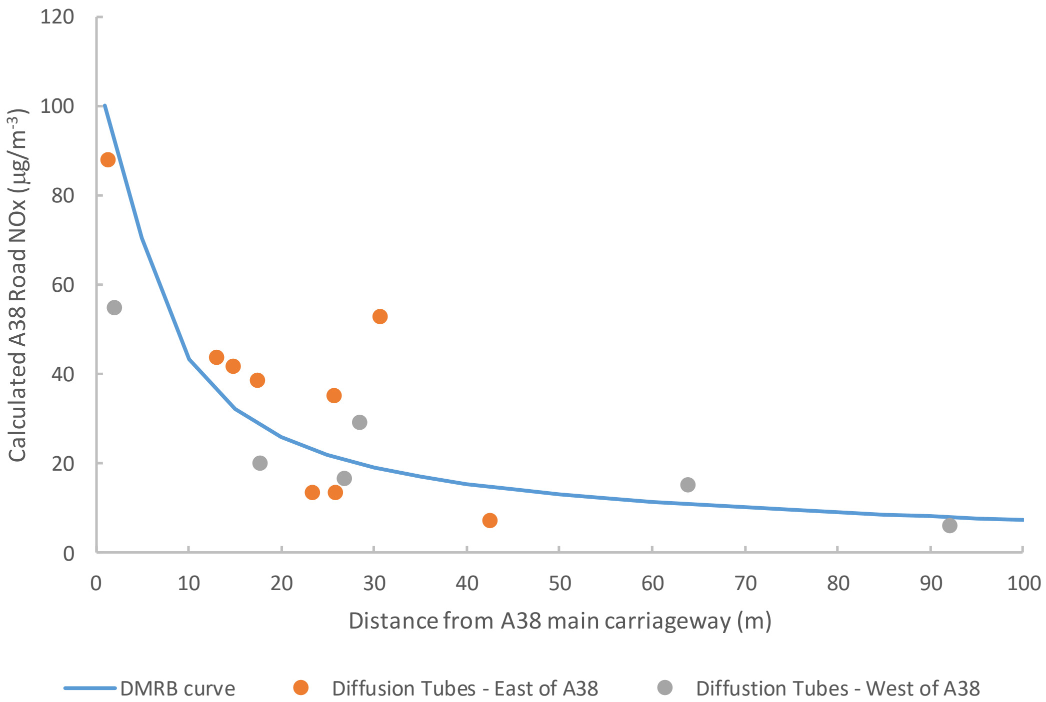


Figure 17: Normalised Road-NOx with distance against idealised DMRB curve – A38 diffusion tubes

In summary, all the measurements follow the idealised curve reasonably well. The monitoring site which falls furthest away from the line in **Figure 17** is R4, which is the only monitor chosen that was close to another significant road source. It is thus considered that:

a) emissions from the A38 are largely responsible for the implied road-NOx concentrations at monitoring sites near to the A38; and
b) the NOx signal from the A38 is accurately represented by the curved line in **Figure 17**.

A52 Ashbourne Road Diffusion Tubes

There were fewer NO_2 monitors available for analysis along the A52, with only two recorded exceedances, both located to the East of the Junction with the A38, as shown in **Figure 18**.

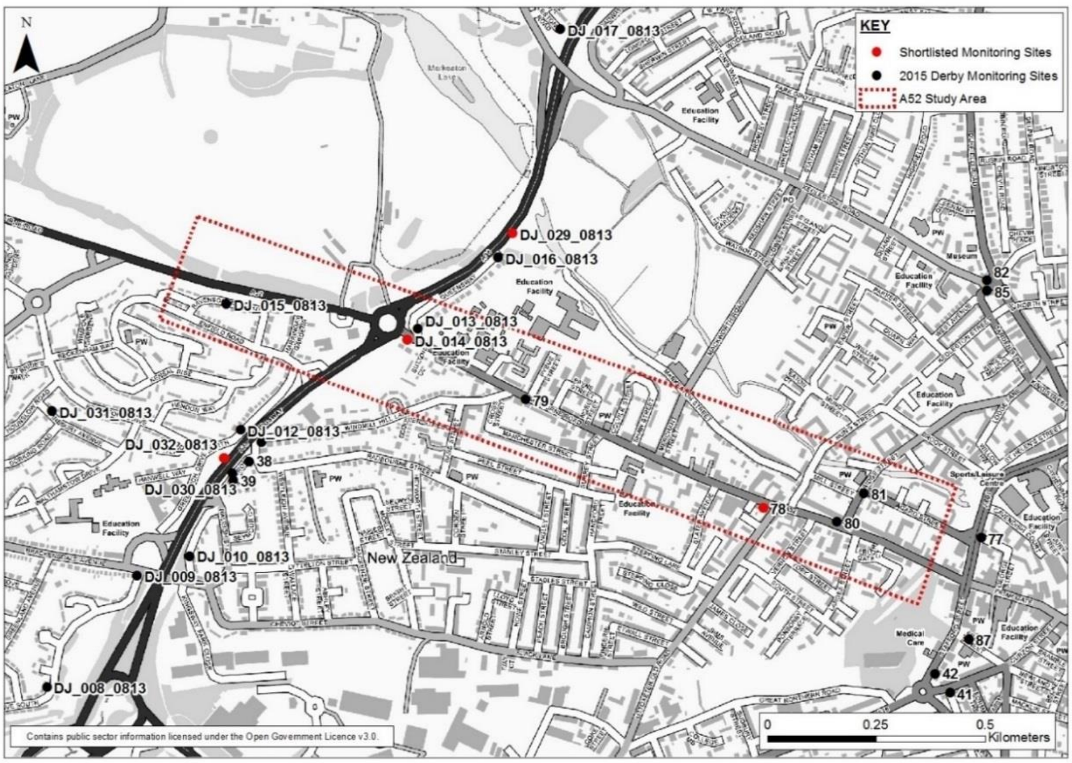


Figure 18: NO_2 Monitors (with shortlisted source apportionment monitors in red) along the A52 area

The results shown in **Figure 19** highlight some deviation between the measured values and those predicted by the DMRB curve at several monitors. Two monitors (DJ_014_0813 and DJ_013_0813) fall above the idealised curve, these are located on either side of the A52 to the east of, and close to the Markeaton Junction. This indicates that free flow traffic emissions on the A52 alone cannot explain concentration patterns near the Markeaton junction. Instead, it is likely that congestion is likely to contribute to these elevated concentrations.

Observed traffic speeds suggest the A52 leading up to the Markeaton Junction does suffer from light congestion, not just during peak periods of traffic. This may be a consequence of the lack of signalling available at the Junction, and therefore one would expect associated air quality problems to improve with the proposed Highways England scheme, which is expected to relieve congestion along this road. Emissions from the A38 are also thought to be a minor contributor at this location, as both monitors were approximately 60 – 70 m away from the Markeaton Junction roundabout, however this contribution was not considered to be easily quantifiable and was not thought to lend itself to this approach.

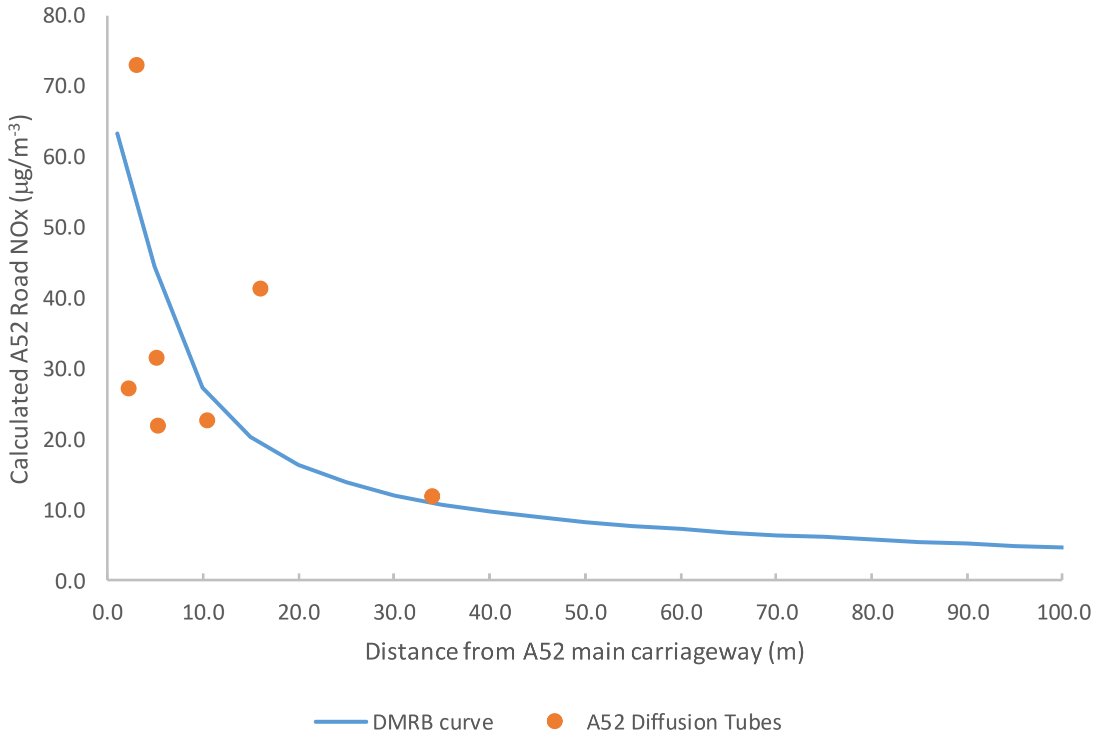


Figure 19: Normalised Road-NOx with distance against idealised DMRB curve – A52 diffusion tubes

Measured NO_2 concentrations at two Derby City Council monitors (79 and 80), located within 5 m of the A52, could not be explained by the idealized drop-off curve, which predicted a higher NOx contribution from the A52 than suggested by the measured concentrations. Both sites are along sections of the A52 that experience light congestion throughout the day, therefore it is unclear why measured concentrations at these sites are below predicted values. It is possible that given these monitors were both on drain pipes (on property facades) this may have influenced dispersion and measured concentrations were therefore lower than might otherwise be the case.

The 2015 measured annual mean NO_2 concentration at DJ_015_0813 is about 3 µg/m^3 lower than the idealised curve based on its distance from the A52. Despite not being a large difference, an explanation for this may be that the site was located upwind of the main pollution source and therefore the true contribution from the A52 is not reflected in the idealised curve, which does not account for meteorology. Another explanation may be that the idealised drop-off curve is based on data along the eastern section of the A52 focus area, where background concentrations are slightly more elevated than the western section, where this monitoring site is located.

A516/A5111 (Derby Ring Road Area) Diffusion Tubes

The A516 and A5111 area is, as has already been alluded to, among the areas with the highest NO_2 concentrations in the A38 Derby area. These two adjoining arterial roads suffer from queuing traffic from a combination of general commuters that live or work in the area (e.g. Royal Derby Hospital), and retail traffic particularly around the Kingsway Retail Park.

The air quality monitors in this area showed that there have been more annual mean NO_2 exceedances along these roads in recent years than there have been along the A38 and A52 combined. From the select link analysis results it appears the A516 is a reasonably favoured route into Derby (via the A38 for traffic originating in western areas of Derby), probably the only exception to an otherwise divorced relationship seen between the A38 and its adjoining arterial roads.

The A516 and A5111 monitors were a combination of Highways England and Derby City Council passive diffusion tubes, all of which are roadside locations implying they were measured closer to the road than the nearest receptors. In contrast to other areas in the study area however, receptors are located closer to road traffic emission sources than the monitoring sites. **Figure 20** shows the monitoring sites alongside the A516 and A5111 that have been considered in this analysis:

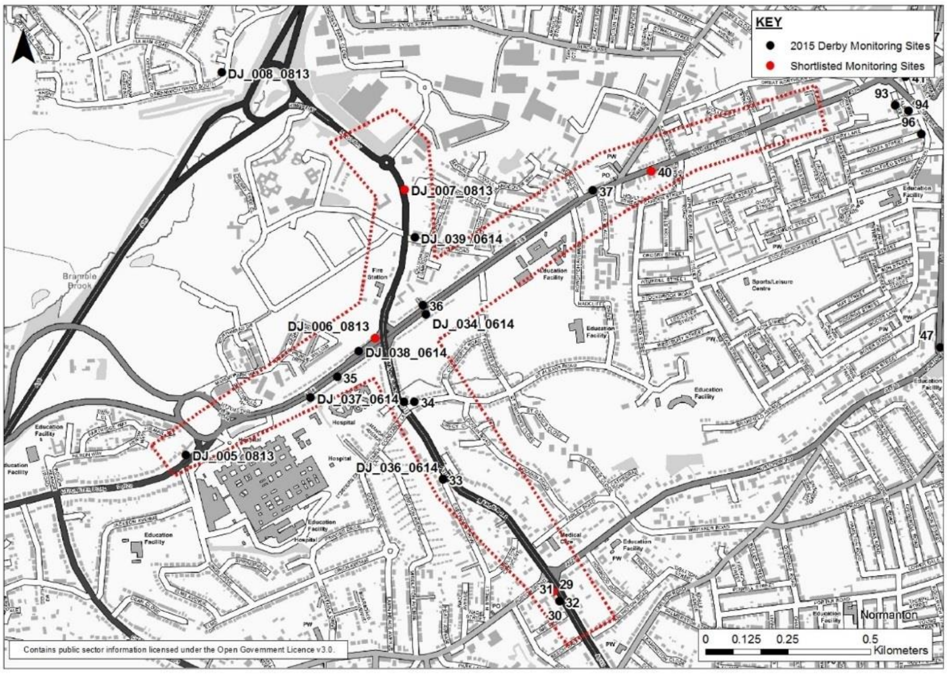


Figure 20: NO_2 Monitors (with shortlisted source apportionment monitors in red) along the A516 Uttoxeter New Road/A5111 area

Figure 21 shows calculated road-NOx with distance based on the idealised NOx drop-off curve for the A5111, which indicates only a few of the A5111 monitoring results fit the idealised curve reasonably well, with large differences for the majority of monitoring results within 5m of the A5111. Monitor DJ_038_0614 is about 2 m from eastbound traffic on Uttoxeter New Road west as it approaches the intersection with the A5111. The calculated road-NOx at this site is lower than suggested by the idealised curve for its distance from the kerb and it was not clear why this should be the case. In contrast, monitor 35 is about 3.1 m from the kerb of the A516 Uttoxeter New Road, but is 10 $\mu g/m^3$ above the idealised curve. This discrepancy is however easier to explain as this monitoring site is located east of a bus layby and downwind of the stop, and therefore idling buses could account for some of the additional measured NOx. Based on observed speeds, it is also likely that stop-start behaviour may be contributing to increased acceleration hot-spots that lead to higher peaks in emissions that are not accounted for in the idealised curve.

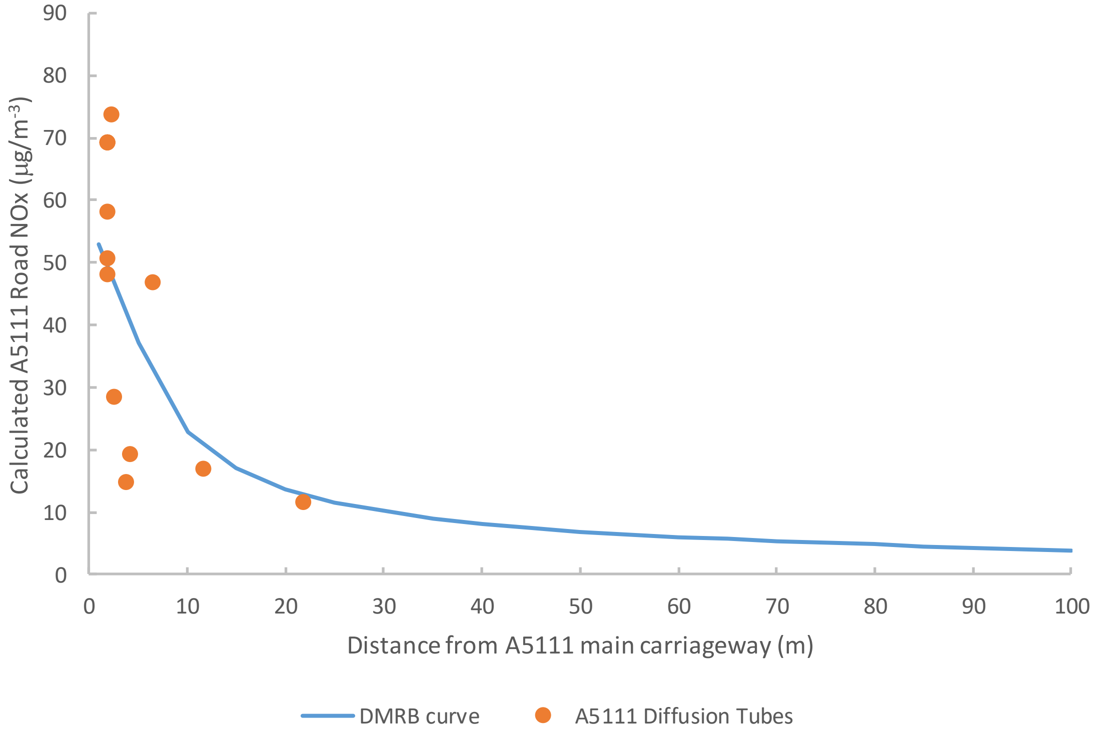


Figure 21: Normalised Road-NOx with distance against idealised DMRB curve – A5111 diffusion tubes

Similarly to the A5111 monitors, **Figure 22** indicates there is a large spread of concentrations for the monitoring results adjacent to the A516 which do not fit the idealised curve well. There is some general agreement at two monitors along the A516 Uttoxeter New Road, which have the smallest deviation from the idealised curve (R5 and DJ_037_0614 between about 1 and 3 µg/m^3) and are both located to the west of the A5111/A516 Junction. The calculated road-NOx at R5 is lower than predicted by the idealised curve. This may be because the monitor is located adjacent to the left turning lane from the A516 Uttoxeter New Road onto the A5111 Kingsway northbound, and therefore is not affected by the same volume of traffic as other sites, and therefore the measured road-NOx at this site is not directly comparable to other monitoring sites on Uttoxeter New Road.

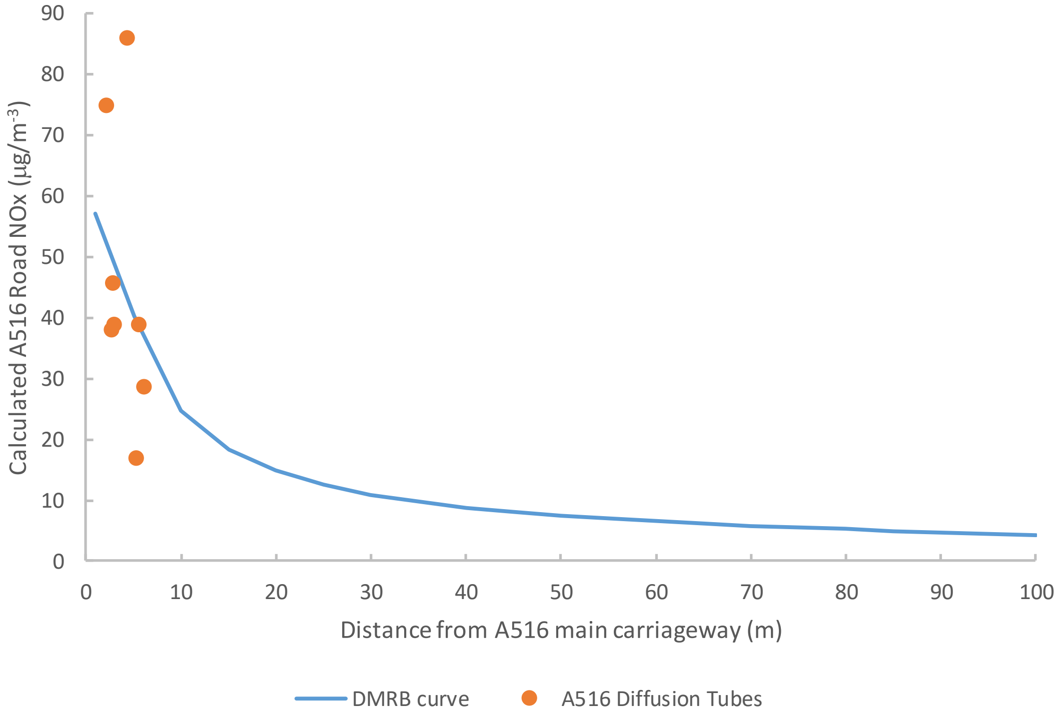


Figure 22: Normalised Road-NOx with distance against idealised DMRB curve – A516 diffusion tubes

The implied road-NOx concentration at monitor 37 is only slightly above the idealised curve. This monitor is located adjacent to the westbound A516 Uttoxeter New Road close to the entrance to the Royal Derby Hospital. The small difference between the measured concentration and the curve may be due to the influence of emissions from congestion associated with vehicles accessing the hospital.

The calculated road-NOx for monitor DJ_005_0614 is below the idealized curve for the B5020 by about 4 $\mu g/m^3$. Combining the normalised road-NOx for Uttoxeter New Road and the B5020, the resultant NO_2 concentration is about 9 $\mu g/m^3$ above the measured concentrations at DJ_005_0614. This suggests that a physical obstruction may have influenced dispersion around the monitoring site, as it is unclear why the measured concentration does not reflect the combined contribution from Uttoxeter New Road and the B5020.

Finally, site DJ_005_0614 is higher than the idealised road-NO_x drop-off curve for the A516 Uttoxeter New Road by about 6 $\mu g/m^3$; this indicates that another emissions source may have influenced the measured values. The site is about 3.5 m from the kerb of Uttoxeter Road (B5020) as it approaches the roundabout for the A38 slip road and the Royal Derby Hospital. Traffic on the B5020 may explain this difference, which was tested when the normalisation was repeated for this road.

NO_2 Source Apportionment

Introduction

ANPR surveys were commissioned by Highways England and took place in April of 2016 at ten locations. Similarly, the Department for Transport (DfT) collected traffic data in October 2015 at several sites around Derby. The ANPR data provided a breakdown of the proportion of the fleet by vehicle type and Euro class, and the DfT data provided total traffic volume and HGV proportions. Using available traffic data and count information (including ANPR information where applicable) the local road NO_2 component at each monitoring site has been attributed to different vehicle types and Euro classes.

The proportion of various vehicle-type contributions to the local road NO_2 component are not necessarily proportional to the number of vehicles of that type within the fleet due to differences in vehicle emission rates. Therefore, there is no way to determine the relative contribution from different vehicle types to measured concentrations without relying on emissions modelling.

A combination of ADMS-Roads and Defra's Emissions Factor Toolkit (EFT v7.0, 2016) was used to attribute the local road NO_2 component. It should be noted that this version of the EFT is shortly to be superseded as it is thought to under predict NOx emissions from diesel cars. ADMS outputs provided the road-NOx component, accounting for specific road characteristics and pollutant dispersion. The EFT outputs provided NOx emission rates for different vehicle types based on the ANPR proportions. The proportions calculated for NOx were applied to the non-background NO_2 component. The source apportionment at each site is summarised in a series of flowcharts in **Appendix 7**.

Emission calculations

Emissions calculations were undertaken using EFT v7.0 using the "Alternative Technologies" option of the EFT for each road link by hour of day (or where hourly data were unavailable, the corresponding value for the AM, IP, PM or OP period) and day of week (weekday, Saturday, Sunday). The year for calculation was set at 2016 to match the ANPR fleet composition data. The "User Euro" function was selected to allow the proportion of each vehicle type by Euro Standard to be defined, the data for which were derived from the ANPR survey data for motorway and non-motorway roads respectively.

User defined Euro compositions were adjusted to account for the proportion of failed catalysts on cars and LGVs, in accordance with the proportions contained in the DfT's traffic fleet projection database (published July 2013[3]). The option for "Output % Contributions from Euro Classes" was selected to ascertain the percentage contribution of each Euro Standard to the emission rate of the corresponding vehicle type. The EFT was run separately, according to the type of road (urban or motorway to represent the A38) to account for the varying proportions of vehicle type by Euro Standard by road type derived from the ANPR surveys.

Two outputs are provided by the EFT. The first is an emission rate (g/km/s) for each link by vehicle type. The second output is the percentage contribution of each Euro standard to the emission rate for each

[3] Source: naei.beis.gov.uk/resources/rtp_fleet_projection_Base2013_v3.0_final.xlsx

vehicle category. This information was used to determine the relative contribution of each vehicle type by Euro standard at selected receptors. The EFT requires a single speed to be entered to calculate the contribution by Euro standard, as the contribution outputs are speed specific. After checking traffic data, 96 kph was used for the A38 and 48 kph was used for the local roads.

Appendix 6 also presents the results of dispersion modelling which has been used to determine the relative contributions of different vehicle types to concentrations at specific receptors.

Breakdown by Vehicle Type

This section of the analysis has drawn on the detailed speed and fleet composition data described previously, and has used Defra's EFT v7.0. As explained previously, it is likely that the EFT has different degrees of reliability for different types of vehicle and so this analysis should be treated as indicative

Figure 23 shows the location of modelled receptors within the A38 Derby focus areas. All receptors and monitoring locations have been selected for NO_2 source apportionment based on one or more of the following criteria:

- exceedance of the annual mean criterion of 40 µg/m^3;
- roadside monitoring location;
- proximity to the A38; and
- location in relation to prevailing wind direction.

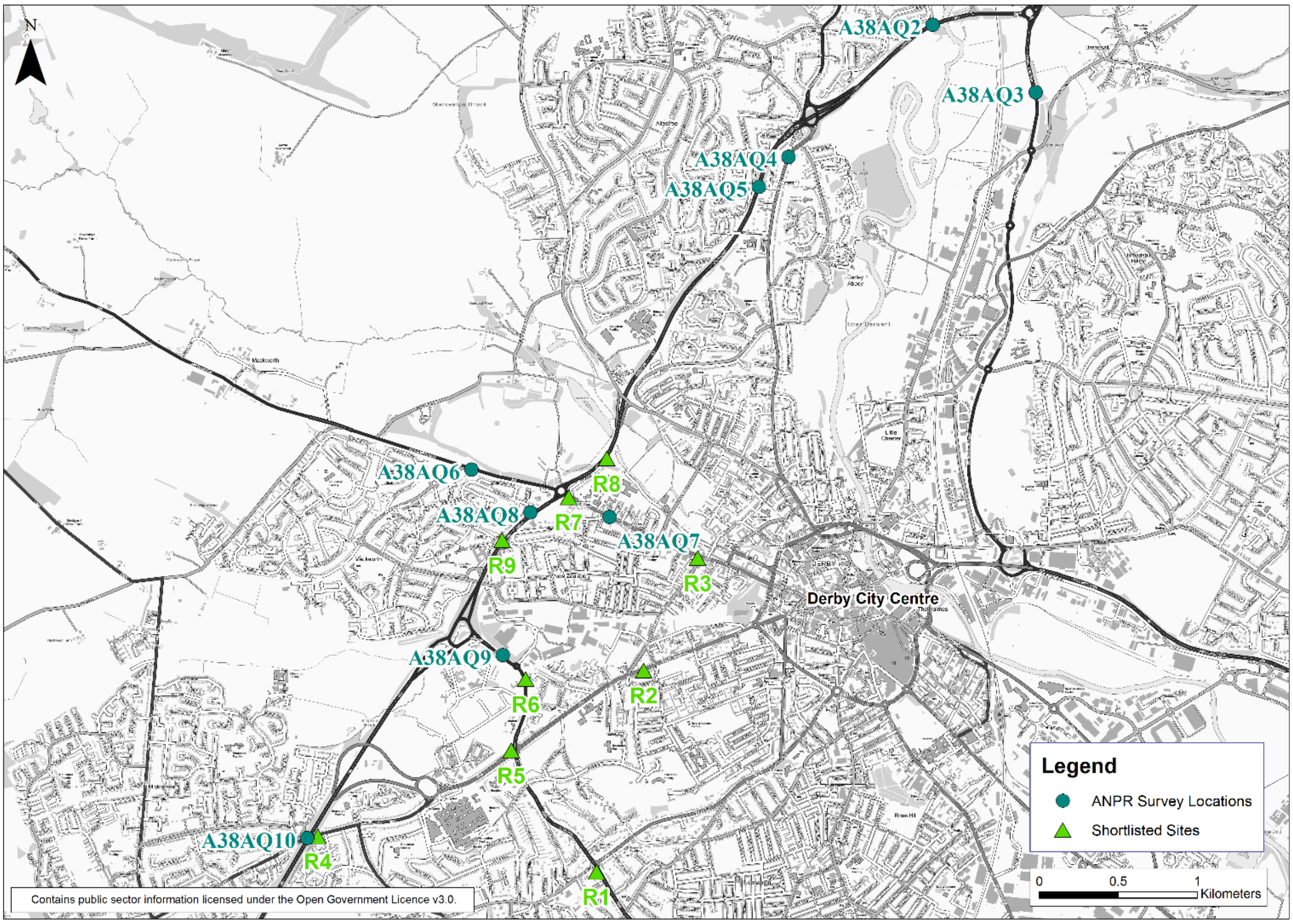


Figure 23: Shortlisted sites (R1 – R9) and ANPR survey locations (A38AQ2 – A38AQ10)

Table 6 provides a summary of the 2015 annual mean NO_2 concentration, local road component of NO_2 and the major vehicle-type breakdown of the local road component at each shortlisted receptor.

Diesel cars and LGVs combined contribute the most to the local road NO_2 component at all receptors, regardless of location, with Euro 5 diesel cars making the largest contribution. HGV contributions are understandably different at locations adjacent to the A38 and local roads respectively. The HGV contribution at all A38 sites (R4, R8 and R9) is between 26 and 30%, whereas at local road sites it is between 10 and 16%. Overall, sites closer to roads that are more prone to queuing traffic show higher measured NO_2 concentrations and therefore higher local road NO_2 components.

The differences in vehicle type NO_2 contributions appear to be mostly similar at all shortlisted receptors. **Table 6** suggests that diesel cars and LGVs contribute to more than two thirds of the local road NO_2 concentrations at all receptors. The second largest contributor to the local road NO_2 concentrations are HGVs, particularly adjacent to the A38.

Receptor	Measured 2015 Annual Mean NO_2 (µg/m^3)	Local Road Component (µg/m^3)	% Contribution to Local Road Component						
			Diesel Cars	Diesel LGVs	Petrol Cars	Petrol LGV	Rigid HGVs	Artic HGVs	PSVs
R1	51.7	30.4	62%	15%	6%	0%	11%	5%	1%
R2	38.0	16.2	62%	15%	6%	0%	11%	5%	1%
R3	37.1	12.9	54%	22%	6%	0%	9%	1%	8%
R4	41.4	21.8	47%	23%	2%	0%	11%	15%	2%
R5	42.6	20.7	62%	15%	6%	0%	10%	5%	1%
R6	43.0	21.1	62%	15%	6%	0%	11%	5%	1%
R7	51.9	29.6	54%	22%	6%	0%	9%	1%	8%
R8	54.4	35.2	43%	25%	2%	0%	12%	18%	1%
R9	45.1	22.8	42%	22%	2%	0%	13%	19%	1%

Table 6: Vehicle-Type Breakdown of Local NO_2 Component at each Shortlisted Receptor with % Vehicle Contributions of local NO_2

Buses and coaches account for a small contribution to the local NO_2 concentrations in Derby, with the largest contribution (8% of local NO_2) seen on the A52 for R3 and R7. This is probably attributable to the relatively small proportions of buses observed from ANPR surveys on the A38 and its adjoining local roads in Derby.

The vehicle euro class proportional contributions are presented based at locations adjacent to the A38 and A52 in **Figure 25** and **Figure 27** respectively. It is found that Euro 4 and Euro 5 are the largest contributors to NO_2 concentrations associated with diesel cars and LGVs and petrol cars. Euro V HGVs make this largest contribution to NO_2 concentrations associated with this vehicle type.

It should be stressed that these conclusions are not precise or definitive. The numbers presented here represent best estimates. The EFT predicts a single emission rate for each vehicle type at any given speed when, in practice, emissions at a given speed can vary significantly with engine temperature and load. Even in the absence of these factors, the uncertainty of utilising an average-speed based emissions model does not capture the true emission profiles of vehicles and may significantly under predict emissions from some vehicle types while providing reasonable prediction for others (Marner *et al*, 2015[4]).

This may create a bias in source apportionment information that is not captured here. It is not within the scope of this geographical pilot study to assess the performance of national and international models on national and international settings.

[4] Source: http://www.aqconsultants.co.uk/getattachment/Resources/Download-Reports/Emissions-of-Nitrogen-Oxides-from-Modern-Diesel-Vehicles-210116.pdf.aspx

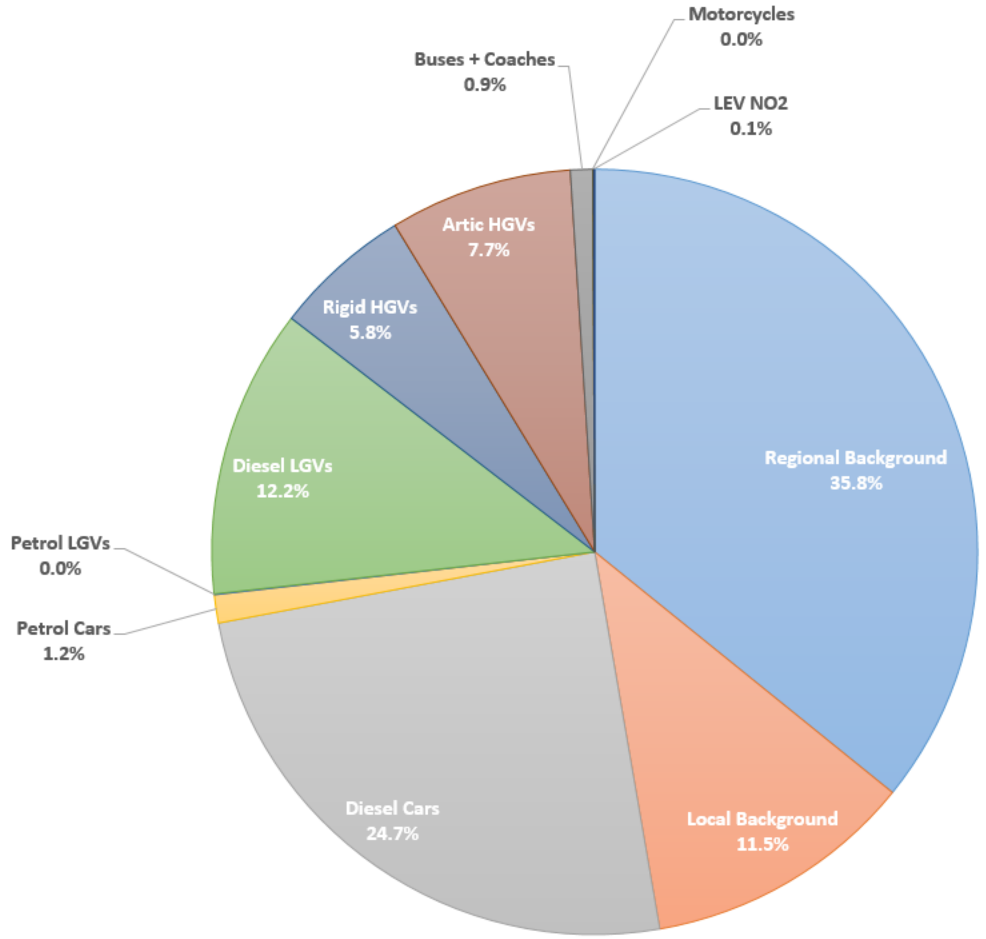


Figure 24: Indicative Breakdown of the Total NO_2 Concentration at the A38-A516 Area (R4 - ANPR site A38AQ10) by Vehicle Type

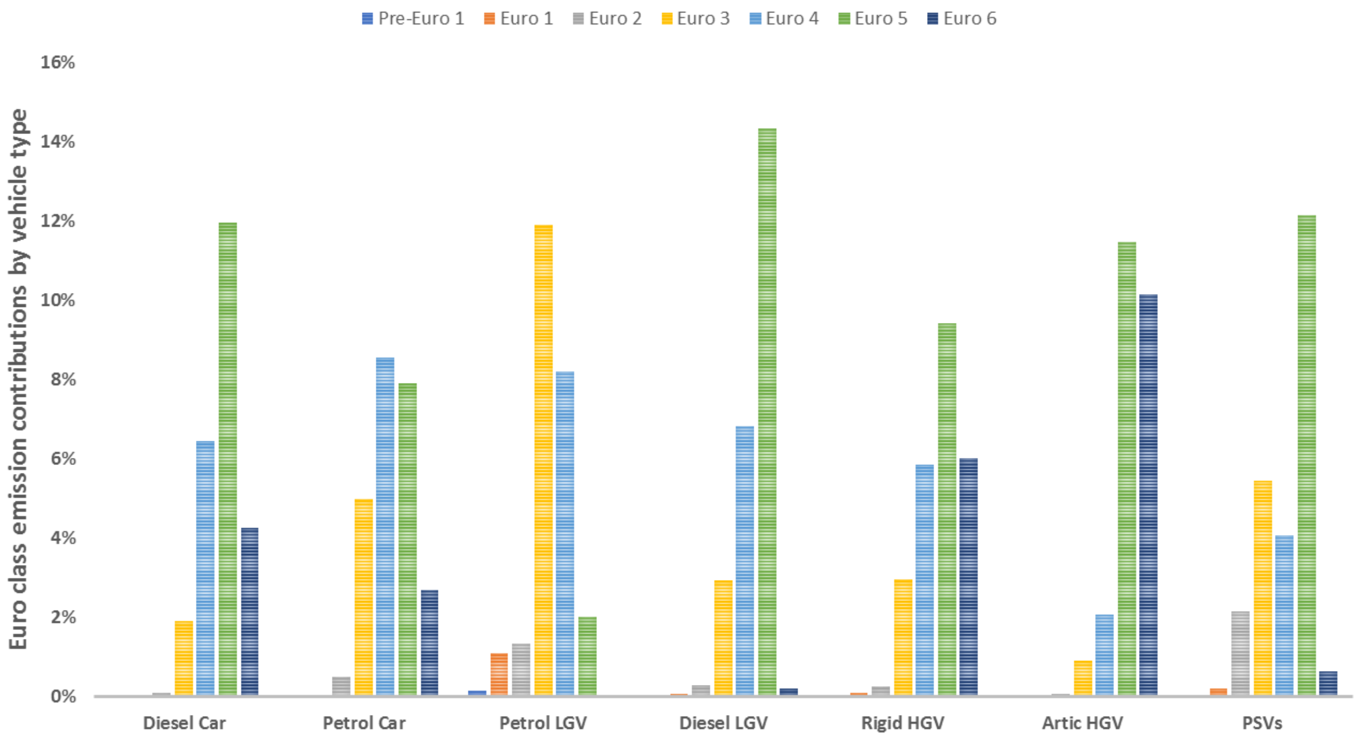


Figure 25: Indicative Euro class proportional contributions of the Total NO_2 by Vehicle Type at the A38-A516 Area (R4 - ANPR site A38AQ10)

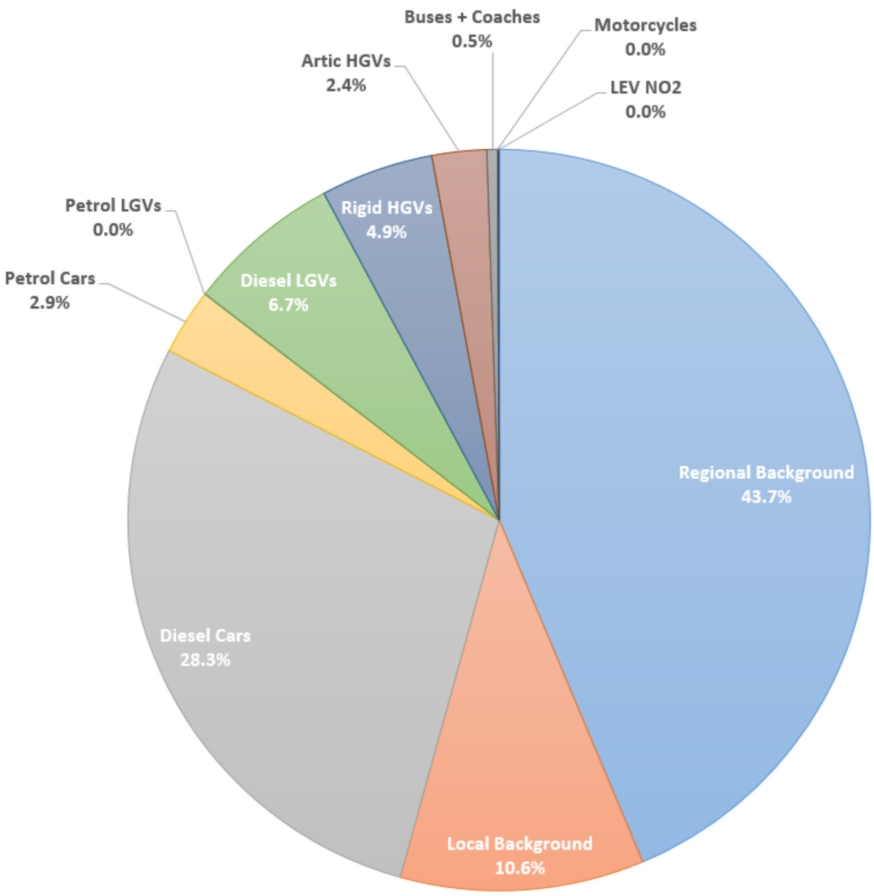


Figure 26: Indicative Breakdown of the Total measured NO_2 Concentration by Vehicle Type at the four shortlisted sites on the A52 Ashbourne Road (R7 - ANPR site A38AQ7)

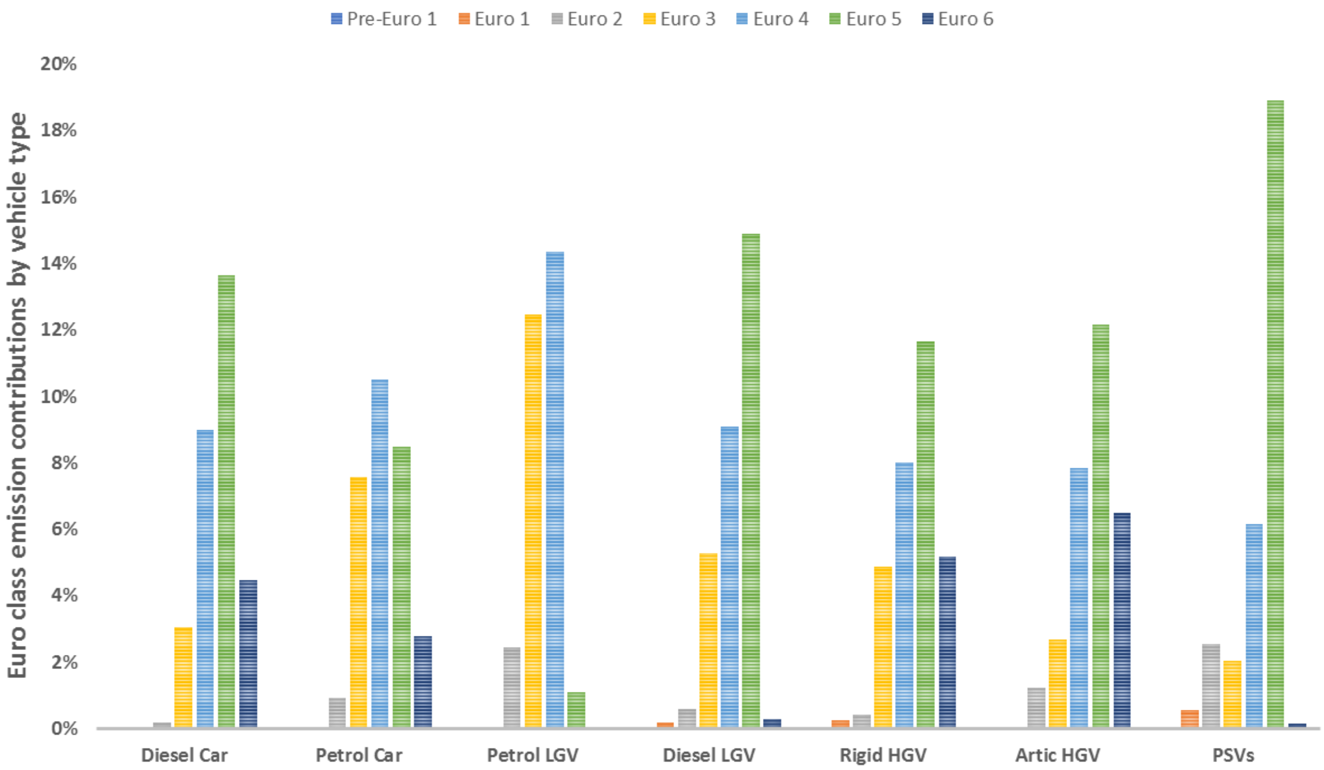


Figure 27: Indicative Euro class proportional contributions of the Total NO_2 by Vehicle Type at the A52 Ashbourne Road (R7 - ANPR site A38AQ7)

5. Conclusions

The study considered the reasons for the elevated NO_2 concentrations in Derby and mainly focused on understanding and quantifying contributions from road traffic. The A38 in Derby could influence air quality by:

1) Direct emissions from the volume of traffic on the A38;
2) Direct emissions due to congestion around the junctions of the A38 with its arterial roads; and
3) Increased traffic on local A-roads caused by vehicles accessing the A38.

Measured exceedances of the annual mean NO_2 AQS objective along the A38 in Derby are most likely due to direct emissions from the volume of traffic on the A38. However, such locations are all in areas where sensitive receptors are set back from the road so there is no (or limited) public exposure to these high concentrations. This suggests that the volume of traffic on the A38 does not result in significant air quality problems, as regards compliance with AQS objectives.

There are, however, exceedances of the annual mean AQS objective for NO_2 along adjoining arterial roads (namely the A52, A516 and A5111). Emissions from traffic on the A38 are not seen to be a major contributor to concentrations here. Congestion on the approaches to each of its junctions with these arterial roads in Derby is, however, considered likely to contribute to a significant proportion of the measured annual mean NO_2 exceedances alongside these adjoining arterial roads. Examples of this are at the approach to the Markeaton Junction, which links the A38 and A52, and the junction of the A38 and A516 Uttoxeter New Road. Traffic on these roads is expected to become more free flowing and the air quality is likely to improve with Highways England's proposed Derby Junctions Scheme in place.

Traffic composition data identified a clear distinction between the A38 fleet makeup and its adjoining arterial roads. For example, there are larger proportions of HGVs on the A38 main carriageway in comparison to its adjoining arterial roads and lower proportions of petrol cars, matching the national EFT "motorway" fleet mix better than "urban road" fleet mix. The key points which can be drawn from the ANPR data are described below:

- A38 main carriageway links show broadly similar vehicle type distributions to one another, and are different in vehicle composition to links on arterial roads, with larger proportions of HGVs (on average close to 10%), and smaller proportions of buses (less than 1% in parts) and petrol vehicles (less than 40%).
- No Petrol LGVs were evident on any link and less than 3% of LGVs were Euro 6 on all links;
- There is also a lower car fleet turnover to Euro 6 than the EFT national average implies, with a lot more Euro 4 and Euro 5 and a lot less Euro 6 in general for both diesel and petrol vehicles. LGVs are mostly Euro 3 and 4 diesels, with no petrol LGVs present.
- Rigid and Artic HGVs on Derby's roads are mostly Euro 4 and 5 with less than half the national projected average of Euro 6 HGVs on Derby roads. This is, however, only of consequence for the A38's NOx emission, as its adjoining arterial roads have relatively low proportions of HGVs of between 1 - 3%. This would mean an attempt to improve HGV emissions may not help address the air quality problems in Derby that predominantly lie along these arterial roads.

The findings of this study point to the air quality problem in and around the A38 in Derby being dominated by emissions from a combination of queuing traffic and the prominence of Euro 4 and 5 diesel cars and LGVs.

Evidence from the select link analysis suggested that there was little mixing between the traffic along the A38 and its arterial roads at the A52, A5111 and A516 Junctions, which were chosen to be the focus areas of our study. Consequently. reducing emissions from the A38 main carriageway would do very little to reduce concentrations on its arterial roads, where the NO_2 concentrations in areas of public exposure are high.

Detailed traffic analysis carried out in this study confirmed the A38 is an important strategic route for north-south journeys and most of its traffic, particularly HGVs, use the road for this purpose (i.e. long range transport between Yorkshire and Midlands area).

There is little interaction with the A52, which serves as an East-West strategic route across Derby, suggesting that the presence of the A38 is not leading to an increase in traffic along that road. There is, however, a significant volume of traffic that uses the A38 south of Derby to access the A516, which contributes to some exceedances of the NO_2 air quality objective along that road. This is one of the junctions that is being considered as part of the Highways England scheme. When implemented, this change in road layout is expected to improve the air quality adjacent to the Royal Derby Hospital.

Further on along the A516 Uttoxeter New Road, there is a clear hot spot for air quality at the intersection with the A5111, which is evident from the high NO_2 measurements. Low observed speeds are a contributing factor to higher road traffic emissions in this area. This intersection is not considered as part of the Highways England scheme and it is thought likely that the scheme will not lead to major improvements along this intersection, given the likely knock-on effects by adding traffic volumes to an already congested part of the local road network. A way of improving the congestion leading up to this intersection between the A516/A5111 could be explored as a measure to improve air quality in this area of Derby. A freer flowing intersection that alleviates traffic congestion is regarded a sensible measure for improving the air quality in this area of Derby. This poor air quality hotspot could be addressed through measures that may include junction re-alignments or bypasses which may be of benefit to the large quantity of residential properties within close proximity of this A516/A5111 intersection.

Reducing emissions from through-traffic on the main carriageway of the A38 would only lead to a small effect on concentrations at the nearest receptors to the road, as these receptors are set back from the A38 (>10 m). The worst receptors on arterial roads may experience some air quality improvements if this leads to less congestion on the approaches to these junctions with the A38. The Highways England scheme is regarded as a means to addressing these air quality problems, because it is expected that the scheme will reduce emissions associated with congestion at these adjoining arterial roads (A52, A5111 and A516) and reduce NO_2 concentrations at worst case receptors that are close to the A38 and its junctions in Derby. However, with a programme end date currently set for March 2023 for this improvement scheme, it is not an immediate solution and therefore cannot be treated as a measure that will lead to improvements in air quality in the short term.

The Derby Clean Air Zone could help reduce the Euro 4 and Euro 5 proportions of the fleet that have resulted in the largest contributors to the local road NO_2 concentrations in Derby. It is unclear at this stage what effects the Derby Clean Air Zone may have on traffic flows and the specification of any Clean Air Zone has yet to be agreed. The current plan excludes restrictions for LGVs and private cars which have been shown from our study to be the main contributors to NO_2 concentrations on Derby roads.

6. Lessons Learnt

The approach followed in this project was guided by Highways England and based on experience of carrying out air quality assessments elsewhere. The intention was to provide a different way of understanding air quality problems than through carrying out standard air quality assessments. This study has provided indicative information regarding how different emissions sources contribute to the measured annual mean NO_2 concentrations in and around Derby.

This study provided a useful insight into different ways to approach air quality problems and understand them through more detailed transport information and analysis and limited air quality data. This exercise did have its limitations but has exceeded our expectations on the achievements reached and the understanding gained. Whilst the study has provided a level of quantification that could not have been provided without carrying out the analyses, the approach taken means that this quantification retains the uncertainties associated with the information on which it relies. The study does not guide Highways England in terms of measures that could be used to improve air quality around Derby. It will be useful to Derby City Council in developing proposals for a Clean Air Zone.

Some analysis methods have proved insightful to the study, while others have been less useful. The discussion below draws out the key lessons that could be learnt:

Data Availability

The data available included passive diffusion tube NO_2 monitoring and traffic survey data. Highways England traffic and air quality scheme models were also made available for this study. The availability of air quality monitoring data shaped the choice of the assessment methods applied. The absence of any measurements from continuous monitoring stations within the area meant that some analyses that may have been useful could not be carried out. Several diffusion tube monitoring sites also had to be excluded from this study based around data reliability and suitability of monitoring locations to understanding the air quality problems on the Derby local roads.

Data Collection

There were some difficulties in understanding how passive diffusion tube data had been annualised as no documentation was provided on this. The study would have benefitted from continuous monitoring data (i.e. a greater quantity of more highly resolved data).

Highways England collected and provided the data used in this study, but the value of Highways England doing this instead of delegating the authority to do it was limited and in certain cases was found to delay the analysis of the problems. Further data needed to be requested at different stages of the process. The project team had to go through the steps of data collection in any event to ensure all available data had been collected, and the analysis was thus not carried out in the most efficient manner.

Analysis of Diffusion Tube Data

As an alternative to dispersion modelling, which Highways England expressed an opinion on not using for this analysis, the spatial patterns of diffusion tube measurements were interpreted using more empirical methods. The use of an idealized DMRB fall-off curve was a suitable alternative to interpret the relationships between the measurements and distance from the road. This method was considered to provide a useful way to understand the spatial characteristics of the measured air quality data available for Derby. One limitation was that the locations of some diffusion tube data did not lend themselves to this analysis, for instance measurement locations close to junctions could not be used in this work.

Traffic Data Analysis

This study area was relatively short of air quality monitoring data and therefore did have to make full use of other datasets available. A significant element of the work was in fact the detailed transport analysis carried out and the importance of the select link analysis and origin destination was to make best use of the available data to investigate the sources of vehicle emissions which contribute to the air quality problems in Derby. There was value in requesting and making use of transport models already available and linking in the traffic and ANPR survey data to obtain a more detailed understanding of air quality problems in Derby. The use of ANPR data added considerable value to the work, albeit it being data for only one week of April 2016.

The transport data extracted from the Highways England transport scheme models to understand local trips and origin destinations did give some good insight into traffic journey patterns and did link up well with understanding better the air quality problems on local roads in Derby. It was regarded as a useful exercise, particularly in the absence of detailed dispersion modelling or continuous monitoring data. An assessment that combines the breakdown of fleet composition with detailed analysis on journeys of different vehicle types (albeit extracted from a transport model which are a semi-theoretical method of deriving transport information) does benefit the understanding of air quality problems in other areas of the Strategic Road Network.

Sharing Information

This study has been undertaken at the same time as work going on to develop the Clean Air Zone for the city of Derby. It is recommended that the report, or its conclusions should be shared with Derby City Council to facilitate this national initiative to comply with European air quality directive.

Appendix 1 - A38 Derby Air Quality Focus Areas

PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Chris Taylor

This appendix lays the foundation of the technical discussions relating to the A38 Derby pilot study, and presents the specific focus areas identified. They are: the A38 main carriageway (divided into the A38-A516 corridor, the A38 Kingsway and the A38 Queensway), the A52 and Uttoxeter New Road/A5111. **Figure 1** shows a map of these focus areas as well as the names of roads that will be discussed.

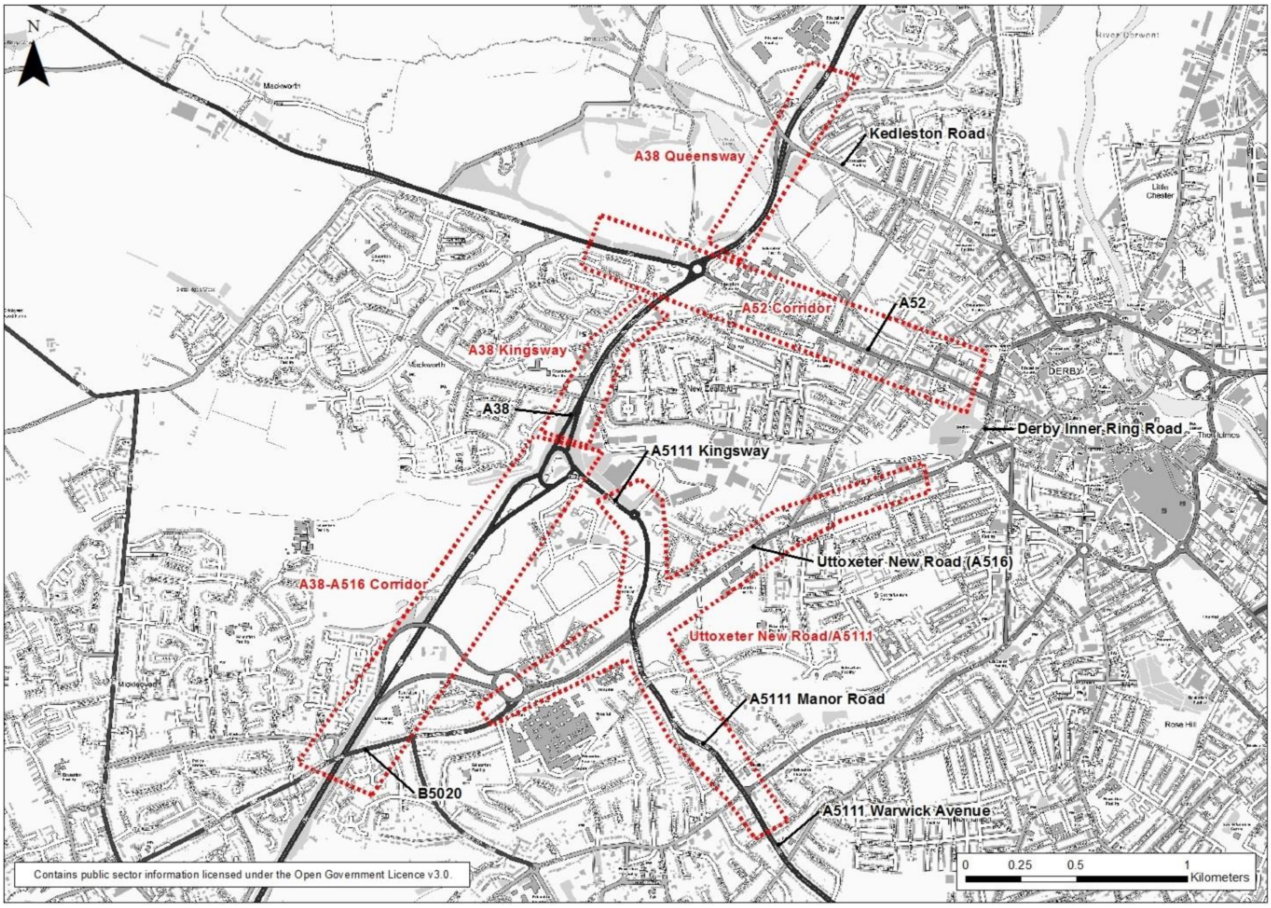


Figure 1: Map of the A38 Derby Pilot Study focus areas and relevant road names

Information covered in this appendix, for each focus area, includes the road network, the surrounding local area and relevant emissions sources, which all aim to provide context for more detailed analyses in subsequent appendices. Traffic conditions are also discussed based on an initial review of Google Maps (2017) "Typical Traffic" trends. These data were analysed before more detailed traffic data was provided, and only provide an indication of traffic trends collected by crowdsourced GPS information from mobile phones. There are no quantitative speed data available from the Google Maps data. Rather, it is plotted on a scale from Fast (Free Flow) to Slow (Heavy Congestion). For more detailed analyses and discussions of traffic data, please refer to **Appendices 8 and 9**.

Monitoring data within each focus area is discussed in detail in **Appendix 4**, including observed long-term trends. Analyses of background NO_2 fields across Derby are detailed in **Appendix 2**.

Based on meteorological data from East Midlands Airport between 2014 and 2016, the dominant wind direction is west-south-westerly, as shown in **Figure 2**. This was the nearest meteorological station available to the A38 near Derby, and is located approximately 16 km southeast of Derby.

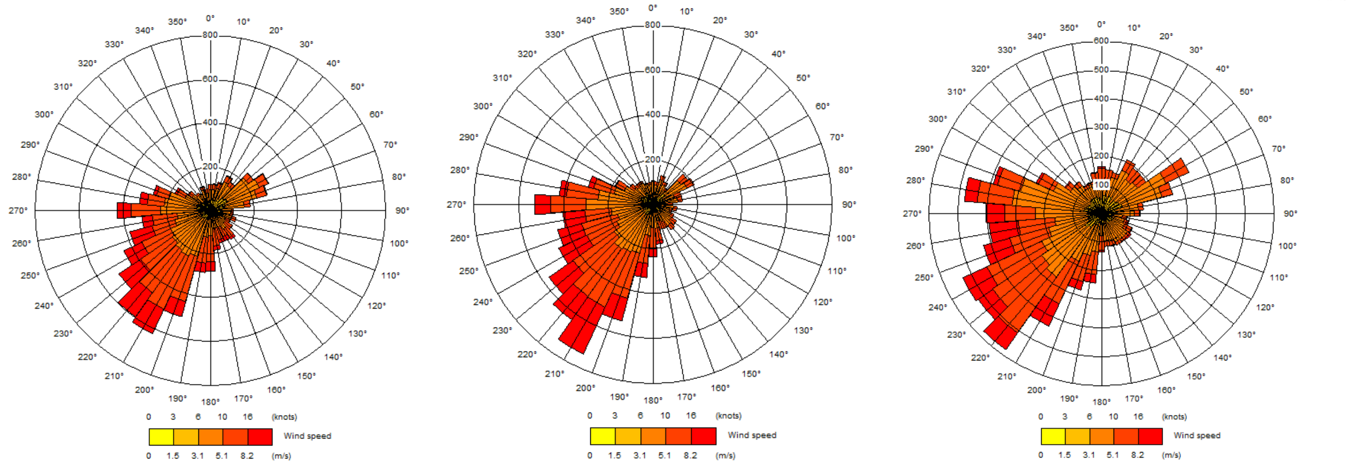


Figure 2: Wind roses for East Midland Airport 2014 - 2016, showing dominant wind direction and speed.

A38 Main Carriageway Focus Area

The A38 is a major (non-motorway) north-south route that is included as part of the UK Government Strategic Road Network between Birmingham and the Nottingham-Derby area. At its northern and southern extent as a strategic route, the road connects the M1 and M6 motorways. The section of the A38 in Derby is included in the Highways England (HE) Derby Junctions scheme, which aims to accommodate future traffic growth with local junction and mainline improvements.

Figure 3 presents a map of the A38 focus areas, which split the A38 mainline into three distinct sections between the bridge for the B5020 to the south and the junction for Kedleston Road to the north (see **Figure 1** for a map of the roads covered in this section). The three sections are as follows (south to north): The A38-A516 Corridor, the A38 Kingsway, and the A38 Queensway.

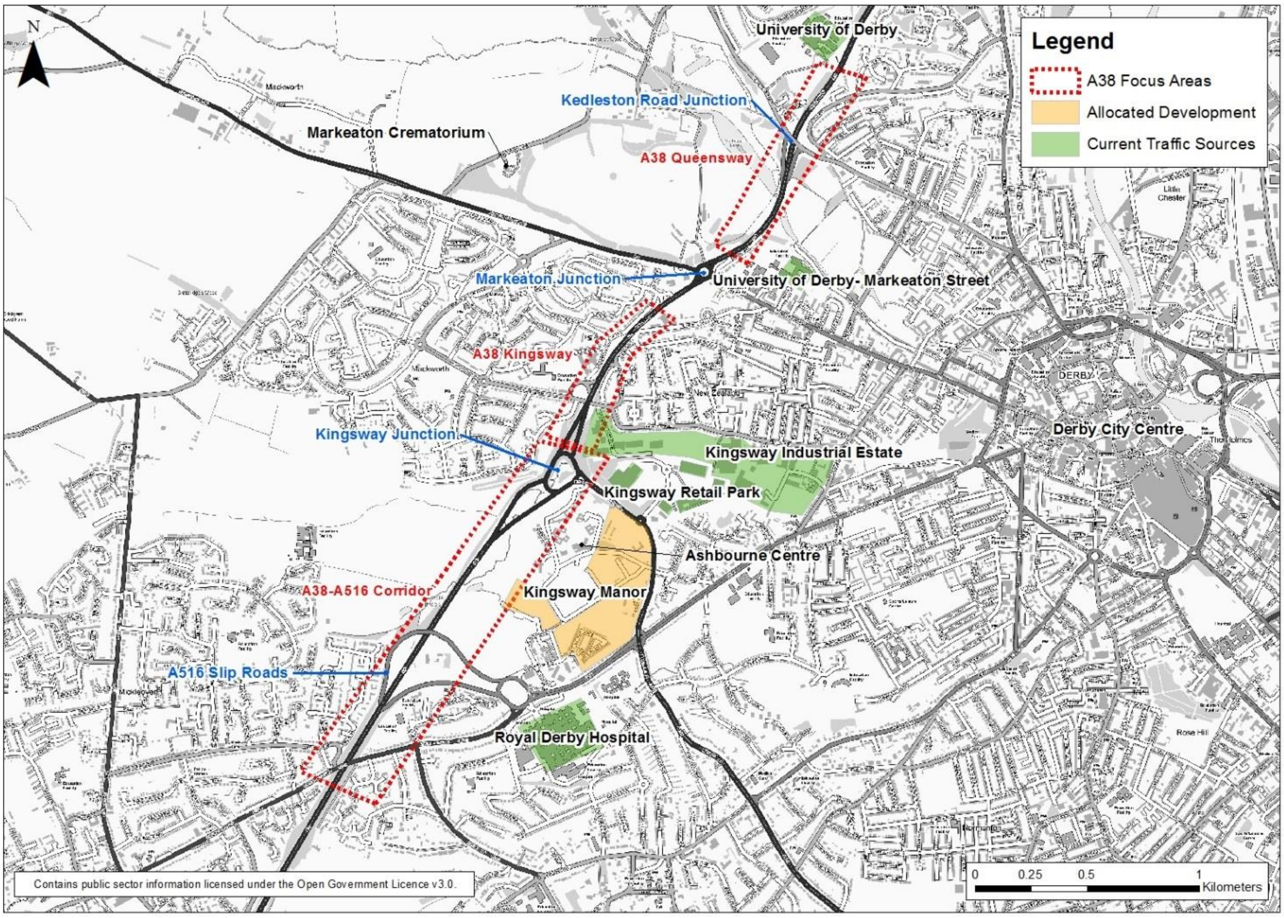


Figure 3: A38 Main Carriageway Focus Areas with current traffic and emissions sources, allocated development sites, and major junction labels.

Road Network

The A38 west of Derby, as it passes through the main carriageway focus area, is all dual carriageway. The national speed limit applies from the A516 intersect up to the Kingsway junction, where it reduces to 40 mph from Kingsway on to the Markeaton Junction (with the A52) until the Kedleston Road junction where the speed limit returns to the national speed limit. The A516 slip roads near to the Royal Derby Hospital link to the roundabout at the junction of the A516 and B5020. The A516 east of this junction becomes Uttoxeter New Road, which serves as a major access route into Derby city centre from the southwest. The Kingsway junction includes both on/off slip roads. These two junctions are coupled in their current alignments. For example, the A516 junction only allows for access to the A38 southbound. Westbound traffic for the A516 follows the A38 south to the next junction where the A516 continues to the west. Users for the northbound A38 must therefore make use of the Kingsway junction via the junction of the A516 (Uttoxeter New Road) and Kingsway (A5111). The A5111 and Uttoxeter New Road are discussed in more detail below.

Both A516 junction slip roads are dualled and the national speed limit applies. The A516, B5020, Uttoxeter New Road roundabout (the junction roundabout) has a speed limit of 40 mph, and has at least two circumnavigating lanes. There are traffic lights on the junction roundabout. Two are associated with the slip road from the A38, one for traffic entering the junction roundabout from the A38, and the other to hold traffic on the roundabout to accommodate traffic from the slip road. The other two traffic lights are pelican crossings near the entrances to the junction roundabout from Uttoxeter New Road and the B5020.

There is a traffic light on the A38 for northbound traffic entering the Kingsway junction roundabout. The Kingsway roundabout has two lanes with one set of traffic lights to hold traffic to allow those entering from the northbound A38. This leads to stop-start traffic conditions along this junction. Slip roads from the roundabout onto the A38 are single carriageway in both directions.

Immediately north of the Kingsway junction is an exit slip leading onto Brackensdale Avenue. Off-slip roads associated with this A38 exit slip road form part of turn lanes from the A38. On-slip traffic must slow down whilst merging with the A38 mainline. Further north mainline traffic is subject to queuing for the signal entering the Markeaton junction roundabout. Southbound traffic exiting the Markeaton roundabout is subject to a signal before merging onto Kingsway. Similarly, north of the Markeaton junction traffic entering and exiting the roundabout is subject to a signal to/from the A38 Queensway. There are no signals further north along the Queensway main carriageway.

Local Area

The A38 main carriageway is separated from residential receptors by roughly 20 m throughout the focus areas, with access to the local road network being via the junctions for the A516, Kingsway, Brackensdale Avenue and Raleigh Street, the A52 Markeaton junction, and Kedleston Road.

There are several employment areas near the A516, Kingsway and Markeaton junctions that may influence traffic flows during weekday peak periods. The Royal Derby Hospital is adjacent to the roundabout for the A516 on/off slip roads of the A38. Staff and patients are a large traffic source on the adjacent A516 roundabout. HGV movements to the hospital, i.e. delivery vehicles, may also influence traffic. There are a few businesses and some residential units to the north of the A516 junction roundabout, and the southern access to the Kingsway Manor development. A thoroughfare to the north to the Kingsway Retail Park is planned as part of the development, however the latest imagery (Google Maps, 2017) shows that access is currently closed.

The north access to the Kingsway Manor development is close to the Kingsway junction via the roundabout for the Kingsway Retail Park. The retail park hosts many large retailers that draw a significant number of users that may come off the A38, putting strain on Kingsway. Similarly, those working at the Ashbourne Centre have access from the A38 via the retail park roundabout only. The completion of the Kingsway Manor development would add further traffic accessing the A38 via the Kingsway junction.

The Kingsway Industrial estate is located near the junction of the A38 with Brackensdale Avenue and Raleigh Street. Some HGV movements to/from the estate from/to the A38 may use that junction; however, access to a majority of installations is on the east side off Uttoxeter Old Road. It is more likely that the majority of the HGV movements from the estate use Uttoxeter New Road and access the A38 via the A516 junction (for southbound traffic), and the Kingsway junction (for northbound traffic). This places additional strain on the junctions that serve access routes for many employment and leisure destinations (e.g. the Kingsway Retail Park).

Surrounding the Markeaton junction are a few businesses, including a petrol station, that serve as rest stop destinations for A38 users. The University of Derby Markeaton Street campus is located nearby off the A52 towards Derby City Centre. The main campus of the university is located adjacent to the A38 north of the Kedleston Road junction.

The surrounding topography is not a significant factor affecting pollutant concentrations in the A38 focus areas. Instead, very localised effects are likely to be experienced where the A38 carriageway is either above or below receptors. The carriageway descends into cuttings between the B5020 bridge to the south and the Kedelston Road junction to the north. The carriageway is above receptors as is passes over Brackensdakle Avenue. In other locations in the A38 focus areas, the carriageway is at the same level as the surrounding land.

The majority of receptors surrounding the A38 focus areas are separated from the carriageway by about 20 m and by large areas of vegetation or open land. A single residential receptor is located approximately 7 m from the kerb of the northbound A38 Queensway, north of the Kedleston Road junction.

Traffic Conditions

Google Maps traffic condition data were used to provide an initial indication of traffic conditions on the road network, before more detailed traffic data was provided; for more detailed discussions of traffic please refer to **Appendices 8 and 9**.

The Google Maps typical traffic conditions reveal that the northbound A38 mainline from the southern extent of the focus area to the Kingsway junction is heavily congested during the weekday AM and PM peak periods. North of the junction the A38 is lightly congested for north and south bound traffic during the AM and PM peak periods.

The traffic condition data indicate that the A516 off-slip road experiences heavy congestion on most days during the AM peak; however, the PM peak is more free-flowing. The A516 on-slip is free-flowing during peak periods. There is light congestion during the AM and PM peak periods on the A516 junction roundabout with Uttoxeter New Road and the B5020.

Google Maps Typical Traffic conditions points towards light congestion on the Kingsway junction during AM and PM peak periods, mainly on the northbound side towards the A38.

On Kingsway during the AM peak traffic is free-flowing except on the approach to the Kingsway junction, which traffic condition data suggests is heavily congested on some days as traffic queues at the traffic light. PM peak traffic is very heavy (stand still) along the westbound Kingsway between the retail park roundabout and the Kingsway junction with the A38.

A52 Corridor

Road Network

Figure 4 shows a map of the A52 focus area, which comprises a section of the A52 centred on Markeaton junction for the A38 (Kingsway and Queensway). The A52 corridor area includes northern and southern sections of the A38 to capture traffic approaching the junction.

The A52 serves as a major arterial route into Derby city centre from the west, providing access to the communities of Kingsway and Markeaton, and farther west towards Ashbourne. The A52 is all single carriageway within our focus area, with the exception of areas close to the A38 (Markeaton) junction to accommodate turning traffic. The A38 is a dual carriageway north and south of the junction.

Markeaton junction is signalled on the western A52 approach, and on the north and south approaches on the A38. Traffic approaching the junction on the A52 from the east is subject to a zebra crossing and must yield before entering the roundabout. Similarly, traffic exiting the junction roundabout onto the eastbound A52 is subject to a zebra crossing.

The speed limit is 40 mph on the A52 to the west of the Markeaton junction, and 30 mph to the east of the junction.

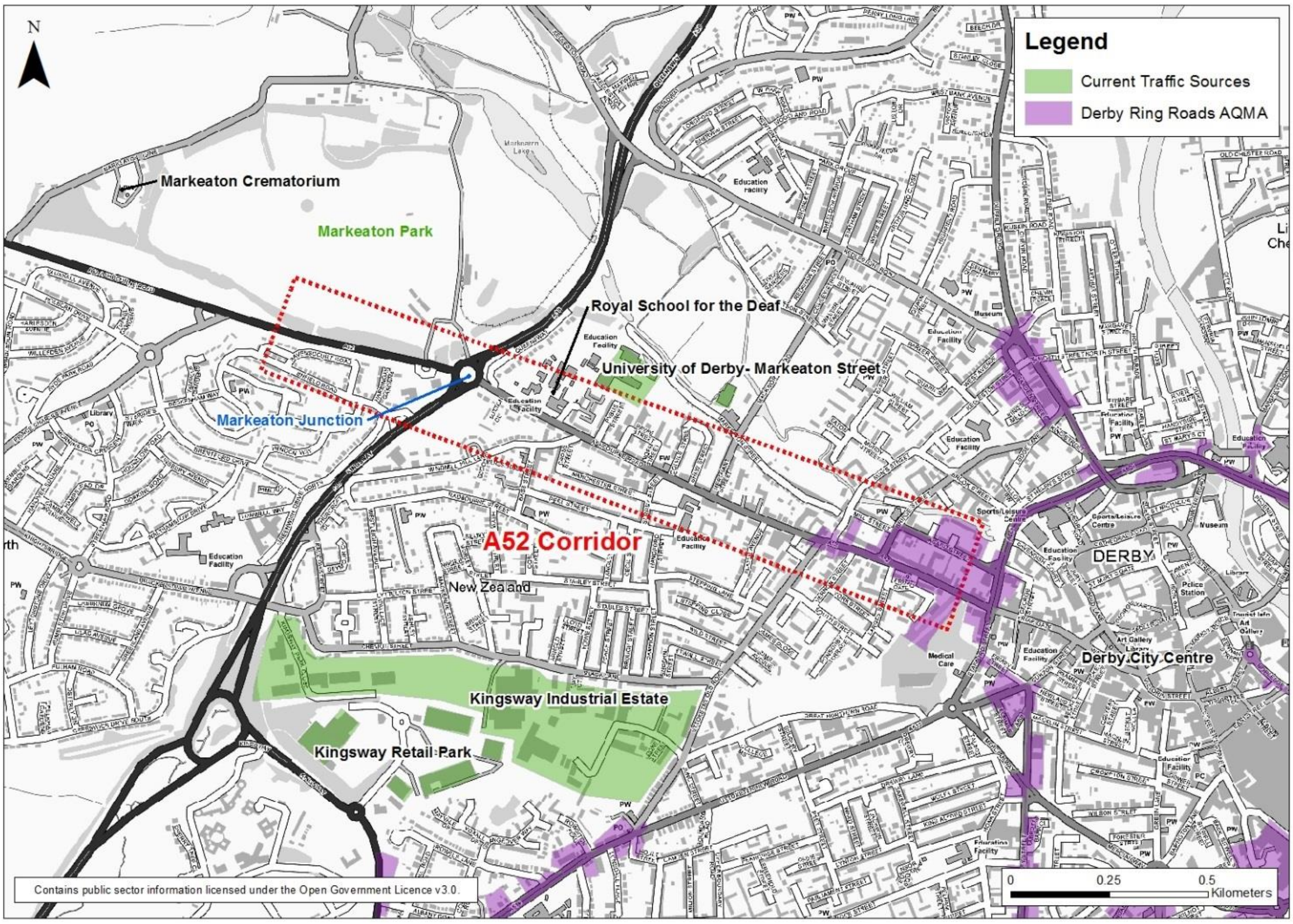


Figure 4: Map of A52 Corridor Focus Area, including the Derby Ring Road AQMA, current traffic and emissions sources, and major junctions.

Local Area

There are discernible differences between the eastern and western halves of the A52, using the A38 (Markeaton) junction as the dividing point. The eastern side of the A52 is more densely developed than the western side, resulting in more of a street canyon effect in some parts. Along the eastern side of the A52 there are a number of academic facilities that may contribute to traffic congestion, including the Royal School for the Deaf, the University of Derby Markeaton Street Campus, and Ashgate Primary School.

There are several businesses along the eastern section of the A52 with on-street parking in the area between Pybus Street and Shaw Street. In addition, there are eight bus stops, four in each direction of travel, without laybys. The combination of on-street parking and the bus stops limits the area for free-flowing traffic and increases the likelihood of queuing traffic. LGV deliveries to the businesses that stop on the side of the road may also cause some queuing traffic. In fact, during a site visit in April 2017, LGVs were observed to park on the side of the road, causing traffic obstruction. These factors are compounded by two pelican crossings that may also contribute to congestion; one is near the entrance to the Royal School for the Deaf and the other near the corner of the A52 and Colvile Street.

The western side of the A52 is more open, with properties set much further back from the road and fewer traffic obstructions, such as crossing signals. On the southwest corner of the Markeaton junction there is a service station that may induce slower traffic as users queue to access it. To the north of the western side of the A52 is Markeaton Park, accessible off the A52/A38 Markeaton junction. There is likely to be transient traffic congestion associated with specific events held at the park. There are also six bus stops along the western side of the A52, three in each direction of travel, all without laybys. Unlike the eastern side, the road is wider in this section allowing traffic to overtake buses, reducing the likelihood of queuing.

The topography of the A52 focus area does not impose a significant impact on pollutant dispersion.

The Markeaton Crematorium, located to the west of Markeaton Park, is listed under the National Atmospheric Emissions Inventory (NAEI) as an industrial point source. The emissions from the site are not expected to have a significant impact on annual mean NO_2 concentrations adjacent to the A52, as the site is more than 1 km from the A52. Its 2014 total NO_2 emissions were 2.4 tonnes. Background NO_2 sources in Derby are discussed in more detail in **Appendix 2**.

The eastern extent of the A52 focus area covers a small section of the Derby Ring Road Air Quality Management Area (AQMA), which was declared in 2002 due to exceedances of the annual mean NO_2 Air Quality Strategy (AQS) objective (40 µg/m^3). The latest Debry City Council (DCC) Updating and Screening Assessment (USA) attributed this to traffic emissions along the inner and outer ring roads (DCC USA, 2016). For discussion of monitoring data within this focus area, refer to **Appendix 4**.

Traffic Conditions

As described previously, Google Maps typical traffic conditions were used to describe traffic conditions on the local network; more detailed traffic analyses are included in **Appendices 8 and 9**. The traffic conditions data reveal that the eastern side of the A52 regularly experiences heavy congestion in the eastbound and westbound directions during weekday AM and PM peak periods.. On the western side of the A52, there is light congestion on the approach to the junction during the weekday AM peak. The data indicate light congestion occurs in both directions near the Markeaton junction during the weekday PM peak. Finally, there is heavy congestion on the north and southbound A38 on the approaches to the Markeaton junction during the weekday AM peak, but only light congestion during the PM peak.

Uttoxeter New Road and Kingsway/Manor Road (A5111)

The A516 connects the communities of Hilton, Etwall and Mickleover with the A50 and the A38 to the southwest of Derby. Moving east, the road then merges with the A38 before splitting again onto Uttoxeter New Road, which serves as another major arterial route into Derby City Centre. The road also provides access to the Royal Derby Hospital.

The A5111 forms the Outer Derby Ring Road that circulates the city to the south, and connects to the A6 on the southeast side of the city. The road runs through the Pear Tree, Allenton and Alvaston neighbourhoods, which host many large industrial installations. At the north-western end of the A5111, within the focus area, the road connects to the A38 at the Kingsway junction near the Kingsway Retail Park.

Discussions for this focus area are separated by the following sections of road: Uttoxeter New Road from the roundabout for the A38 slip roads to the junction with the A5111, Uttoxeter New Road from the junction with the A5111 to slightly past the intersection with Uttoxeter Old Road, A5111 Kingsway from Kingsway Retail Park Roundabout to the junction with Uttoxeter New Road, and the A5111 Manor Road from the junction with Uttoxeter New Road to north of Burton Road.

Road Network

Figure 5 presents a map of the Uttoxeter New Road/A5111 focus area, which is centred on the junction of Uttoxeter New Road (A516) and Kingsway and Manor Road (A5111).

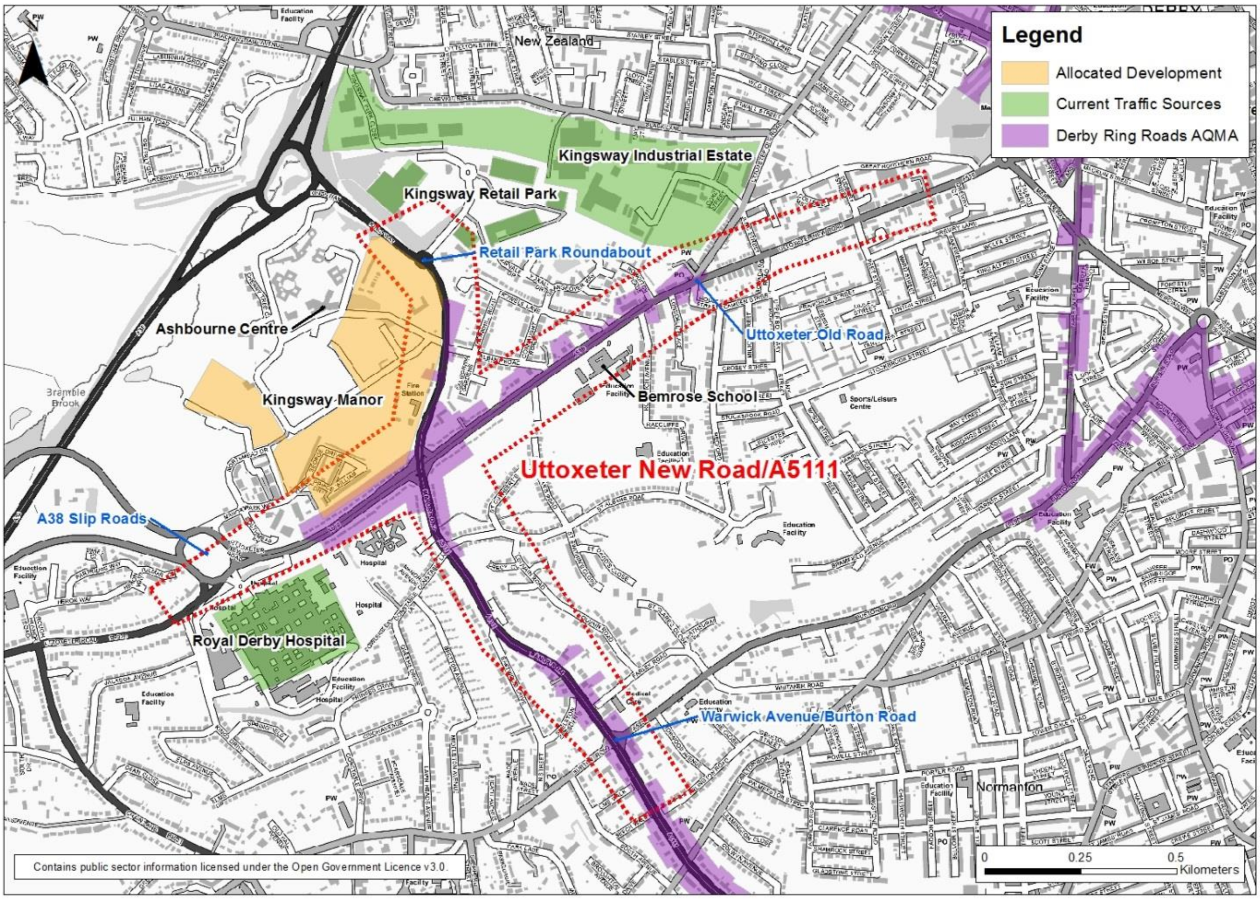


Figure 5: Map of the Uttoxeter New Road (A516)/A5111 Focus Area, current traffic and emissions sources, allocated development sites, the Derby Ring Roads AQMA, and major junctions.

Along Uttoxeter New Road (A516) the focus area extends from the roundabout with the A38 slip roads and Royal Derby Hospital access to the west, to the intersection with Uttoxeter Old Road to the east. For the A5111, the focus area extends north of the junction with Uttoxeter New Rd to the Kingsway Retail Park roundabout, and south towards Burton Road.

Uttoxeter New Road is a dual carriageway from the roundabout for the A38 slip roads to the junction with the A5111. East of the junction the road continues with two lanes in each direction, but with only one travel lane for local traffic moving eastbound; the other eastbound lane is a bus lane. Closer to the intersection with Uttoxeter Old Road, Uttoxeter New Road is a two-lane single carriageway, with additional lanes to accommodate turning traffic at the intersection.

Eastbound traffic exiting the A38 slip roads roundabout onto Uttoxeter New Road is subject to a pelican crossing. There are no other traffic discontinuities along this section of road until the junction with the A5111. For westbound traffic on Uttoxeter New Road the only traffic discontinuity is the pelican crossing on the entrance to the roundabout for the A38 slip roads. The speed limit is 40 mph for both travel directions on this section of road.

There are two pelican crossings along the eastern half of Uttoxeter New Road. One is near the corner of Albany Road and the other is incorporated into the intersection with Uttoxeter Old Road. The speed limit along this section of road is 40 mph from the junction with the A5111 to just after the corner of Albany Road. Further east, the speed limit is 30 mph.

The A5111 has different characteristics on the north and south sides of the junction with Uttoxeter New Road. To the north, the A5111 (Kingsway) is a two-lane single carriageway up to the roundabout for Kingsway Retail Park, with an additional centre turn lane near the intersection with Cherry Tree Close and Albany Road. The Kingsway Retail Park roundabout was widened and realigned in 2016 to include a new road into the Kingsway Manor development to the south. South of the junction with Uttoxeter New Road the A5111 (Manor Road) is a dual carriageway. There are additional lanes in both directions on the A5111 to accommodate turning traffic closer to the junction with Uttoxeter New Road.

Northbound and southbound traffic entering and exiting Kingsway (A5111), respectively, is subject to a puffin crossing immediately north of the junction with Uttoxeter New Road. Travel lanes reduce to one in each direction, further north of the junction. There is a toucan crossing near the corner of Cherry Tree Close and Albany Road. Finally, there are puffin crossings on the entrance and exit of the A5111 to/from the Kingsway Retail Park roundabout.

Eastbound, Kingsway is single lane until about halfway to the retail park roundabout where it is dualled. There is a traffic light for eastbound Kingsway traffic to enter the retail park roundabout; latest Street View (Google Maps, 2017) imagery from October 2016 indicates that the lights are not yet operational, as the retail park roundabout was recently widened to accommodate a new road for the Kingsway Manor development. Westbound, Kingsway is also single lane immediately after the retail park roundabout, but is dualled as it approaches the junction with the A38. Traffic is subject to a traffic light to enter the junction roundabout for the A38.

Local Area

A majority of the focus area lies within the Derby Ring Roads AQMA. The latest DCC USA (December, 2016) concluded that the AQMA extents are under review to include the entirety of Uttoxeter New Road between the A5111 and Derby Inner Ring Road.

The Royal Derby Hospital is a significant traffic source in the area; based on 2011 employment figures, approximately 7,000 staff commute daily to this hospital (The Guardian, 2011). According to the Derby Teaching Hospitals 2015 Travel Plan, approximately 49% of hospital staff arrive to work via single occupancy vehicles which is likely to cause a strain on the road network in the area. In addition, it is estimated that a large number of ambulances and other LGVs access the hospital daily. The impact of traffic associated with the hospital is likely to contribute significantly to traffic volumes and congestion on the local road network within this area.

There are four bus stops, two in each direction of travel, along Uttoxeter New Road, and five within the hospital grounds. The bus stops in the hospital are part of the Royal Derby bus service from the hospital to Derby city centre and London Road Community Hospital (LRCH) via Uttoxeter New Road and Manor Road (A5111). The frequency of the buses serving these stops is roughly every 15 minutes during peak travel times, and closer to 20 minutes during off-peak periods (Trentbarton, 2017). The Royal Derby also serves as a park and ride scheme for hospital staff from LRCH.

East of the junction with the A5111, Uttoxeter New Road narrows to a single carriageway with one travel lane for eastbound traffic and two for westbound traffic. The other eastbound lane is a bus lane. East of the intersection with Uttoxeter Old Road, Uttoxeter New Road is a two-lane single carriageway with no bus laybys. There are ten bus stops along this section of road, four eastbound and six westbound.

Buildings along this stretch of Uttoxeter New Road are closer to the road moving east towards the city centre, with the exception of Bemrose School. Access to the school is just off the main road on Peet Street. A large number of school “drop-offs” and “pick-ups” may contribute to additional queueing along Uttoxeter New Road during peak periods. Businesses near the intersection with Uttoxeter Old Road have on-street parking, reducing the travel area for traffic.

The Kingsway Retail Park hosts a large Sainsbury’s supermarket and petrol station, and several other retailers that draw large quantities of users to the area. On the south side of the upgraded retail park roundabout is the Ashbourne Centre, which has staff that access the area every day. Around 700 new homes are under construction as part of the Kingsway Manor Development directly south of the retail park roundabout. Construction of the development started in 2014, and the latest imagery from 2016 (Google Maps, 2017) indicates that two large sections have been completed. A recent site visit confirms this observation, with more houses under construction near the newly aligned roundabout.

The addition of the houses to the area is likely to increase traffic on the local network near the Kingsway junction for the A38. As previously mentioned, this junction is coupled with the A516 (Uttoxeter New Road) junction. Additional traffic in the area may cause more congestion on the A5111 and Uttoxeter New Road near the Royal Derby Hospital and the retail park roundabout.

There is a fire station and training centre on Kingsway located off the northbound side, close to the junction with Uttoxeter New Road. HDV movements from the site may impact traffic on Kingsway. There are no current bus stops on Kingsway between the retail park roundabout and the junction with Uttoxeter New Road.

The A5111 Manor Road south of the junction with Uttoxeter New Road has fewer traffic sources and obstructions within the extent of the focus area. There are two bus stops, one north and one south, as part of the Royal Derby service. The northbound stop includes a layby whereas the southbound stop does not, which forces traffic to move around stopped buses thus increasing the likelihood of queuing traffic.

The Kingsway Industrial Estate is located north of this focus area without direct access to Uttoxeter New Road, the A5111, or the A38. HGVs travelling to/from the A38 from the estate may likely use the junction with Brackensdale Avenue and Raleigh Street, see below. However, on inspection of Google Maps imagery, access to the majority of installations is via Parcel Terrace off Uttoxeter Old Road, which may require most HGVs to/from the estate to use Uttoxeter New Road to access the A38. In addition, because access to the A38 from Uttoxeter New Road is restricted to southbound traffic, northbound traffic is forced onto Kingsway, putting additional strain on this road and the retail park roundabout.

Topographic features do not significantly impact pollutant concentrations for most of the Uttoxeter New Road/A5111 focus area. The intersection of Warwick Avenue (A5111) and Burton Road is the only area with topographic effects. Warwick Avenue slopes uphill on the approach to Burton Road, potentially increasing engine load and emissions from vehicles travelling in this direction. Vehicles moving downhill on either side of the junction will have relatively lower emissions.

There are no major industrial installations in the focus area that contribute significantly to background NO_2 concentrations. The Royal Derby Hospital is included in the NAEI as an industrial point source due to large energy consumption and NO_x emissions, as evidenced by two onsite stacks. NAEI 2014 total NO_x emissions from the site are 9.8 tonnes. The nearest Defra background NO_X mapping grid square to the hospital has a 'Domestic' (covering the hospital emissions) in-square NO_X contribution of around 1.7 $\mu g/m^3$, which is greater than 5% of the total background NO_X concentration. **Appendix 2** includes more detailed discussions of background NO_2 sources in Derby.

The 2009 DCC USA report highlighted that a 1000 kW wood fuel (biomass) burner is included in the Kingsway Manor Development. The report stated that the planning application included an air quality assessment that suggested the maximum NO_2 concentration increase would be around 0.04 $\mu g/m^3$. DCC concluded that the facility, and the development, would not have a significant impact on annual mean NO_2 concentrations. The facility was not mentioned in the latest DCC LAQM report (2016).

Traffic Conditions

Google Maps typical traffic data were used to describe traffic conditions on the local network. For more detailed analyses of traffic data please refer to **Appendices 8 and 9**.

On Uttoxeter New Road, between the A38 slip roads and the intersection with the A5111, the Google maps traffic conditions data show that the AM peak is the busiest period for eastbound traffic. The data indicate that during the PM peak there is light congestion in both travel directions.

The Google Maps traffic data show that the AM peak is the busiest along eastbound Uttoxeter New Road from the A5111 to Rowditch Place, where the number of travel lanes in each direction reduces to one. There are similar congestion patterns for westbound traffic, with light congestion during the AM peak. During the PM peak, there is light congestion in both travel directions.

On Kingsway (A5111) the Google Maps data indicate that the PM peak period is the busiest for northbound traffic, and on the Kingsway retail park roundabout. There is a similar traffic pattern for southbound traffic near the intersection with Uttoxeter New Road.

Google Maps traffic data indicate that there is light congestion on Manor Road (A5111) for north and south bound traffic during the weekday AM and PM peaks on the approaches to the junction with Uttoxeter New Road (north) and with Burton Road (south). There is less congestion on the road between these junctions.

References

- Derby City Council, Updating and Screening Assessment and Progress Report (2009, 2016)
- Derby Teaching Hospitals, Travel Plan 2015 Summary Report (2015)
- The Guardian, Healthcare Network (2011), https://www.theguardian.com/healthcare-network/2011/aug/10/derby-hospitals-nhs-foundation-trust-profile
- Google Maps (2017)
- Trentbarton Royal Derby Bus Timetables (2017), (https://www.trentbarton.co.uk/services/royalderby/timetable)

Appendix 2 – Background Mapping Analysis

PREPARED BY:	Ben Marner
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Luke Farrugia

This appendix provides a review of the Defra background mapping data for nitrogen dioxide (NO_2) and oxides of nitrogen (NO_X) for the A38 Derby pilot study area. The 2013 Defra base background maps were used to project 2015 data. Pollutant concentrations are provided on 1 km^2 grids over the Derby City Council authority area. Annual mean concentrations were compared to the EU Limit Value/UK AQS objective for NO_2 (40 µg m^{-3}). There is not a human health based EU Limit Value or UK AQS objective for NO_X as it comprises all oxides of nitrogen (i.e. nitric oxide (NO) and NO_2), and NO is not a human health issue. Instead, the grid squares with the highest NO_X concentrations were identified to understand source attribution. Defra background mapping provides individual source contributions, for road and non-road sources, for NO_X. “Hot spot” locations were identified as grid squares where the NO_2 concentration was at least 75% of the AQS objective (i.e. 30 µg m^{-3}).

Background map review

Figure 1 shows the total mapped background (2015) NO_x concentrations for all grid squares (177 grid squares) within the Derby study area which contain an ‘A’ road. Those cells shaded grey have predicted background concentrations above 30 µg/m^3. Most of the background concentrations along the A38 are lower than this.

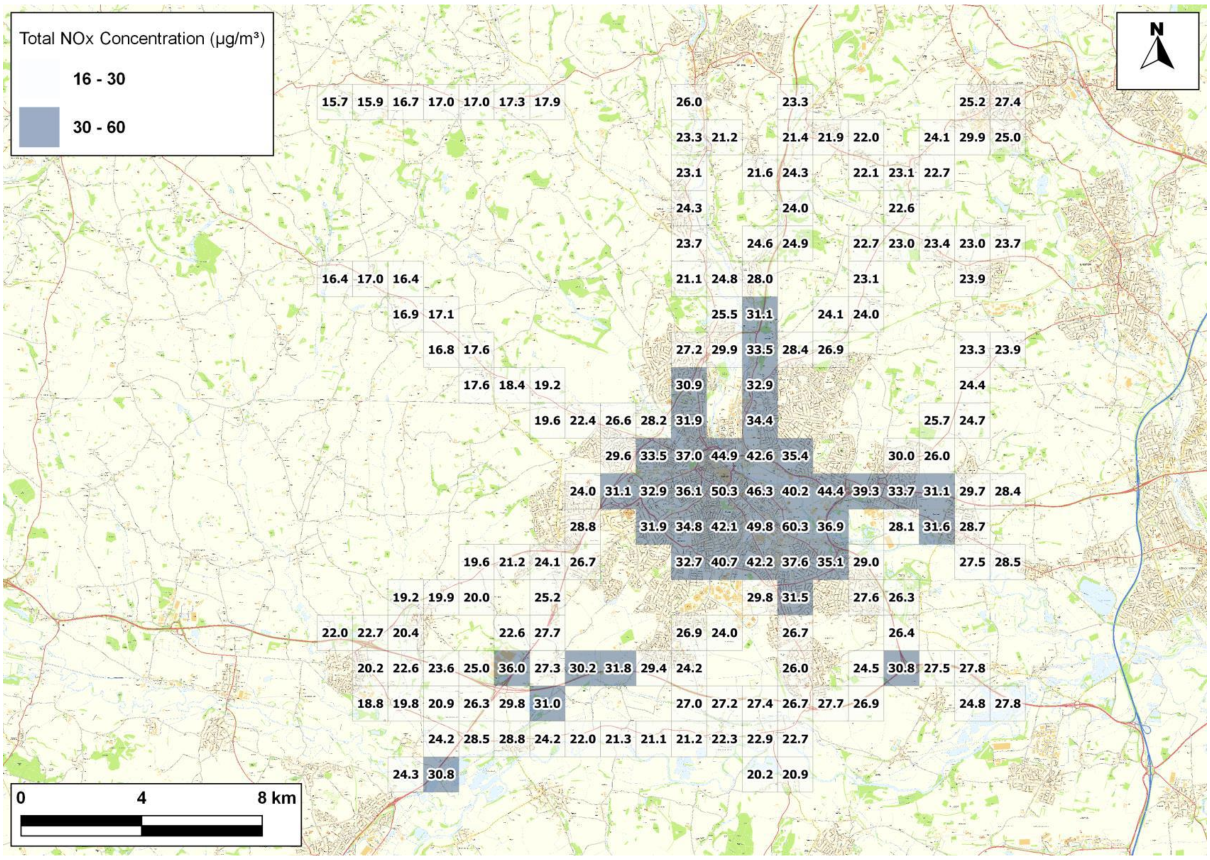


Figure 1: Grid Squares Showing Total NO_X Concentrations. Dark Shaded Squares have Concentrations Greater than 30 µg/m^3

For the grid squares containing ‘A’ roads, **Figure 2**, **Figure 3** and **Figure 4** show respectively:

a) the total ‘in-square’ NO_x (excluding traffic);

b) the total ‘out-square’ NO_x (including point sources and traffic but excluding the rural component); and

c) the total rural NOx component, both as an absolute concentration and as a percentage to the total for that grid square.

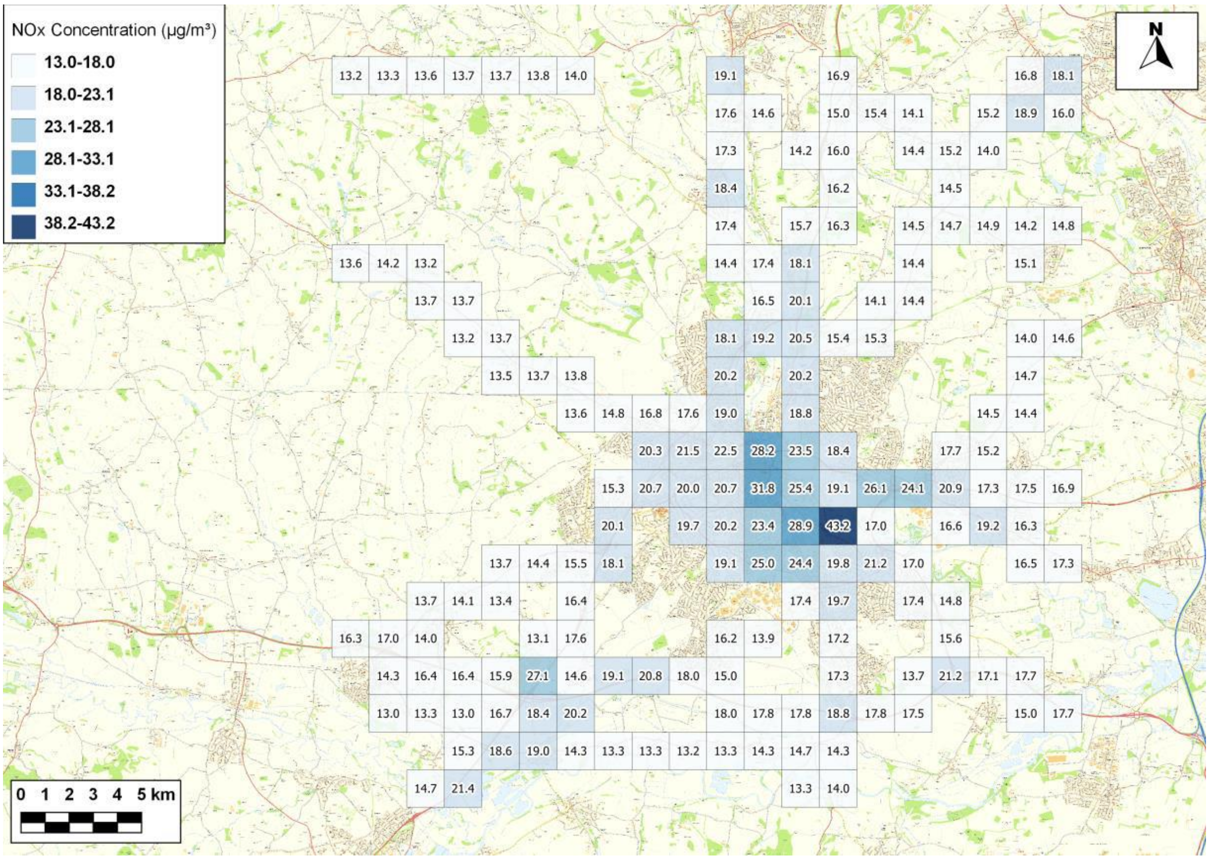


Figure 2: Total 'In-Square' NO_X Concentrations (Excluding Traffic) for Relevant Squares for Derby (numbers denote the same concentrations as the colour bands)

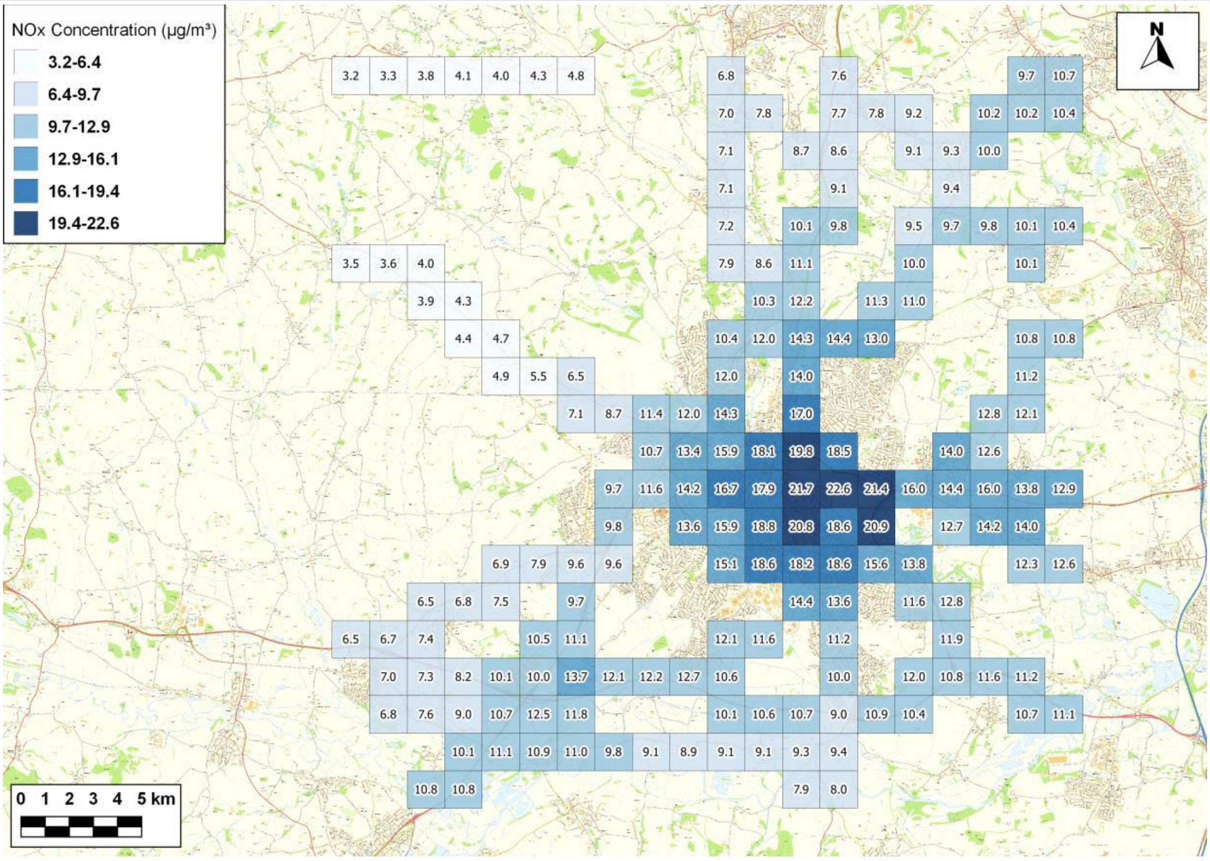


Figure 3: Total 'Out-Square' NO_X Concentrations (Excluding Rural) for Relevant Squares for Derby (numbers denote the same concentrations as the colour bands)

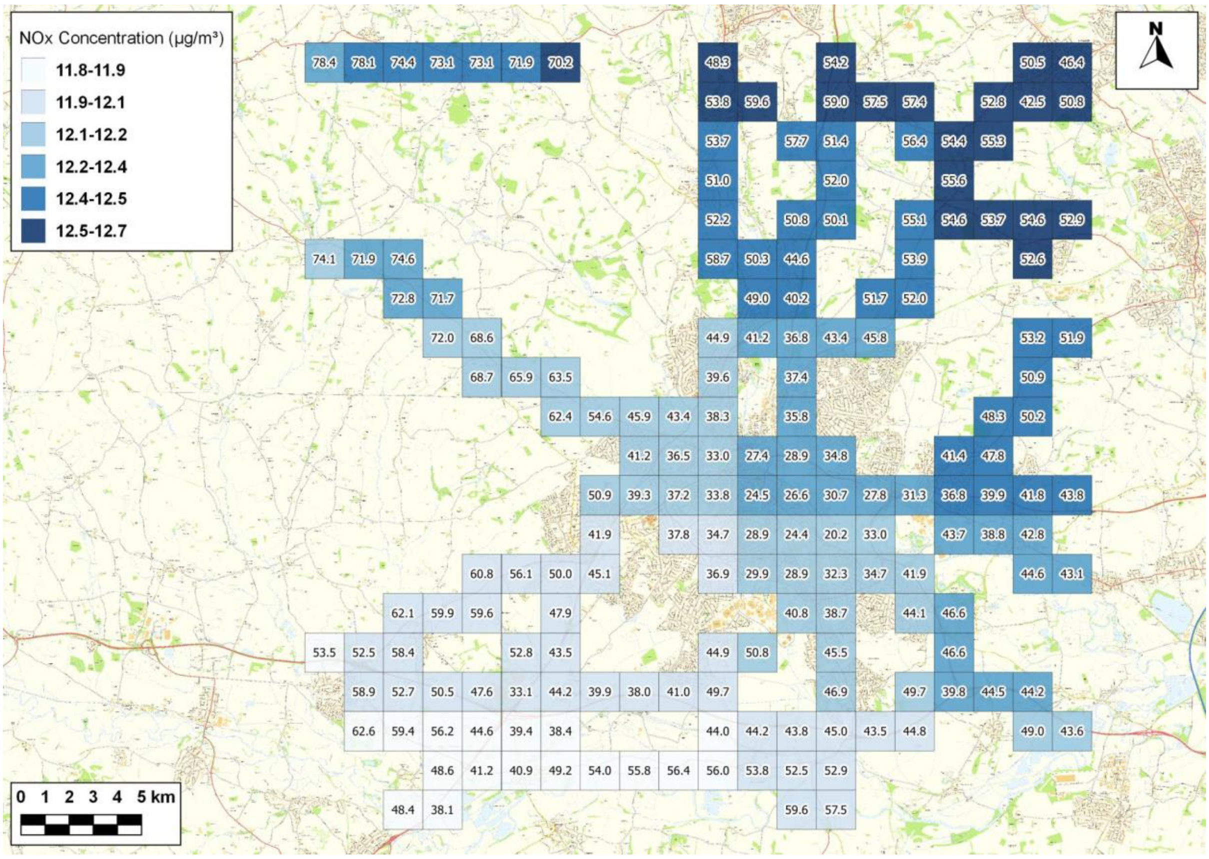


Figure 4: Total Rural NO_X Contribution Colour Mapped According to Absolute Concentrations with Numbers Showing the Percentage Contribution of Rural to Total Background NO_X

Figure 5 and **Figure 6** show box and whisker diagrams for the 'in-square' and 'out-square' percentage contributions separately, subdividing each into the various source sectors. These charts show the relative contribution that each sector makes to the total for each square. The whiskers represent the maximum and minimum percentages, whilst the box is formed from the lower quartile (25%), upper quartile (75%) and the median.

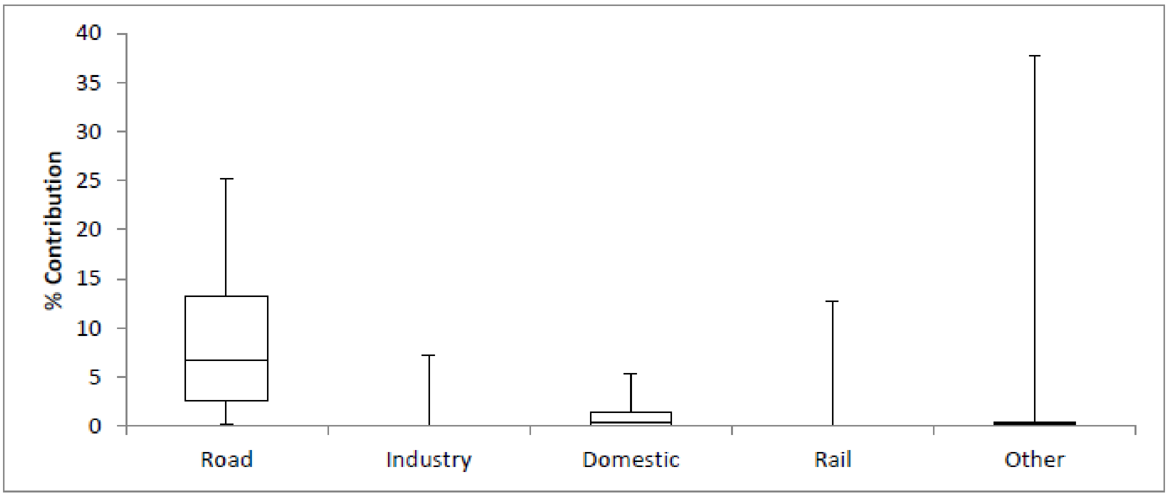


Figure 5: Derby 'In-Square' Contributions (% contribution to in-square NO_X)

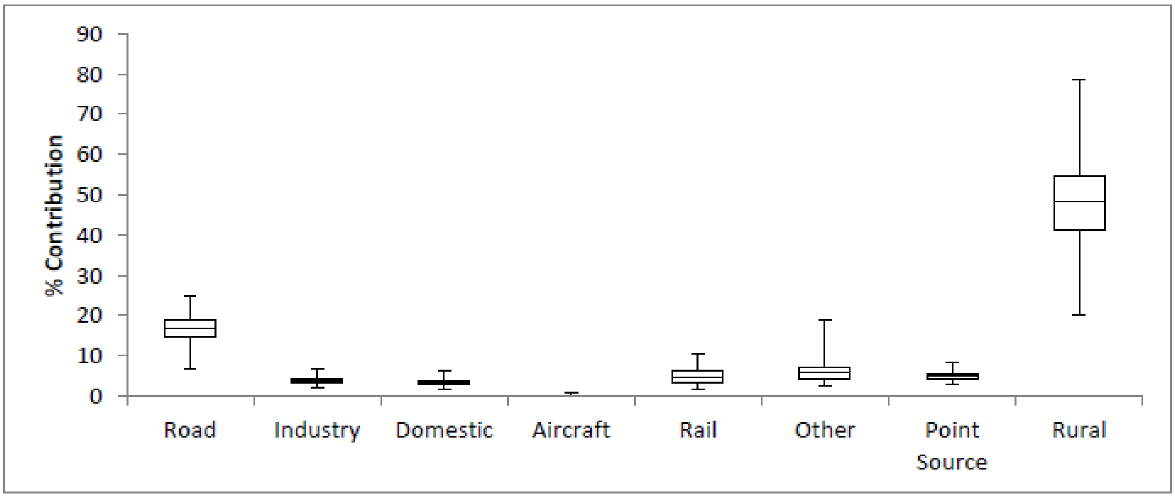


Figure 6: Derby 'Out-Square' Contributions (% contribution to out-square NO_X)

Figure 7 and **Figure 8** show the numbers of grid squares which contain sizable contributions from each source sector. Taking **Figure 7** as an example, this shows that rail contributes more than 5% to total background NO_x within about 20 grid squares in the Derby area.

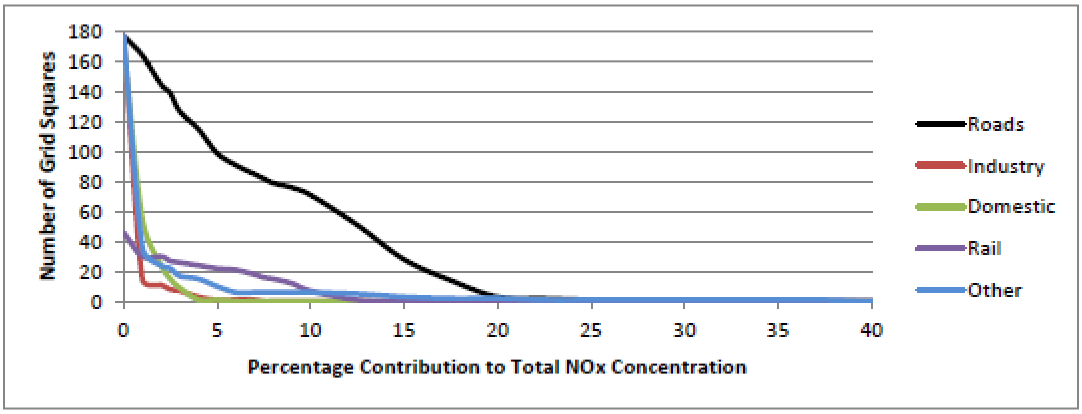


Figure 7: The number of Grid Squares with varying 'In-Square' Percentage Contributions to NOx by Source Sector

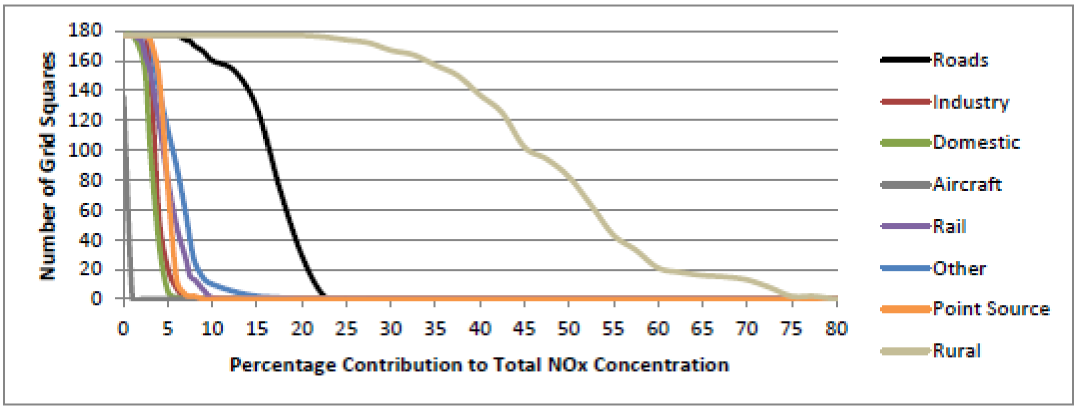


Figure 8: The number of Grid Squares with varying 'out-Square' Percentage Contributions to NOx by Source Sector

Summary

Highest 'In-Square' NO_x concentrations are centred on the primarily industrial area southeast of Derby city centre. Higher 'In-Square' NOx concentrations also follow major traffic routes, including the A52 east towards Nottingham, the A38/A61 north, the A5111 through southern sections of the city, and a railway line extending to the southwest towards the A38/A50 junction.

There are higher NO_X concentrations on the east side of Derby then the west side. This is consistent with the prevailing wind direction for the area (i.e. the west-southwest), determined from meteorological data available for East Midlands airport. Background monitoring data were not available for 2015 at the time of writing this report. One background site recorded a 2014 annual mean NO_2 concentration of approximately 25 µg m^{-3}. The nearest equivalent Defra background concentration for 2015 is 28.2 µg m^{-3} suggesting reasonable agreement.

The maximum background NO_X concentration (60.3 µg m^{-3}) is located southeast of Derby city centre. Hot spot locations for NO_X are located east, southeast of Derby city centre. The majority of emissions for these hot-spot locations are from non-road sources. Excluding the regional rural contribution, most NO_x emissions are from industrial, domestic, rail and other (off-road) sources. Point source contributions are less significant.

The grid point with the maximum concentration is in the vicinity of many active industrial areas, namely the Bombardier UK manufacturing facilities, the Etches Park train depot, Rolls Royce and Balfour Beatty industrial sites, waste treatment facilities and other industrial units including distribution facilities.

In-square Source Apportionment

Figure 9 shows those grid squares (covering the network of 'A' roads) which contain an individual 'in-square' source sector contributing more than 5% to total background NO_x. Most of these are well away from the A38. For all grid squares which are not shown in **Figure 9**, there are no individual source sectors which contribute more than 5% to background NO_x. For the squares not shown, it is considered that there is little value in identifying individual emission sources, since any effect of controlling these emissions will be extremely small. The analysis has thus focused on those locations shown in **Figure 9** where 'hot-spots' of individual emission sources are predicted; even where these are some distance from the A38.

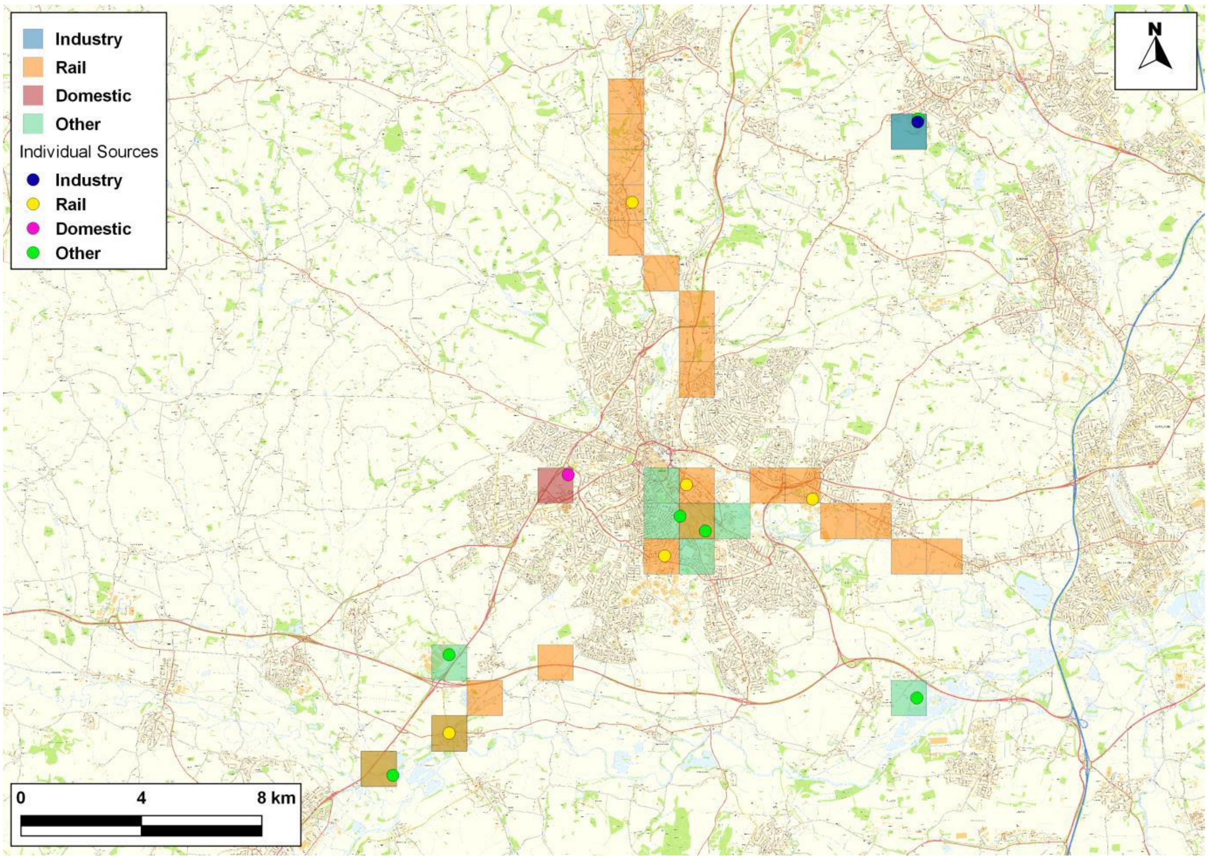


Figure 9: Grid Squares in Derby for Sources which Contribute More than 5% to the Total Background NO_X Concentration including the Location of Several Potential Key Individual Sources

Figure 9 also shows the locations of the key individual emission sources which have been identified as key contributors to the source-sector hot-spots. Additional detail of the individual emissions sources contributing to these source-sector hot-spots is given in **Figure 10** to **Figure 13**. The notes under each figure list the most likely contributors.

One point to note is that the only significant 'in-square' industrial source sector is outside of Derby. The more well-known industries (Bombardier, Rolls Royce and Toyota) appear to be included in the background maps as 'other' rather than 'industry'.

In the case of the 'other' sources shown in **Figure 13**, a very high 'in-square' contribution (22 $\mu g/m^3$) is predicted around the A6 to the southeast of the city centre. The NAEI emissions maps identify this as being driven by "other transport and mobile machinery". Apart from a small industrial estate, there are no clear emission sources within this grid square, and it seems most likely that this is a misplacement of emissions from the nearby Rolls Royce Marine Power facility. The NAEI maps also show that the remaining grid cells shown in **Figure 13** appear to have significant "other transport and mobile machinery" emissions. In the case of Bombardier and Toyota, the most likely contributor has been easy to identify. Similarly, in the case Willington Quarry and Shardlow Landfill, there are no other potential emission sources in the area. It has not been possible to identify specific sources which are likely to, on their own, drive the 'other' source-sector hot-spots.

All grid squares with contributions to total NO_x greater than 5% in Derby are shown by source sector in **Figure 10** to **Figure 13**. Where individual sources which may contribute to each sector have been located from Google Maps, these have been included. In several squares, there are no obvious sources. These include:

- Grid Square 263 (Other)
- Grid Square 265 (Other)
- Grid Square 285 (Other)

- Grid Square 383 (Other)

It is possible that there are several small ‘other’ sources that cumulatively constitute a significant source, or alternatively a lack of other source sectors makes a sector stand out that otherwise should not.

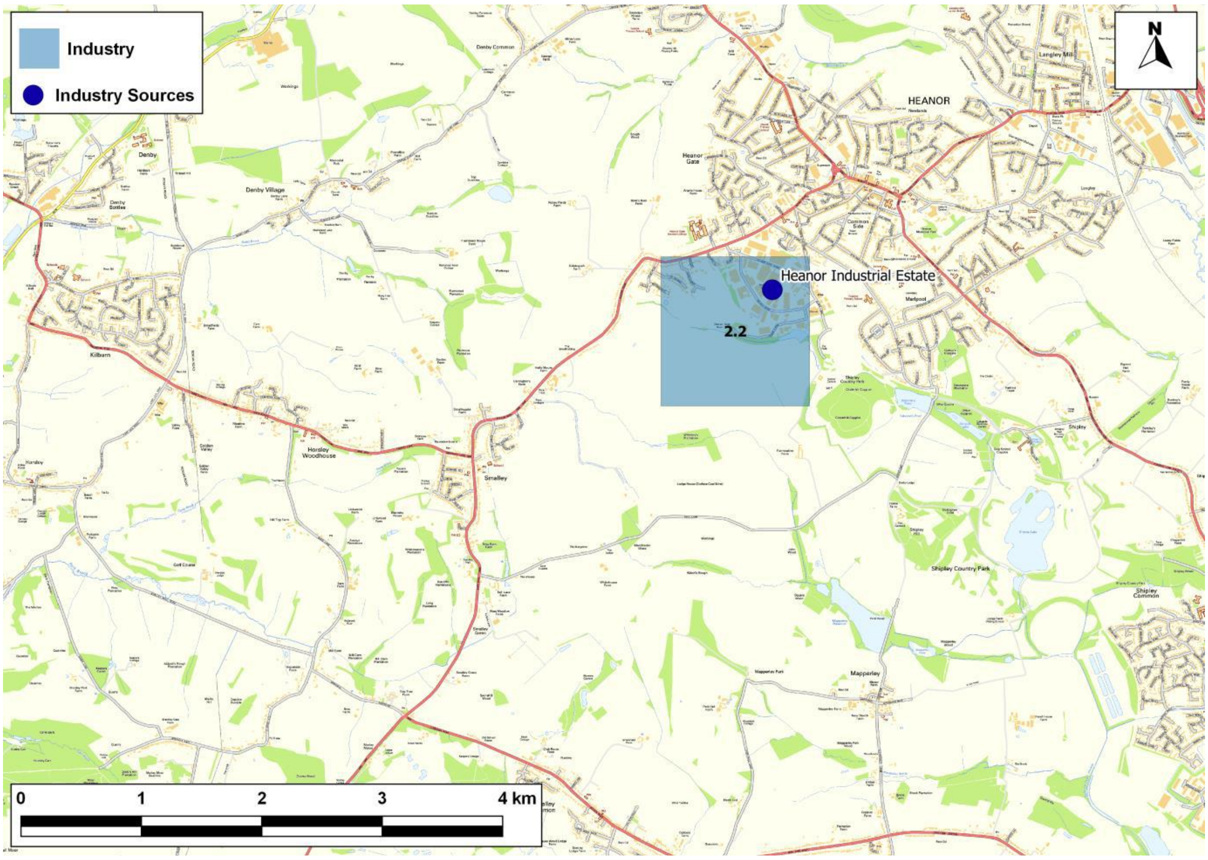


Figure 10: Grid Squares where ‘In-Square’ Industry Contributes More than 5% to the Total Background NO_X Concentration (In-Square Industry NOx Concentration in bold)

Companies located within the Heanor Industrial Estate include:

- DSM Nutritional Products (vitamins)
- Concept Plastic Packaging (thermoform plastics)
- Fix Auto (Car repairs ~100/month)
- Advanced Composites Group (industrial materials)
- Easibind International (printer services)
- Callum Detuners (jet engine test facilities)
- Bowers Electricals (electrical supply manufacturers)
- Matthew Walker (food products supplier)
- DS Smith (packaging)

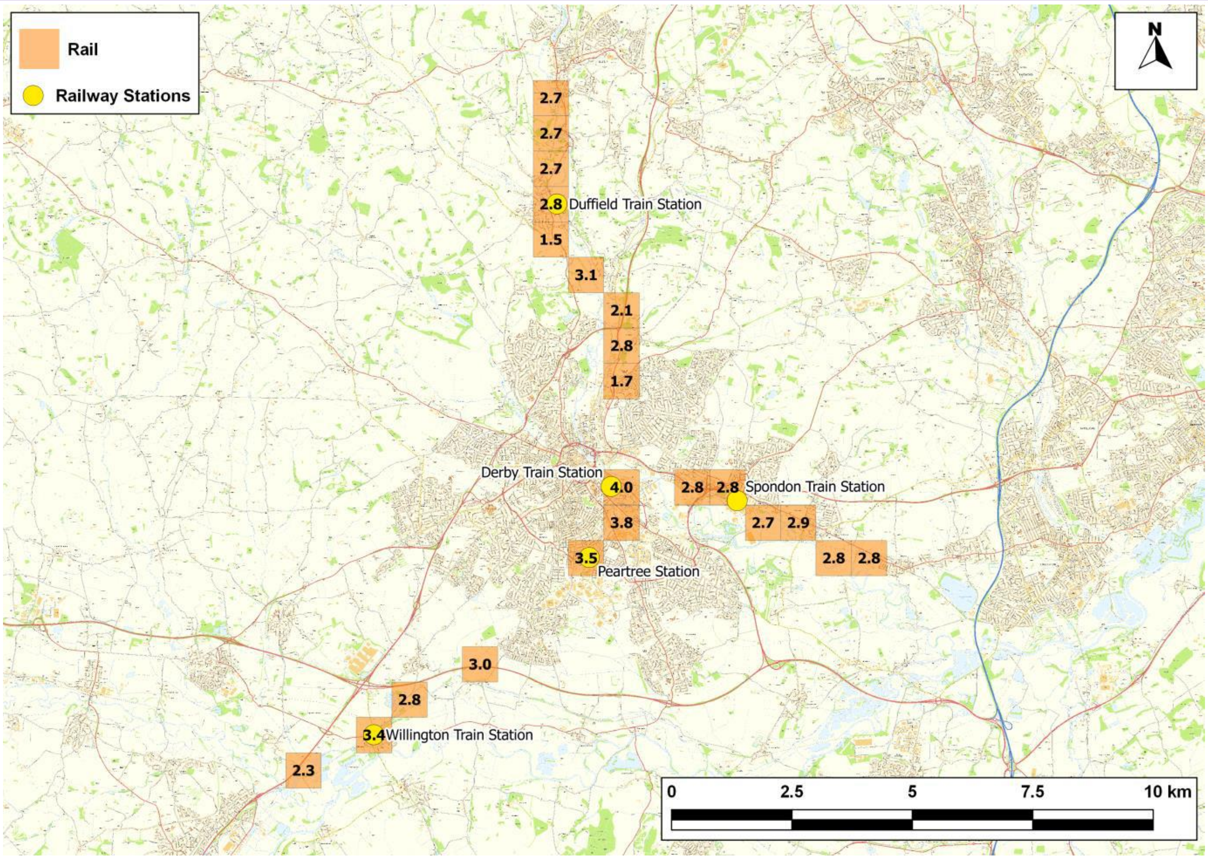


Figure 11: Grid Squares where 'In-Square' Rail Contributes More than 5% to the Total Background NO_X Concentration with Railway Stations Indicated (In-Square Rail Concentration in bold)

Train services running through the relevant grid squares include:

- Cross Country Trains service: Cardiff-Nottingham, Birmingham-Nottingham, Sheffield-Long Eaton;
- Ecclesbourne Valley Railway services: Duffield-Wirksworth; and
- East Midlands Trains service: Newark-Matlock.

Railway stations include:

- Willington (Grid ID = 383)
- Peartree (Grid ID = 284)
- Derby (Grid ID = 243)
- Spondon (Grid ID = 246)
- Duffield (Grid ID = 73)

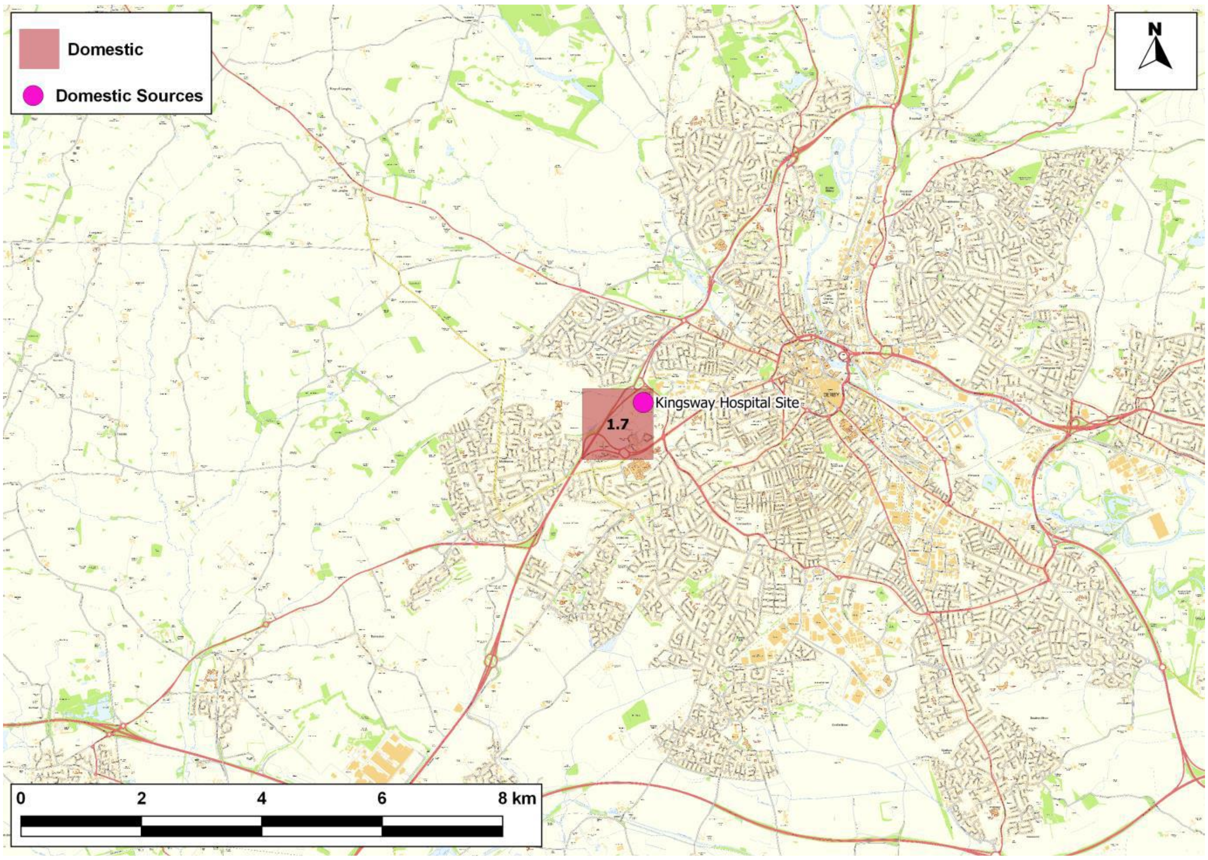


Figure 12: Grid Squares where 'In-Square' Domestic and Institutional Contributes More than 5% to the Total Background NO_X Concentration with Potential Key Sources Indicated (In-Square Domestic Concentration in bold)

This source represents the Kingsway Hospital Site, which includes a 1000 kW biomass CHP Energy facility according to Derby City Councils 2009 Updating and Screening Assessment.

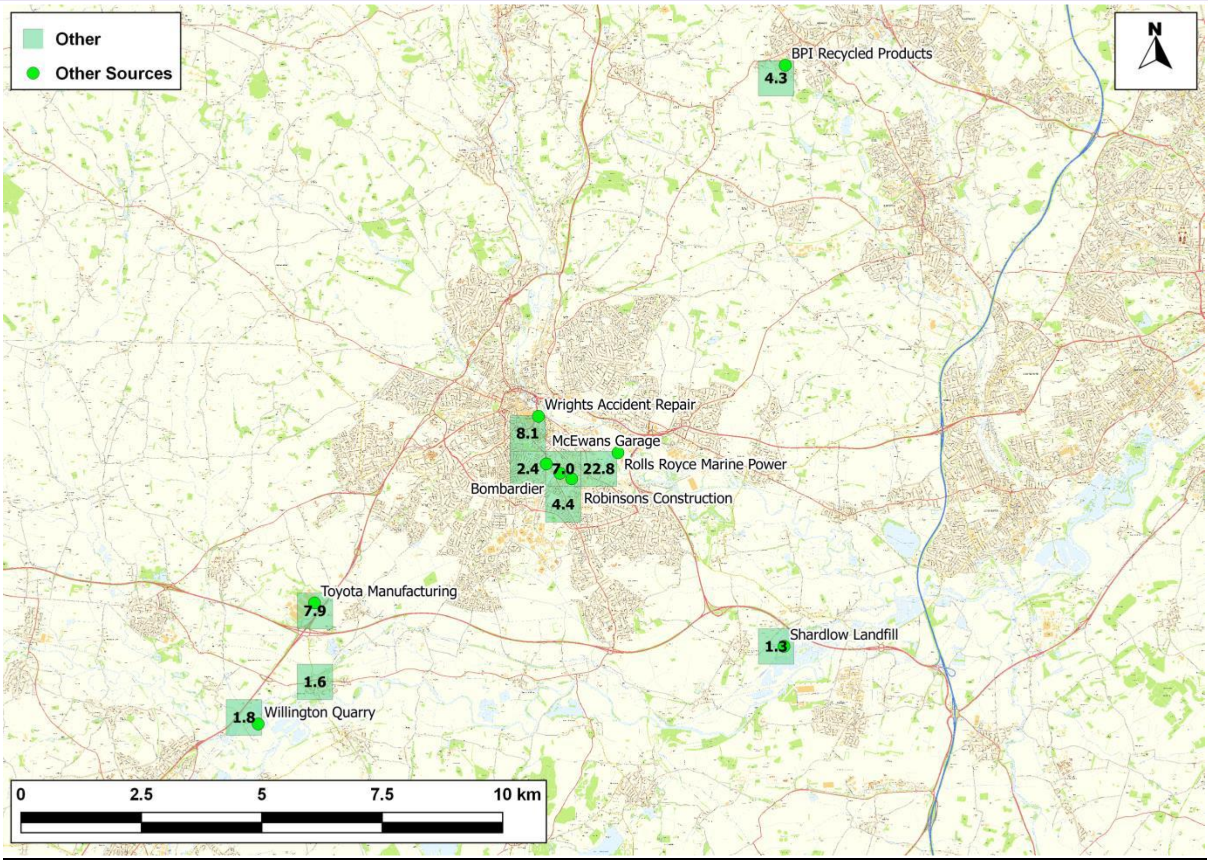


Figure 13: Grid Squares where 'In-Square' Other Contributes More than 5% to the Total Background NO_X Concentration with Potential Key Sources Indicated (In-Square Other Concentration in bold)

Companies within these grid squares include:

- Rolls Royce Marine Power (Manufacturing) – Grid ID = 266
- BPI Recycled Products (Waste Treatment) – Grid ID = 39
- McEwans Garage (Waste Oil Burner Licence) – Grid ID = 264
- Robinson Construction (Metal Coating Part B Licence) – Grid ID = 264 (no longer 2016)
- Wrights Accident Repair Centre (Vehicle Respraying) Grid ID = 242 (Site has Part B licence)
- Shardlow Landfill (Waste Landfilling) – Grid ID = 375 (Small site holds Part B licence)
- Toyota Motor Manufacturing (Fuel and Power) – Grid ID = 341 (From PRTR: 852 TNE hazardous waste, domestic recovery) – Central building holds Part B Regulated Process license
- Willington Quarry (Mineral extraction and concrete plant) – Grid ID = 402 (One small site holds Part B licence)

Discussion

In terms of 'in-square' sources, the biomass boiler at Kingsway Hospital stands out as being a source which, if it were removed, could reduce concentrations in the vicinity of the A38; albeit by a relatively modest amount (total sector-specific in-square NO_x is 1.7 μg/m^3). The Toyota plant is also adjacent to the A38 and contributes more to background NO_x (total sector-specific 'in-square' NO_x is 7.9 μg/m^3), but there appears to be little or no relevant exposure in terms of the annual mean NO_2 objective within this grid square.

Emissions from operations at Rolls Royce Marine Power are predicted to have a significant impact on 'in-square' NO_x concentrations (total sector-specific 'in-square' NO_x is 22.8 μg/m^3) to the southeast of the city centre. The nearby Bombardier facility also appears to be a significant source of NO_x emissions (total sector-specific 'in-square' NO_x is 7.0 μg/m^3).

Railway emissions are also clearly important to mapped background NO_x concentrations along the various lines. It must be borne in mind that both the spatial representation of sources within the National Atmospheric Emissions Inventory, and the emissions assigned to those sources, is subject to uncertainty. An analysis such as this, which takes the maps as its starting point, is thus also subject to that uncertainty.

Out-square Source Apportionment

This section considers the possibility that individual emissions sources which are some distance from the A38 focus areas may make a significant contribution to mapped background NO_x concentrations within them. These sources are classified within Defra's background maps as 'out-square' and 'point' sources.

Overview of how 'Out-square' and 'Point' Source Sectors are Included in the National Background Maps

When Ricardo Energy and Environment, on behalf of Defra, compiled the current background maps, it took the following approach:

- Large point sources were modelled explicitly using the ADMS dispersion model and hourly-sequential meteorological data from Waddington. For each source, concentrations were calculated for a 99 km x 99 km square composed of a regularly spaced 1 km x 1 km resolution receptor grid.
- For small point sources, dispersion kernels were prepared using a selection of nominal point-source release conditions (depending on calculated emission rate). Meteorological data from Heathrow were used in the assessment. For each source, concentrations were calculated for a 30 km x 30 km square composed of a regularly spaced 1 km x 1 km resolution receptor grid.
- For area sources, dispersion kernels were used, this time extending 33 km x 33 km from the source. Meteorological data from Waddington were used.

Description of 'Out-square' and 'Point' Components

Figure 14 shows how the 'out-square' and 'point' components of background NO_x concentrations vary across the study area (all grid squares containing an 'A' road within the 20 km x 20 km study area are shown). It is clear that out-square contributions are not spatially homogenous; rather they vary significantly over these areas. This suggests that relatively local sources have an appreciable effect on predicted background concentrations.

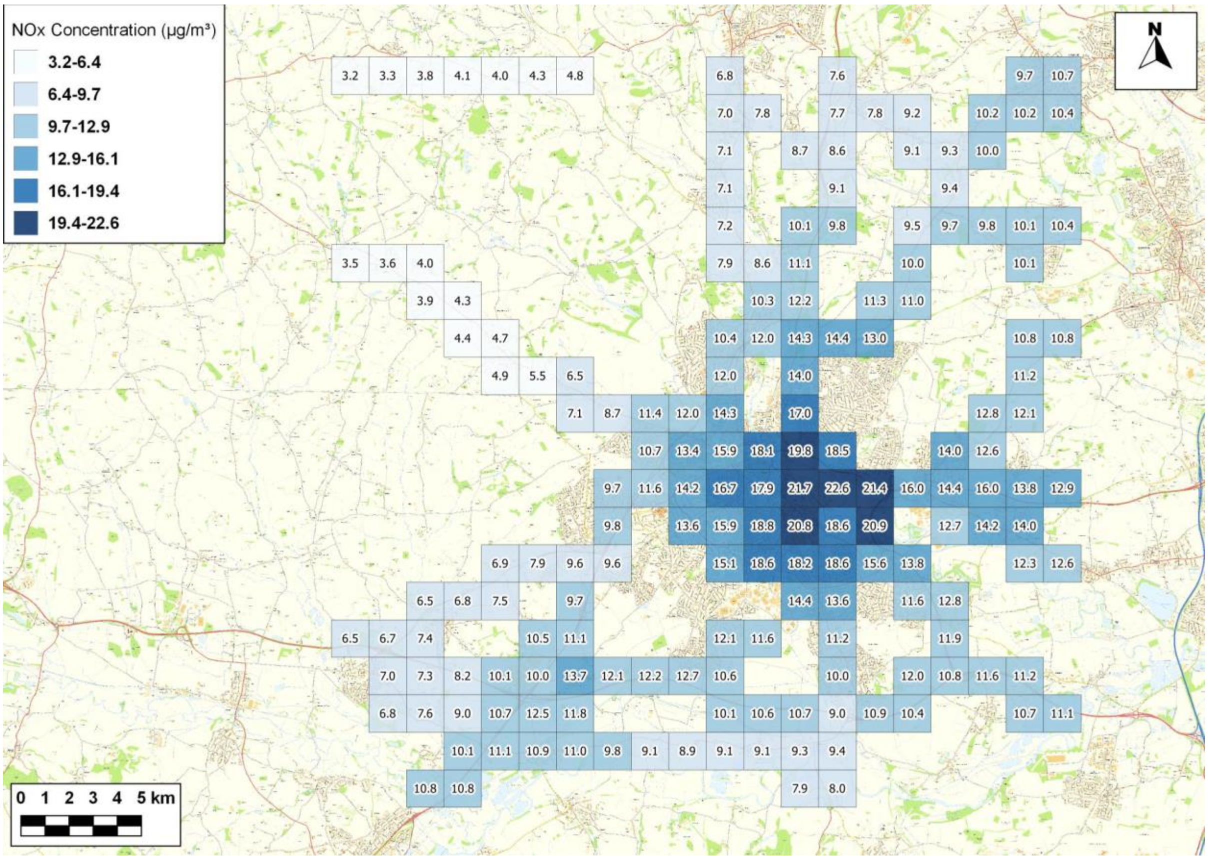


Figure 14: Derby Out-Square Concentrations (Excluding Rural) (Colour map and Numbers Designate the Actual Concentration in that Grid Square)

High-level Quantitative Analysis of 'Out-square' Area Sources (Excluding 'Point' Sources)

In order to determine how significant the impact of an individual source might be on background concentrations some distance away, the UK-wide background maps have been searched for locations with large 'in-square' sources and with no other nearby 'in-square' sources of the same activity sector. Sites were chosen which were outside of major towns and cities, and given that the background mapping methodology uses (almost) consistent meteorological data across the UK, the sites were not restricted to those within any of the pilot areas.

For each isolated 'in-square' source grid, the 'out-square' source contributions over the surrounding 11 km x 11 km grid were identified. Beyond this distance, it was judged to be impossible, within this high-level analysis, to determine whether the source in the centre of the 11 km x 11 km grid was driving the 'out-square' contributions. These 'out-square' contributions were then expressed as a percentage of the 'in-square' contribution in each grid's centre.

There was quite some variability in the spatial patterns shown, which is most likely to reflect the confounding influence of other emission sources outside of the grids. Because of this, it was considered appropriate to combine the datasets so as to derive a smoothed relationship between source-sector-specific 'in-square' concentrations and nearby 'out-square' concentrations. This was done for each compass point (N, NE, E etc.) by plotting the percentages derived against the distances between 1km grid centre points. The best-fit relationship between source-sector-specific 'in-square' concentrations and the 'out-square' contribution in nearby squares is represented by:

$$y = - 8.996 \ln(x) + 22.743$$

Where 'y' is the 'out-square' contribution as a percentage of the 'in-square' concentration, and 'x' is the distance between the respective grid centre points in kilometres. It should be recognised that this relationship will be affected by the confounding influence of other nearby sources and this causes some of the predictions to be clearly erroneous; since the predicted 'out-square' contribution from a specific source occasionally exceeds the total 'out-square' concentration in the background maps. Despite this, it is considered to give a useful indication of the likely contributions from different sources.

Applying this relationship to two nominal locations in Derby, which were identified as having large individual in-square contributions, allows the concentration increment, driven by this in-square source, to be approximated as shown in **Figure 15** and **Figure 16**. These figures show that the Rolls Royce facility has the potential to contribute more than 2 μg/m^3 to 'out-square' NO_x beside the A38, while the contribution of the Toyota plant is likely to be smaller.

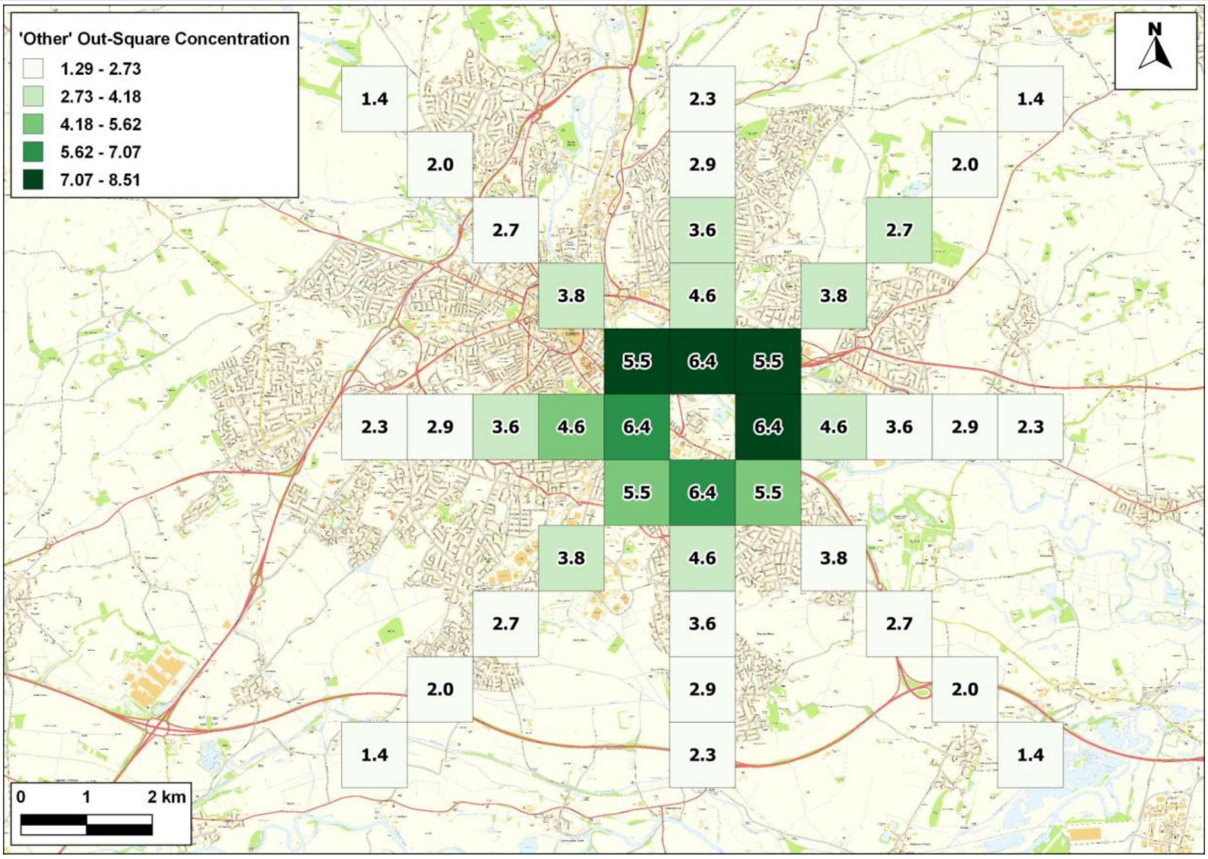


Figure 15: Rolls Royce Facility (Colour map Designates the Actual Out-Square Concentration, Numbers Indicate Predicted Out-Square Concentration from Rolls Royce Plant)

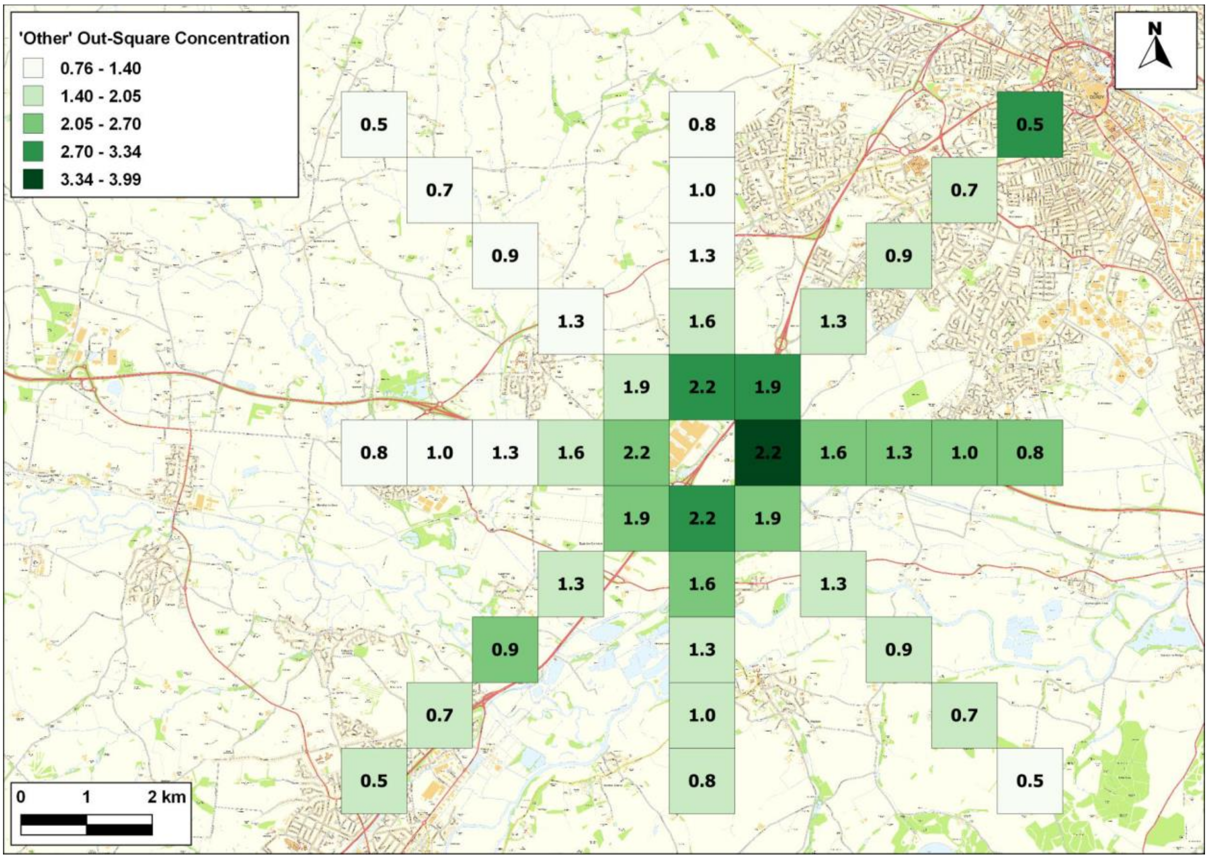


Figure 16: Toyota (Colour map Denotes the Actual Out-Square Concentration, Numbers Indicate Predicted Out-Square Concentration from Toyota Plant)

High-level Analysis of Point Sources

In order to provide an indication of how ‘point’ sources included in the background maps might be contributing to the predicted background concentrations, the total ‘point’ source contribution within the national maps has been overlaid onto the point sources as catalogued in the National Atmospheric Emissions Inventory (i.e. the data which underpin the background concentrations maps). The results are shown in **Figure 17** and **Figure 18**, which indicate total ‘point source’ contributions within Derby and the focus areas are relatively small and could be attributed to a number of sources.

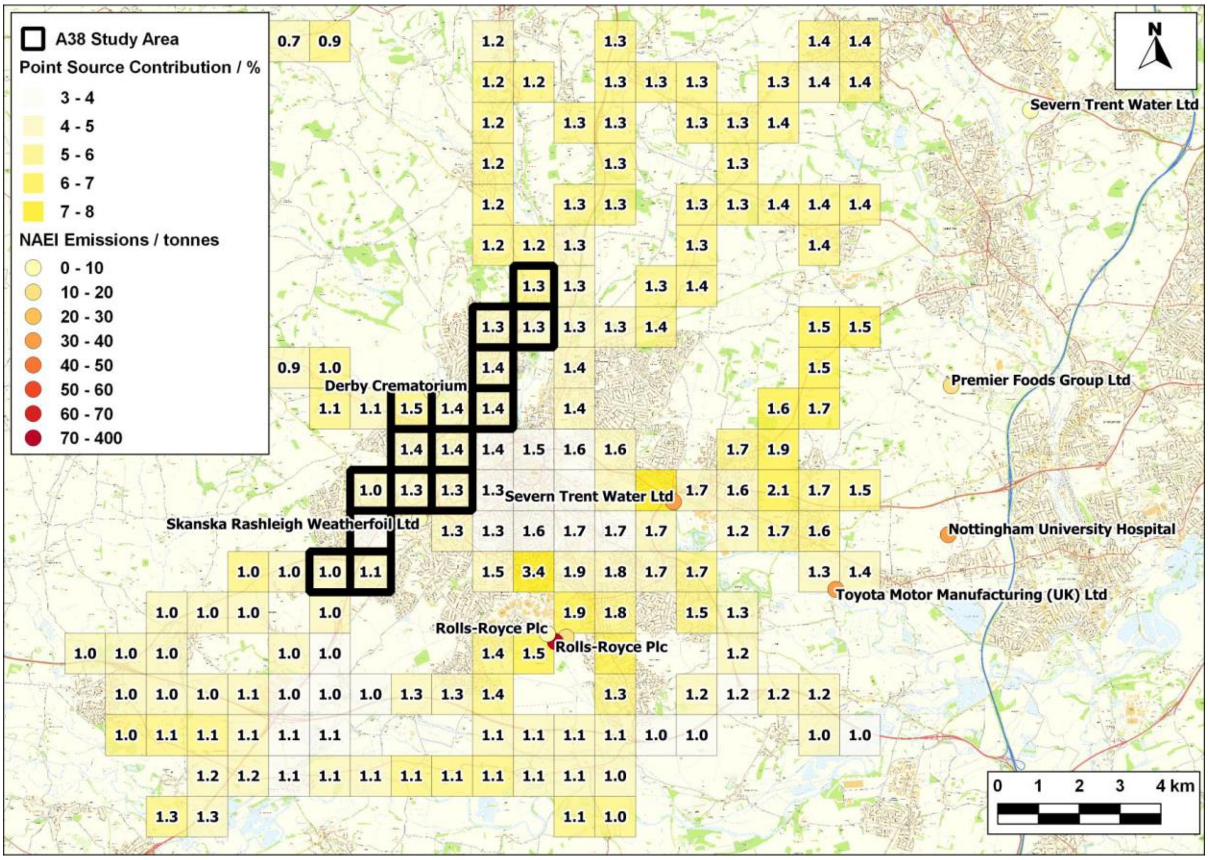


Figure 17: Mapped Point Source Contributions to Background Maps and Nearby Point Source Emissions in Derby (Labels show the point source contribution to background concentrations in µg/m³, coloured square shows the percentage contribution of point sources to the mapped background total, and circles show the point source emissions in tonnes)

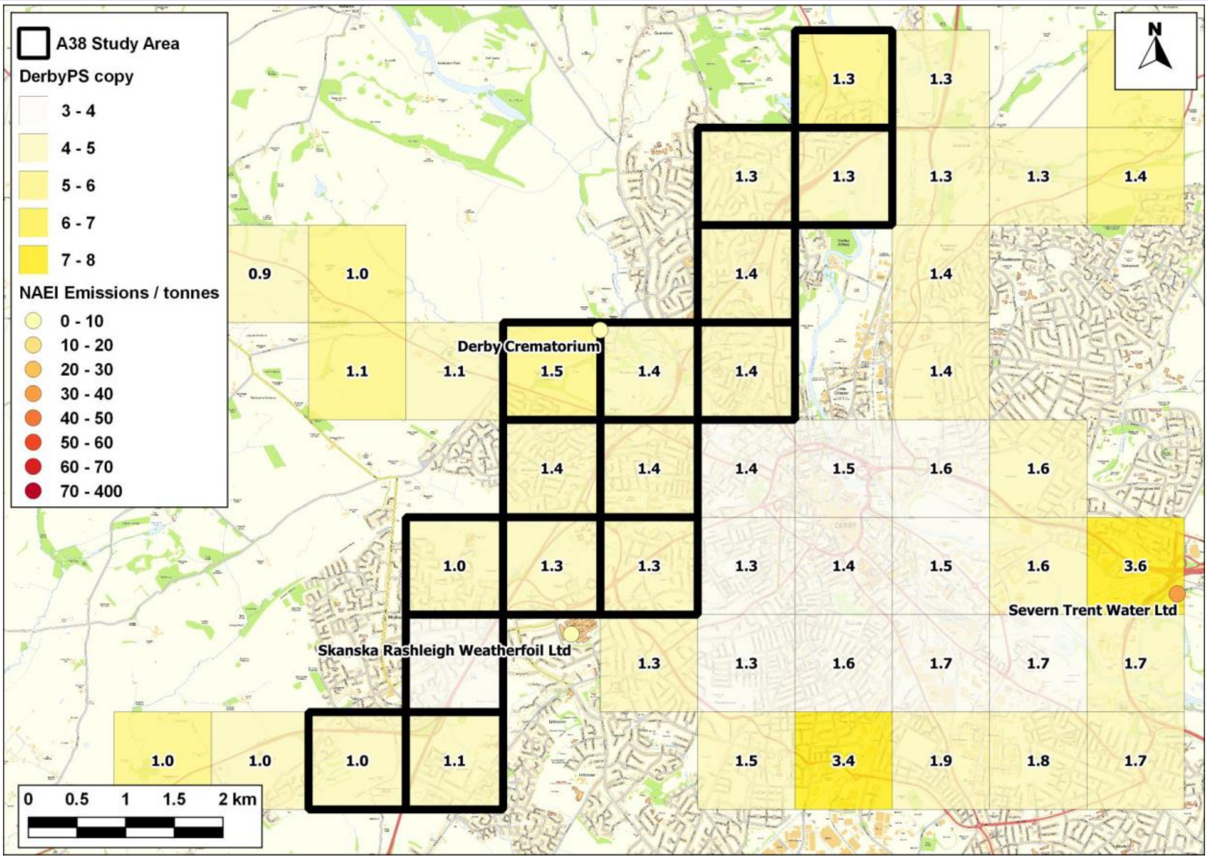


Figure 18: Mapped Point Source Contributions to Background Maps and Nearby Point Source Emissions in the A38 Focus Area (Labels show the point source contribution to background concentrations in μg/m³, coloured squares show the percentage contribution of point sources to the mapped background total, and circles show the point source emissions in tonnes)

Appendix 3 - Quality assurance of air quality monitoring data

PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Chris Taylor

This Appendix covers the quality assurance procedures applied to the diffusion tube monitoring data for the A38 Derby Pilot Study, the results of which are discussed in **Appendix 4**. Included is an overview of the sifting process applied to the monitoring data, which describes the differentiation between roadside and background monitoring sites, and the method used to exclude certain monitoring sites. Annualisation and bias adjustment factors are also included in separate discussions below. All discussions describe the sources of data used for each analysis. Finally, **Table 4** summarises the data sources and the quality assurance methods applied.

Diffusion Tube Data

Diffusion tube measurements were available from the following sources:

- Derby City Council (DCC) – 2010 to 2015
- Highway England (HE) – 2013 to 2015

Sifting Process

The classifications of each monitoring site provided by Derby City Council and Highways England were reviewed to confirm validity and for consistency between monitoring surveys. An initial criterion of 30 m from the edge of a major road (any A-road) was used to differentiate between roadside and background sites. Additional classifications were used for sites that did not have monitoring between 2013 and 2015, as these years were not used for source apportionment, which is detailed in **Appendix 6**.

Another step of filtering was undertaken, comparing absolute pollutant concentrations and Defra background mapping concentrations. If the monitored annual mean NO_2 concentration was comparable (i.e. within ~5%) to the background concentration, then the site was classified as a background site. A final check was made, using site-specific factors such as traffic volumes, to ensure roadside and background sites classifications were appropriately filtered.

Geographic filtering was also applied to the monitoring data, which revealed some sites for exclusion from further analysis. All of the excluded sites were from DCC, and were excluded based on unclear site descriptions, inappropriate locations for diffusion tubes, or non-existent sites or properties in recent years. Google Street View and visible satellite imagery were used to confirm the locations of excluded sites.

Annualisation and Bias Adjustment

Monitoring data from both DCC and HE surveys were subject to incomplete data capture. Following Defra LAQM TG(16) guidance (Box 7.10), the data were annualised for sites with data capture less than 75% (9 months). For consistency, the same AURN sites were used to annualise data in each year and for both surveys. **Table 3** presents a summary of the Defra AURN sites used for annualisation; all sites have over 85% data capture between 2010 and 2015.

Table 1: Defra AURN site summary with data capture between 2010 and 2015

AURN Site	Site Type	Data Capture (%)					
		2010	2011	2012	2013	2014	2015
Stoke-on-Trent Centre	Urban Background	97.3	97.9	98.7	92.0	96.5	98.1
Birmingham Tyburn	Urban Background	98.7	99.1	99.3	90.6	99.2	96.3
Nottingham Centre	Urban Background	98.7	96.1	97.5	96.4	96.8	86.8

Table 2 presents the annualisation factors used for both surveys between 2010 and 2015, for years during which each survey was undertaken. Annualisation factors for each year differ between the two surveys due to differences in monitoring periods. Annualised concentrations were provided for 2015 DCC data without an annualisation factor (DCC USA, 2016); therefore, this process was not completed for those data.

Table 2: 2010 to 2015 annualisation factors for Derby City Council monitoring and the Highways England Derby Junctions program

Year	Monitoring Survey	
	Derby City Council	Highways England
2010	0.99	-
2011	1.01	-
2012	1.00	-
2013	1.00	0.95
2014	0.99	1.06
2015	-	1.01

After annualisation, as recommended by Defra LAQM.TG16 guidance, bias adjustment factors were applied to the monitoring data. **Table 3** provides the bias adjustment factors applied to the data from each monitoring survey.

DCC used a local bias adjustment factor derived from a triplicate diffusion tube site at the Warwick Avenue Continuous Monitoring Station (CMS) site between 2010 and 2012. After the diffusion tube supplier went into administration in 2013, national bias adjustment factors were used from 2013 to 2015. Highways England used Defra national bias adjustment factors for every year.

Table 3: 2010 to 2015 Bias Adjustment factors for Derby City Council monitoring and the Highways England Derby Junctions program

Year	Monitoring Survey	
	Derby City Council	Highways England
2010	0.80	-
2011	0.70	-
2012	0.60	-
2013	0.81	0.87
2014	0.81	0.83
2015	0.79	0.84

Table 4: Diffusion Tube Data Sources and Quality Assurance Comments

Study Area	Monitors Operated by	Are the tubes consistent year on year?	How do diffusion tube results compare with those from the automatic monitors?	What lab and lab method was used for the DT analysis, is it consistent for all tubes?	What bias adjustment factor was used, local/national? Was the same factor used for all tubes? Is the factor appropriate? If a local factor was used how was it determined?	Are there any significant periods of missing data, was any annualisation carried out?
A38	DCC	The two sites have six years of data Between 2010 and 2015. 2011 and 2012 were lower than expected due to lower bias adjustment factors. The overall trend shows no improvement of monitored values.	No automatic monitors in the area.	Between 2010 and 2013, tubes were provided/analysed by Casella CRE Air with 10% TEA in Water. From 2013, Environmental Scientific Group (ESG) Ltd. provided some tubes with 50% TEA Acetone.	No clear information other than bias-adjustment being based on local co-location studies at the Warwick Avenue CMS between 2010 and 2012. From 2013 National Bias Adjustment Factors were used. Local Factors applied*: 2010 (0.80), 2011 (0.70), 2012 (0.60), National Factors Applied: 2013 (0.81), 2014 (0.81), 2015 (0.79). *No national bias adjustment factor available for Casella CRE Air between 2010 and 2013.	Only one site had DC less than 75% in 2013. In all other years, the site had sufficient DC. The other site had sufficient DC between 2010 and 2015.
	HE	Of the 13 sites, only one does not have three years of data between 2013 and 2015. All other sites have data for three years. Only one site shows a new exceedance of the NO_2 objective in 2015, bringing the total to three. Over the three years, however, the overall trend across all sites shows no improvement of monitored values.		Staffordshire Scientific Services 20% TEA in Water Between 2013 and 2015	National bias-adjustment factor applied to HE diffusion tubes, these were: 2013 (0.87). 2014 (0.83), 2015 (0.84).	For 2013, data were only available for period August 2013 to January 2014. For 2015, data were available from February 2015 to 2016, due to anomalous data in January 2015. Data have been annualised for all three years using factors of 0.95 (2013), 1.06 (2014) and 1.01 (2015) based on Nottingham Centre, Stoke-on-Trent Centre and Birmingham Tyburn.

Study Area	Monitors Operated by	Are the tubes consistent year on year?	How do diffusion tube results compare with those from the automatic monitors?	What lab and lab method was used for the DT analysis, is it consistent for all tubes?	What bias adjustment factor was used, local/national? Was the same factor used for all tubes? Is the factor appropriate? If a local factor was used how was it determined?	Are there any significant periods of missing data, was any annualisation carried out?
A52	DCC	Four sites have six years of data between 2010 and 2015. One site exceeds the NO_2 objective in 2010 and 2013, but improves thereafter. 2011 and 2012 are lower than expected due to lower bias adjustment factors available. The other sites do not show improvement from 2010 to 2015.	No automatic monitors in the area.	Between 2010 and 2013, tubes were provided/analysed by Casella CRE Air with 10% TEA in Water. From 2013, Environmental Scientific Group (ESG) Ltd. provided some tubes with 50% TEA Acetone.	No clear information other than bias-adjustment being based on local co-location studies at the Warwick Avenue CMS between 2010 and 2012. From 2013 National Bias Adjustment Factors were used. Local Factors applied*: 2010 (0.80), 2011 (0.70), 2012 (0.60), National Factors Applied: 2013 (0.81), 2014 (0.81), 2015 (0.79). *No national bias adjustment factor available for Casella CRE Air between 2010 and 2013.	Various sites had DC less than 75% in all years except 2013. In 2013 all sites had a DC of 75% or greater.
	HE	Of the three sites, one has only two years of data from 2014 and 2015. All other sites have three years of data between 2013 and 2015. There is no discernible trend from the data.		Staffordshire Scientific Services 20% TEA in Water Between 2013 and 2015	National bias-adjustment factor applied to HE diffusion tubes, these were: 2013 (0.87). 2014 (0.83), 2015 (0.84).	For 2013, data were only available for period August 2013 to January 2014. For 2015, data were available from February 2015 to 2016, due to anomalous data in January 2015. Data have been annualised for all three years using factors of 0.95 (2013), 1.06 (2014) and 1.01 (2015) based on Nottingham Centre, Stoke-on-Trent Centre and Birmingham Tyburn.

Study Area	Monitors Operated by	Are the tubes consistent year on year?	How do diffusion tube results compare with those from the automatic monitors?	What lab and lab method was used for the DT analysis, is it consistent for all tubes?	What bias adjustment factor was used, local/national? Was the same factor used for all tubes? Is the factor appropriate? If a local factor was used how was it determined?	Are there any significant periods of missing data, was any annualisation carried out?
Uttoxeter New Road/A5111	DCC	Ten sites have six years' consecutive data between 2010 and 2015. Monitored values are lower across all sites in 2011 and 2012 due to lower bias adjustment factors. Concnetration increase in 2013 for all sites, and decrease to 2015. However, despite this variability, the overall trend from 2010 to 2015 shows no improvement.	Only one automatic monitor within the study are, the Warwick Avenue CMS, operated from before 2010 to 2014. However, from 2010 the data "became increasingly unreliable" due to financial issues with the maintenance company. In 2014 automatic monitoring was discontinued (DCC USA, 2016).	Between 2010 and 2013, tubes were provided/analysed by Casella CRE Air with 10% TEA in Water. From 2013, Environmental Scientific Group (ESG) Ltd. provided some tubes with 50% TEA Acetone.	No clear information other than bias-adjustment being based on local co-location studies at the Warwick Avenue CMS between 2010 and 2012. From 2013 National Bias Adjustment Factors were used. Local Factors applied*: 2010 (0.80), 2011 (0.70), 2012 (0.60), National Factors Applied: 2013 (0.81), 2014 (0.81), 2015 (0.79). *No national bias adjustment factor available for Casella CRE Air between 2010 and 2013.	DC was 75% or greater at all tubes in all years between 2010 and 2015.
	HE	Out of 12 sites, six have three years of data between 2013 and 2015, and six have only one year in 2015 due to poor data capture. There is no discernible trend from the data.		Staffordshire Scientific Services 20% TEA in Water Between 2013 and 2015	National bias-adjustment factor applied to HE diffusion tubes, these were: 2013 (0.87). 2014 (0.83), 2015 (0.84).	For 2013, data were only available for period August 2013 to January 2014. For 2015, data were available from February 2015 to 2016, due to anomalous data in January 2015. Data have been annualised for all three years using factors of 0.95 (2013), 1.06 (2014) and 1.01 (2015) based on Nottingham Centre, Stoke-on-Trent Centre and Birmingham Tyburn.

Appendix 4 - Air quality monitoring data

PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Luke Farrugia

This appendix provides an overview of the available monitoring data in Derby between 2010 and 2015, which included both automatic and diffusion tube monitoring locations. After the summaries of data availability, the discussions are separated out into those measurements made in each focus area (as described in **Appendix 1**), and those made outside of the focus areas.

The key discussions in this appendix are those regarding the monitored concentrations of nitrogen dioxide (NO_2) between 2010 and 2015 in each focus area. These data highlight "hotspot" locations that exceeded the annual mean NO_2 objective (40 $\mu g/m^3$), which ultimately led to further analyses of 2015 monitoring data for normalisation in **Appendix 5** and source apportionment in **Appendix 6**.

Quality assurance methods, including the annualisation, bias adjustment and the monitoring site sifting process, are described in **Appendix 3**.

Continuous Monitoring data

Continuous Monitoring Station (CMS) data were limited for the A38 Derby study area. DCC operated a series of automatic monitors for many years until to 2014. DCC noted in its latest Updating and Screening Assessment (2016) that from 2010 the automatic monitoring data became increasingly unreliable due to financial issues relating to the maintenance company. No reliable data were therefore captured from 2013, and eventually in 2014 DCC decided to discontinue all CMS sites. **Table 1** presents a summary of the available data from the DCC automatic monitoring sites.

Table 1: Annual mean NO_2 concentrations from Automatic Monitoring sites operated by Derby City Council between 2010 and 2014.

Site	X	Y	Site Type	Annual Mean NO_2 Concentrations ($\mu g/m^3$)			
				2010	2011	2012	2013
Warwick Avenue	334531	433678	Kerbside	**51.0**	**41.0**	39.0	38.0
Abbey Street	335294	434838	Roadside	**51.0**	**42.0**	**44.0**	-
Council House	336252	435472	Urban Background	30.0	-	-	-

No CMS sites were available within the study area as part of Defra's Automatic Urban and Rural Network (AURN). In January 2017, Defra installed an Urban Traffic CMS site off St. Alkmund's Way, to the east of Derby City Centre. This has so far not yielded sufficient data to be considered in this study.

NO_2 Diffusion Tube Monitoring

Derby City Council (DCC) conducted NO_2 diffusion tube monitoring between 2010 and 2015 in accordance with local air quality management (LAQM) procedures. The results are reported in the DCC 2016 Updating and Screening Assessment (DCC USA, 2016). Highways England (HE) implemented a diffusion tube air quality monitoring survey in August 2013 through to February 2016 as part of the Derby Junctions scheme. Results were collated by AECOM and included in the Derby

Junctions Environmental Assessment Report (September 2016). Construction works around the Markeaton Junction and Little Eaton carried over from late 2014 into early 2015, thus affecting monitored values. Therefore, the 2015 monitored concentrations from the HE survey are over the period from February 2015 to February 2016 in order to capture an entire year of monitoring. **Table 2** presents a summary of the air quality monitoring surveys in Derby, and the data availability for each year between 2010 and 2015.

Table 2: Derby Monitoring Surveys Summary

Monitoring Program	Year	Date Commissioned	Date De-commissioned
Derby City Council (LAQM)	2010-2015	January 2010	December 2015
HE Derby Junctions	2013-2016	August 2013	February 2016

The annualisation and bias adjustment methods applied to these diffusion tube data are described in more detail in **Appendix 3**.

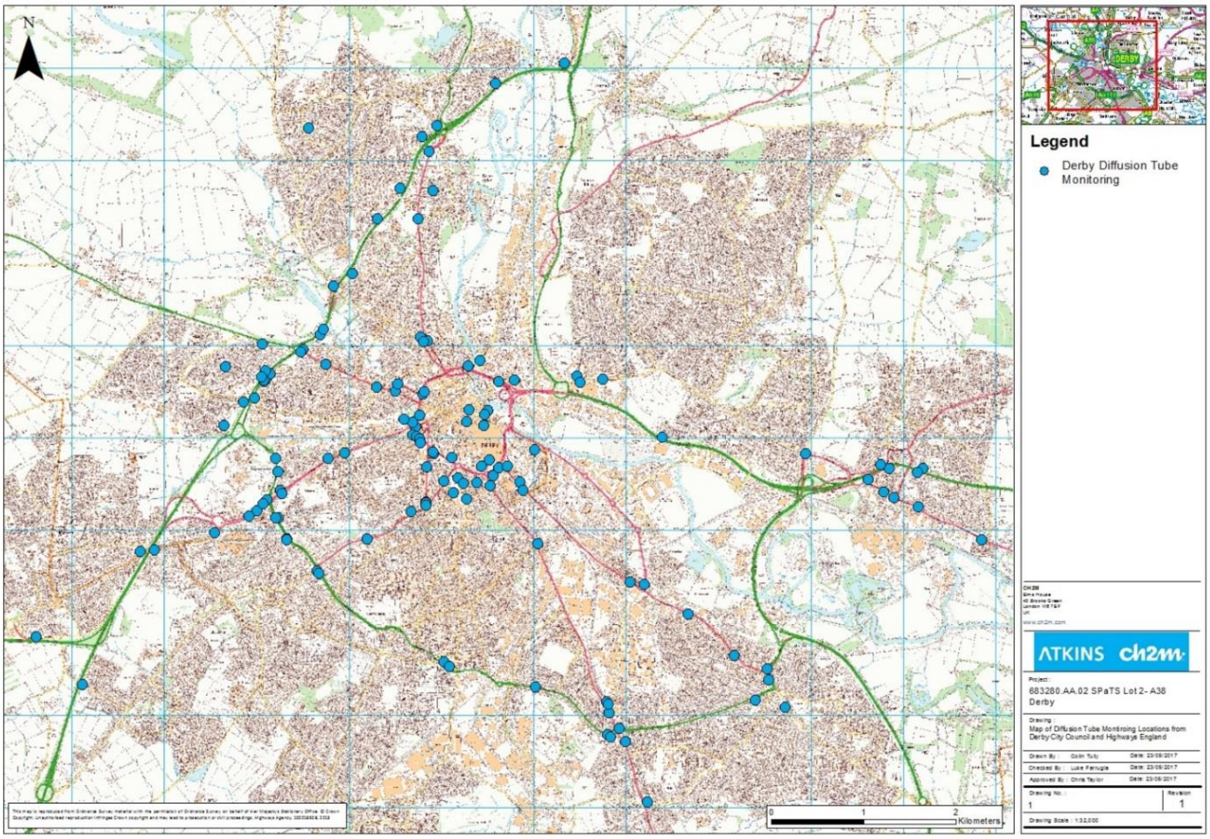


Figure 1: Spatial coverage of diffusion tube monitoring in Derby, included in either Derby City Council or Highways England surveys between 2010 and 2015.

Figure 1 shows a map of all diffusion tube monitoring sites in Derby between 2010 and 2015. There was wide coverage of monitoring across Derby in these years, comprising roadside and background sites. The sifting process to distinguish between roadside and background sites, and sites for exclusion, is detailed in **Appendix 3**. The discussions, hereafter, are split between the focus areas described in **Appendix 1**; they cover observations and long-term monitoring trends. Maps showing the monitoring data within the focus areas between 2010 and 2015 are shown below as well.

A38 Main Carriageway Focus Area

Table 3 summarises the monitoring data available along the A38 between 2010 and 2015. The majority of sites were included in the HE Derby Junctions monitoring program, so data are available from 2013 onwards. Data from only two DCC sites are available between 2010 and 2013; these were located east of the A38 Kingsway. **Figure 2**, **Figure 3**, and **Figure 4** display maps of the monitoring data between 2010 and 2015 for the A38-A516 corridor, the A38 Kingsway and the A38 Queensway respectively.

Table 3: Summary of all diffusion tube monitoring data from Derby City Council and Highways England surveys in the A38 focus areas

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 ($\mu g/m^3$)					
					2010	2011	2012	2013	2014	2015
A38-A516 Corridor										
DJ_003_0813	HE	431893	334784	Roadside	NA	NA	NA	39.1	**40.7**	**41.4**
DJ_004_0813	HE	431746	334771	Background	NA	NA	NA	26.5	26.4	25.0
DJ_008_0813	HE	432654	336133	Background	NA	NA	NA	22.5	25.9	22.1
A38 Kingsway										
38	DCC	433118	336650	Roadside	32.9	24.3	25.1	31.7	29.5	27.3
39	DCC	433082	336608	Roadside	32.9	21.1	21.5	32.3	31.5	27.3
DJ_009_0813	HE	432860	336388	Background	NA	NA	NA	NA	31.5	27.1
DJ_010_0813	HE	432982	336432	Roadside	NA	NA	NA	37.2	34.3	35.5
DJ_011_0813	HE	433146	336695	Roadside	NA	NA	NA	36.9	37.8	38.6
DJ_012_0813	HE	433098	336723	Roadside	NA	NA	NA	32.1	35.0	30.4
DJ_030_0813	HE	433080	336623	Roadside	NA	NA	NA	38.1	38.9	39.9
DJ_032_0813	HE	433061	336657	Roadside	NA	NA	NA	**47.0**	**50.8**	**45.1**
A38 Queensway										
DJ_016_0813	HE	433689	337118	Roadside	NA	NA	NA	37.5	36.3	37.7
DJ_017_0813	HE	433832	337642	Background	NA	NA	NA	30.4	31.0	31.4
DJ_018_0813	HE	434039	337777	Background	NA	NA	NA	26.4	23.6	24.2
DJ_029_0813	HE	433723	337173	Roadside	NA	NA	NA	**59.5**	**53.4**	**54.4**

Figure 2 presents a map of the 2010 to 2015 monitoring for the A38-A516 corridor. Monitored NO_2 concentrations in 2014 and 2015 exceeded the annual mean objective (40 $\mu g/m^3$) at site DJ_003 on Uttoxeter Road (B5020). The 2013 monitored was slightly below the objective value. A measured annual mean concentration of 41.4 $\mu g/m^3$ was recorded in 2015. The monitor is located approximately 20 m from the nearest site of relevant exposure, and within 4 m of the kerb of the B5020. The main sources of NO_2 within closest proximity to the monitor are the A38 (about 30 m), and the B5020. The site has been included in the normalisation and source apportionment analyses described in **Appendix 5** and **Appendix 6** as site R4.

The other monitoring sites within the focus area, DJ_004, off Uttoxeter Road on the west side of the A38, and DJ_008, west of the Kingsway junction, were both consistently below the annual mean NO_2 objective, measuring between 25 and 30 $\mu g/m^3$ during 2013 to 2015.

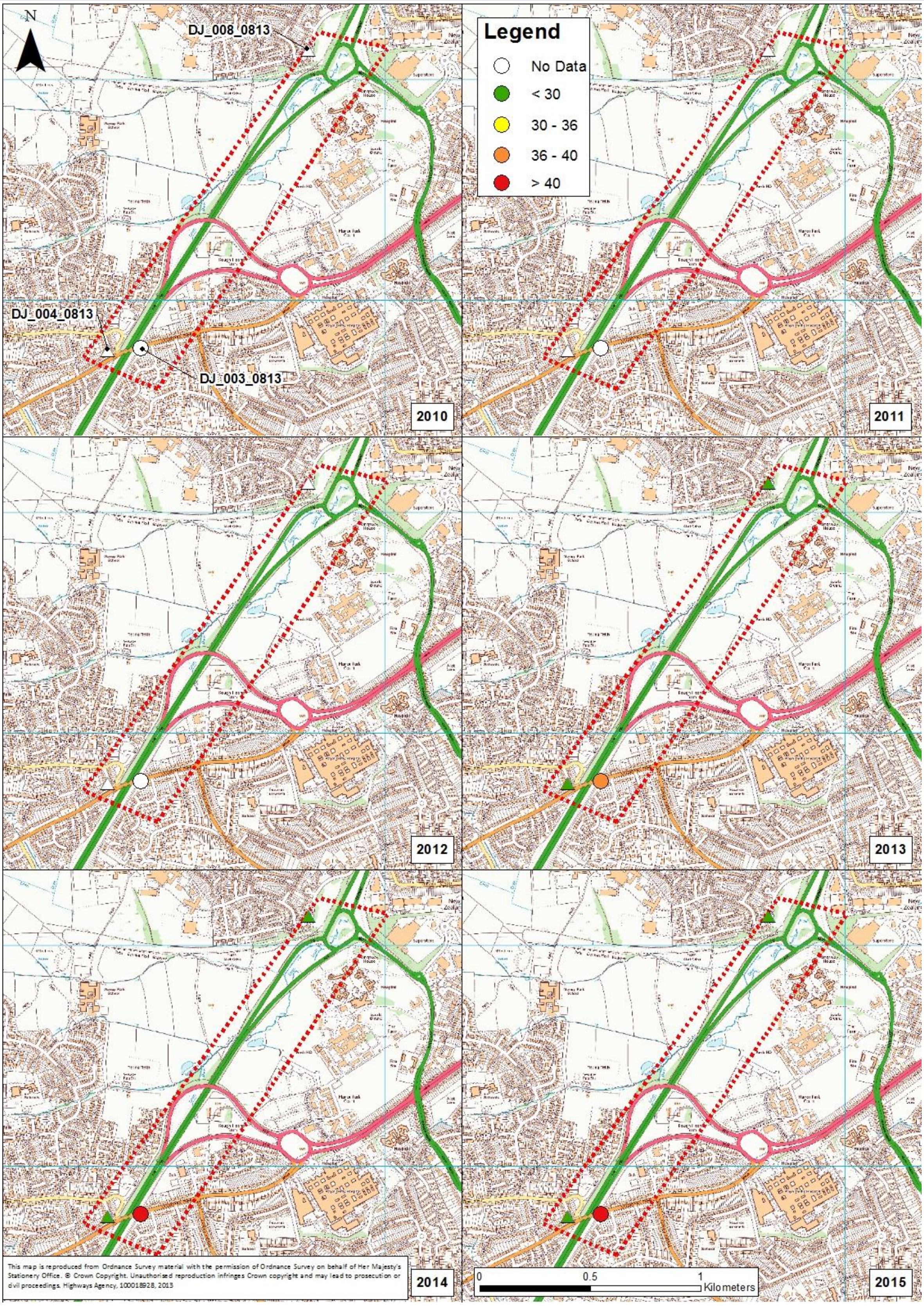


Figure 2: 2010 to 2015 Monitoring sites within the A38-A516 Corridor focus area.

Figure 3 presents a map of the 2010 to 2015 monitoring for the A38 Kingsway. Only one site monitored concentrations that exceeded the NO_2 objective (40 µg/m^3) consistently between 2013 and 2015. The site, DJ_032, is located on a signpost approximately 2 m from the northbound A38 Kingsway carriageway; it is included in the normalisation and source apportionment analyses as Site R9 (see **Appendices 5** and **6**). The maximum concertation was recorded in 2014 at 50.8 µg/m^3. As described in the Derby Junction EAR, roadworks on the A38 may have influenced this value by increasing emissions as a result of congestion.

Other sites that are set further back from the A38 did not exceed the NO_2 objective in any year. Two sites, DJ_030 and DJ_011, are at similar distances from the A38 kerb (14.8 and 17.4 m respectively) and measured values between 36 and 40 µg/m^3. Similarly, DCC Sites 38 and 39 are about 23 m from the A38 and measured values for both sites were between 27 and 33 µg/m^3 between 2010 to 2015.

Figure 3: 2010 to 2015 monitoring sites in the A38 Kingsway Focus area

Figure 4 presents a map of the 2010 to 2015 monitoring for the A38 Queensway. There are four sites that are included in the focus area; two are roadside and two are background.

Of the two roadside sites, site DJ_029 was the only monitor to measure annual mean concentrations above the objective (40 µg/m^3) between 2013 and 2015; this site is included in the normalisation and source apportionment analyses as Site R8 (**Appendices 5** and **6** respectively). The maximum concentration, recorded in 2013, was 59.5 µg/m^3. The site is located on a lamppost within 2 m of the southbound A38 Queensway carriageway. It is not located in an area of relevant exposure.

Site DJ_016, further south from DJ_029, is located on a lamppost approximately 10 m in front of a site of relevant exposure. It is set back from the southbound A38 carriageway by about 11 m. Concentrations recorded at the site were consistently between 36 and 38 µg/m^3 from 2013 to 2015.

The two background sites towards the northern extents of the focus area are located near sites of relevant exposure, in residential areas. DJ_018 recorded concentrations below 30 µg/m^3 between 2013 and 2015. The other site, DJ_017, is located on a lamppost at the end of Kedleston Old Road. It recorded concentrations around 31 µg/m^3 between 2013 and 2015. The site is located near a house that is within 10 m of the northbound A38 carriageway. Due to its proximity, this property may be subject to exceedances of the NO_2 annual mean AQS objective. This was highlighted in the Derby Junctions EAR, which revealed that in the base year (2015) concentrations at the property exceeded the objective. However, in the opening year (2024) in both with and without the scheme scenarios, the concentration at the property was predicted to be below the objective.

Figure 5 presents the long-term trends in measured NO_2 concentrations in all A38 sections. Measured values in 2011 and 2012 are lower than other years due to the bias adjustment factor used by DCC (see **Appendix 3** for further details). Therefore these concentration values should be treated with caution. With the addition of HE monitors in 2013, the trend still indicates very little change overall.

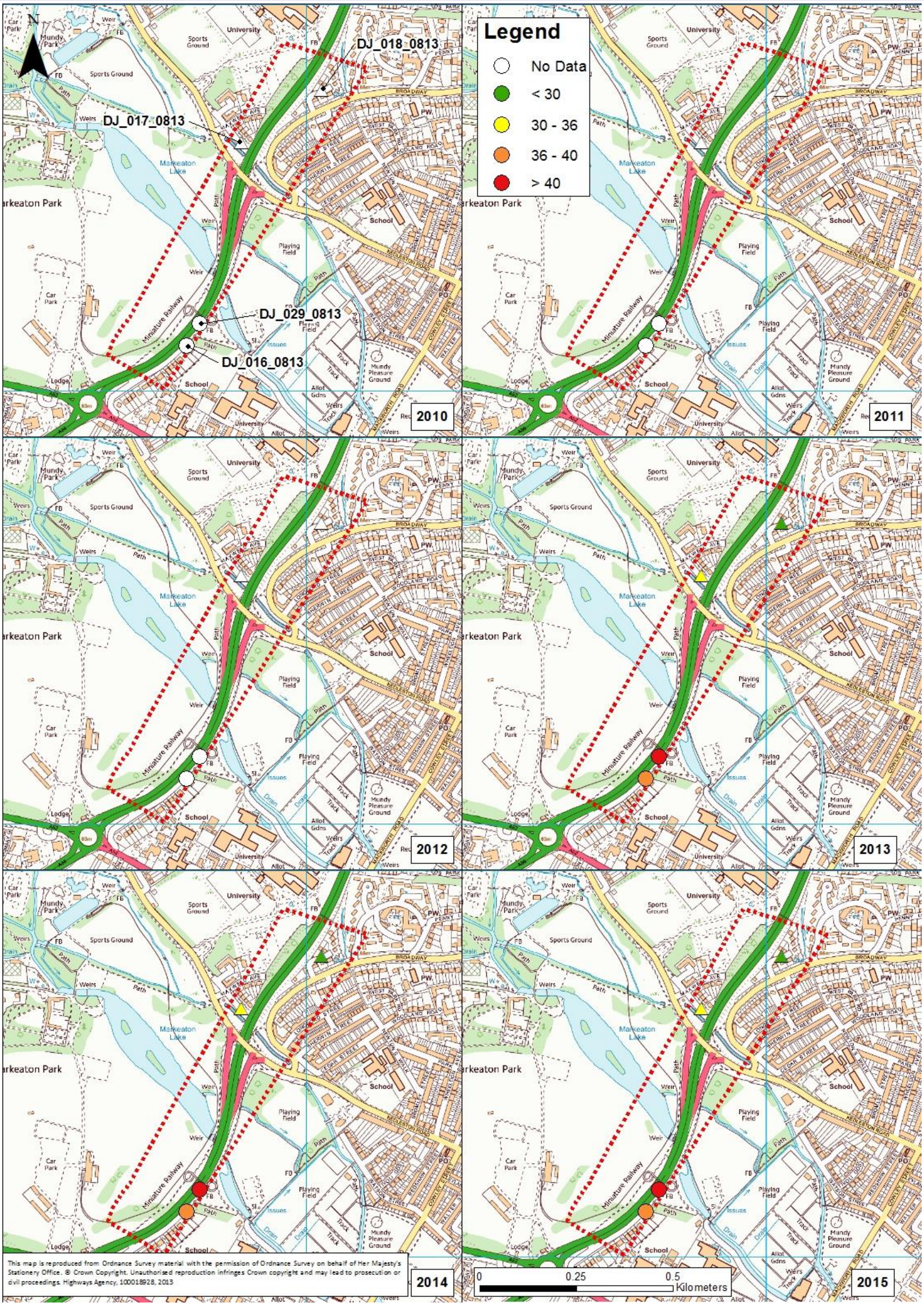


Figure 4: 2010 to 2015 monitoring sites within the A38 Queensway focus area

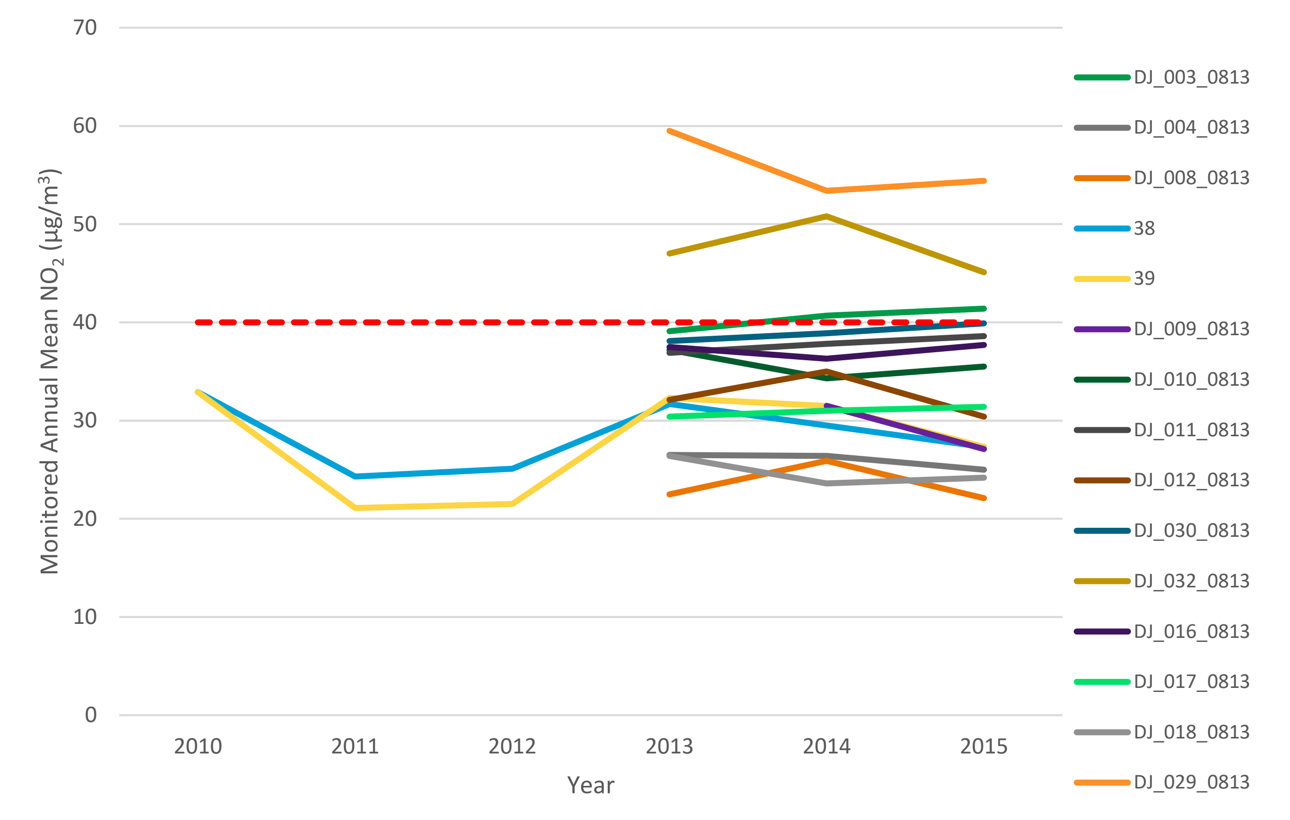


Figure 5: 2010 to 2015 long-term measured trends for A38 monitoring sites.

A52 Corridor

Table 4 summarises the monitoring data available in the A52 focus area. Between 2010 and 2012 only DCC monitoring data were available. In 2013, three HE sites were added. However, one site (DJ_013) on the north side of the A52 near the Markeaton junction was excluded from the 2013 discussion due to poor data capture. **Figure 6** displays maps of the monitoring data between 2010 and 2015 for the A52 focus area.

Table 4: Summary of all diffusion tube monitoring data from Derby City Council and Highways England surveys in the A52 focus area.

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 (µg/m^3)					
					2010	2011	2012	2013	2014	2015
78	DCC	434299	336544	Roadside	39.3	31.1	26.5	38.3	38.7	37.1
79	DCC	433754	336793	Roadside	35.1	23.3	17.6	32.7	29.4	31.2
80	DCC	434468	336512	Roadside	**43.2**	29.8	25.8	**41.7**	35.2	35.1
81	DCC	434530	336577	Roadside	37.8	20.2	26.1	32.9	31.6	33.2
DJ_013_0813	HE	433506	336955	Roadside	NA	NA	NA	NA	38.4	39.7
DJ_014_0813	HE	433481	336929	Roadside	NA	NA	NA	**48.2**	**57.7**	**51.9**
DJ_015_0813	HE	433066	337011	Background	NA	NA	NA	25.9	27.1	23.4

The NO_2 annual mean objective (40 µg/m^3) was exceeded at two sites along the A52: at DJ_014 every year from when it was installed in 2013, and DCC 80 in 2010 and 2013. The maximum concentrations at these sites were recorded in 2014 at 57.7 µg/m^3 and in 2010 at 43.2 µg/m^3, respectively. DJ_014 is adjacent to westbound A52 traffic as it approaches the Markeaton junction, which is subject to queuing as it yields to enter the roundabout.

DCC 80 is located on a lamppost near the signal for Friar Gate and Bridge street. Queuing emissions are also likely to have contributed to higher concentrations at this site.

DJ_013, is approximately 17m north east (downwind of the prevailing wind direction) of the Markeaton junction roundabout and consistently recorded concentrations above 38 µg/m³.

Concentrations at DCC 78 were between 37 and 39 µg/m³ from 2013 to 2015; the maximum concentration, 38.7 µg/m³, was recorded in 2014. Monitored values at DJ_014 consistently exceeded the NO_2 objective between 2013 and 2015. Sites DCC 78 and DJ_014 are included in the normalisation and source apportionment analyses (see **Appendix 5** and **Appendix 6**) as R3 and R7 respectively.

Two other sites along the A52 did not show exceedances between 2012 and 2015. DCC 79 was consistently around 30 µg/m³ and DCC 81 was between 31 and 34 µg/m³.

Figure 7 presents the long-term trends of the individual monitoring sites within the A52 focus area. Lower values in 2012 are thought to be due to the low bias adjustment factor used on the data (see **Appendix 3**) and should be treated with caution. Overall, the trend in the data shows very little change between 2010 and 2015.

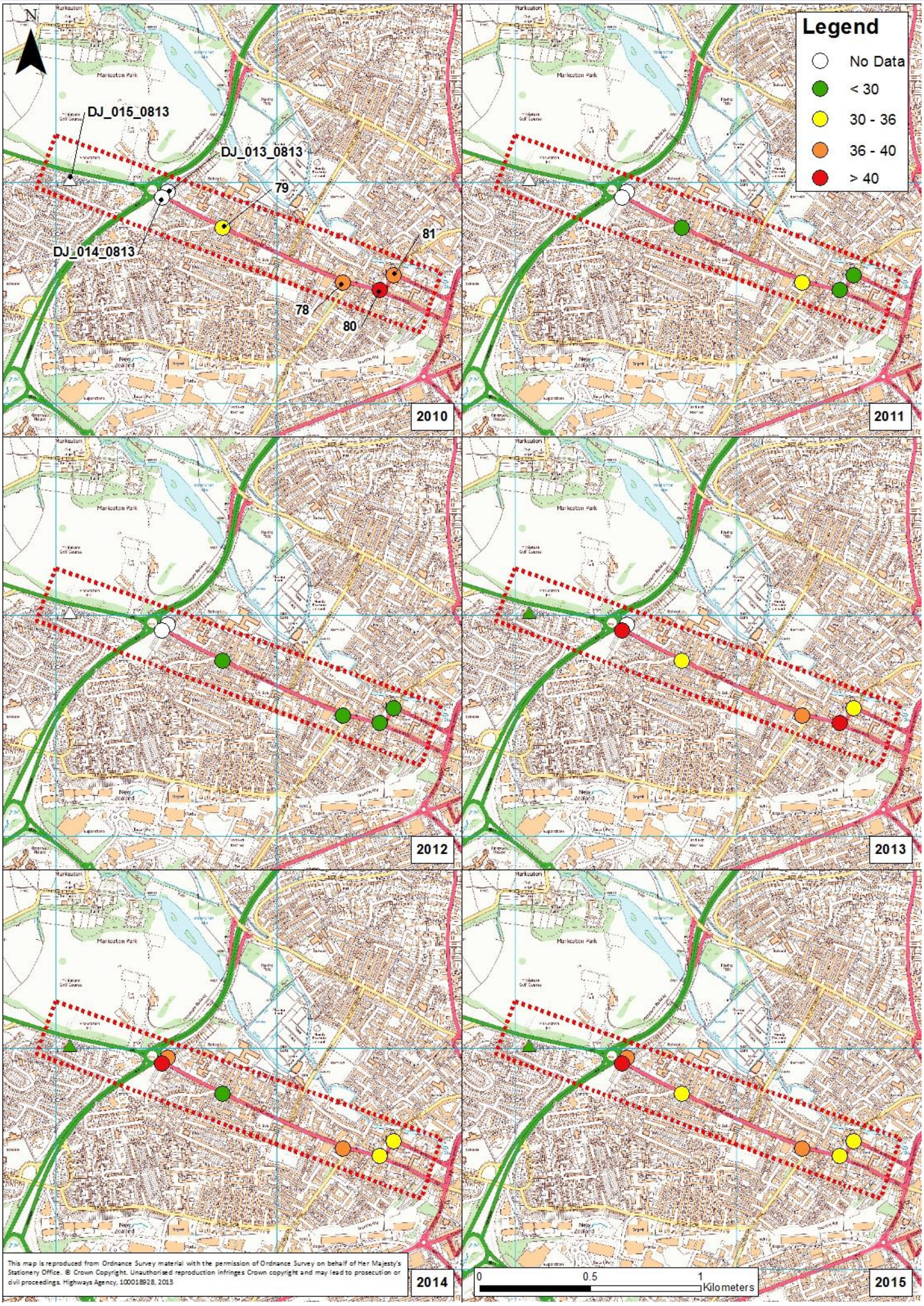


Figure 6: 2010 to 2015 monitoring sties within the A52 Focus area

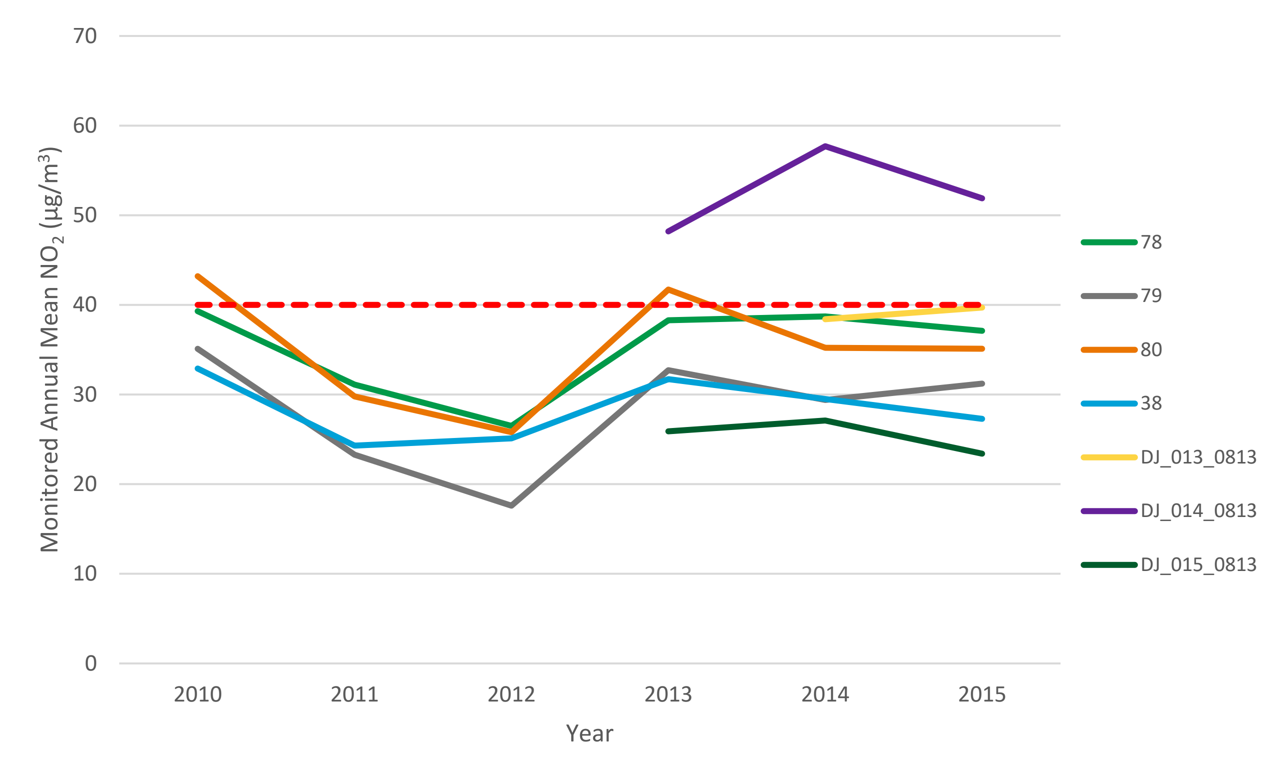


Figure 7: 2010 to 2015 long-term monitoring trends within the A52 Focus area

Uttoxeter New Road and Kingsway/Manor Road (A5111)

Table 5 summarises the monitoring data available within the Uttoxeter New Road/A5111 focus area between 2010 and 2015. Six years of monitoring data are available, however before 2013, only DCC monitoring data are available. In 2013, HE added six more diffusion tubes in the area, three of which were included as a triplicate colocation with the Warwick Avenue CMS, namely HE DJ_033A, B and C, and DCC 30, 31 and 32. Automatic monitoring at the Warwick Avenue CMS ended in 2014 for financial reasons in addition to unreliable data collection. Additional HE monitoring sites were commissioned in 2014, but are not included in the discussion for that year due to poor data capture. 2015 has the widest spatial coverage of monitoring for the Uttoxeter New Road/A5111 focus area, with both DCC and HE survey data available. **Figure 8** display maps of the monitoring data between 2010 and 2015 for the Uttoxeter New Road/A5111 focus area.

Table 5: Summary of all diffusion tube monitoring data from Derby City Council and Highways England surveys in the Uttoxeter New Road/A5111 focus area.

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 (µg/m^3)					
					2010	2011	2012	2013	2014	2015
29	DCC	433658	334559	Roadside	**58.8**	**53.8**	**46.7**	**57.5**	**55.5**	**51.7**
30	DCC	433678	334531	Roadside	**47.4**	39.2	38.4	**49.1**	**48.3**	**45.8**
31	DCC	433678	334531	Roadside	**47.7**	**40.6**	**40.3**	**49.0**	**46.4**	**42.9**
32	DCC	433678	334531	Roadside	**49.0**	39.3	37.4	**47.4**	**46.5**	**41.9**
33	DCC	433324	334901	Roadside	30.2	26.8	24.3	33.8	32.8	27.3
34	DCC	433238	335135	Background	33.0	29.3	26.7	32.2	30.1	28.3
35	DCC	433004	335210	Roadside	**62.5**	**53.5**	**50.3**	**66.6**	**62.5**	**57.5**
36	DCC	433264	335428	Roadside	27.1	27.3	23.0	29.0	29.9	28.3
37	DCC	433779	335775	Roadside	35.2	28.1	26.6	**42.6**	**43.1**	38.0
40	DCC	433957	335833	Roadside	33.3	31.9	32.7	**42.9**	**42.8**	38.0
DJ_005_0813	HE	432545	334974	Roadside	NA	NA	NA	34.3	33.1	30.0

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 ($\mu g/m^3$)					
					2010	2011	2012	2013	2014	2015
DJ_006_0813	HE	433118	335328	Roadside	NA	NA	NA	**42.3**	**45.3**	**42.6**
DJ_007_0813	HE	433209	335777	Roadside	NA	NA	NA	**44.1**	**46.5**	**43.0**
DJ_33A_0813	HE	433678	334531	Roadside	NA	NA	NA	**47.2**	**51.5**	**50.0**
DJ_33B_0913	HE	433678	334531	Roadside	NA	NA	NA	**49.6**	**53.1**	**50.0**
DJ_33C_0913	HE	433678	334531	Roadside	NA	NA	NA	**49.2**	**51.1**	**50.0**
DJ_034_0813	HE	433274	335400	Roadside	NA	NA	NA	NA	NA	33.6
DJ_035_0813	HE	433207	335134	Roadside	NA	NA	NA	NA	NA	33.6
DJ_036_0813	HE	433326	334899	Roadside	NA	NA	NA	NA	NA	29.5
DJ_037_0813	HE	432923	335147	Roadside	NA	NA	NA	NA	NA	**51.4**
DJ_038_0813	HE	433070	335288	Roadside	NA	NA	NA	NA	NA	39.4
DJ_039_0813	HE	433239	335633	Roadside	NA	NA	NA	NA	NA	27.6

Four monitoring sites in this focus area have been included in the normalisation and source apportionment analyses (**Appendices 5** and **6**), including:

- DCC 29: Warwick Avenue (Site R1)
- DCC 40: 179 Uttoxeter New Road (Site R2)
- DJ_006: northwest corner of Uttoxeter New Road and the A5111 Kingsway (Site R5)
- DJ_007: A5111 Kingsway (Site R6)

The monitoring data highlights some key “hotspot” areas of NO_2 objective exceedances. Namely, the A5111 (Warwick Avenue) near the signal for Burton Road, and Uttoxeter New Road between the Royal Derby Hospital and the A5111.

The Warwick Avenue sites were adjacent to northbound traffic on the approach to the signal with Burton Road, where local conditions may increase emissions from road traffic. For example, the road slopes uphill at this point and traffic is subject to queuing at the signal, which was confirmed in past Google Street View imagery. Concentrations at most sites near Warwick Avenue were above 45 $\mu g/m^3$ between 2013 and 2015.

Similarly, monitoring sites in the “hotspot” section of Uttoxeter New Road are located near roads that may be subject to queuing, thus increasing road traffic emissions in this area. DJ_006 and DJ_038 are located alongside eastbound traffic on the approach to the signal for the A5111, with DJ_006 on the corner. DJ_037 is located alongside westbound traffic on the approach to the Royal Derby Hospital entrances. DCC site 35 is located downwind from a bus stop on the westbound traffic side of the Uttoxeter New Road. Concentrations are likely to be influenced by idling and accelerating bus emissions, as values between 2013 and 2015 were around 60 $\mu g/m^3$. Only one year of data for 2015 are available for DJ_037 and DJ_038, so trends for both sites cannot be determined; however, DJ_037 showed an exceedance in 2015. DJ_006 consistently exceeded the NO_2 objective between 2013 and 2015; the maximum concentration (45.3 $\mu g/m^3$) was recorded in 2014.

Another area with high concentrations was Uttoxeter New Road near the intersection with Uttoxeter Old Road, closer to Derby City Centre. The two monitoring sites (DCC 37 and 40) showed exceedance of the NO_2 objective in 2013 and 2014, but dropped to 38.0 $\mu g/m^3$ in 2015.

DJ_007 on the A5111 Kingsway recorded exceedances between 2013 and 2015. The likely cause is queuing during peak periods. Traffic along the route was affected in 2015 with the construction of a new roundabout alignment for the Kingsway Retail Park and Kingsway Manor development, which may have compounded the queuing effect.

Other sites in the focus area did not show exceedances in any year, as they are located near suspected free flow sections of roads. One site of particular interest is DJ_005, located on Uttoxeter Road directly across from Royal Derby Hospital. Though the site is not exceeding, concentrations may have been affected by emissions from the stacks on the hospital grounds, in addition to traffic queuing for the larger hospital roundabout. The site is also located next to a bus stop, so emissions from accelerating buses may have had some affect as well.

Figure 9 presents the long-term trends of the individual monitoring sites in the Uttoxeter New Road/A5111 focus area. Like the other focus areas, there is a decrease in measured values in 2012, thought to be due to the bias adjustment factor used by DCC (see **Appendix 3**). Even with the addition of sites in 2013 by HE the overall trends across the area show very little change. This is consistent across the Derby focus areas.

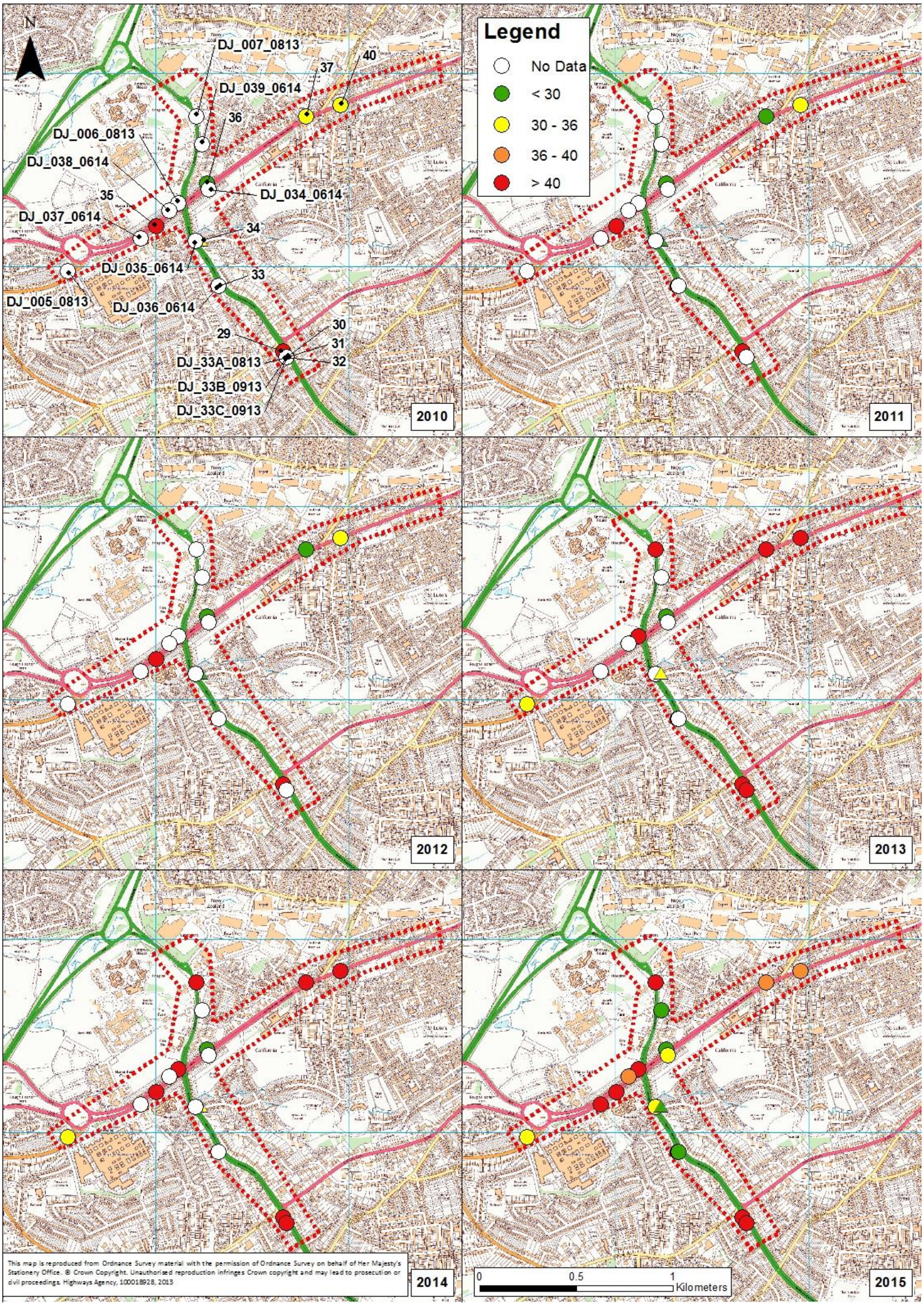


Figure 8: 2010 to 2015 monitoring sites within the Uttoxeter New Road/A5111 Focus Area

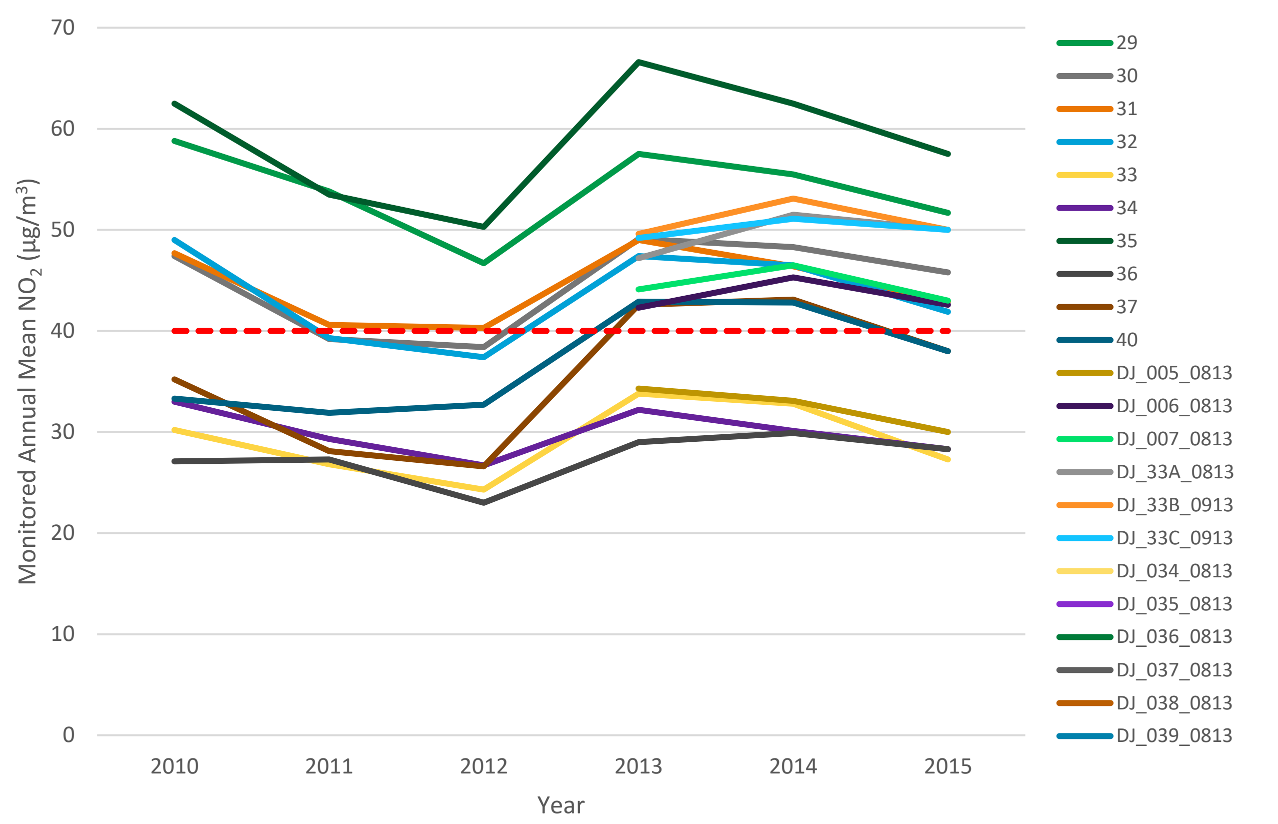


Figure 9: 2010 to 2015 long-term monitoring trends for the Uttoxeter New Road/A5111 Focus Area

Other Derby Monitoring

Table 6 summarises all Derby monitoring data outside one of the pilot study focus areas between 2010 and 2015.

Table 6: Summary of all diffusion tube monitoring data from Derby City Council and Highways England surveys outside the pilot study focus areas.

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 (µg/m³)					
					2010	2011	2012	2013	2014	2015
13	DCC	438542	333382	Roadside	34.5	27.9	23.3	34.3	33.2	30.2
15	DCC	438397	333159	Roadside	26.5	17.0	NA	NA	NA	NA
14	DCC	433238	335135	Background	33.0	29.3	26.7	32.2	30.1	28.3
48	DCC	433118	336650	Roadside	32.9	24.3	25.1	31.7	29.5	27.3
77	DCC	434799	336475	Background	28.6	24.9	18.0	27.0	27.1	26.3
76	DCC	435289	336772	Roadside	34.5	29.2	24.6	34.9	33.1	31.2
74	DCC	435622	336610	Roadside	34.9	24.8	23.0	34.9	32.5	33.2
53	DCC	435181	335566	Roadside	**46.1**	35.8	31.3	**47.8**	35.9	**41.0**
54	DCC	435241	335505	Background	32.2	19.7	22.9	29.7	28.1	27.3
63	DCC	435561	335591	Background	**40.1**	31.0	30.4	37.0	38.5	37.1
62	DCC	435622	335677	Roadside	**40.9**	34.1	26.8	**42.1**	**40.2**	38.0
73	DCC	435792	336625	Roadside	36.9	28.7	29.2	37.7	34.4	32.2
22	DCC	436813	333022	Roadside	**43.8**	37.1	31.4	**42.3**	**43.8**	**41.9**
25	DCC	436998	332707	Roadside	28.1	23.6	22.0	27.6	26.6	25.4
23	DCC	436801	332791	Roadside	32.2	21.8	23.8	30.7	28.5	27.3
24	DCC	436838	332766	Roadside	32.3	26.8	25.5	35.7	31.8	27.3

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 (µg/m^3)					
					2010	2011	2012	2013	2014	2015
26	DCC	436926	332853	Roadside	33.5	19.8	18.4	35.5	35.4	37.1
47	DCC	434832	335299	Roadside	**44.5**	31.8	29.6	37.1	37.5	34.1
51	DCC	435033	335532	Roadside	**41.4**	30.8	22.6	33.8	29.6	31.2
57	DCC	435131	335407	Background	38.1	21.8	17.5	23.3	23.7	21.5
56	DCC	435278	335333	Background	38.2	28.9	25.7	36.2	34.5	31.2
60	DCC	435438	335689	Background	39.7	29.8	28.2	34.8	33.0	30.2
64	DCC	435849	335524	Roadside	30.8	23.7	21.4	26.1	24.5	25.4
65	DCC	435720	335689	Background	39.0	22.6	25.4	29.6	27.3	27.3
67	DCC	436015	335873	Background	31.3	23.8	16.9	28.7	27.1	26.3
71	DCC	435462	336131	Background	**47.7**	30.1	24.2	39.6	37.0	37.1
28	DCC	435028	333578	Roadside	**47.8**	**42.3**	35.0	**49.6**	**47.2**	**48.8**
46	DCC	434677	335198	Roadside	35.6	29.1	26.6	33.6	33.2	31.2
61	DCC	435524	335763	Background	**46.6**	**44.0**	33.7	**52.9**	**53.6**	**45.8**
82	DCC	434812	337067	Roadside	**40.9**	30.8	20.6	37.8	38.3	35.1
4	DCC	439846	335667	Roadside	**40.2**	33.7	32.7	36.6	37.8	35.1
8	DCC	438944	335825	Roadside	34.0	30.9	29.3	36.6	34.0	34.1
9	DCC	437397	336008	Roadside	27.9	28.1	24.4	29.4	30.1	28.3
11	DCC	436467	336670	Background	25.9	25.0	21.0	26.0	25.2	23.4
14	DCC	438725	333085	Façade	23.2	18.8	NA	NA	NA	NA
27	DCC	437233	332056	Background	32.3	29.8	26.3	34.1	33.3	34.1
21	DCC	436792	333142	Background	35.0	25.9	28.8	39.4	37.8	31.2
20	DCC	436809	333118	Background	33.2	27.6	25.8	33.2	30.1	28.3
45	DCC	434204	334906	Roadside	32.1	23.5	19.7	27.0	26.4	27.3
86	DCC	434820	336501	Roadside	**43.2**	24.8	33.2	**43.4**	**43.4**	**41.9**
59	DCC	435529	335483	Roadside	**52.6**	**46.8**	34.9	**45.5**	**46.2**	**45.8**
72	DCC	435276	336172	Background	30.3	25.7	21.3	28.9	27.9	26.3
12	DCC	438526	333495	Roadside	36.0	29.6	28.4	36.8	35.2	30.2
6	DCC	439794	335415	Roadside	36.6	23.4	24.6	37.1	29.5	26.3
16	DCC	438171	333641	Roadside	37.4	31.2	29.3	35.1	35.4	35.1
17	DCC	437671	334092	Roadside	**43.3**	**41.4**	33.3	**48.7**	**47.3**	**47.8**
43	DCC	434922	335824	Background	23.0	19.4	18.1	22.6	23.0	19.5
48	DCC	434838	335294	Façade	**43.2**	35.9	27.0	NA	NA	NA
52	DCC	435117	335787	Background	26.8	23.0	17.5	26.1	24.6	30.2
83	DCC	434776	337086	Background	34.0	28.7	25.7	34.3	34.1	30.2
84	DCC	434854	337045	Roadside	32.7	29.1	26.1	36.3	33.6	34.1
85	DCC	434813	337042	Background	27.6	21.1	19.8	27.9	22.3	17.6
5	DCC	439617	335545	Roadside	28.9	24.6	25.6	30.8	29.3	27.3
1	DCC	439760	335708	Background	27.7	16.8	19.3	29.5	27.4	29.3
2	DCC	440210	335668	Background	27.9	24.5	17.3	29.2	28.6	27.3
3	DCC	440151	335626	Background	26.6	22.3	21.7	27.8	24.9	24.4
7	DCC	439896	335350	Roadside	**41.2**	34.6	28.3	38.0	39.0	35.1
18	DCC	437195	334409	Roadside	32.8	29.7	26.8	32.0	30.0	29.3
19	DCC	437048	334438	Roadside	30.0	23.0	23.1	26.5	22.6	22.4
44	DCC	434847	335688	Roadside	**44.6**	20.0	25.1	34.2	29.7	29.3
58	DCC	436046	334856	Roadside	34.1	29.6	25.1	35.3	33.4	31.2

Site ID	Source	X	Y	Site Type	Monitored Annual Mean NO_2 (µg/m^3)					
					2010	2011	2012	2013	2014	2015
66	DCC	435884	335430	Roadside	34.9	26.4	23.0	30.6	27.0	25.4
75	DCC	435421	336832	Background	35.7	30.0	27.3	33.4	31.2	29.3
41	DCC	434728	336120	Background	25.7	19.0	18.8	29.4	26.1	24.4
88	DCC	433565	339348	Background	14.5	11.8	11.5	14.9	13.3	10.7
89	DCC	440163	335248	Roadside	25.8	24.0	23.5	26.9	25.9	27.3
90	DCC	440850	334897	Roadside	24.6	20.8	20.0	22.7	19.7	19.5
42	DCC	434693	336163	Roadside	27.0	31.3	30.2	**40.6**	**44.2**	39.0
55	DCC	435384	335517	Background	**40.4**	18.2	20.9	29.7	27.2	25.4
91	DCC	436024	333305	Roadside	NA	NA	15.1	27.0	26.7	NA
92	DCC	435091	333526	Roadside	NA	NA	26.9	38.8	**40.4**	NA
93	DCC	434695	336033	Background	NA	NA	NA	23.8	20.4	18.5
94	DCC	434736	336016	Background	NA	NA	NA	24.7	22.2	19.5
95	DCC	434770	335990	Background	NA	NA	NA	28.6	25.2	22.4
68	DCC	435501	336296	Background	NA	NA	NA	29.3	25.1	23.4
96	DCC	434776	335946	Background	NA	NA	NA	29.5	26.1	26.3
97	DCC	434910	335848	Background	NA	NA	NA	25.3	22.2	20.5
10	DCC	436747	336630	Roadside	39.5	27.5	30.5	**40.7**	**40.5**	39.0
87	DCC	434771	336243	Roadside	**42.9**	24.3	27.5	35.4	34.7	30.2
6Na	DCC	435472	336252	Urban Centre	31.7	16.2	14.1	NA	NA	NA
6Nb	DCC	435472	336252	Urban Centre	31.5	16.4	16.1	NA	NA	NA
6Nc	DCC	435472	336252	Urban Centre	30.9	16.5	16.2	NA	NA	NA
DJ_001_0813	HE	431121	333327	Background	NA	NA	NA	28.8	26.4	26.6
DJ_002_0813	HE	430620	333846	Background	NA	NA	NA	29.7	28.4	27.8
DJ_019_0813	HE	434307	338372	Background	NA	NA	NA	26.2	24.0	22.1
DJ_020_0813	HE	434555	338695	Background	NA	NA	NA	23.0	24.1	20.9
DJ_021_0813	HE	434792	339262	Background	NA	NA	NA	24.9	26.5	24.5
DJ_022_0813	HE	434868	339097	Roadside	NA	NA	NA	33.4	30.7	30.3
DJ_023_0813	HE	434954	339377	Roadside	NA	NA	NA	29.9	32.3	32.4
DJ_024_0813	HE	435588	339833	Background	NA	NA	NA	23.7	24.9	21.5
DJ_025_0813	HE	436336	340050	Background	NA	NA	NA	30.7	34.6	31.9
DJ_026_0813	HE	436661	341585	Background	NA	NA	NA	23.5	28.0	23.4
DJ_027_0813	HE	434914	338674	Background	NA	NA	NA	19.3	18.4	18.6
DJ_028_0813	HE	434749	338365	Roadside	NA	NA	NA	31.8	34.3	30.1
DJ_031_0813	HE	432666	336766	Background	NA	NA	NA	20.4	19.8	18.6

Appendix 5 - Normalisation of NO_2 monitoring data

PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Chris Taylor

This Appendix explains the likely localised sources contributing to high monitored NO_2 concentrations in the focus areas of the A38 Derby Pilot Study.

The monitoring data presented in **Appendix 4**, highlight some "hotspot" areas along major routes where NO_2 concentrations exceeded, or were close to exceeding, the annual mean objective (40 µg/m^3). Within these areas, a few monitoring sites were identified (i.e. "shortlisted") to be included in the source apportionment analysis (**Appendix 6**). Those receptors are used here for more detailed discussions among other observations of monitoring data. **Table 1** presents the shortlisted receptors included in the discussions.

Table 1: Summary of the shortlisted sites

Source ID	Description	Shortlisted ID	Focus Area
DCC 29	Warwick Avenue	R1	Uttoxeter New Road/A5111
DCC 40	179 Uttoxeter New Road	R2	Uttoxeter New Road/A5111
DCC 78	Friar Gate-Brick Street	R3	A52 Corridor
HE DJ_003_0813	Uttoxeter Road South (B5020)	R4	A38: A38-A516 Corridor
HE DJ_006_0813	A516/A5111 Junction	R5	Uttoxeter New Road/A5111
HE DJ_007_0813	A5111 Kingsway	R6	Uttoxeter New Road/A5111
HE DJ_014_0813	Ashbourne Road (A52)	R7	A52 Corridor
HE DJ_029_0813	Queensway (CMP2)	R8	A38: Queensway
HE DJ_032_0813	Kingsway (CMP4)	R9	A38: Kingsway

The monitoring data were used to investigate the contribution of road traffic to annual mean NO_2 concentrations in each focus area. The analysis tests whether monitored values can be attributed to the volume of traffic on the nearest major road (under free flow conditions) and the distance of the monitoring sites from the kerb of that road. Discrepancies highlight that other factors may be influencing monitored values, such as other roads, congestion, and impaired dispersion caused by buildings or topography. The roads considered in the analyses are presented in **Table 2**.

Table 2: List of roads considered in analyses of each focus area, in order they appear in the report

Road	Focus Area
A38	All A38 sections
B5020	A38-A516 Corridor, Uttoxeter New Road/A5111
A52	A52 Corridor
Uttoxeter New Road- West	Uttoxeter New Road/A5111
Uttoxeter New Road- East	Uttoxeter New Road/A5111
A5111	Uttoxeter New Road/A5111

2015 annual mean background NO_2 concentrations were obtained from Defra mapping. Road contributions were removed from the background concentrations using the latest Defra NO_2 Adjustment for NO_X Sector Removal Tool (v5.1, October 2016).

The measured 2015 annual mean NO_2 concentration was used to determine the annual mean road-NO_X concentration at each monitor using Defra's NO_x to NO_2 Calculator (v5.1, June 2016). The resultant road-NO_X concentrations for monitors within 20 m of the kerb of a major road were then normalised to a distance of 10 m, using the fall-off with distance curve produced by AQC for the DMRB Air Quality Model (2013 iteration). This curve can be expressed as:

C_B=C/(IF(A<1.4765,3.92454283234404,(IF(A<4.704,(EXP((0.0289*(LN(A)^3))-0.2988*(LN(A)^2)+0.2197*(LN(A))+1.3253)),(IF(A<73.47,EXP((0.0064*(LN(A)^3))-0.0656*(LN(A)^2)-0.5226*(LN(A))+1.9991),EXP((-0.0752*(LN(A)^2))-0.2556*(LN(A))+1.5368)))))))*(IF(B<1.4765,3.92454283234404,(IF(B<4.704,(EXP((0.0289*(LN(B)^3))-0.2988*(LN(B)^2)+0.2197*(LN(B))+1.3253)),(IF(B<73.47,EXP((0.0064*(LN(B)^3))-0.0656*(LN(B)^2)-0.5226*(LN(B))+1.9991),EXP((-0.0752*(LN(B)^2))-0.2556*(LN(B))+1.5368)))))))

where

C_B = road-NO_X at distance B;
A = input/monitor location distance to the edge of the road (m);
B = output/normalised location distance to the edge of the road (m); and
C = road-NO_X at distance A from the edge of the road.

These values were then averaged for each road under investigation, with the resultant average concentration used to extrapolate concentrations along the DMRB fall-off curve from the kerb to as far as 100 m away. Each individual point on this NO_X curve was then converted back to NO_2 using the NO_X to NO_2 Calculator (v5.1). This resulted in an idealised NO_2 concentration profile which was, effectively, fitted through the average of all the measurements.

Close correlation between the idealised curve and the measured values indicate that the source of the NO_2 emissions being described by the curve is driving the measured concentrations. In other words, the curve has its origin at the edge of the road, so the idealised curve shows how concentrations would be expected to behave if emissions from that road were solely responsible for the difference between measured and background concentrations. The curve assumes free flow conditions along the road of interest, and does not account for local meteorology or dispersion.

The upper and lower limits of the sample standard deviation as a proportion of the average normalised road NO_X is plotted with each drop-off curve that highlight particularly anomalous monitoring sites.

The normalisation analysis was completed for each of the A38, A52 and Uttoxeter New Road focus areas. Discussions of traffic data are included as supplemental material to explain results for each focus area. Speed data are presented as speed banding descriptors from the DMRB IAN 185/15.

Figure 1 presents a map of the focus areas covered in this appendix for reference. For more detailed discussions of each focus area that add context to the discussion herein, please refer to **Appendix 1**. For maps of monitoring locations please see **Appendix 4**.

A discussion on the limitations of this analysis is included at the end of this document.

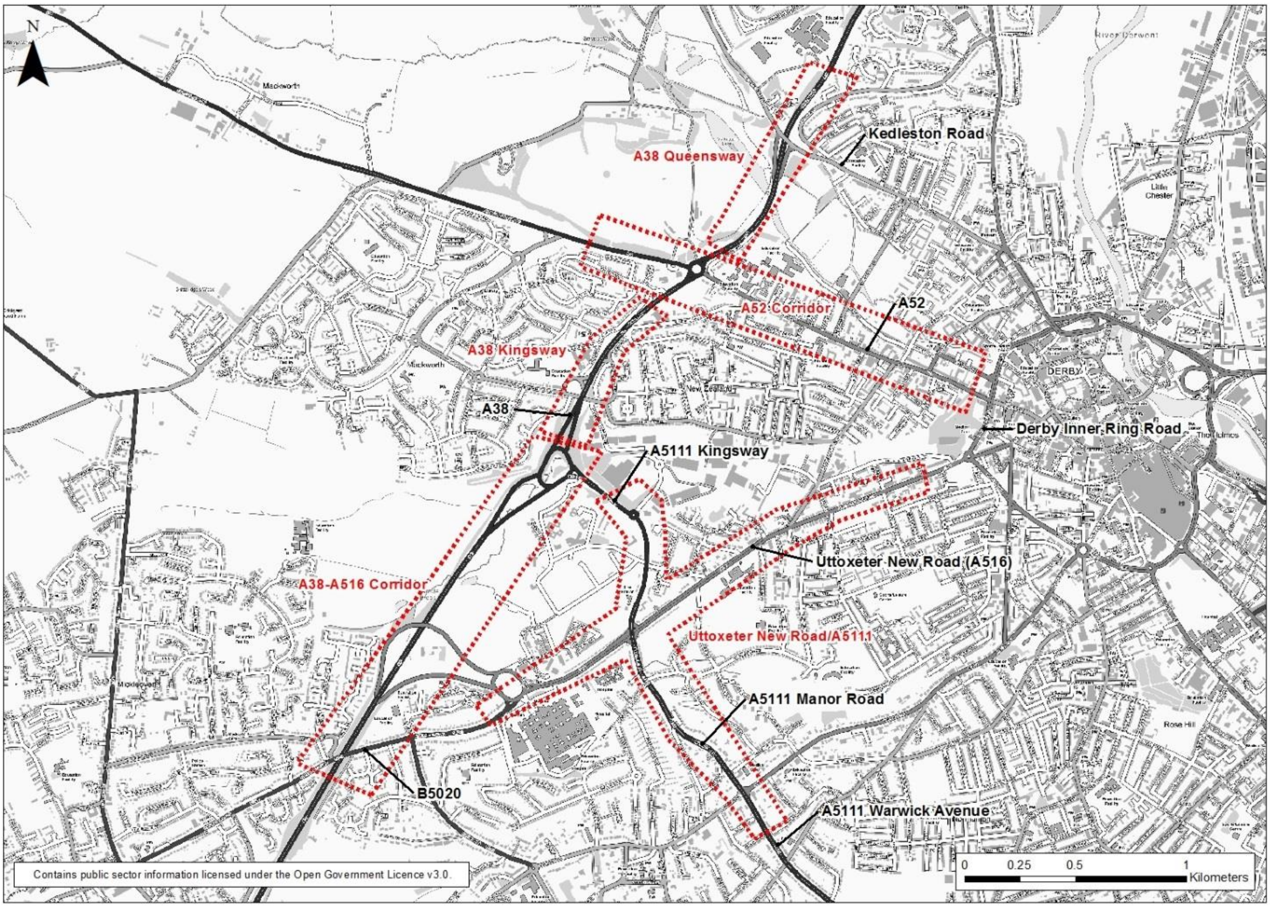


Figure 1: Map of the A38 Derby Pilot Study focus areas and relevant road names

A38 Focus Area

The normalisation of A38 data was undertaken over the entire stretch of road within the pilot study area, including the three sections mapped in **Figure 1**. The idealised NO_2 drop-off curve is presented in **Figure 2**, and includes monitoring for all A38 sections.

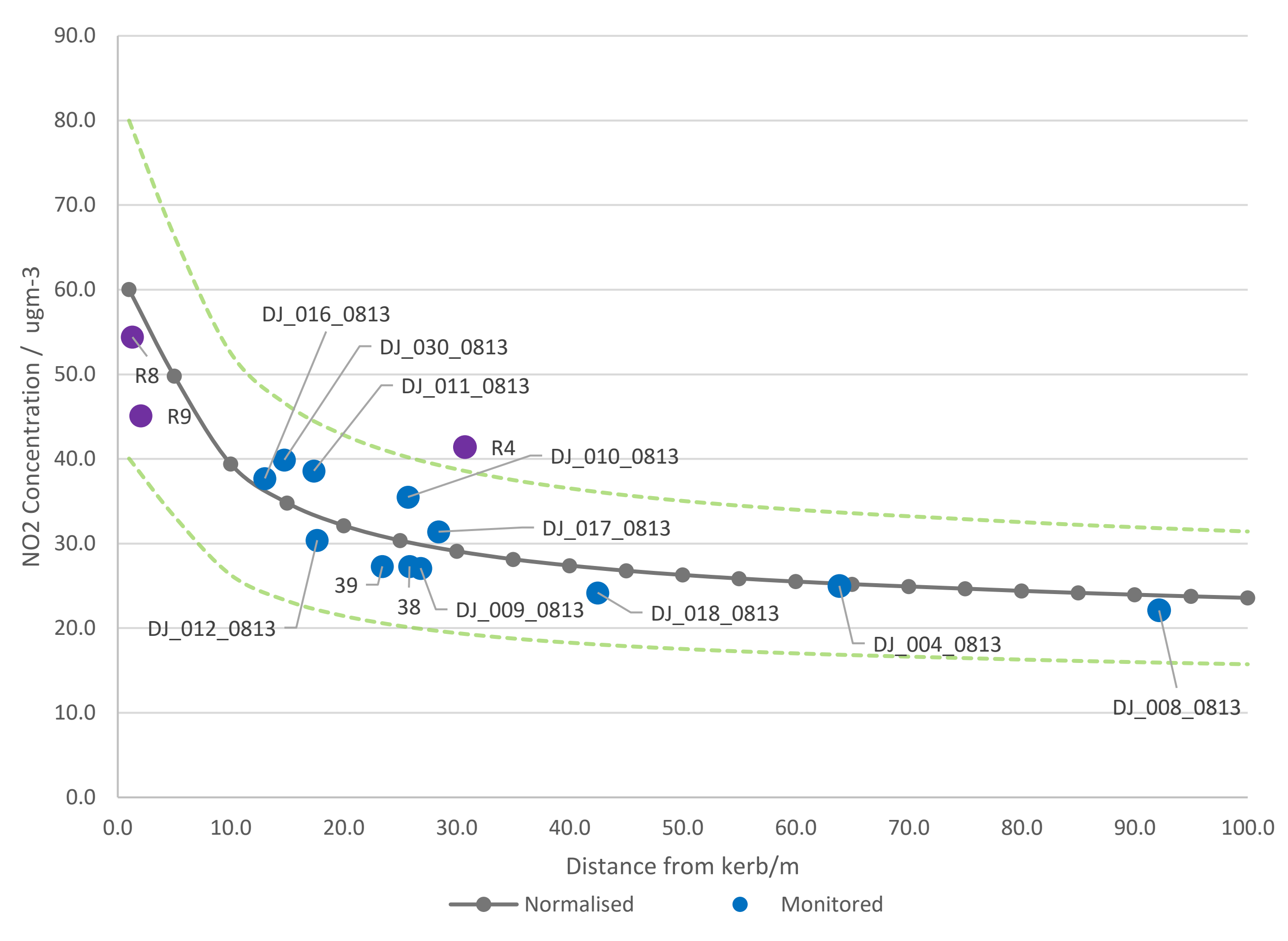


Figure 2: Comparison of measured annual mean NO_2 concentrations with the idealised concentration fall-off curve for the A38. Shortlisted sites are shown in purple.

A38-A516 Area

Three monitoring sites were available within the A38-A516 area. Sites R4 (DJ_003) and DJ_004 are set back from the carriageway by about 30 m and 62 m respectively. Both sites are elevated from the carriageway as it passes under the bridge for the B5020; the difference in elevation is between 5 and 10 m. DJ_008 was located about 92 m west of the Kingsway junction with no elevation difference.

Monitored concentrations at the three sites are between 22 and 41 µg/m^3. Values appear to match the idealised NO_2 drop-off curve in **Figure 1** well, with the exception of site R4 (see below). This suggests that the distance from the A38 kerb is sufficient to explain the spatial pattern of concentrations at sites DJ_004 and DJ_008.

The measured NO_2 concentration at R4 (41.4 µg/m^3) is higher than predicted at 30 m from the A38, using the idealised drop-off curve, by about 12 µg/m^3. This site is within 3 m of the B5020, so it is likely that the contribution from traffic on that road explains this difference. This hypothesis was tested when the normalisation was repeated for the B5020. The resultant drop-off curve is presented in **Figure 3**. HE site DJ_005 was added to the normalisation, as it is located along the B5020, however it is included in the discussion for Uttoxeter New Road below. Revised background NO_2 concentrations for this analysis excluded the in-square minor road component.

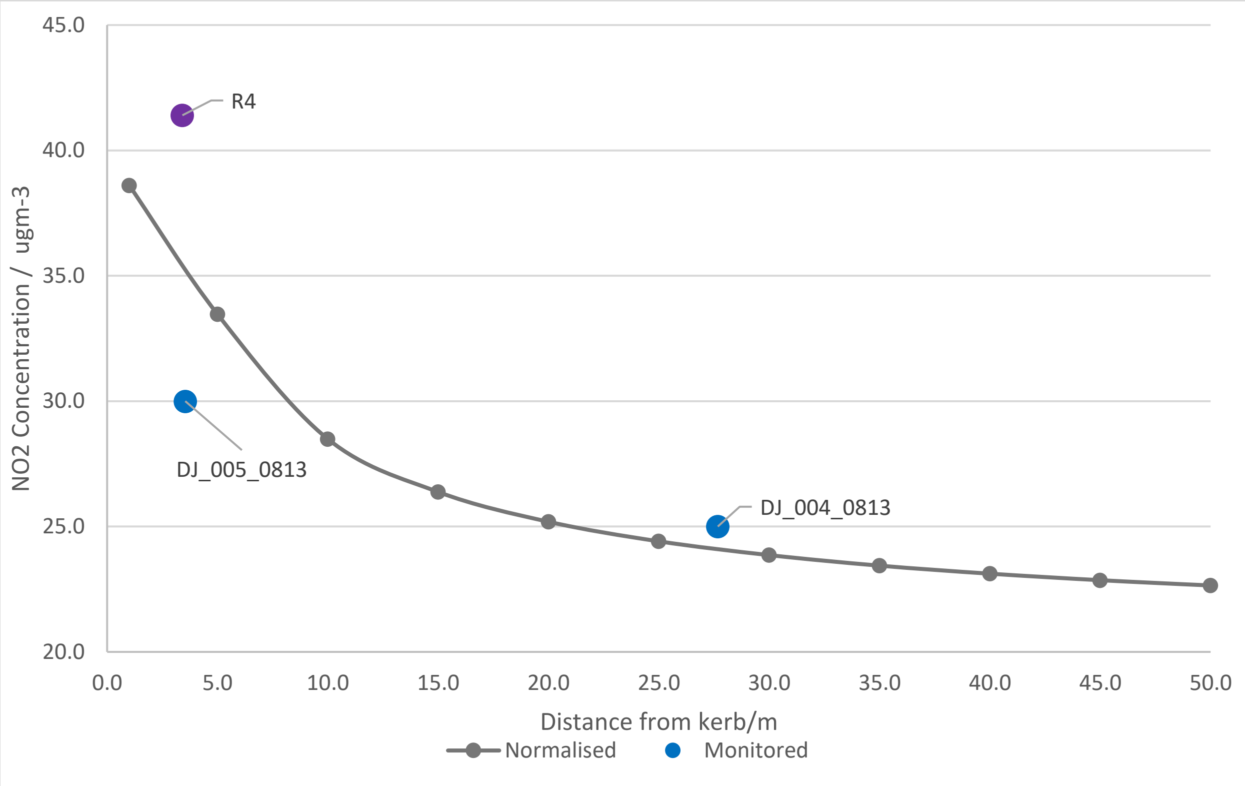


Figure 3: Comparison of measured annual mean NO_2 concentrations with the idealised concentration fall-off curve for the B5020. Shortlisted sites are shown in purple.

The 2015 monitored concentration at R4 is higher than expected for its distance from the B5020 by about 6 µg/m^3, indicating some influence from the A38. When the normalised road NO_X contributions from both the A38 and the B5020 at site R4 were combined, the resultant NO_2 concentration derived from the Defra NO_X to NO_2 calculator, is within 0.2 µg/m^3 of the monitored concentration. Therefore, the combined influence from free flow conditions on the A38 and the B5020 explains the 2015 annual mean monitored value at site R4.

A38 Kingsway

Several monitoring sites were available around the A38 Kingsway. These are listed, along with their 2015 monitored NO_2 concentrations and distances from the kerb, in **Table 3**.

Table 3: List of available monitoring data for the A38 Kingsway and distances to the kerb

Site	2015 Annual Mean NO_2 (ug/m^3)	Distance to the Kerb (m)
R9	**45.1**	2.1
DJ_009	27.1	26.8
DJ_010	35.5	25.7
DJ_011	38.6	17.4
DJ_012	30.4	17.7
DJ_030	39.9	14.8
DCC 38	27.3	25.8
DCC 39	27.3	23.4

Figure 2 shows the Kingsway monitoring data along with the idealised drop-off curve for the A38, which indicates that none of the measured values agree with the concentration predictions at their respective distances from the kerb.

The results point out a striking difference between monitored values on the east and west side of the A38 Kingsway. Eastern side monitors (DJ_010, DJ_011 and DJ_030), with the exception of DCC sites 38 and 39, have higher concentrations than those predicted for their distance. On the contrary, western side (R9, DJ_009 and DJ_012) monitored concentrations are all less than expected. The largest discrepancy is at R9, which is about 10 µg/m^3 less than expected; the site still exceeded the annual mean NO_2 objective (40 µg/m^3) due to its proximity to the kerb. Modelled traffic data provides a combined two-way flow at nearly 57,000 AADT for this link; however, modelled data did not pick up queuing in both directions on this stretch of road that was observed in a site visit in April 2017.

The east/west A38 divide is clear between DJ_011 and DJ_012; both sites are approximately 17 m from the A38 kerb, yet DJ_011 recorded a 2015 annual mean NO_2 concentration of 38.6 µg/m^3, and DJ_012 30.4 µg/m^3. The same trend is evident with DJ_009 and DJ_010 (approximately 28 m from the kerb), where the one on the eastern side (DJ_010) recorded a 2015 concentration about 8 µg/m^3 higher than its western counterpart.

Such stark differences between eastern and western side monitored values indicate that meteorology is likely to be a significant factor affecting pollutant dispersion around Kingsway. The dominant wind direction in 2015, as highlighted in **Appendix 1**, was south-southwesterly, thus pushing traffic emissions more towards the eastern side of the A38. The DMRB curve does not account for meteorological conditions, as it assumes symmetrical concentration drop-offs with distance. This further explains the discrepancies observed in the results of the comparison of the A38 idealised NO_2 drop-off curve and 2015 monitored annual mean concentrations.

As alluded to above, the east-west concentration differences are consistent except for the two DCC monitoring sites (38 and 39) on the eastern side of the A38. The 2015 annual mean NO_2 concentration at both sites was 27.3 µg/m^3, which was lower than predicted by the drop-off curve. A possible explanation could be the location of both sites on the facades of houses, which may have affected dispersion.

A38 Queensway

Four monitoring sites were available surrounding the A38 Queensway. These are listed, along with their 2015 monitored NO_2 concentrations and distances from the kerb, in **Table 4** below.

Table 4: List of available monitoring data for the A38 Queensway and distances to the kerb

Site	2015 Annual Mean NO_2 (µg/m^3)	Distance to the Kerb (m)
R8	**54.4**	1.3
DJ_016	37.7	13.0
DJ_017	31.4	28.4
DJ_018	24.2	42.5

Figure 2 shows these monitored NO_2 values plotted with the idealised NO_2 drop-off curve for the A38. The monitored values match the drop-off curve relatively well with only small discrepancies.

An east-west difference of monitoring data, and the influence of another road is not evident for monitoring sites surrounding the A38 Queensway.

Site R8 was adjacent to the southbound Queensway carriageway. The 2015 monitored concentration is below predicted values for its distance, however still exceeded the NO_2 objective (40 µg/m^3). Modelled traffic data show that the southbound carriageway is subject to light congestion during peak hours, with a modelled flow of around 56,400 AADT. A possible explanation of the discrepancy with the idealised NO_2 drop-off concentrations may be because of a nearby tree inhibiting pollutant dispersion at this site.

For sites DJ_016 and DJ_017, concentrations are slightly higher than predicted (between 1 and 2 µg/m^3). These discrepancies do not indicate another signal of emissions sources in the monitored values at these sites, and are within the error margin of the normalisation method.

The A38 normalised drop-off curve indicates that exceedances of the NO_2 objective (40 µg/m^3) are likely within 10 m from the kerb. A house at the end of Kedleston Old Road, near DJ_017, is within this range, and may be subject to NO_2 exceedances. This is the only property along the A38 study area within this distance. The benefits of reducing congestion and associated emissions on some parts of the local road network may therefore be counteracted by air quality impacts associated with higher traffic volumes at this location. However, results from the HE Derby Junctions Environmental Assessment Report (EAR, September 2016) showed that concentrations at this property are expected to comply with the NO_2 objective in the opening year of the scheme.

The 2015 annual mean NO_2 concentration at DJ_018 (24.2 µg/m^3) is below the idealised NO_2 drop-off curve for its distance from the A38 kerb. The site was located over 40 m from the A38, with a thick vegetation barrier and some houses between it and the carriageway. Thus, vehicle emissions dispersed towards the site may be inhibited. The 2015 annual mean concentration is within about 3 µg/m^3 of the mapped Defra background NO_2 concentration, indicating this site is primarily affected by background sources.

Queuing on southbound Queensway during peak periods increases the overall emissions around this area. With the dominant wind direction in 2015 being south-southwesterly, emissions from southbound moving vehicles are typically directed towards R8 and DJ_016, elevating concentration values. The access road contribution, near DJ_016, is negligible.

A52 Corridor

The A52 normalisation was completed using all available monitoring data within the focus area mapped in **Figure 1**. Several monitoring sites were available to complete the A52 normalisation. These are listed, with their 2015 annual mean NO_2 concentration and distances to the kerb, in Table 5 below. The majority of sites were located in the eastern section of the A52 focus area, as described in **Appendix 1**. There was one background-monitoring site (DJ_015) located off the western section in the Kingsway/Macworth neighbourhood.

Table 5: List of available monitoring data for the A52 Corridor and distances to the kerb

Site	2015 Annual Mean NO_2 (µg/m^3)	Distance to the Kerb (m)
R3	37.1	5.2
R7	**51.9**	3.1
DCC 79	31.2	5.3
DCC 80	35.1	10.5
DCC 81	33.2	2.2
DJ_013	39.7	13.0
DJ_015	23.4	34.0

Figure 4 shows these monitoring sites along with the idealised NO_2 drop-off curve for the A52. The results highlight some discrepancies between the monitored values and those predicted by the DMRB curve at various monitoring sites.

Sites R7 and DJ_ 013 are located on the northern and southern sides of the A52, respectively, on the west side of the Markeaton junction. The measured 2015 annual mean concentrations at both sites are above the predicted values. This indicates that free flow traffic emissions on the A52 alone cannot explain concentration patterns near the Markeaton junction. Instead, it is likely that heavy congestion in this area contributes to elevated concentrations. In fact, modelled traffic data show some congestion for the A52 and Markeaton junction during peak periods. Wind further explains the discrepancy at site DJ_013, as the dominant wind direction in 2015 was south-southwesterly (see **Appendix 1**), thus dispersing emissions towards the site.

Site 80 had a 2015 monitored NO_2 concentration that agreed well with the estimates from the idealised curve, with a small discrepancy of 0.5 µg/m^3.

Other sites had monitored NO_2 values that were below that predicted by the idealised NO_2 drop-off curve. The NO_2 concentration at Site R3 was approximately 5 µg/m^3 lower than the predicted value, which is most likely due to the building on which the monitor is located inhibiting dispersion; the north-facing façade of the building was shielded from the dominant wind direction, therefore affecting pollutant dispersion.

Sites 79 and 81 recorded 2015 annual mean concentrations approximately 10 µg/m^3 less than the predicted values from the idealised curve. Both sites are along sections of the A52 that have light congestion throughout the day. It is unclear why concentrations at these sites are below predicted values, as there were no obstructions to affect dispersion. This potentially highlights a limitation in this analysis, which is described in more detail below.

The 2015 monitored annual mean NO_2 concentration at DJ_015 is about 3 µg/m^3 lower than the idealised concentration value for its distance. Despite not being a large discrepancy, an explanation may be that the site was located upwind of the main pollution source and therefore the true comparison is not captured by the idealised curve, which does not account for meteorology. Another explanation may be that the site is compared to the idealised drop-off curve that was made using data along the eastern section of the A52 focus area, where background concentrations are higher than the western section.

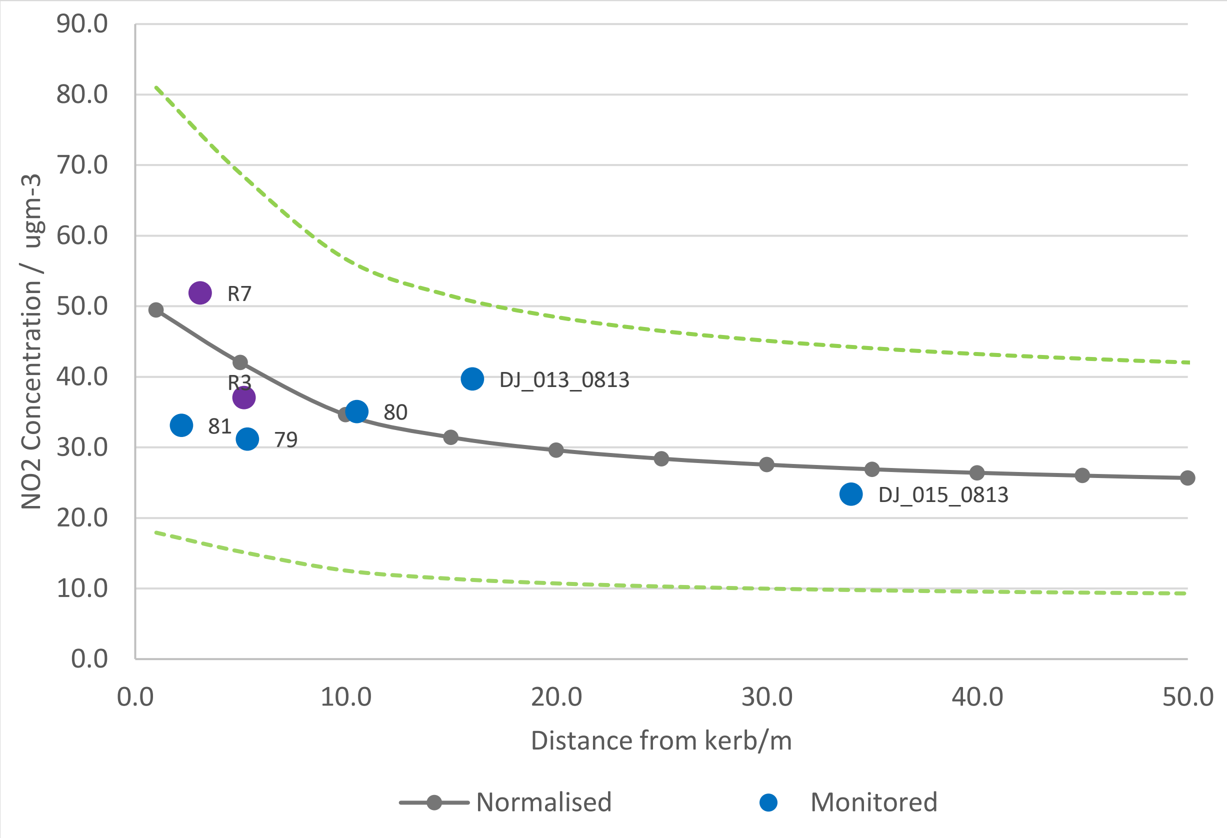


Figure 4: Comparison of measured and interpolated annual mean NO_2 concentrations with the idealised concentration fall-off curve for the A52 (Shortlisted sites in purple)

Uttoxeter New Road and Kingsway/Manor Road (A5111)

The normalisation analysis for this focus area has been split into the following three sections:

- Uttoxeter New Road West;
- Uttoxeter New Road East; and
- A5111.

The analysis initially combined all monitoring sites along Uttoxeter New Road in normalisation calculations. The data did not fit the drop-off curve well, therefore the road was divided between east and west sections. This accounts for the different road characteristics of each section as detailed in **Appendix 1**. The split of Uttoxeter New Road between its eastern and western sections is the intersection of the A5111 (see **Figure 1** for reference).

There are several monitoring sites within each subsection that were used in the normalisation analyses. **Table 6** lists these sites, along with their monitored 2015 annual mean NO_2 and distance to the kerb.

Figure 5 presents the idealised NO_2 drop-off curve for Uttoxeter New Road West alongside monitored annual mean concentrations.

Table 6: List of available monitoring data for the Uttoxeter New Road and Kingsway/Manor Road (A5111) and distances to the kerb

Site	2015 Annual Mean NO_2 (µg/m[3])	Distance to the Kerb (m)
Uttoxeter New Road - West		
R5	37.1	5.2
DCC 35	51.9	3.1
DJ_005	31.2	5.3
DJ_037	35.1	10.5
DJ_038	33.2	2.2
Uttoxeter New Road - East		
R2	38.0	2.9
DCC 36	28.3	5.2
DCC 37	38.0	5.6
DCC 41	24.4	46.4
DJ_034	33.6	6.1
A5111		
R1	51.7	2.3
R6	43.0	6.5
DCC 30	45.8	1.8
DCC 31	42.9	1.8
DCC 32	41.9	1.8
DCC 33	27.3	3.7
DCC 34	28.3	11.7
DJ_033A	50.0	1.8
DJ_033B	50.0	1.8
DJ_033C	50.0	1.8
DJ_035	33.6	2.6
DJ_036	29.5	4.1
DJ_039	27.6	21.8

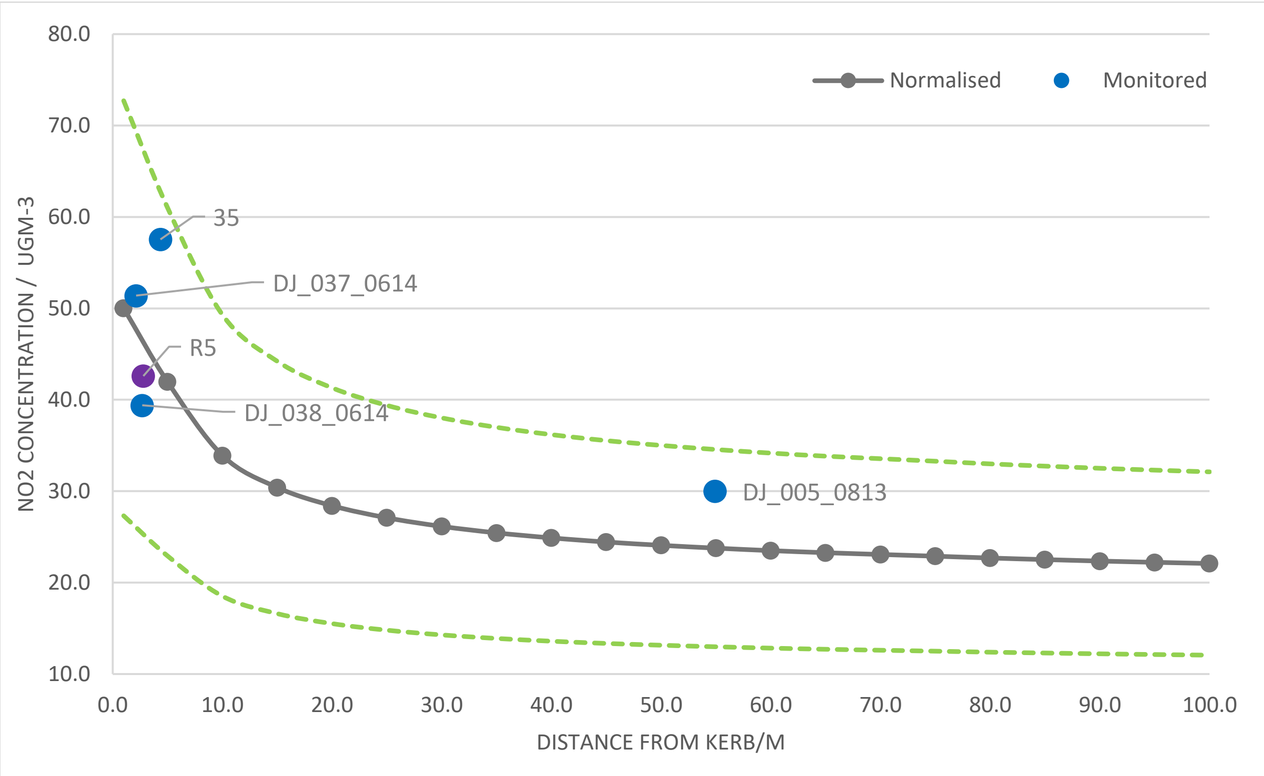


Figure 5: Comparison of measured and interpolated annual mean NO_2 concentrations with the idealised concentration fall-off curve for Uttoxeter New Road West, shortlisted sites are plotted in purple.

The results of the normalisation analysis for Uttoxeter New Road west indicate that free flow conditions along the road are not sufficient to fully explain the spatial pattern of monitored concentrations.

Sites R5 and DJ_037 have the smallest discrepancies from the idealised curve (between about 1 and 3 µg/m^3). The monitored concentration at R5 is lower than predicted values. This may be due to the fact that the site is located adjacent to the left turning lane from Uttoxeter New Road onto the A5111 Kingsway northbound. Therefore, the measured concentrations are not fully representative of free flow conditions on Uttoxeter New Road. Site 37 is only slightly above the idealised curve. The site is located adjacent to the westbound Uttoxeter New Road close to the entrance to the Royal Derby Hospital. The small discrepancy between the monitored concentration and the ideal NO_2 value indicates a slight influence of congestion on the road, likely from users accessing the hospital.

Site DJ_038 is about 2 m from eastbound traffic on Uttoxeter New Road west as it approaches the intersection with the A5111. The monitored concentration is lower than expected for its distance from the kerb; there were no obstructions for the monitor. It is not clear, therefore, why concentrations are lower than expected at this site.

Site 35 is about 3.1 m from the kerb of Uttoxeter New Road, and the 2015 monitored NO_2 is over 10 µg/m^3 above the predicted value. According to the DCC site description, the site was located east of a bus layby; the site is downwind of the stop and therefore potentially affected by emissions from idling and accelerating buses. In addition, modelled traffic data show that this road experiences light congestion throughout the day. These factors may explain why the monitored NO_2 concentration is higher than the idealised curve.

Finally, site DJ_005 is higher than the idealised NO_2 drop-off curve for Uttoxeter New Road by about 6 µg/m^3; this indicates that another emissions source may have influenced the monitored values. The site is about 3.5 m from the kerb of Uttoxeter Road (B5020) as it approaches the roundabout for the A38 slip road and the Royal Derby Hospital. Traffic on the B5020 may explain this difference, which was tested when the normalisation was repeated for this road. **Figure 3** presents the idealised NO_2 drop-off curve for the B5020. The monitored concentration at site DJ_005 is lower than the idealised curve for the B5020 by about 4 µg/m^3. Combining the normalised road NO_X for Uttoxeter New Road and the B5020, the resultant NO2 concentration is about 9 µg/m^3 above the monitored concentrations at DJ_005. This highlights that an obstruction may have influenced dispersion around the monitoring site, as it is unclear why the monitored concentration does not reflect conditions on Uttoxeter New Road and/or the B5020.

Figure 6 presents the idealised NO_2 drop-off curve for Uttoxeter New Road East alongside the monitoring data within this section.

There is good agreement between monitored NO_2 concentrations at sites R2 and DJ_034, and the idealised drop-off values. Thus, free flow traffic emissions on Uttoxeter New Road east explains the monitored values well at these sites.

Site 36 is located about 5.2 metres from the kerb of Uttoxeter New Road east. The monitored NO_2 concentration is about 6 µg/m^3 lower than the predicted value. According to the DCC site description, the monitor was located on the back side of a bus lane sign. Dispersion may have been obstructed by the sign, thus lowering the concentration below the predicted value.

The monitored NO_2 concentration at Site 37 is about 4 µg/m^3 higher than the predicted value from the idealised drop-off curve. The site was located on the façade of a building close to eastbound traffic approaching the signal for Uttoxeter Old Road. Queuing at the signal may be responsible for elevating the concentration above the drop-off curve. In addition, the dominant wind direction in 2015 was south-southwesterly (see **Appendix 1**), pushing traffic emissions directly towards the monitor. The two factors may explain why the NO_2 concentration at the site was above the idealised curve.

Site 41 is a background site on Kensington Street to the east of the roundabout for Uttoxeter New Road and the Derby Inner Ring Road, in Derby City Centre. The concentration is higher that the idealised curve, owing to other factors within Derby City Centre and a possible Inner Ring Road influence.

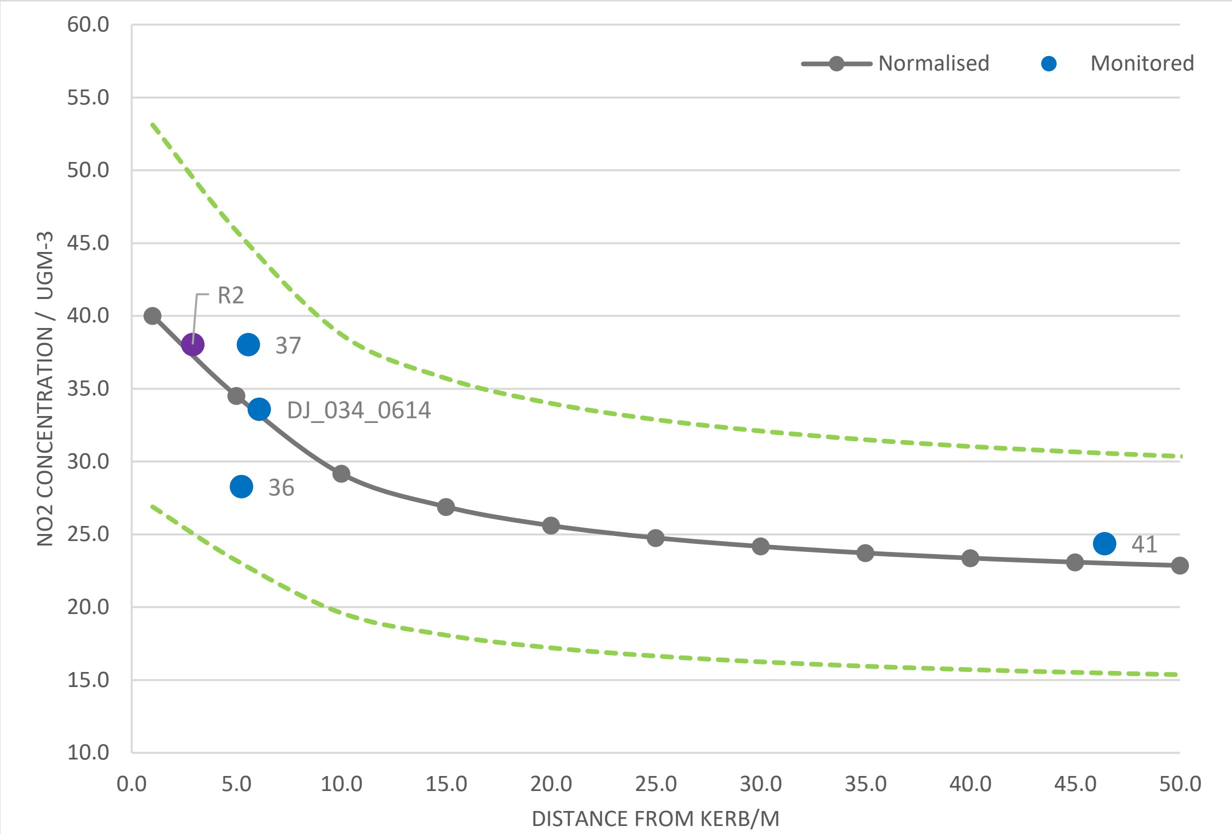


Figure 6: Comparison of measured and interpolated annual mean NO_2 concentrations with the idealised concentration fall-off curve for Uttoxeter New Road East

Figure 7 presents the idealised NO_2 drop-off curve for the A5111 alongside monitored 2015 annual mean values.

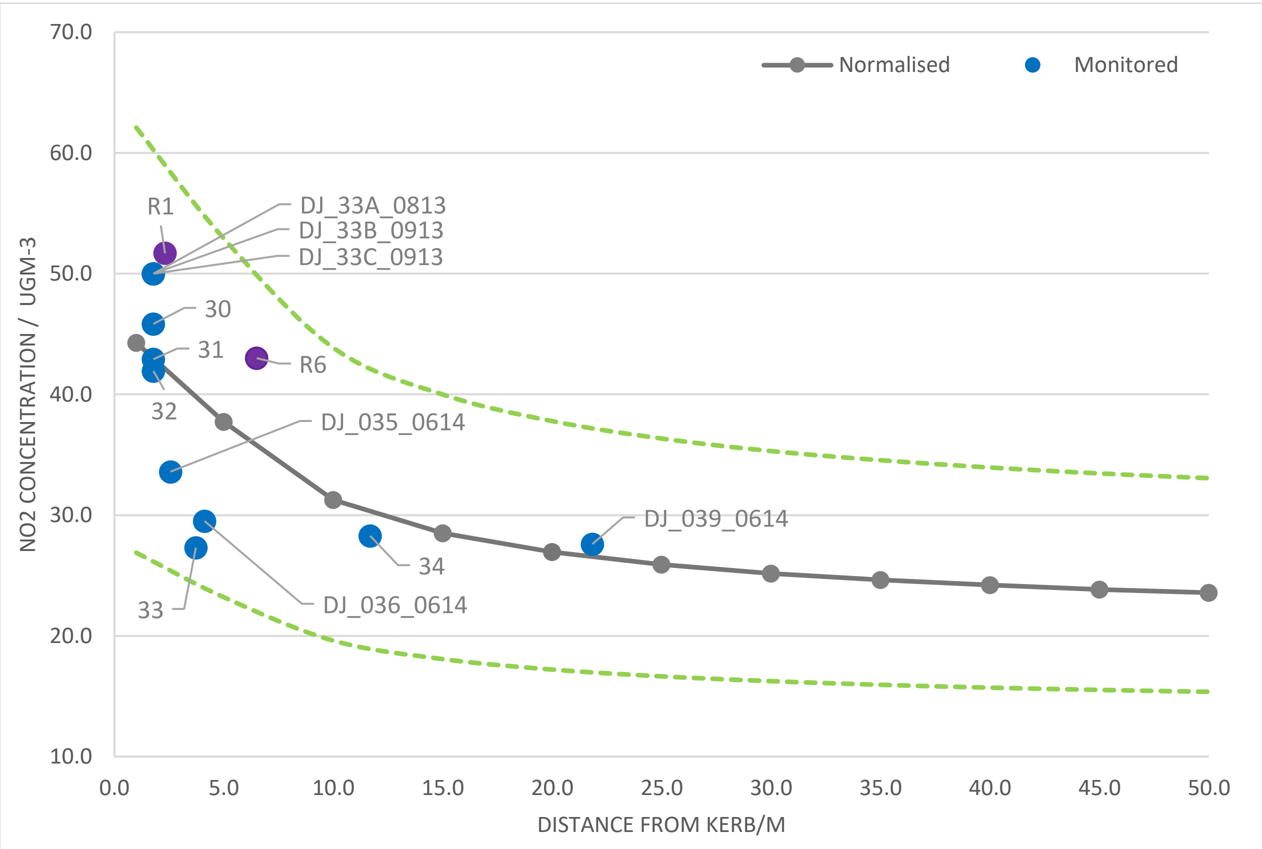


Figure 7: Comparison of measured and interpolated annual mean NO_2 concentrations with the idealised concentration fall-off curve for the A5111

Results from the normalisation analysis indicate that free flow conditions on the A5111 are not sufficient to explain the spatial patterns of monitoring for most sites along the road.

Six of the monitoring sites in the area were included as triplicate colocation sites for DCC and HE monitoring surveys (three for each survey) on the DCC Warwick Avenue CMS. The measured NO_2 concentrations at the DCC monitors, sites 30, 31 and 32, mostly agree with the idealised drop-off curve; the maximum difference at site 30 is about 3 $\mu g/m^3$ higher than the predicted value. Sites 31 and 32 align well with the predicted concentrations on the idealised curve. Therefore, free flow conditions along the A5111 explain the monitored values at the DCC triplicate sites.

This is not the case for the other triplicate sites from HE (DJ_033A, B and C), which have a 2015 monitored annual mean concentration above the predicted value on the idealised curve. Site 29 is nearby, and recorded a 2015 monitored concentration above the predicted value. This may be explained by heavy congestion throughout the day seen in the modelled traffic data; past Google Street View imagery confirms this notion. In addition, the road is uphill on the northbound section near the monitors. Emissions from idling and subsequently accelerating vehicles uphill has the potential to greatly influence concentration values.

The difference between HE and DCC monitoring agreements with the idealised curve highlights differences in monitoring survey methodologies, which include diffusion tube providers, preparation and analysis techniques.

All sites between Burton Road and Uttoxeter New Road, DJ_035, DJ_036, 34 and 33, have concentrations below those predicted by the idealised drop-off curve. Despite being more free flow, the A5111 in this section is downhill, which may influence vehicular emissions enough to lower ambient concentrations, relative to other sections of the road. This may explain why concentrations for monitors along this section of the A5111 are lower than predicted values.

Sites north of Uttoxeter New Road (R6 and DJ_039) have concentration values above those predicted by the idealised drop-off curve. The difference at site DJ_039 is around 1 $\mu g/m^3$; the site is set back from the A5111 along a smaller residential street. A small amount of emissions from the smaller street may explain the slightly higher concentration at this site.

Site R6 recorded a 2015 annual mean concentration approximately 8 $\mu g/m^3$ higher than the predicted value. This indicates that traffic conditions on this section of the A5111 were not regularly free flow, as there are no other emissions sources in the vicinity. There was construction along the road, associated with the realignment of the Kingsway retail park roundabout, that started in the latter half of 2015; Google Street View imagery form June and October 2015 confirm this. Slower traffic through the works may explain the higher concentration recorded at R6.

Analysis Limitations

There are a few limitations to this analysis that are key to the interpretation of the normalisation results.

There are systematic differences between the DCC and HE monitoring surveys, both of which used different diffusion tube providers and thus different bias adjustment procedures were employed, see **Appendix 3**. HE used diffusion tubes from Staffordshire Scientific Services with 20% TEA in Water, and DCC used tubes from ESG Didcot with 50% TEA in Acetone. This difference is highlighted in the results for the A5111 where the triplicate colocation sites showed drastically different values between surveys; DCC sites were lower and agreed well with the idealised drop-off curve, whereas HE sites were much higher than predicted values.

The calculation of the idealised drop-off curve assumes that NO_2 concentrations decrease equally in each direction from the kerb under free flow traffic conditions. It does not account for dispersion obstructions or meteorological conditions, which may greatly influence monitored values. The normalisation calculation, and thus the idealised curve, may also be skewed by using monitoring sites that are adjacent to roads that do not regularly have free flow traffic. This has potential to elevate the idealised drop-off estimates.

Appendix 6 – NO_2 Source Apportionment - Methodology and Results

PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Luke Farrugia

This appendix provides detailed discussions on the NO_2 source apportionment analysis of shortlisted sites in three focus areas: A38 Focus areas (subdivided into A516, Kingsway and Queensway), the A52 corridor and Uttoxeter New Road/A5111. The annual mean NO_2 concentration at each receptor is broken down by source in several different ways:

- *Basic split* – by each of the broadest source categories (local background, regional background and road vehicles);
- *Road type / Link* – by each type of road (Motorway and Non-motorway) and identification of the highest contributing road links in each category;
- *Vehicle type* – by each vehicle type modelled and further split by road type; and
- *Euro Standard* – by top contributing vehicle type and Euro standard combination.

The methodology used is summarised first followed by the relative contribution of different source types to monitored annual mean NO_2 concentrations at each receptor. The contributions were calculated in accordance with the methodology described in Defra's Local Air Quality Management Technical Guidance Note (LAQM TG(16))[1] Box 7.5. The resultant breakdown of the NO_2 concentration at each receptor is presented within this document.

Methodology

Source Apportionment

Undertaking source apportionment for NO_2 is not as straightforward as it is for NO_X, due to the non-linear relationship between the emissions of NO_2 and NO_X. This is additionally complicated by the different proportions of primary NO_2 in the NO_X emission for different sources, for example, petrol cars versus diesel cars. The following advice is therefore provided in LAQM TG16:

- Background contributions: These should be apportioned to regional and local background using the ratio of the background NO_X concentrations attributable to these two sources, derived from Defra background maps for the corresponding 1 x 1 km grid square; and
- Local contributions: the local contribution to NO_2 is the difference between the total (measured or modelled) NO_2 and the total background NO_2. This is then apportioned to the local sources, for example, buses, HGVs, taxis, cars, using the relative contributions of these sources to the local NO_X concentration.

An example of how to carry out source apportionment for NO_2 is set out in Box 7.5 of LAQM TG(16). This is the method used here. The first step of the NO_2 source apportionment was to separate out the background (regional and local) and local road components of the monitored NO_2 data. Defra background mapping NO_X and NO_2 data were used to complete the breakdown, following Box 7.5 of Defra LAQM TG(16). Local components (non-background) have been assumed as the local road component at each shortlisted site.

The regional background NO_X ($RBNO_X$) was calculated as the sum of all mapped "out-square" components, and included rural and point sources. The proportion of the $RBNO_X$ to the total background NO_X ($TBNO_X$) was applied to the total background NO_2 ($TBNO_2$) to obtain the regional background NO_2 ($RBNO_2$). See the equation below:

[1] Defra, 'Local Air Quality Management Technical Guidance (LAQM.TG(16))', April 2016.

$$RBNO_2 = TBNO_2 * (RBNO_X / TBNO_X)$$

The local background NO_X ($LBNO_X$) is the difference between the $TBNO_X$ and the $RBNO_X$. The same method was applied, where the proportion of the $LBNO_X$ to the $TBNO_X$ was applied to the $TBNO_2$ to obtain the local background NO_2 ($LBNO_2$). See the equation below:

$$LB\_NO_2 = TB\_NO_2 * (LB\_NO_X / TB\_NO_X)$$

The local road component of monitored NO_2 was derived by the subtraction of the $LBNO_2$ from the monitored annual mean NO_2 (TNO_2) for each shortlisted receptor site.

Automatic Number Plate Recognition (ANPR) surveys undertaken at 10 different sites in the study area between 22/04/16 and 28/04/16 were used to determine local fleet composition for road links in the study area. This included the proportions of different vehicle types by hour of day and the average proportions of vehicle types by Euro standard.

The vehicle types identified included:

- Diesel Cars
- Petrol Cars
- Diesel LGVs
- Petrol LGVs
- Articulated HGVs
- Rigid HGVs
- Buses and coaches
- Motorcycles
- Petrol Electric Cars
- Diesel Electric Cars
- Electric Cars
- Petrol Alcohol Cars
- Petrol Gas Cars
- Petrol Gas LGVs
- Electric LGVs

The small proportion of vehicles that were unable to be classified were removed from subsequent calculations. The percentage breakdown of the remaining vehicles at each count site by hour of day was then calculated, which was then used to determine an average hourly fleet composition for an average weekday and weekend day at each survey site. Averages for motorway and non-motorway roads were also derived which were used to disaggregate measured / modelled HDV and LDV flows for those road links for which ANPR survey data were unavailable.

Emission Calculations

Emissions calculations were undertaken using Defra's Emissions Factor Toolkit v7.0 (EFT) using the "Alternative Technologies" option of the EFT for each road link by hour of day (or where hourly data were unavailable, the corresponding value for the AM, IP, PM or OP period) and day of week (weekday, Saturday, Sunday). The year for calculation was set at 2016 to match the ANPR fleet composition data. The "User Euro" function was selected to allow the proportion of each vehicle type by Euro Standard to be defined, the data for which were derived from the ANPR survey data for motorway and non-motorway roads respectively. User defined Euro compositions were adjusted to account for the proportion of failed catalysts on cars and LGVs, in accordance with the proportions contained in the DfT's RTP fleet projection database (2013). The option for "Output % Contributions from Euro Classes" was selected to ascertain the percentage contribution of each Euro Standard to the emission rate of the corresponding vehicle type. The EFT was run separately, according to the type of road (urban or motorway) to account for the varying proportions of vehicle type by Euro Standard by road type.

Two outputs are provided by the EFT. The first is the emission rate (g/km/s) for each link entered by vehicle type. The vehicle types consist of:

- All Vehicles
- All LDVs
- All HDVs
- Petrol Cars
- Diesel Cars
- Taxis
- Petrol LGVs
- E85 Bioethanol Cars
- LPG Cars
- Full Hybrid Petrol LGVs
- Plug-In Hybrid Petrol LGVs
- Battery EV LGVs
- FCEV LGVs
- E85 Bioethanol LGVs

Diesel LGVs	LPG LGVs
Rigid HGVs	B100 Rigid HGVs
Artic HGVs	B100 Artic HGVs
Buses / Coaches	B100 Buses
Motorcycles	CNG Buses
Full Hybrid Petrol Cars	Biomethane Buses
Plug-In Hybrid Petrol Cars	Biogas Buses
Full Hybrid Diesel Cars	Hybrid Buses
Battery EV Cars	FCEV Buses
FCEV Cars	B100 Coaches

The second output is the percentage contribution of each Euro standard to the emission rate for each vehicle category. This information is used to determine the relative contribution of each vehicle type by Euro standard at selected receptors.

The EFT requires a single speed to be entered to calculate the contribution by Euro standard, as the contribution outputs are speed specific. After checking traffic data, a speed of 96 kph was used for the A38 and 48 kph was used for the local roads.

Traffic data

Traffic data were collected by HE in April 2016 using ANPR cameras. Similarly, the Department for Transport (DfT) collected traffic data in October 2015 at several sites around Derby. The ANPR data provided a breakdown of the proportion of the fleet by vehicle type and Euro class, and the DfT data provided total traffic volume and HGV proportions. Using available traffic data and count information (including ANPR information where applicable) the proportions of the local component NO_2 were attributed to different vehicle types and Euro classes.

The source apportionment used traffic data from traffic counts, supplemented with modelled data from local scheme assessments where necessary, collated by Atkins' traffic team. These data were processed into average hourly flows, %HDV and speed (kph) for an average weekday, Saturday and Sunday, for use in emissions calculations. The traffic count data consisted of HATRIS count data which were adjusted to the assessment year (2015). Where there were gaps in the HATRIS data, DfT average daily count data were obtained and converted to hourly flows using an average diurnal profile determined from HATRIS data. Where traffic count data were not available, modelled data were used from the latest local scheme assessment (i.e. the EAR for Derby Junctions Scheme). These modelled data included vehicle flows, %HDV and Speed (kph) for average weekday and weekend days during certain time periods. These periods included: AM (07:00 – 09:00), IP (09:00 – 16:00), PM (16:00 – 19:00) and OP (19:00 – 07:00).

The proportion of various vehicle-type contributions to the local NO_2 component are not necessarily proportional to the number of vehicles of that type within the fleet due to differences in emissions technologies. Therefore, there has been no way to determine which vehicle types contribute most to local component of concentrations without relying on emissions modelling.

A combination of ADMS-Roads and Defra's Emissions Factor Toolkit (EFT v7.0, 2016) was used to attribute the local NO_2 component. ADMS outputs provided the road NO_X component, accounting for specific road characteristics and pollutant dispersion. The EFT outputs provided NO_X emission rates for different vehicle types based on the ANPR proportions. The proportions calculated for NO_X were applied to NO_2. The source apportionment at each site is summarised in a series of flowcharts in **Appendix 7**.

Shortlisted Receptors

Figure 1 shows the location of receptors within the A38 Derby focus areas. All receptors and monitoring locations and have been selected for NO_2 source apportionment based on some or all of these criteria:

- exceedance of the annual mean criterion of 40 µg/m^3;
- roadside monitoring locations;
- coverage of A38 and local road locations; and
- location in relation to prevailing wind direction.

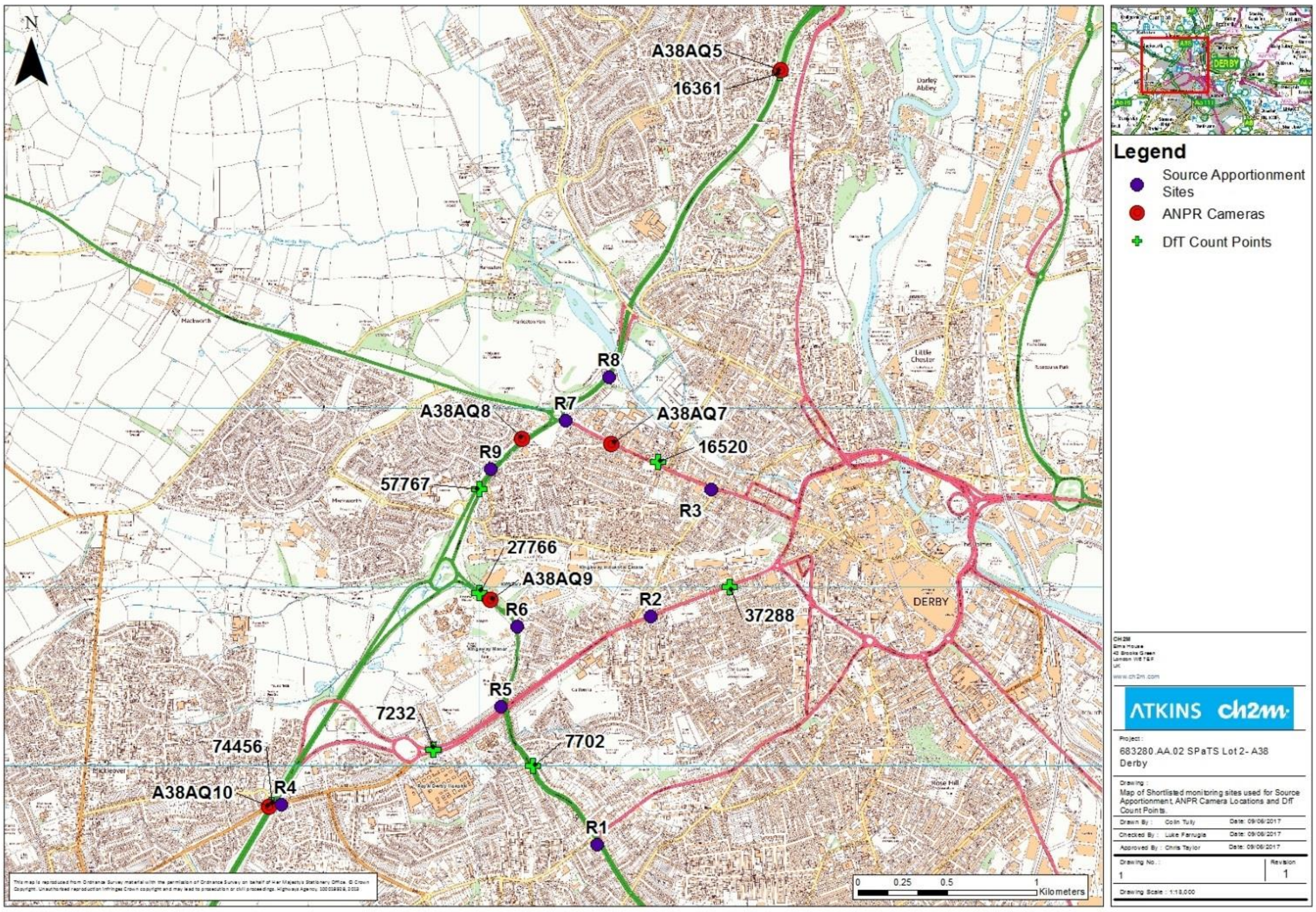


Figure 1: Map of the shortlisted monitoring sites chosen for the source apportionment analysis, and the locations of ANPR cameras and DfT count points.

Table 1 shows the measured annual mean NO_2 concentrations at selected monitoring sites within the study area in 2015. The full analysis of monitoring data is presented in **Appendix 4** (note all selected sites are diffusion tubes). The measured NO_2 concentrations have been broken down into Regional Background, Local Background and Road NO_2 components in accordance with the approach set out in Box 7.5 of LAQM TG(16).

Table 1: Breakdown of Measured NO_2 at Selected Monitoring Sites

Receptor	Source	Source ID	Site Type	X,Y	Measured 2015 Annual Mean NO_2 ($\mu g/m^3$)	Relative Contribution (%)		
						Regional Background NO_2	Local Background NO_2	Road NO_2
R1	DCC	DCC 29	Roadside	433659, 334560	**51.7**	33.1%	8.1%	58.8%
R2	DCC	DCC 40	Roadside	433957, 335834	38.0	46.3%	11.3%	42.5%
R3	DCC	DCC 78	Roadside	434340, 336553	37.1	49.6%	15.6%	34.8%
R4	HE	DJ_003_0813	Roadside	431894, 334784	**41.4**	35.9%	11.5%	52.6%
R5	HE	DJ_006_0813	Roadside	433119, 335328	**42.6**	41.3%	10.1%	48.6%
R6	HE	DJ_007_0813	Roadside	433209, 335778	**43.0**	40.9%	10.0%	49.1%
R7	HE	DJ_014_0813	Roadside	433482, 336929	**51.9**	32.8%	10.1%	57.1%
R8	HE	DJ_029_0813	Roadside	433723, 337174	**54.4**	30.3%	5.0%	64.7%
R9	HE	DJ_032_0813	Roadside	433061, 336658	**45.1**	37.7%	11.7%	50.6%
Based on a 12 months of monitoring annualised according to the methodology described in LAQM.TG(16).								

Road NO_2 is a significant contributor to the total measured annual mean concentration at all the receptors provided in Table 1, however these values point to some “hot-spot” areas, which are also reflected in the monitored concentrations.

All shortlisted sites exceeded the NO_2 objective in 2015 except for R2 and R3. Both sites were located at sites of relevant exposure on Uttoxeter New Road and the A52 near Brick Street, respectively, which are closer to Derby City Centre. The Road NO_2 proportions are also lower at these sites than the others (less than 45%).

Sites R1, R7 and R8 have the highest concentrations (above 50 $\mu g/m^3$) and the highest Road NO_2 proportions (greater than 55%). Two of the three sites (R1 and R7) were located near relevant exposure sites, and all three were adjacent to areas more prone to queuing traffic (i.e. approaches to signals). Site R5 was also located near a road prone queuing, and in a location of relevant exposure, however its concentration value and Road NO_2 proportion is lower than other similar sites.

The other three sites, R4, R6 and R9, were located adjacent to busy roads, and the Road NO_2 proportion was around 50%.

To understand what measures may help improve air quality in the study area, it is important to understand in greater detail the key contributors to the Road NO_2 component at each receptor in terms of road type, vehicle type and Euro standard.

Conceptual Modelling

This methodology was applied in other Lot 2 pilot studies and was considered a suitable approach to use here. The intention is to convert an emission rate to a concentration at a point and thus enable the contribution of each vehicle type to measured road NO2 to be determined. Some form of modelling is therefore necessary. In the absence of conceptual modelling, there would be no account for the influence of wind direction (which, in the case of major roads perpendicular to the prevailing wind, can be significant).

By modelling a unitised emission rate for each road link in ADMS-Roads, it is possible to estimate the corresponding contribution from each link to total concentrations at a specific receptor based solely on distance and the prevailing wind direction, for each hour of the day. The latter is important because of the difference in day time and night time meteorological conditions. By keeping the modelling conceptual, the requirement for multiple model runs is limited.

The model was run to provide the hourly contribution of each model link at each receptor for each hour of the year. An average contribution was then derived by hour of day to determine the average hourly contribution from each road link at each receptor. These average hourly contributions serve as a ‘dispersion factor’ which accounts for distance and location of a receptor in relation to the modelled road network together with variations in metrological conditions. Resulting annual average road-NOx contributions were calculated by multiplying the derived hourly ‘dispersion factor’ by the corresponding emission factor for each link for an average weekday, Saturday and Sunday, obtained from the Emission Factors Toolkit, and weighting accordingly.

A38 Focus Areas

A38-A516 Focus Area

Receptor 4 (R4) was located on a lamppost adjacent to the B5020 just east of the bridge over the A38, and was used for source apportionment in the A38-A516 focus area. The site is about 20 m closer to the road than the nearest relevant exposure location. The B5020, despite being a small road, hosts many bus routes and serves as an access route to the Mickleover community, the Royal Derby Hospital and Derby City Centre.

Traffic volume data came from DfT count point 74456 and fleet proportions were obtained from ANPR camera A38AQ10; both were located under the B5020 bridge close to where the A516 and A38 merge.

See **Figure 1** for a map of Receptor R4 and the traffic data collection points.

Immediate sources of air pollution that will affect the A38-A516 focus area are:

- Traffic on the A38 (including the Kingsway Junction and A516 slip roads);
- Traffic on the B5020;
- domestic heating sources and point sources in the vicinity; and
- regional rural emissions.

No significant point sources are located near R4. The nearest point source is a biomass CHP stack located within Royal Derby Hospital, which from a review of the UK National Atmospheric Emissions Inventory (NAEI) contributes up to 1.7 µg/m^3 of NO_X. Given that the stack is also downwind of the monitor it is unlikely to have much influence on NO_2 concentrations.

Contributions to pollutant concentrations from the regional background component are made up of the combined effect of long-range sources, including those outside of the UK.

Breakdown of Measured Concentrations

Figure 2 summarises the indicative calculated composition of the measured (2015) annual mean NO_2 concentrations at site R4 (41.4 µg/m^3).

The regional background component contributes 14.9 µg/m^3 and the local background 4.8 µg/m^3. The local road component is approximately 21.8 µg/m^3, making it the largest overall contributor to the measured annual mean NO_2 concentration at this site. Given the lack of point sources within proximity of R4, this suggests that traffic on the A38, A516 and B5020 has the largest influence on the monitored value.

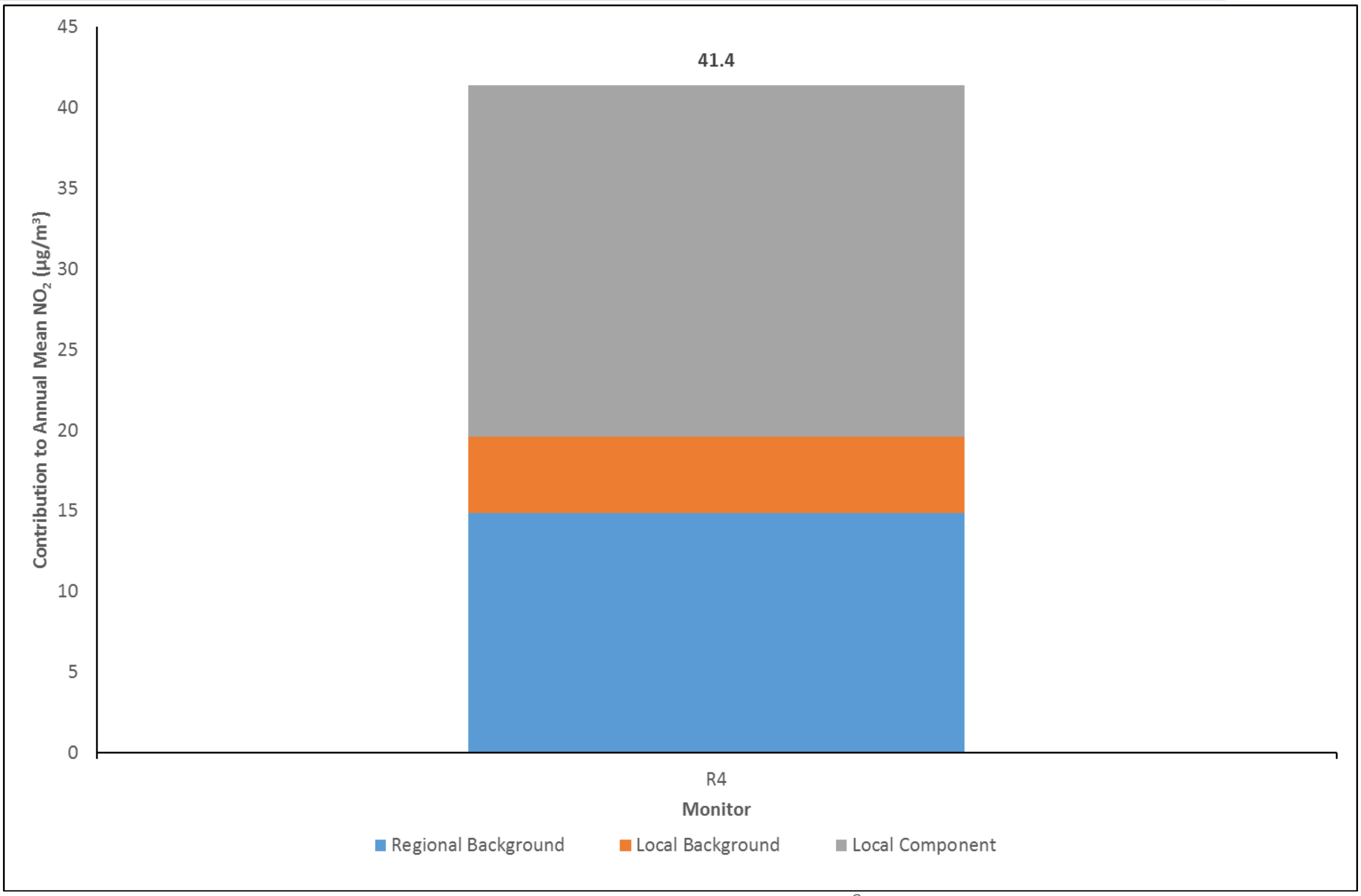


Figure 2: Indicative Composition of Annual Mean NO_2 (41.5 µg/m^3) at R4 in the A38-A516 Focus Area

Composition of the Local Background

Figure 3 shows how the 4.8 µg/m^3 of NO_2, which is classified in **Figure 2** as "Local Background" is likely to be broken down further, although it should be noted that this distribution is based on an interpretation of Defra PCM modelling and is thus subject to some uncertainties.

The Defra PCM model suggests that approximately 92% of the local background (about 4.4 µg/m^3) comes from road traffic on major and minor roads. Domestic and commercial sources make up another 8% (0.4 µg/m^3) of the local background; the area surrounding R4 is residential, therefore domestic heating sources is the most likely explanation of this contribution. Industrial sources, motorways and railway lines are not present near R4, and therefore do not contribute to the local background component.

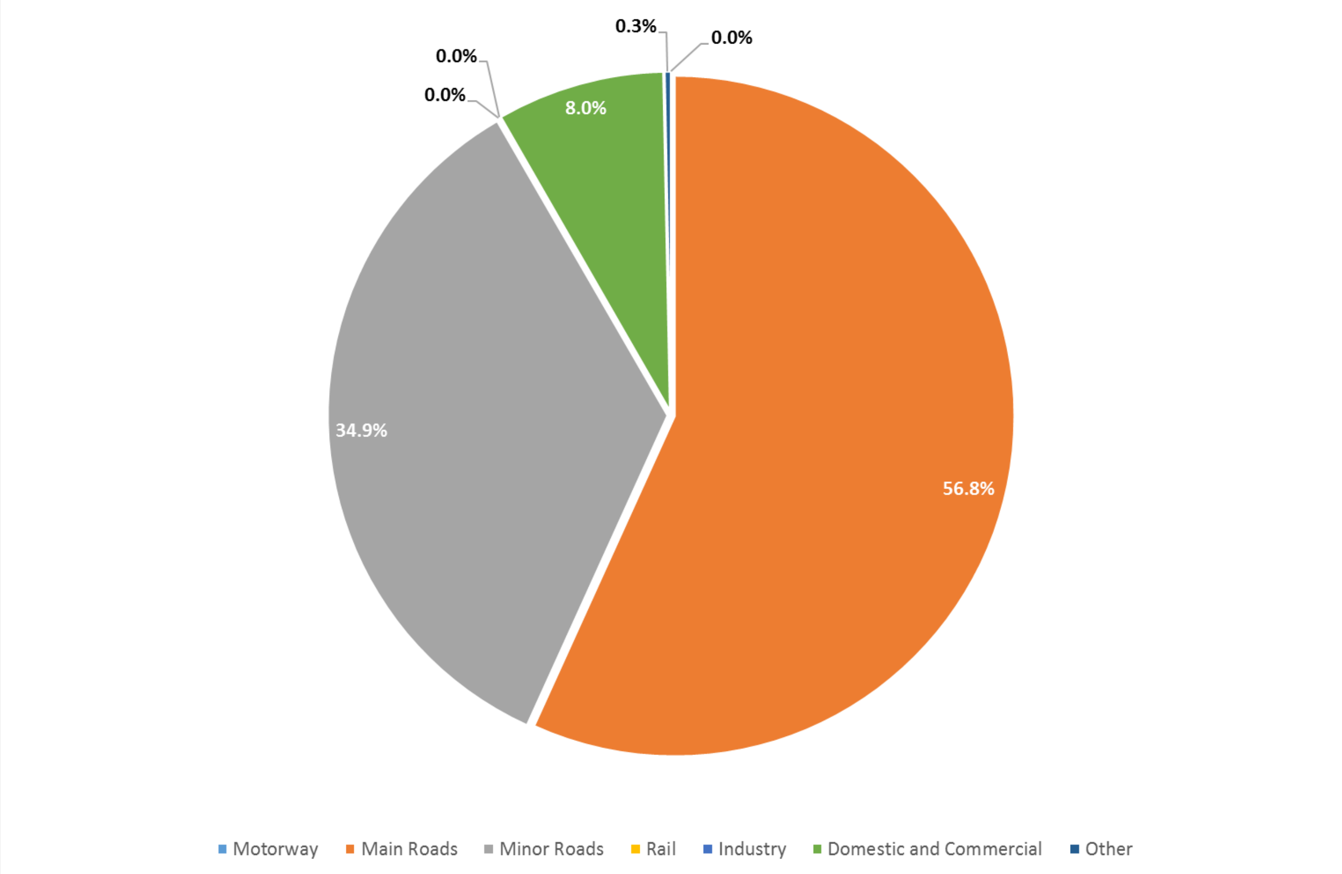


Figure 3: Indicative Composition of Local (non-Rural) Background NO_2 (4.8 µg/m^3) at R4 in the A38-A516 Focus Area (%)

Local Component- Traffic Contribution

Figure 4 presents the breakdown of the local NO_2 component by vehicle type at R4. The largest contribution to the local NO_2 component is from Diesel Cars - 47% (10.2 µg/m^3). In total, diesel light duty vehicles (cars and LGVs) contribute to roughly 70% (15.3 µg/m^3) of the total local NO_2 component. HGVs contribute to 26% (5.7 µg/m^3) of the local NO_2 component.

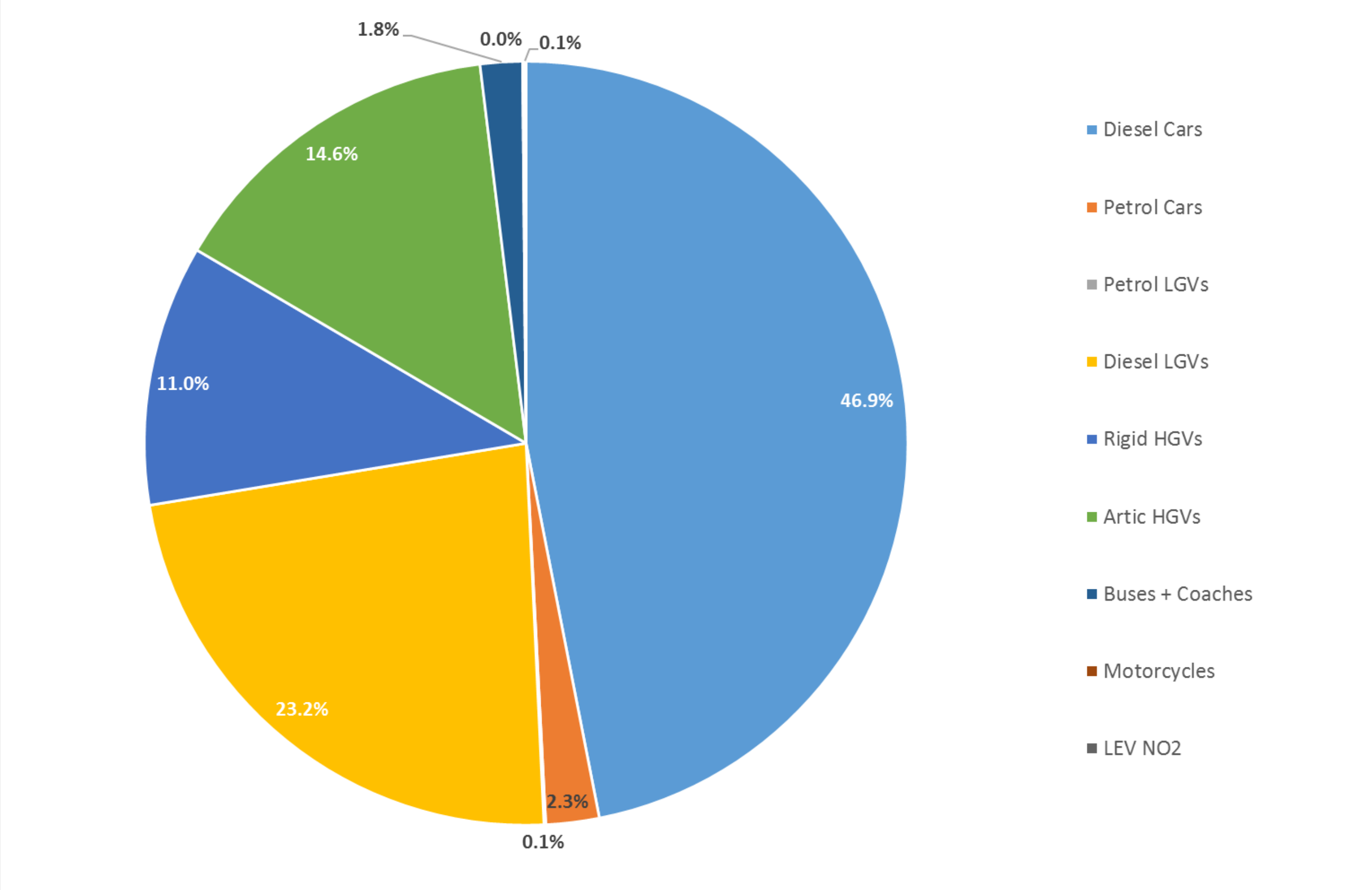


Figure 4: Indicative Breakdown of the Local Component of NO_2 Concentration (21.8 µg/m^3) at R4 in the A38-A516 Focus Area by Vehicle Type

The ANPR data, from camera A38AQ10, was used to estimate the relative NO_2 contribution by Euro class per vehicle type, as presented in **Figure 5**. Euro 5 vehicles are the largest contributors of NO_2 for diesel cars, LGVs and Articulated HGVs. Petrol car contributions are highest for Euro 3, whilst Euro 1 petrol LDVs make the largest contribution. Euro 3 and 5 buses and coaches make a similar contribution for those vehicle types. Euro 4 is the highest contributing class for Rigid HGVs.

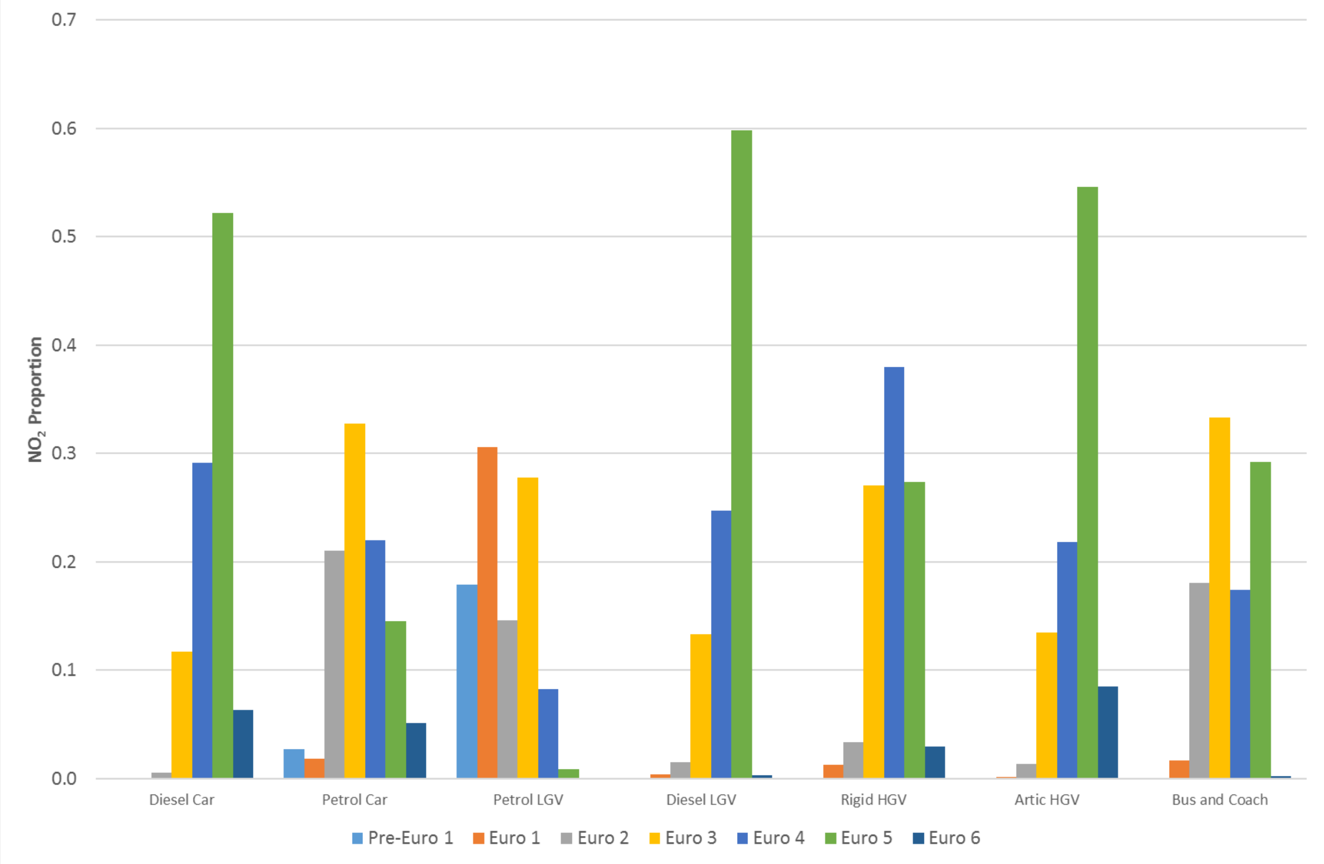


Figure 5: Relative NO_2 Contribution for Each Vehicle Type Euro Class on the A38-A516 Corridor near R4

A38 Kingsway

Receptor 9 (R9) is located on a signpost 2 m from the northbound A38 Kingsway carriageway; see **Figure 1** for a map of its location. The surrounding area is mostly residential, with the Kingsway Retail Park and Kingsway Industrial Estate to the southwest. Access to the A38 to/from the industrial estate is nearby at Raleigh Street and Brackensdale Avenue.

Traffic volume data were obtained from DfT count point 57767 and ANPR fleet proportions came from A38AQ8. Immediate sources of air pollution that will affect the A38 Kingsway focus area are:

- Traffic on the A38;
- Domestic heating sources and point sources in the vicinity;
- Traffic on smaller local roads; and
- Regional rural and industrial emissions sources.

Contributions to pollutant concentrations from the regional background component are made up of the combined effect of long-range sources, including those outside of the UK.

Breakdown of Measured Concentrations

Figure 6 summarises the indicative calculated composition of the measured (2015) annual mean NO_2 concentrations at site R9 (45.1 µg/m^3) on the A38 Kingsway.

The regional background component contributes approximately 17 µg/m^3 and the local background is around 5.3 µg/m^3. The local component, that is the residual NO_2 from roads, is approximately 22.8 µg/m^3, making it the largest single contributor to the annual mean.

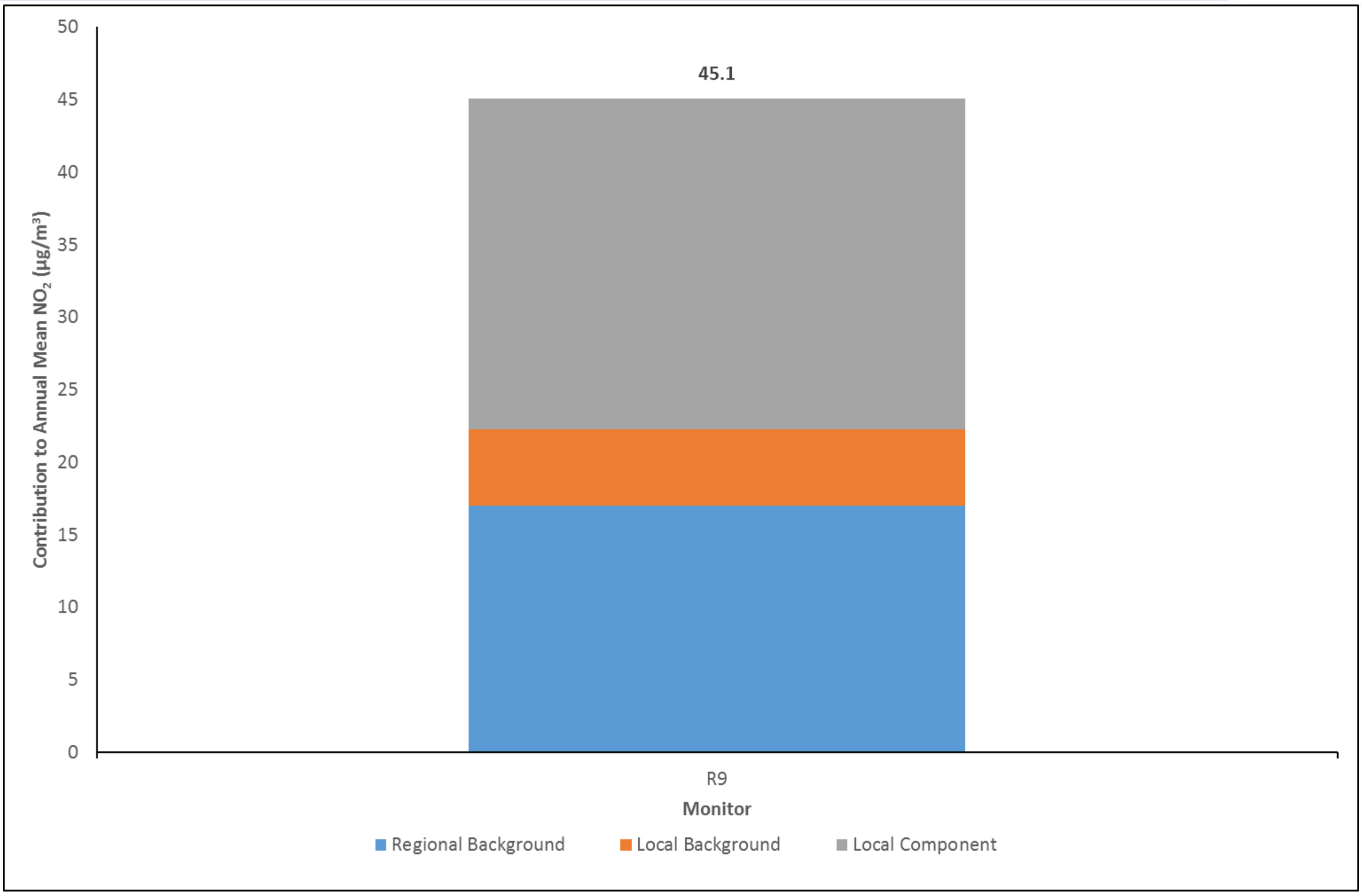


Figure 6: Indicative Composition of Annual Mean NO_2 at R9 in the A38 Kingsway Focus Area

Composition of Background

Figure 7 presents the breakdown of the Local Background NO_2 (5.3 µg/m^3). Approximately 82% of the local background (4.4 µg/m^3) is from road traffic on major and minor roads. Domestic and commercial sources make up another 12% (0.4 µg/m^3) of the local background.

There are no contributions from motorways or railway lines at R9. Similarly, industrial sources may include the influence of the Markeaton Crematorium, located on the west side of Markeaton Park, however emissions from this source are relatively minor. No other industrial sources are located nearby that would contribute to the local background.

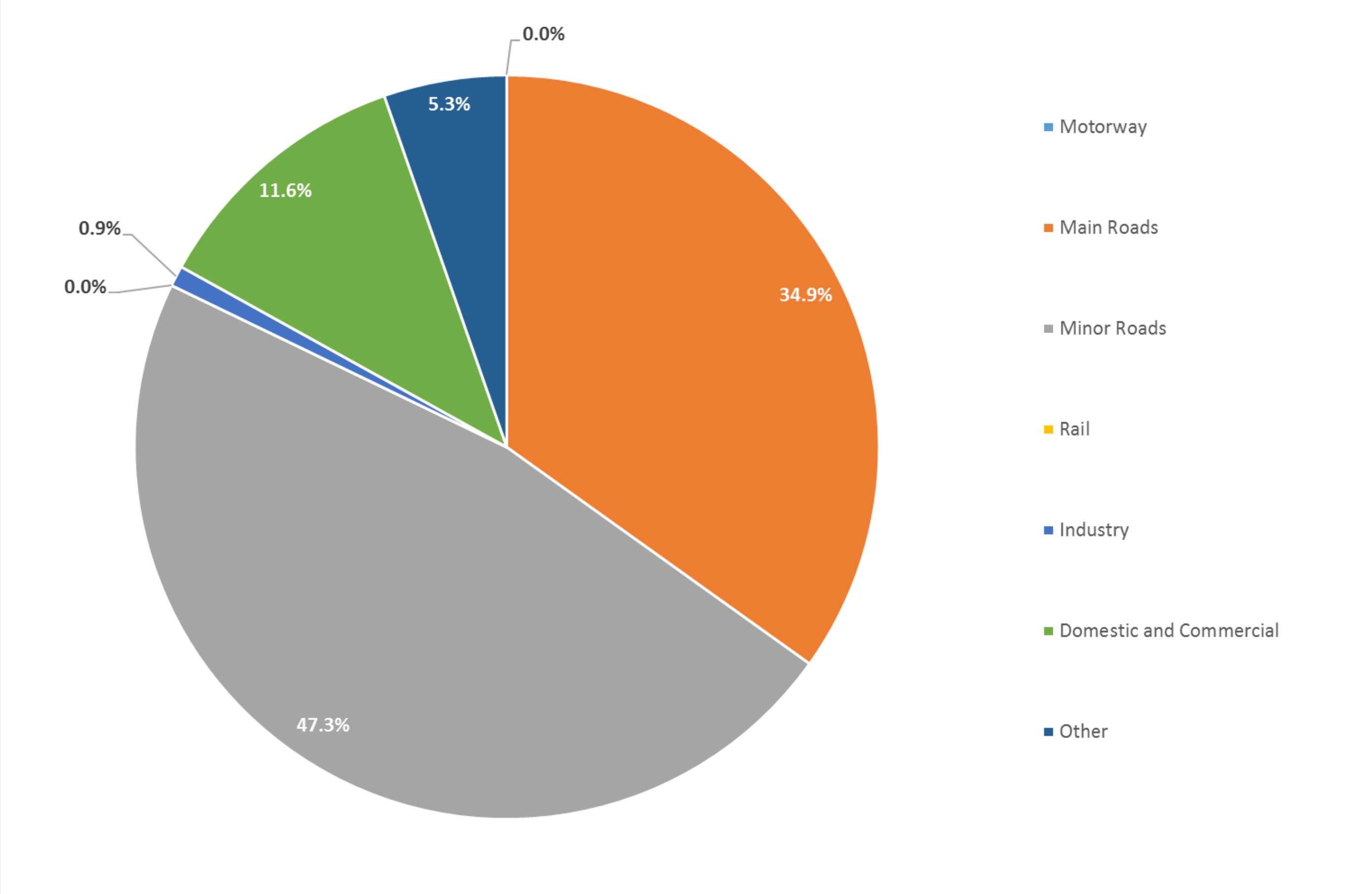


Figure 7: Indicative Composition of Local (non-Rural) Background NO_2 (5.3 µg/m^3) at R9 in the A38 Kingsway Focus Area (%)

Local Component- Traffic Contribution

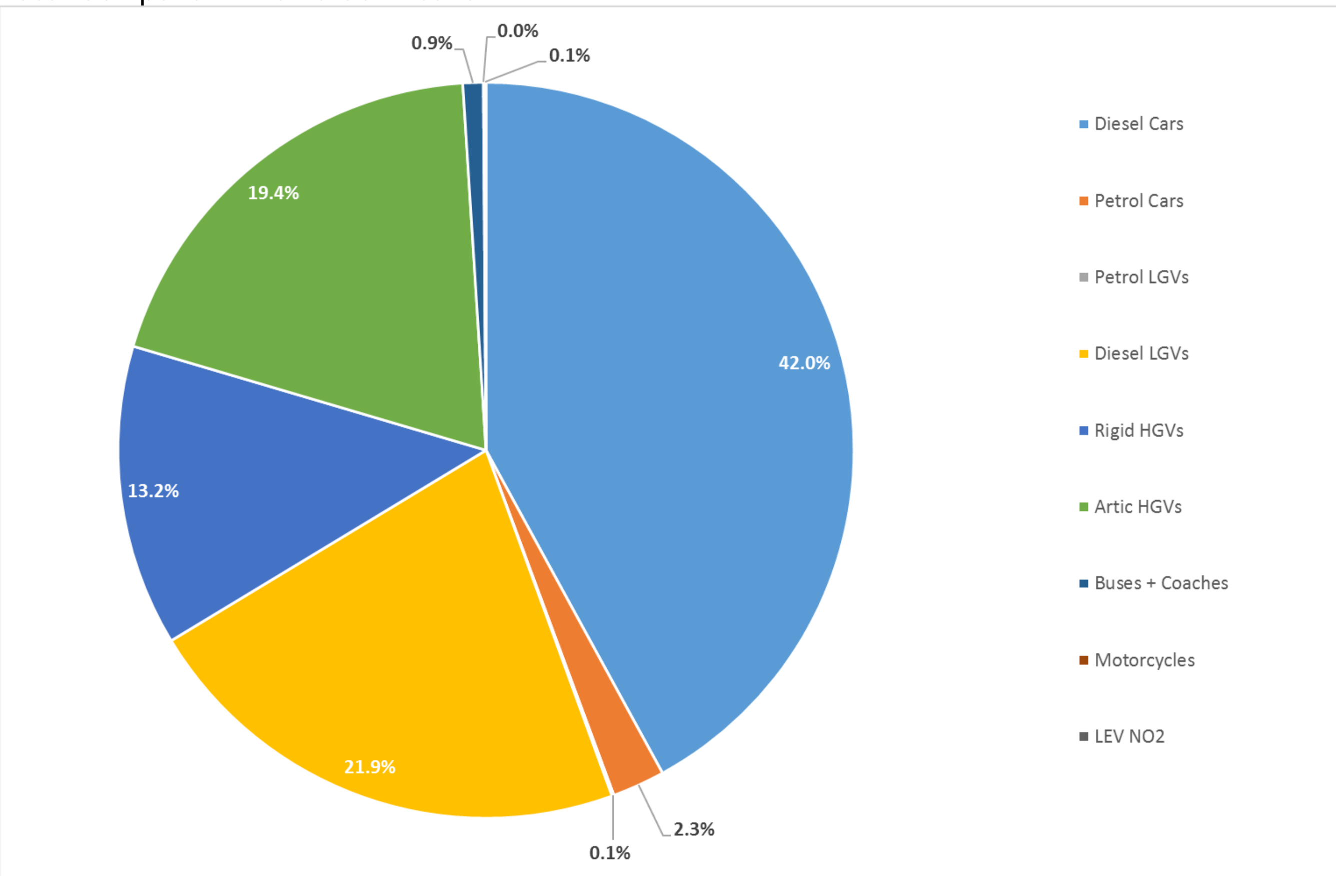


Figure 8 shows the breakdown of the local NO_2 component by vehicle type. Around 42% (9.6 µg/m^3) of the local component is from Diesel Cars, with a total contribution from light duty diesel vehicles (cars and LGVs) of approximately 64% (14.6 µg/m^3). This value is comparable to the A516 corridor, which showed a slightly higher diesel vehicle contribution. HGVs (both rigid and articulated) contribute an additional 33% (7.5 µg/m^3) of the local NO_2 component. Petrol cars, and Buses and Coaches contribute very little to the overall local NO_2 component. Other contributions are negligible.

Figure 9 provides additional detail of the relative contributions of each Euro class to the local NO_2 component for each vehicle-type derived from the ANPR data. Like the other A38 sections, Euro 5 is the largest contributing class for Diesel cars and LGVs, and Articulated HGVs. Petrol car contributions are also heavily influenced by older vehicles, Euro 3, in this section. The largest contributing classes for Petrol LGVs (Euro 1) and Rigid HGVs (Euro 4) are the same as well.

Euro 2 Buses and Coaches are the largest contributor for this vehicle type to the local NO_2 component, with the proportions tailing off linearly with higher classes. This indicates a slight difference in bus fleet composition north of the Kingsway and Uttoxeter New Road (A516) junctions.

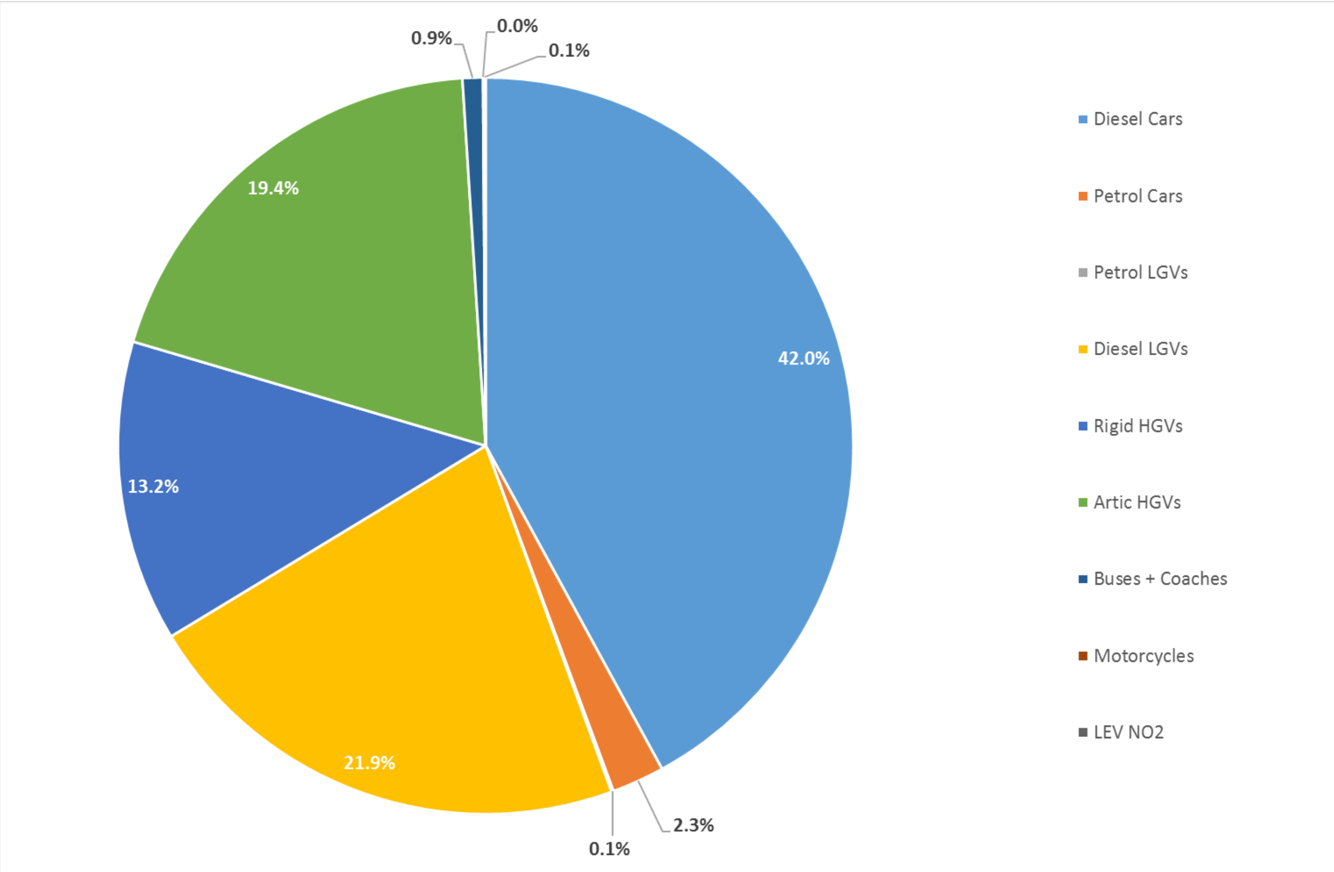


Figure 8: Indicative Breakdown of the Local Component (22.8 µg/m^3) of the Monitored NO_2 Concentration at R9 by Vehicle Type (%)

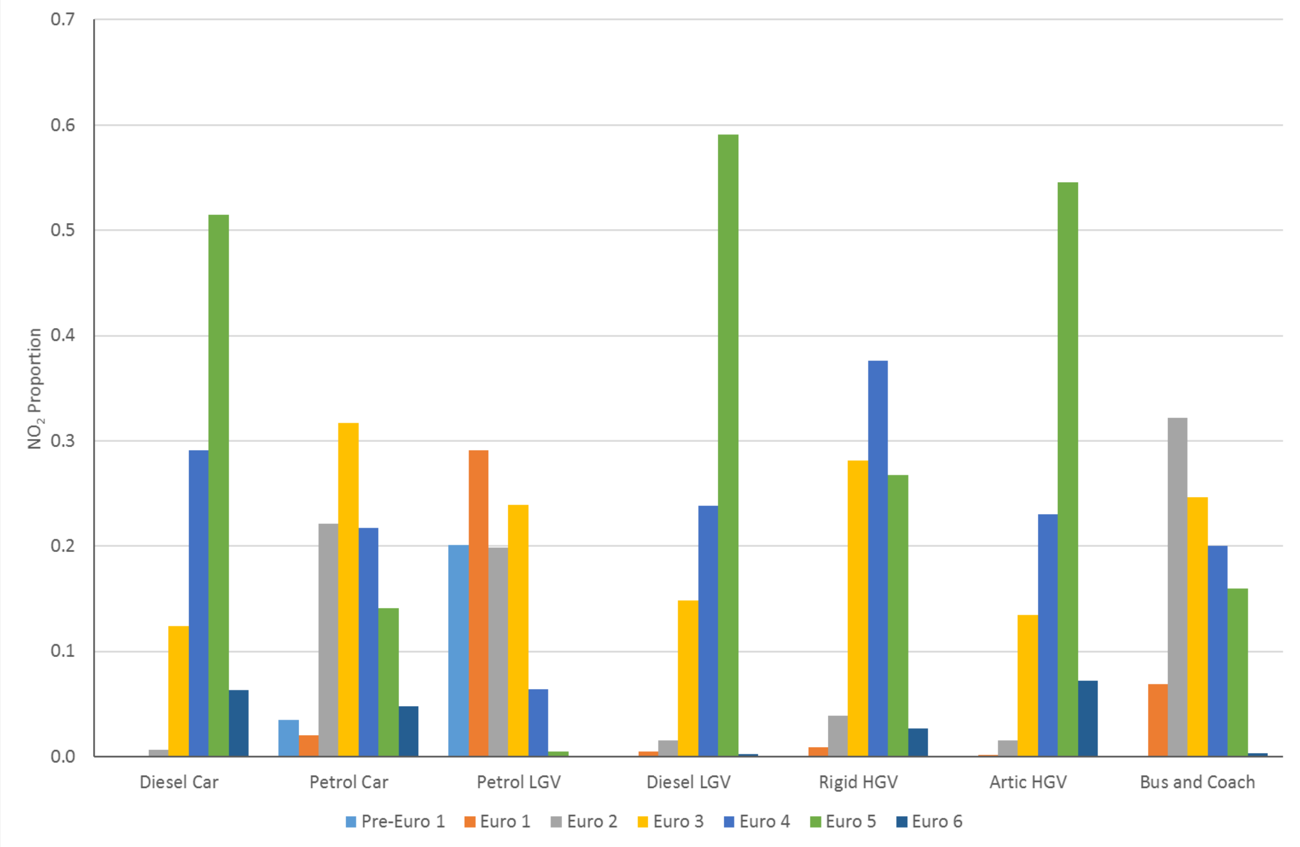


Figure 9: Relative NO_2 Contribution from Each Vehicle Type Euro Class on the A38 Kingsway near R9

A38 Queensway

Receptor 8 (R8) is located on a lamppost within 2m of the southbound Queensway carriageway. R8 was used for source apportionment in the A38 Queensway focus area; see **Figure 1** for a map of its location. The site was downwind from Queensway, the main pollution source, and the 2015 monitored concentration exceeded the NO_2 objective by over 14 µg/m^3. The site was not located at a relevant exposure location.

Traffic volume data came from DfT count point 16361 and ANPR fleet proportions came from A38AQ5. Both traffic monitors were located about 2km north of R8 on the A38. Immediate sources of air pollution that will affect the A38 Queensway focus area are limited to:

- Traffic emissions from the A38; and
- Regional (long-range) sources.

As the Queensway area is not immediately surrounded by residential properties, and is downwind of a large park, residential and domestic heating sources are a negligible factor. In addition, industrial emissions are negligible as there are no large installations nearby. The Markeaton Crematorium is more than 1km from the area and is shown to contribute a small amount to the background. Other industrial sources are further away and contribute to the regional background.

Breakdown of Measured Concentrations

Figure 10 summarises the indicative calculated composition of the measured (2015) annual mean NO_2 concentration at site R8 alongside the southbound A38 Queensway.

The regional component contributes approximately 16.5 µg/m^3, and the local background is 2.7 µg/m^3. The local component NO_2 is the largest contribution to the overall annual mean and is estimated to be around 35.2 µg/m^3.

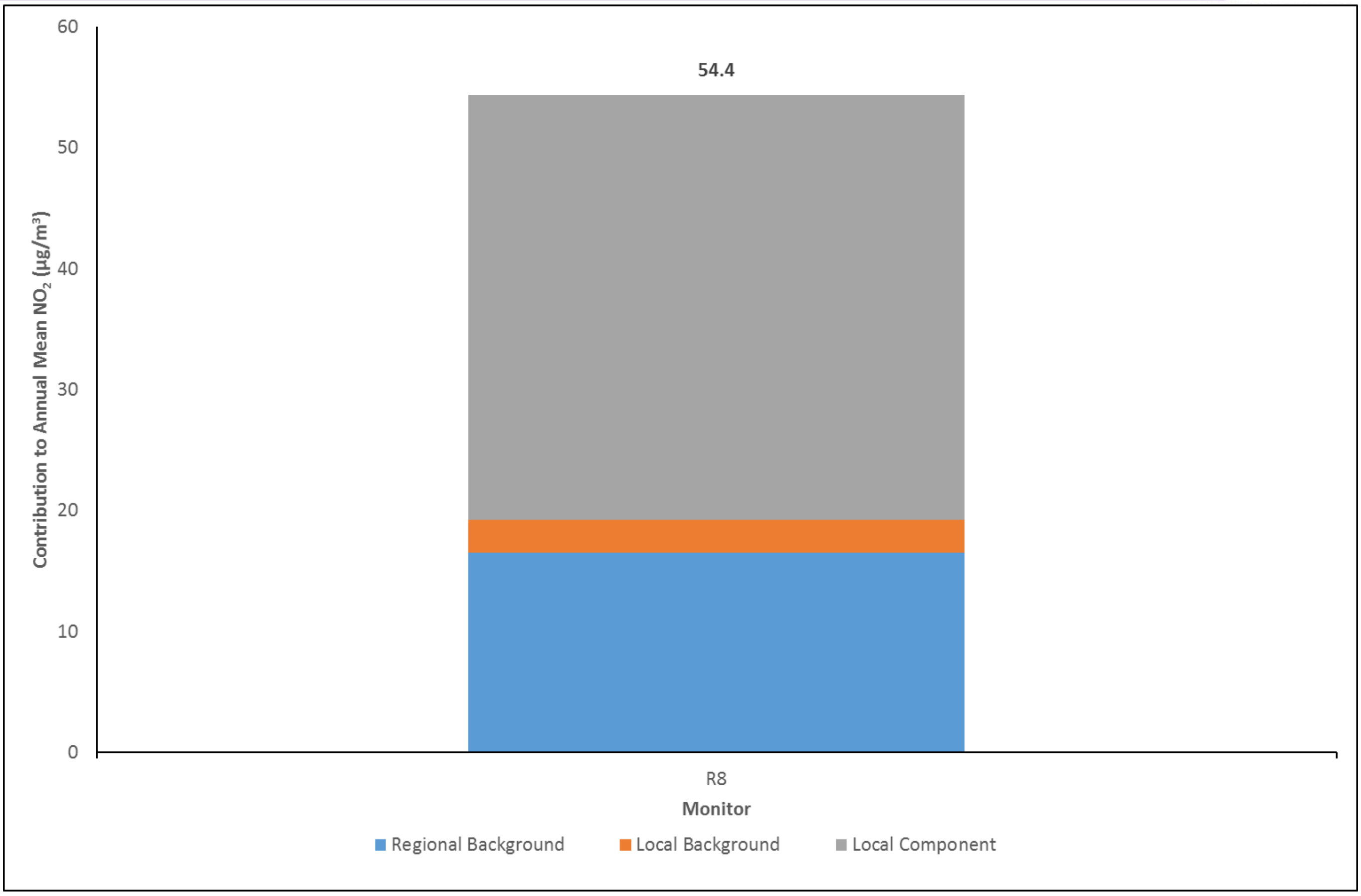


Figure 10: Indicative Composition of Annual Mean NO_2 at R8 in the A38 Queensway Focus Area

Composition of Background

Figure 11 shows that of the 2.7 µg/m^3 local background NO_2 contribution, approximately 81% is attributed to Main Roads, which includes contributions from the A38 and the A52. Another 17% is from smaller local roads in the area which brings the total road contribution to the local background to 98%. This is more than the other A38 areas in percentage terms, where the local background NO_2 was higher and the contribution from other sectors made up more of the local background component. The area surrounding R8 is less residential than other A38 sites. Markeaton Park is located directly west and upwind of the area. Based on this evidence, road traffic emissions are likely to be the only significant contributor of NO_2 in the area.

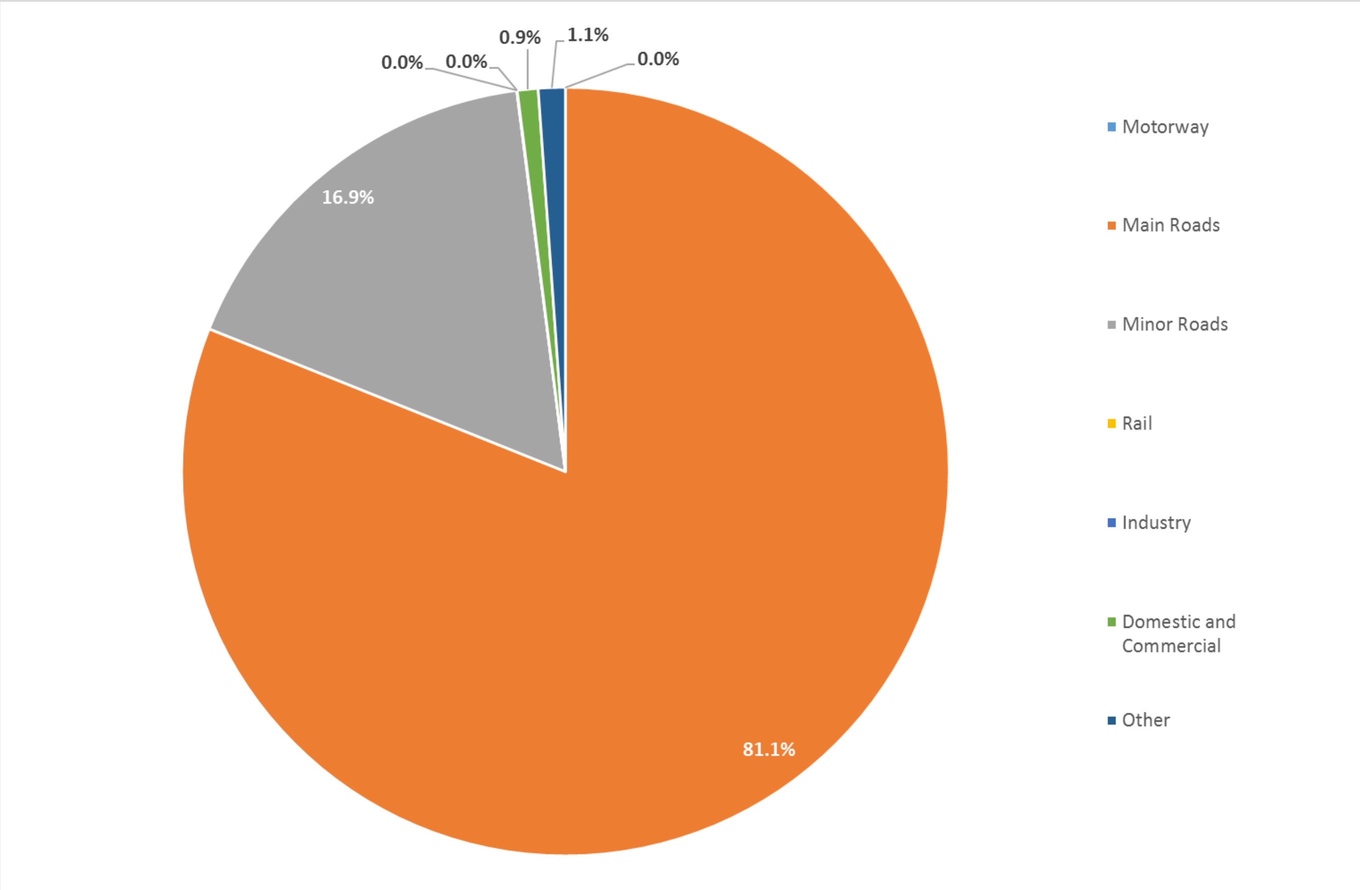


Figure 11: Indicative Composition of Local (non-Rural) Background NO_2 (2.7 µg/m^3) at R8 in the A38 Queensway Focus Area (%)

Local Component - Traffic Contribution

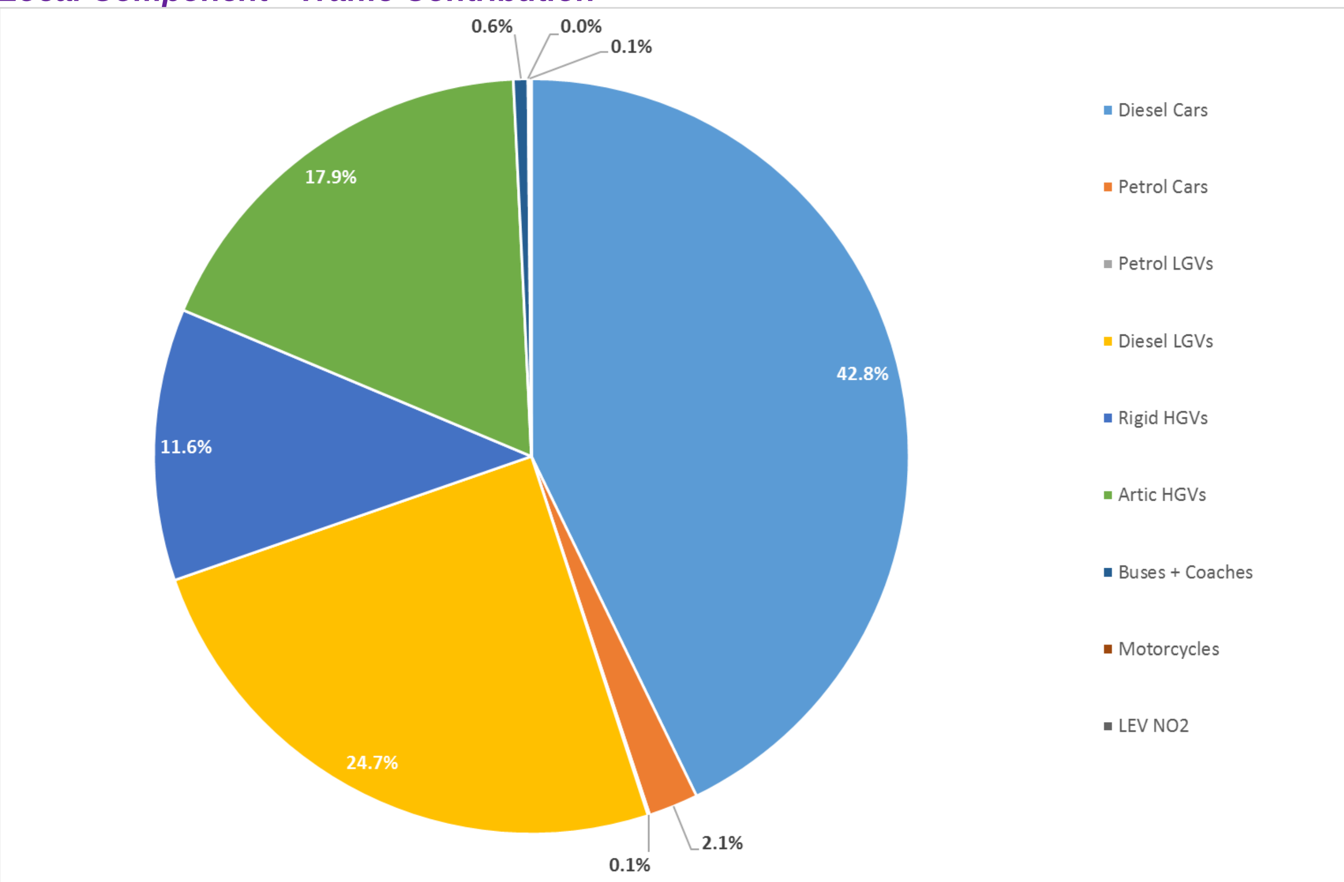


Figure 12 shows the percentage contributions of each vehicle type to the local NO_2 component. Relative

NO_2 contributions by vehicle types are comparable to other A38 focus areas, with the largest contribution (68%) coming from diesel light duty vehicles (cars and LGVs). The second largest contribution is from HGVs at just under 30%, like the other A38 sections. The contribution made by buses (0.6%) is small, similarly to the A38 Kingsway, based on the fact that less buses make use of the A38 north of the Kingsway junction up to A38 Queensway area.

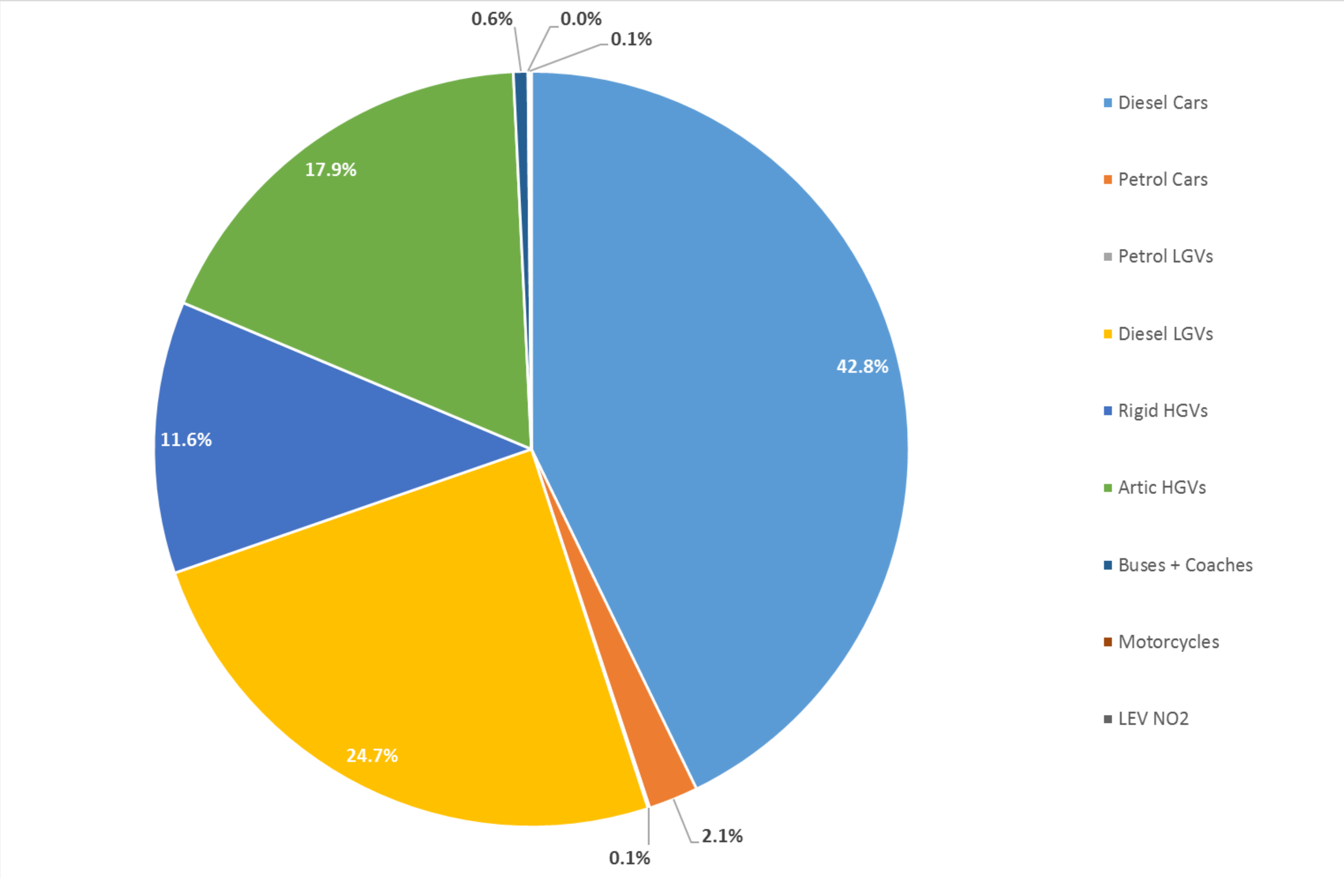


Figure 12: Indicative Breakdown of the Local Component (35.2 µg/m³) of the Monitored NO_2 Concentration at R8 by Vehicle Type

Figure 13 shows Euro 5 to be the largest contributing class to the local NO_2 component for diesel light duty vehicles (cars and LGVs), and articulated HGVs. This is consistent with other A38 areas. Euro 3 buses and coaches have the largest contribution of this vehicle type, significantly more than other Euro classes. This is unlike the A38 main carriageway which highlights the variation between bus fleet age in various areas of Derby.

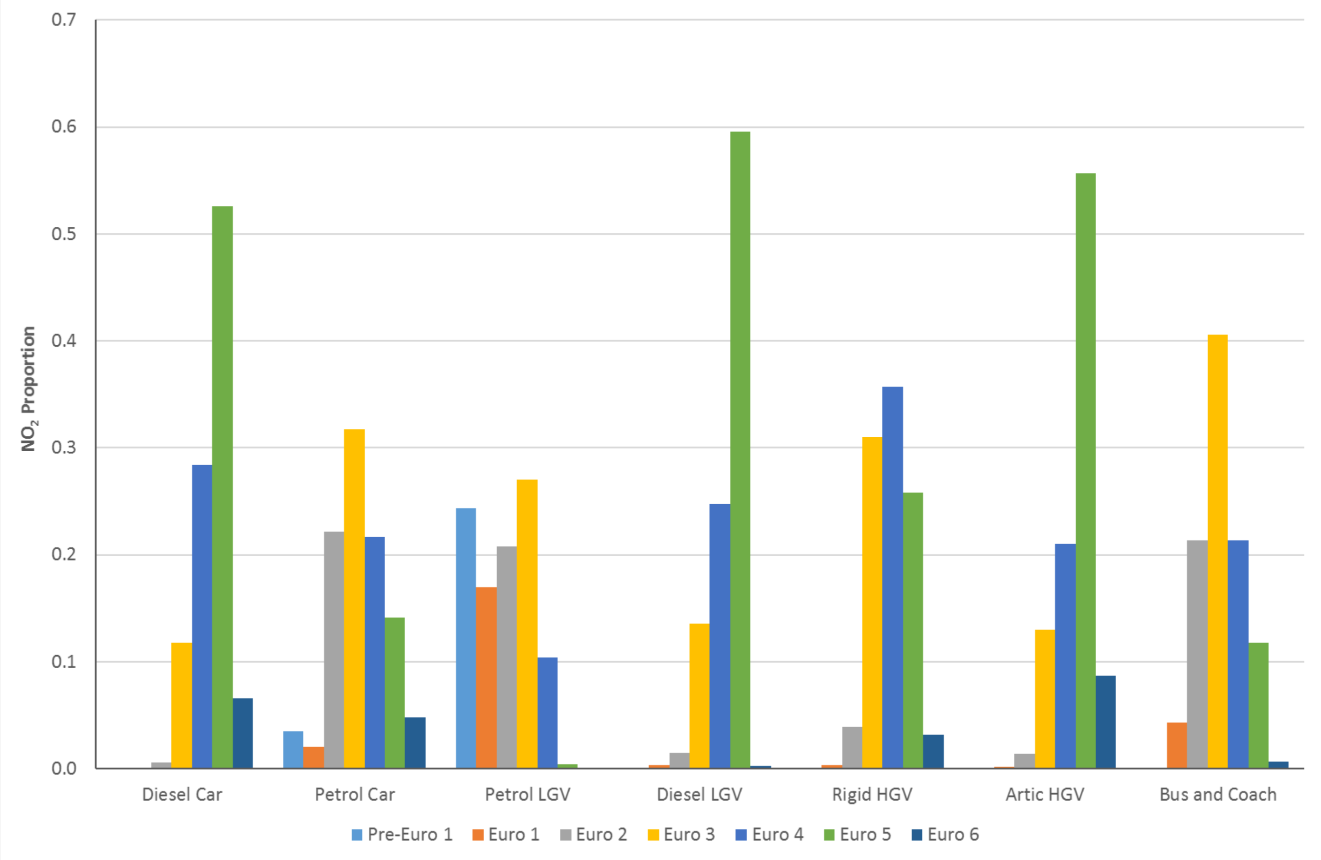


Figure 13: NO_2 Contribution from Each Vehicle Type Euro Class on the A38 Queensway near R8.

A52 Corridor

There are two shortlisted receptors within the A52 area, both located east of the Markeaton junction, towards the Derby Inner Ring Road AQMA. The locations of these receptors are presented in **Figure 1**. Receptor 7 (R7) is located directly east of the junction, and Receptor 3 (R3) is further east towards Derby city centre. Both sites used traffic data from DfT count point: 16520, and ANPR camera: A38AQ7. Immediate sources of air pollution that will affect the A52 focus area are limited to:

- traffic on the A52 accessing Derby City Centre and local businesses and employment sites;
- domestic heating sources in the surrounding neighbourhoods; and
- regional emissions from long-range pollution dispersion (including sources outside the UK).

Breakdown of Measured Concentrations

Figure 14 summarises the indicative calculated composition of the measured (2015) annual mean NO_2 concentrations at R3 and R7. The regional component contributes around 17 to 18 µg/m^3 for both sites, and the local background component is around 5.5 µg/m^3. There is a striking difference in the local NO_2 component between the two sites that indicates the influence of traffic conditions. At R3 the local component is approximately 13 µg/m^3, whereas at R7 it is nearly 30 µg/m^3. R7 is located adjacent to the A52 on the approach to Markeaton junction, queuing traffic on this stretch of road is the likely cause of this higher local NO_2 component.

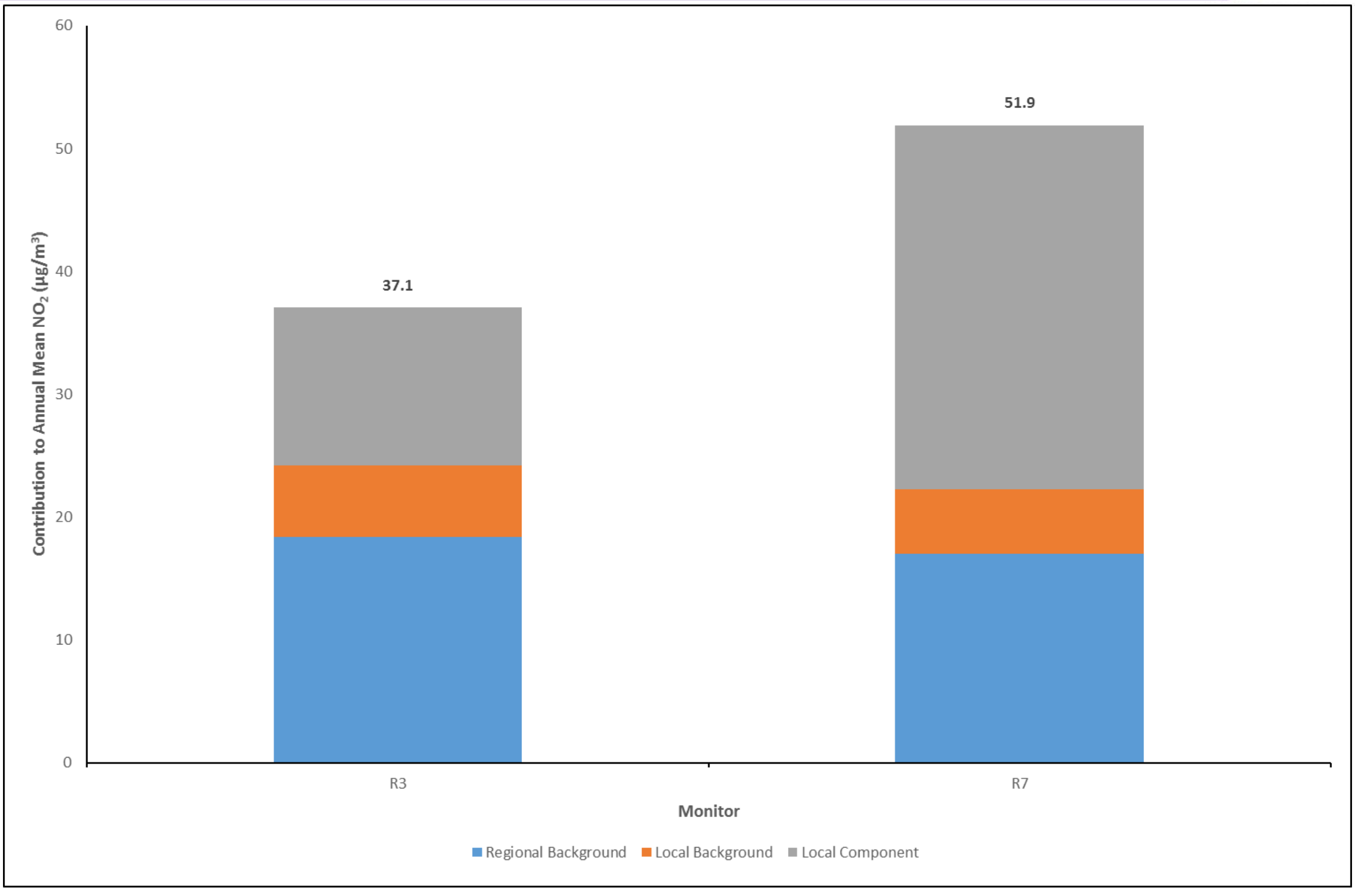


Figure 14: Indicative Composition of Annual Mean NO_2 at R3 and R7 in the A52 Focus Area

Composition of Background

Table 2 provides the breakdown of the local background NO_2 for R3 and R7 into sector contributions. R3 has a higher local background component as it is located closer to Derby city centre, where there are more emissions sources contributing to background NO_2, such as more densely packed road and domestic sources. The sector breakdown is similar at the two sites. The main NO_2 contributions are from major and minor roads, as both grid squares containing the sites include the A52 and many surrounding local roads.

Domestic and commercial sources contribute a similar amount at both sites because the surrounding area is predominantly residential, with some businesses along the A52.

Table 2: Local Background concentration and the breakdown of sector contributions for sites R3 and R7 in the A52 focus area.

Site	Local Background NO_2 (µg/m^3)	% Contribution of Local Background NO_2 Sectors Contributions (µg/m^3)						
		Motorway	Main Roads	Minor Roads	Rail	Industry	Domestic and Commercial	Other
R3	5.8	0.0 (0.0)	37.1 (2.1)	43.5 (2.5)	0.0 (0.0)	0.0 (0.0)	12.6 (0.7)	6.8 (0.4)
R7	5.3	0.0 (0.0)	34.9 (1.8)	47.3 (2.5)	0.0 (0.0)	0.9 (0.0)	11.6 (0.6)	5.3 (0.3)

Local Component - Traffic Contribution

Table 3 presents the breakdown of the local NO_2 component by vehicle type for R3 and R7. The proportions (%) are the same because the same ANPR camera (A38AQ7) was used for both sites. Absolute concentrations differ due to differences in traffic emissions at either site. **Figure 15** represents vehicle-type local NO_2 component splits along the A52 for both R3 and R7. Diesel light duty vehicles (cars and LGVs) make the highest contributions to NO_2 (approximately 75% in total, which is higher than all the A38 sections). Other vehicle types contribute much less, such as HGVs (10%), Buses and Coaches (8%) and Petrol Cars (6%). Other vehicle-type contributions are negligible.

Table 3: Breakdown of the Local NO_2 component by vehicle type by % contribution and concentration ($\mu g/m^3$) for sites R3 and R7 in the A52 focus area.

Component	Contribution (%)	NO_2 Concentration ($\mu g/m^3$)	
		R3	R7
Total, Local NO_2 Component	100.0	12.9	29.6
Diesel Cars	53.8	6.9	15.9
Petrol Cars	6.4	0.8	1.9
Petrol LGVs	0.1	0.0	0.0
Diesel LGVs	22.1	2.8	6.5
Rigid HGVs	9.0	1.2	2.7
Artic HGVs	0.9	0.1	0.3
Buses + Coaches	7.7	1.0	2.3
Motorcycles	0.0	0.0	0.0
LEV	0.1	0.0	0.0

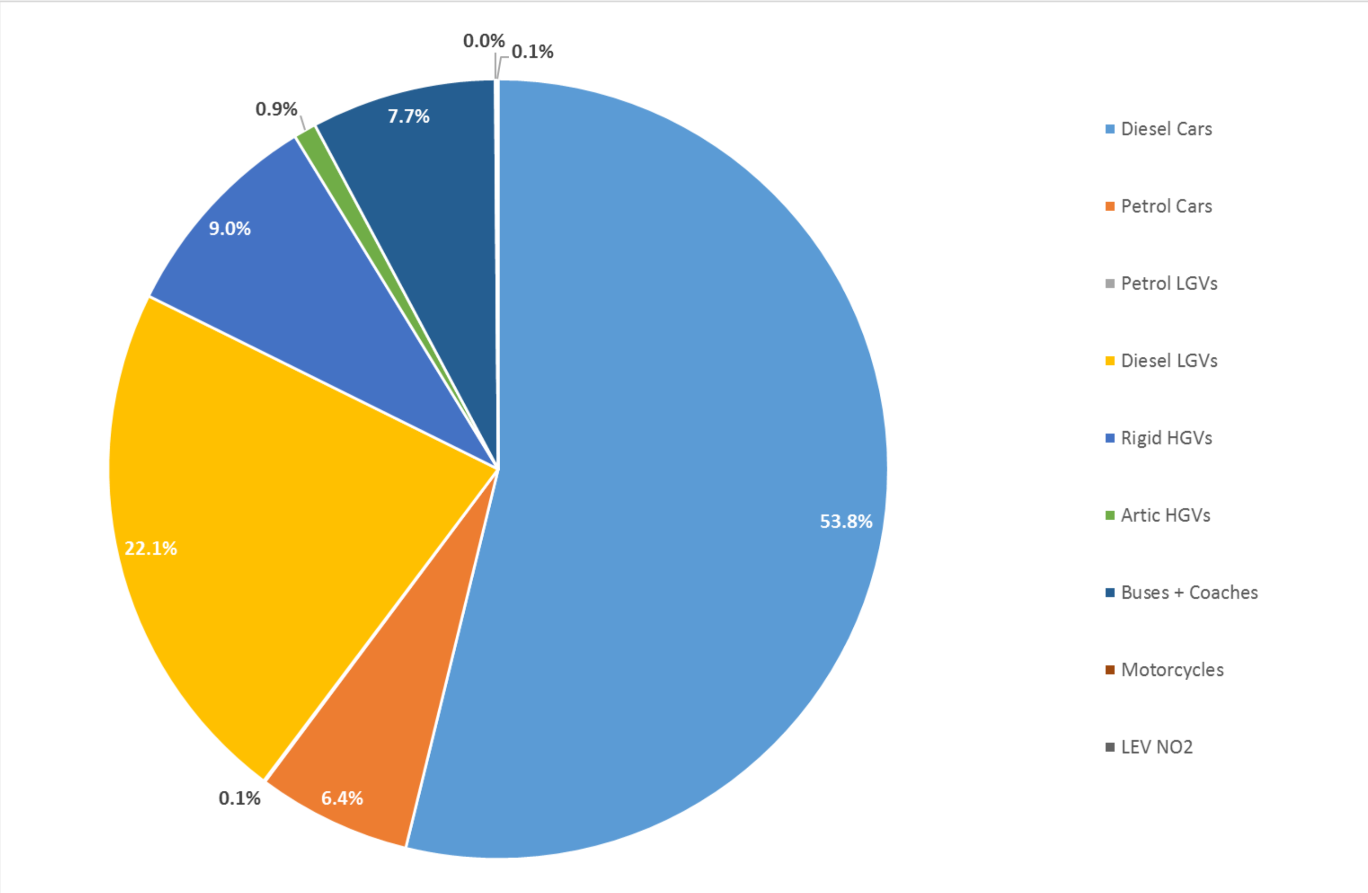


Figure 15: Indicative Breakdown of the Local Contribution of the Monitored NO_2 Concentration at R3 and R7 in the A52 Focus Area by Vehicle Type

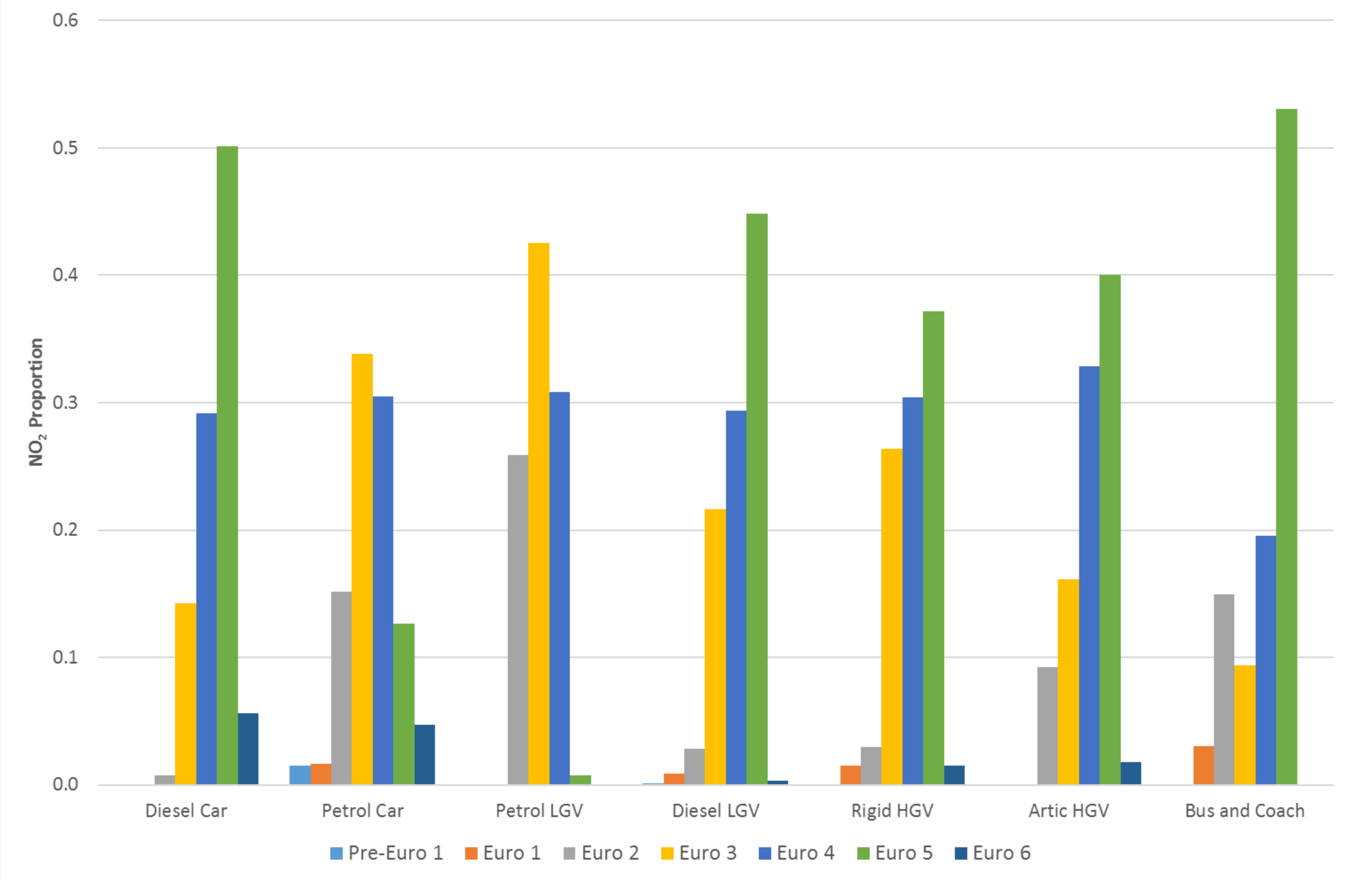


Figure 16: Relative NO_2 Contribution from Each Vehicle Type Euro Class on the A52 for R3 and R7.

Figure 16 shows the relative contribution from each vehicle type by Euro class. Euro 5 vehicles are the largest contributors for all Diesel vehicles (Diesel cars, HGVs, LGVs and Buses and Coaches). For Euro 5 Buses and Coaches the difference is significantly greater than the other Euro classes for this vehicle type; with little influence from the low volumes of Euro 6 Buses. This, again, highlights a different bus fleet is employed on different bus routes in Derby.

Euro 3 is the highest emitting class for Petrol Cars and Petrol LGVs. Petrol cars and LGVs do however make small contributions to the overall local NO_2 component (see **Figure 15**).

Uttoxeter New Road and Kingsway/Manor Road (A5111)

In total, there were four shortlisted receptors within the Uttoxeter New Road/A5111 focus area, these are shown in **Figure 1**. Receptor 1 (R1), on Warwick Avenue near the intersection with Burton Road, Receptor 2 (R2), in front of 179 Uttoxeter New Road close to Derby Inner Ring Road AQMA, Receptor 5 (R5), located on the northwest corner of the intersection of Uttoxeter New Road and the A5111, and Receptor 6 (R6), located along the A5111 Kingsway slightly south of the Kingsway Manor/Retail Park roundabout. There was only one ANPR camera within this focus area that could be used, A38AQ9, which was used for vehicle-type splits and Euro-class breakdowns; the camera was nearest to R6. There were four DfT sites that were used for traffic volumes, they are:

- R1 – DfT site: 7702 on Manor Road A5111
- R2 – DfT site: 37288 on Uttoxeter New Road closer to Derby City Centre
- R5 – DfT site: 7238 on Uttoxeter New Road near the roundabout for Royal Derby Hospital and the A38 slip roads
- R6 – DfT site: 27766 near the slip roads for the A38 Kingsway junction

DfT data provide proportions of different vehicle types making up the total traffic volume, which were compared to the ANPR (A38AQ9) data for R1, R2 and R5, see **Table 4**. Most of the traffic fleet is captured by the ANPR camera, as the proportion of cars is comparable to the three DfT points. Differences are apparent between the proportions of HGVs and Buses. Despite these differences, the DfT data did not distinguish between diesel and petrol cars, which constitute most of the fleet, so were therefore not used to examine the vehicle-type split of the local NO_2 component.

Table 4: Comparison of ANPR and DfT vehicle type proportions (%) of the total fleet volume for shortlisted sites R1, R2 and R5.

Vehicle Types	ANPR9	R1	R2	R5
		DfT 7702	DfT 37288	DfT 7232
Cars	86.1	86.0	86.4	89.1
Rigid HGV	2.6	1.5	0.9	0.9
Artic HGV	1.6	0.6	0.1	0.4
Diesel LGV	8.2	10.5	9.5	7.8
Buses	0.2	0.8	2.4	1.5
Motorcycles	0.0	0.6	0.7	0.4

Description of Sources

Immediate sources of air pollution that will affect the Uttoxeter New Road/A5111 focus area are limited to:

- the traffic on the local road network
- domestic and commercial sources from the residents and businesses surrounding the area
- emissions from two stacks associated with the Royal Derby Hospital

Contributions to pollutant concentrations will additionally include those within the wider area, which forms much of the regional background component (which is made up of the combined effect of long-range sources, including those outside of the UK).

Breakdown of Measured Concentrations

Figure 17 summarises the indicative calculated composition of the measured (2015) annual mean NO_2 concentrations at the four shortlisted monitoring sites in the Uttoxeter New Road/A5111 focus area. The regional and local background components are consistent across all the sites, between 17 and 18 µg/m^3, and around 4.2 µg/m^3 respectively. Differences are apparent between the local NO_2 component at each shortlisted site, which highlights the difference in traffic conditions and emissions. The highest local component, at site R1, is approximately 30 µg/m^3; as noted in **Appendix 4** this site is located on the uphill approach to the signal for Burton Road, with idling and subsequent acceleration emissions thought to result in elevated concentrations. The local NO_2 component at the other sites is between 16 and 18 µg/m^3, with sites R5 and R6 exceeding the NO_2 objective (40 µg/m^3).

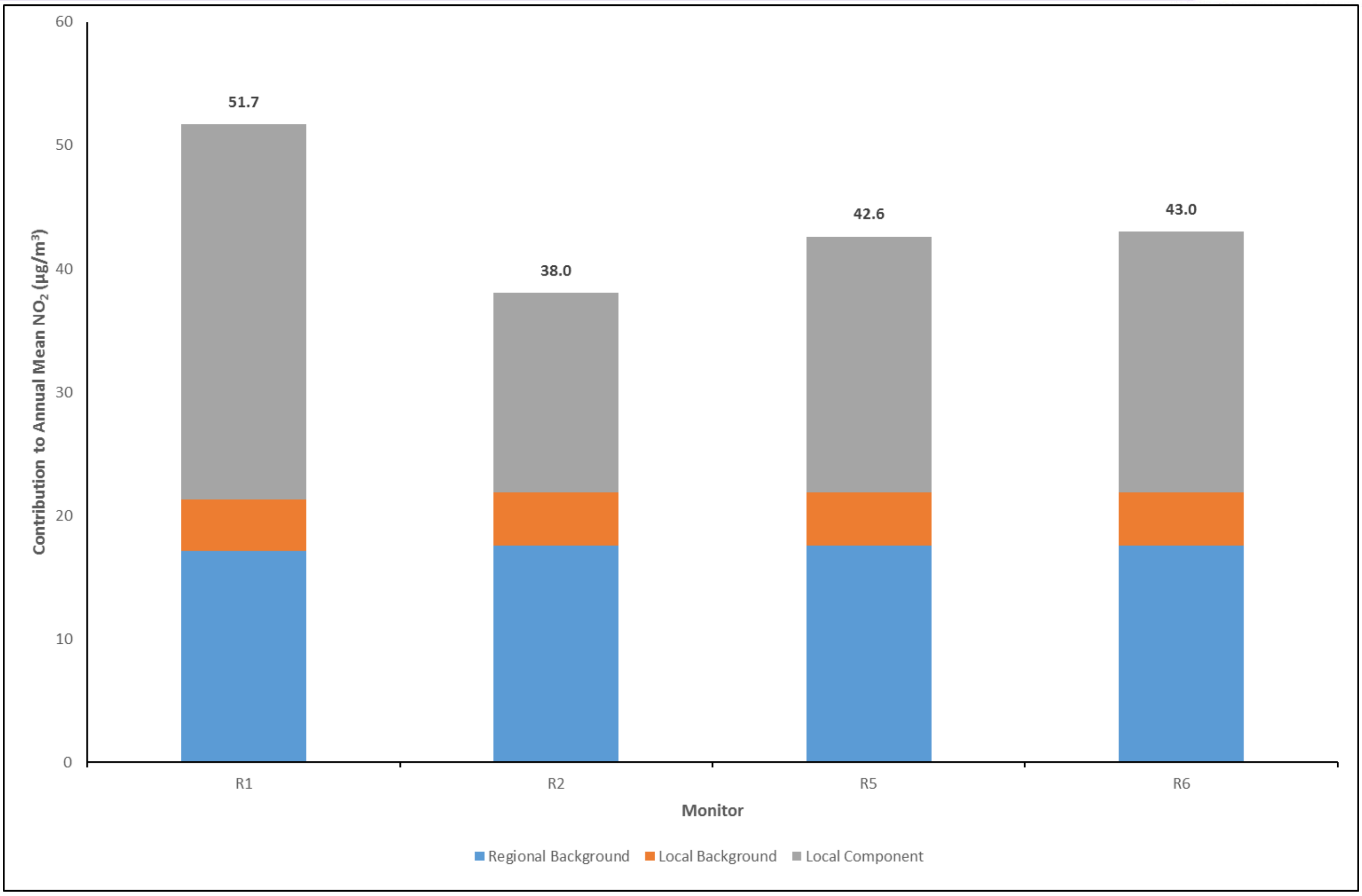


Figure 17: Indicative Composition of Annual Mean NO_2 at Four Locations in the Uttoxeter New Road/Kingsway/Outer Ring Road Focus Area

Composition of Background

Table 5 shows how the local background components are broken down into sector contributions for the shortlisted sites in this focus area. R2, R5 and R6 are all centred around the same Defra background mapping data point, so have the same background component and breakdown.

The data highlights that major and minor roads are the largest contributors to the local background NO_2 component at all sites, however, there is a large difference between the magnitude of both sectors at R1 and R2, R5 and R6 respectively. At R1, the minor road contribution is higher than the major road contribution because the mapped Defra grid-square comprises of mostly minor residential roads. The opposite is true for R2, R5 and R6 where the major road contribution is slightly more than 50%; the mapped area contains a large portion of Uttoxeter New Road and a small section of the A52.

Domestic and commercial emissions are associated with the numerous residential properties surrounding the area, and businesses scattered throughout. This component is comparable at all sites. The Other component is higher for R1 because it may include emissions from schools and or downwind effects associated with emissions from the the stacks at Royal Derby Hospital.

Table 5: Local Background concentration and the breakdown of sector contributions for sites R1, R2, R5 and R6 in the Uttoxeter New Road/A5111 focus area.

Site	Local Background NO_2 (µg/m^3)	% Contribution of Local Background NO_2 Sectors Contributions (µg/m^3)						
		Motorway	Main Roads	Minor Roads	Rail	Industry	Domestic and Commercial	Other
R1	4.2	0.0 (0.0)	34.2 (1.4)	45.3 (1.9)	0.0 (0.0)	0.1 (0.0)	19.3 (0.8)	1.2 (0.0)
R2, R5, R6	4.3	0.0 (0.0)	50.2 (2.1)	32.4 (1.4)	0.0 (0.0)	0.9 (0.0)	17.0 (0.7)	0.4 (0.0)

Local Component - Traffic Contribution

Table 6 shows the breakdown of the local NO_2 component for the four shortlisted monitoring sites in the Uttoxeter New Road/A5111 focus area. Each site used ANPR camera A38AQ9, so the contribution proportions are equivalent, however the absolute concentrations differ due to changes in traffic conditions at each site.

Figure 18 displays the contribution (%) breakdown of the local NO_2 component for the shortlisted sites. Like the A52, over 75% of the local NO_2 component is from light duty diesel vehicles (cars and LGVs), which is more than the A38 focus areas. Around 16% is from HGVs (Rigid and Artic), which is much less than the A38 areas, indicating that the A38 is a more strategic route and therefore has a higher number of HGV movements. Petrol cars contribute a small amount to the overall local component, and buses and coaches even less. All other vehicle types have negligible contributions.

Table 6: Breakdown of the Local NO_2 component by vehicle type by % contribution and concentration (µg/m^3) for sites R1, R2, R5 and R6 in the Uttoxeter New Road/A5111 focus area.

Component	Contribution (%)	NO_2 Concentration (µg/m^3)			
		R1	R2	R5	R6
Total, Local NO_2 Component	100.0	30.4	16.2	20.7	21.1
Diesel Cars	61.8	18.9	10.0	12.8	13.1
Petrol Cars	6.3	1.9	1.0	1.3	1.3
Petrol LGVs	0.0	0.0	0.0	0.0	0.0
Diesel LGVs	14.7	4.5	2.4	3.0	3.1
Rigid HGVs	10.8	3.2	1.7	2.2	2.3
Artic HGVs	5.2	1.6	0.8	1.1	1.1
Buses + Coaches	1.0	0.3	0.2	0.2	0.2
Motorcycles	0.0	0.0	0.0	0.0	0.0
LEV	0.1	0.0	0.0	0.0	0.0

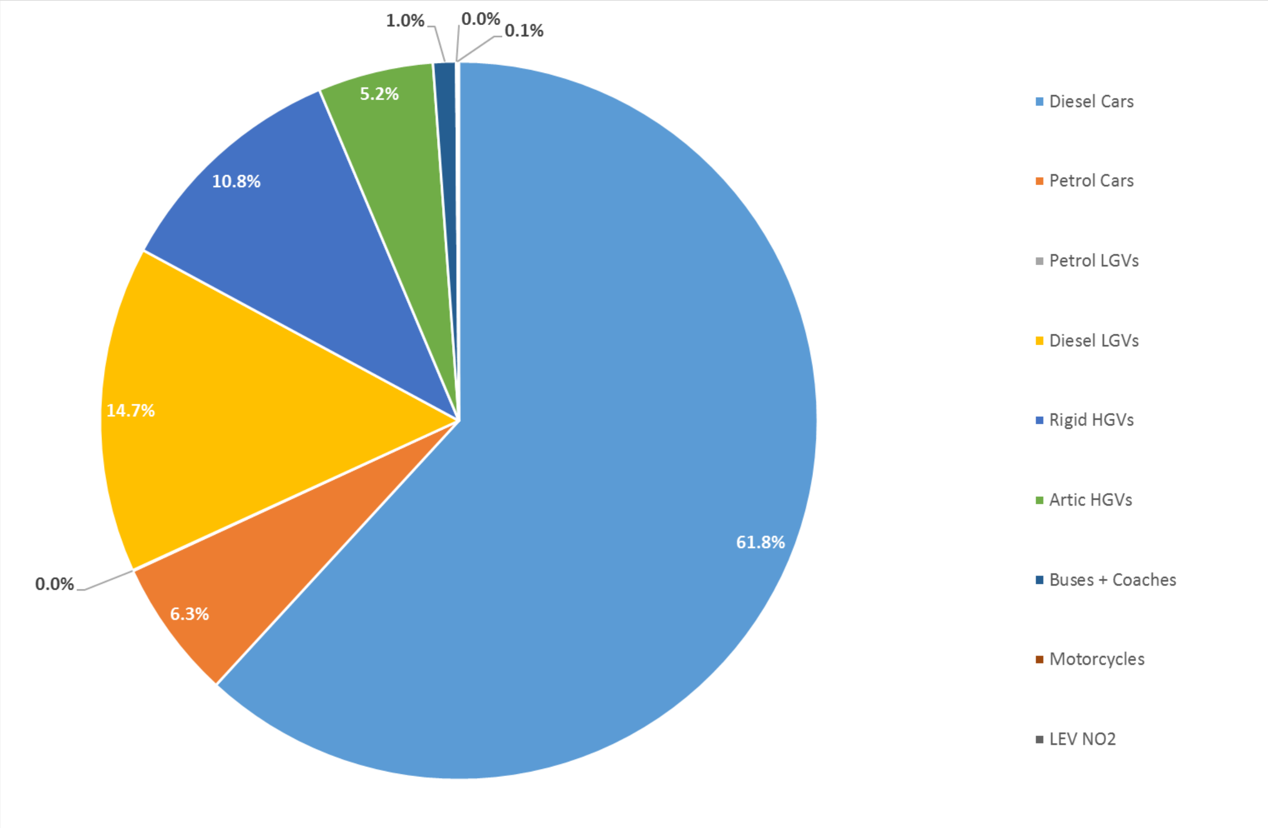


Figure 18: Indicative Breakdown of the Local Component of the Monitored NO_2 Concentration by Vehicle Type at the four shortlisted sites in the Uttoxeter New Road/A5111 focus area.

Figure 19 provides the relative NO_2 contribution for each vehicle type by Euro standard. Euro 5 is the largest NO_2 contributor for light duty diesel vehicles (cars and LGVs) and HGVs (Rigid and Arctic) in this area. For petrol cars the largest contributing class is Euro 4, with similar proportions for Euro 3 Petrol cars. The contribution of Buses and Coaches tends to be dominated by Euro 3 emissions.

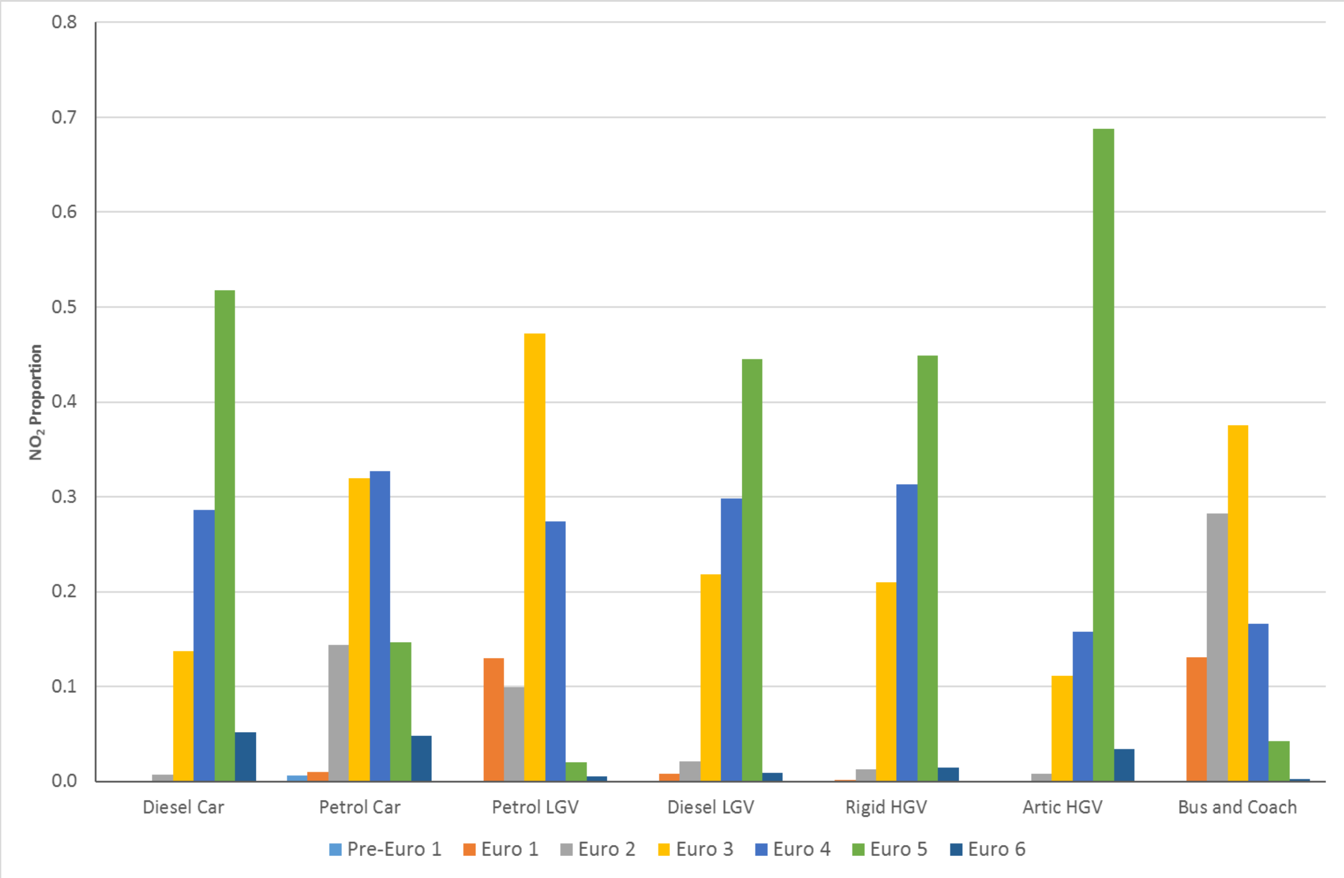


Figure 19: NO_2 Contribution from Each Euro Vehicle Type on the A5111 Kingsway near Receptor 6, representing the whole of the Uttoxeter New Road/A5111 focus area.

Summary

Table 7 presents a summary of the 2015 annual mean NO_2 concentration, the local (road) component of NO_2 and the vehicle-type breakdown of the local component at each shortlisted receptor. Combined, light duty diesel vehicles (cars and LGVs) contribute the most to the local NO_2 component at all receptors, regardless of location. Of this contribution, Euro 5 diesel cars make the largest contribution to emissions. HGV proportions indicate a difference between the A38 and local roads. The HGV contribution proportion at all A38 sites (R4, R8 and R9) is greater than 5 µg/m^3, whereas at local road sties it is less than 5 µg/m^3. Overall, sites closer to roads that are more prone to queuing traffic, show higher monitored NO_2 concentrations and therefore higher local NO_2 components.

Table 7: Vehicle-Type Breakdown of Local NO_2 Component at each Shortlisted Receptor (µg/m^3)

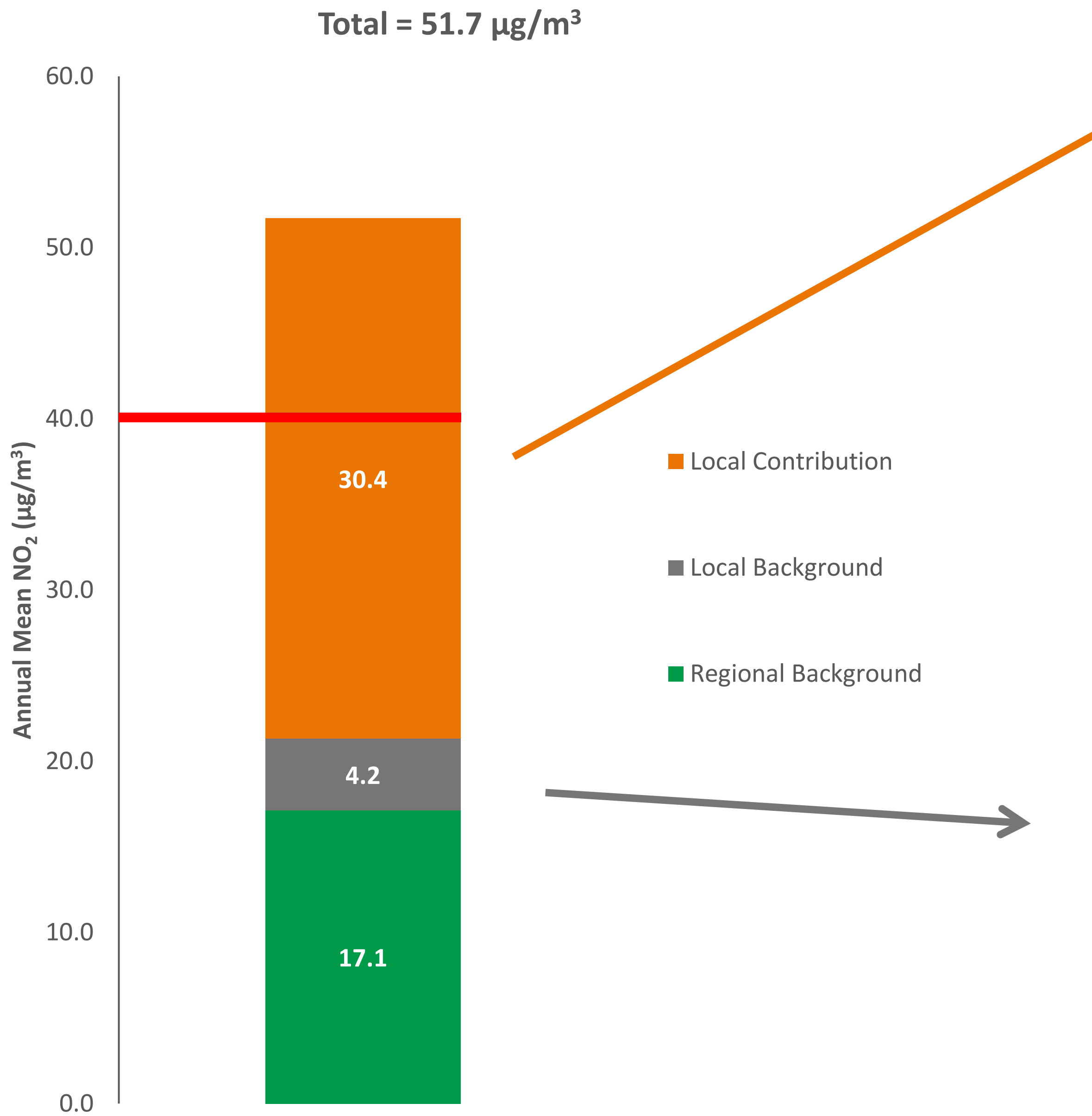
Receptor	Measured 2015 Annual Mean NO_2	Local (Road) Component	Light Duty Diesel Vehicles (Cars + LGVs)	Petrol Vehicles (Cars + LGVs)	HGVs (Rigid + Artic)	Buses + Coaches	Motorcycles	LEVs
R1	**51.7**	30.4	23.3	1.9	4.8	0.3	0.0	0.0
R2	38.0	16.2	12.4	1.0	2.6	0.2	0.0	0.0
R3	37.1	12.9	9.8	0.8	1.3	1.0	0.0	0.0
R4	**41.4**	21.8	15.3	0.5	5.6	0.4	0.0	0.0
R5	**42.6**	20.7	15.9	1.3	3.2	0.2	0.0	0.0
R6	**43.0**	21.1	16.2	1.3	3.4	0.2	0.0	0.0
R7	**51.9**	29.6	22.5	1.9	2.9	2.3	0.0	0.0
R8	**54.4**	35.2	23.7	0.8	10.4	0.2	0.0	0.0
R9	**45.1**	22.8	14.6	0.5	7.5	0.2	0.0	0.0

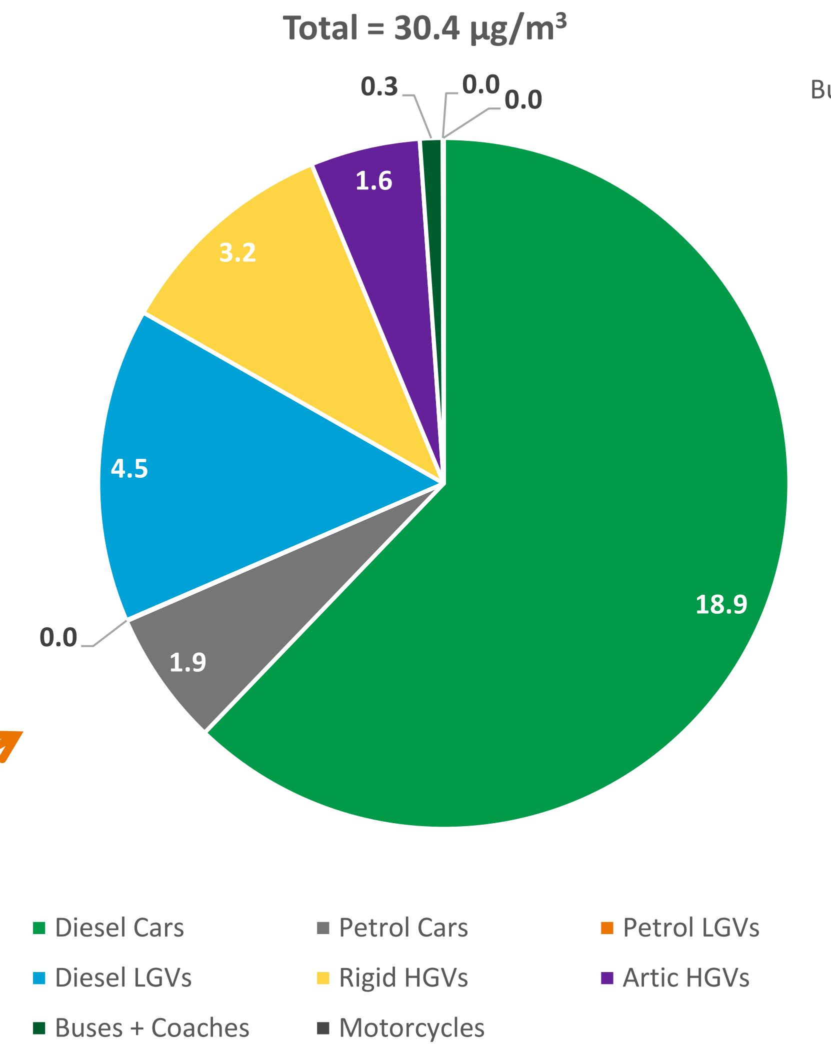
Appendix 7 – Source Apportionment Supplementary Material

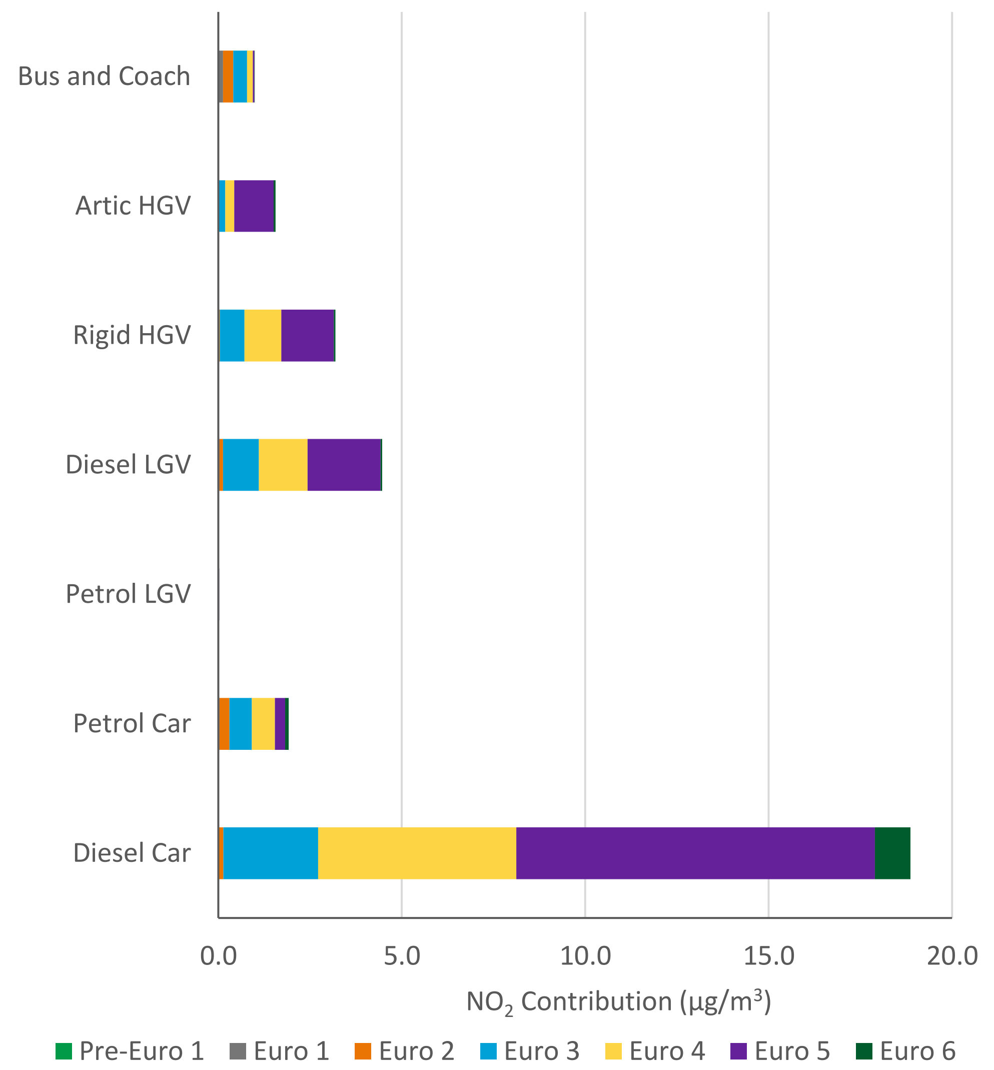
PREPARED BY:	Colin Tully
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Luke Farrugia

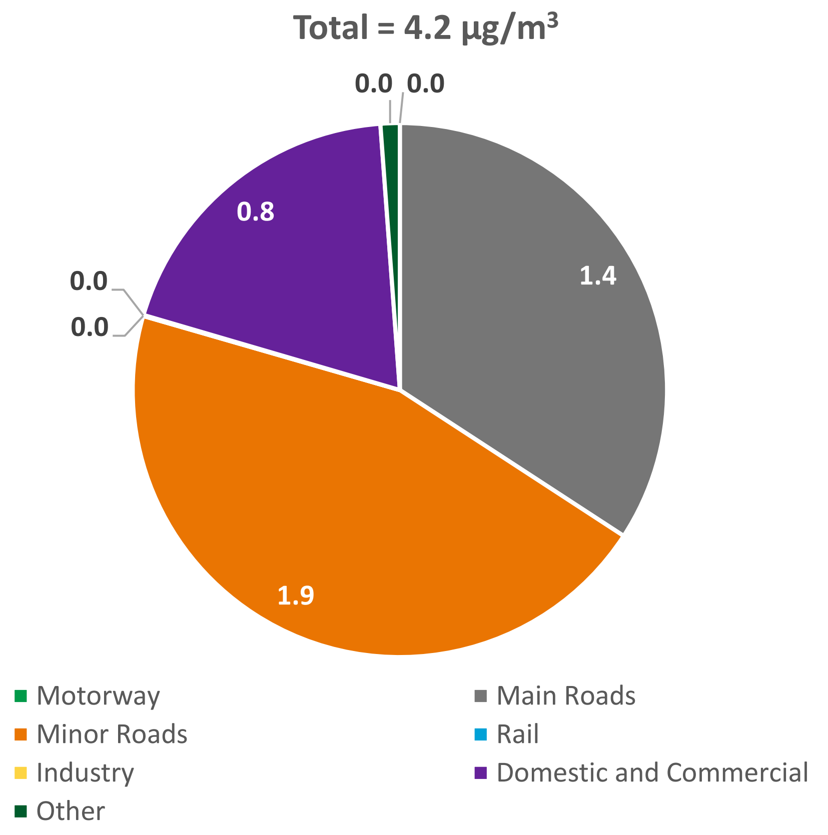
This appendix provides a breakdown of the NO_2 source apportionment findings for each of our shortlisted sites in our three focus areas. The local NO_2 contribution is broken down by source and further evidence is given to highlight the location of the measurement site and traffic count site used for the data analysed. This can be treated as supplementary material when reading **Appendix 6**.

Indicative Breakdown of Annual Mean NO_2 Concentrations at Monitor R1 (µg/m³ in 2015)









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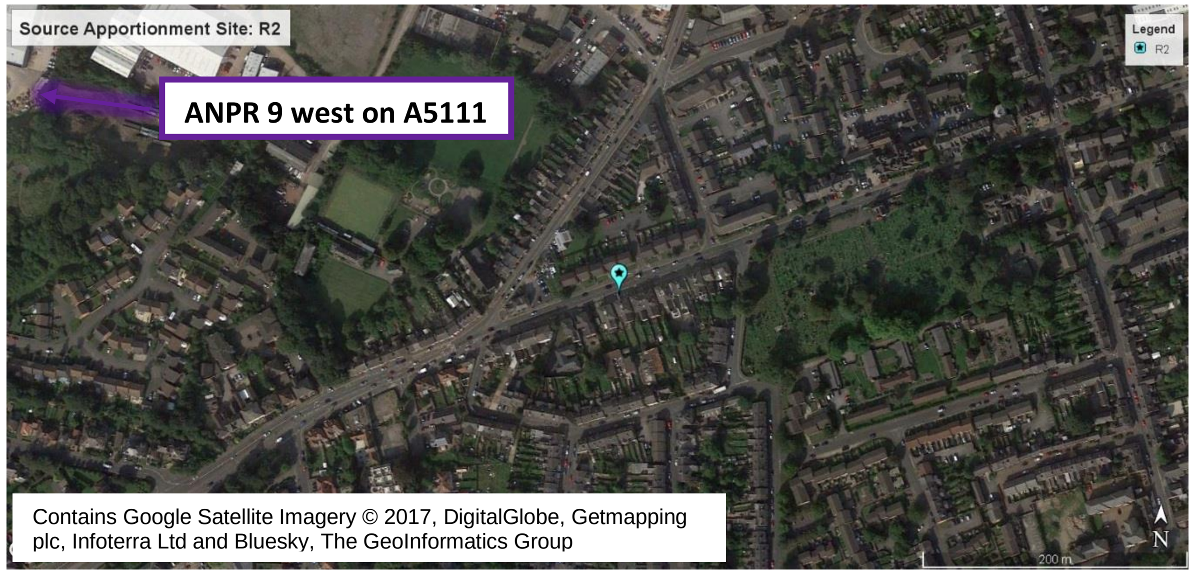

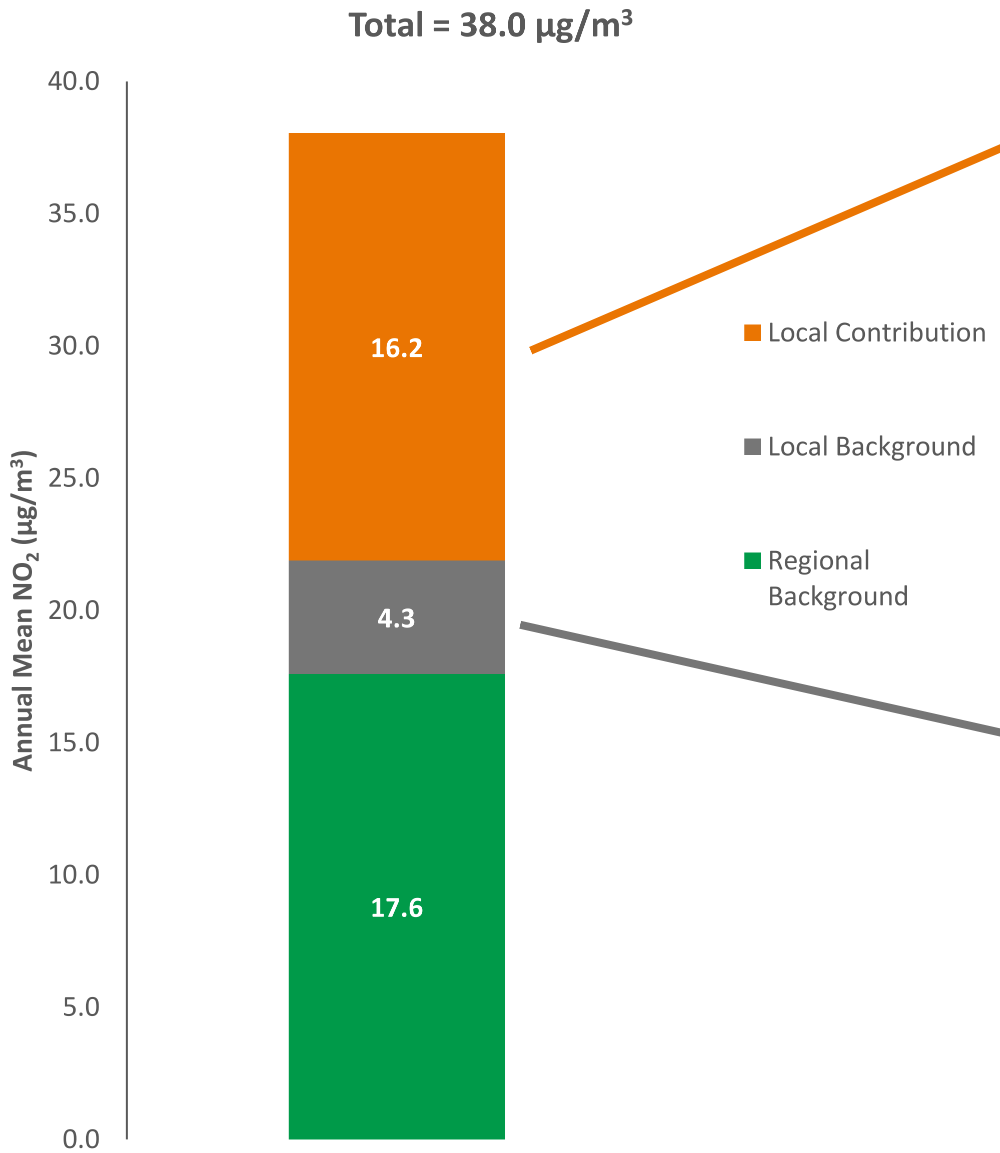

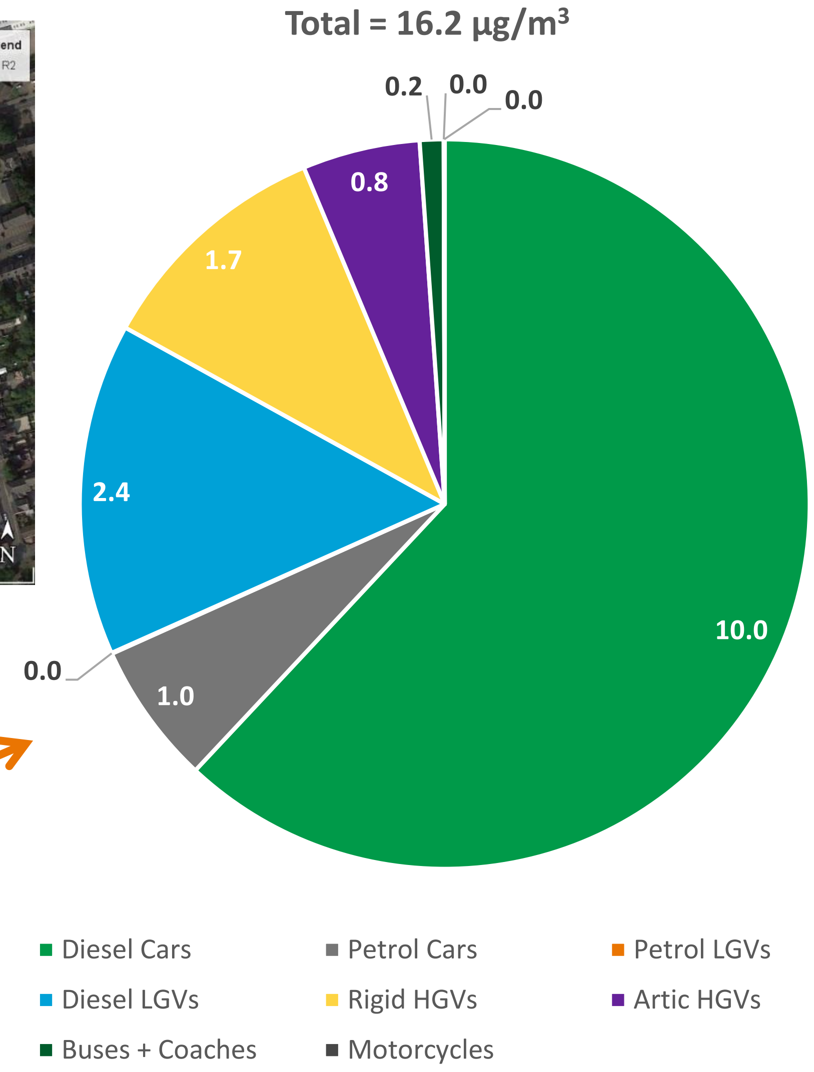

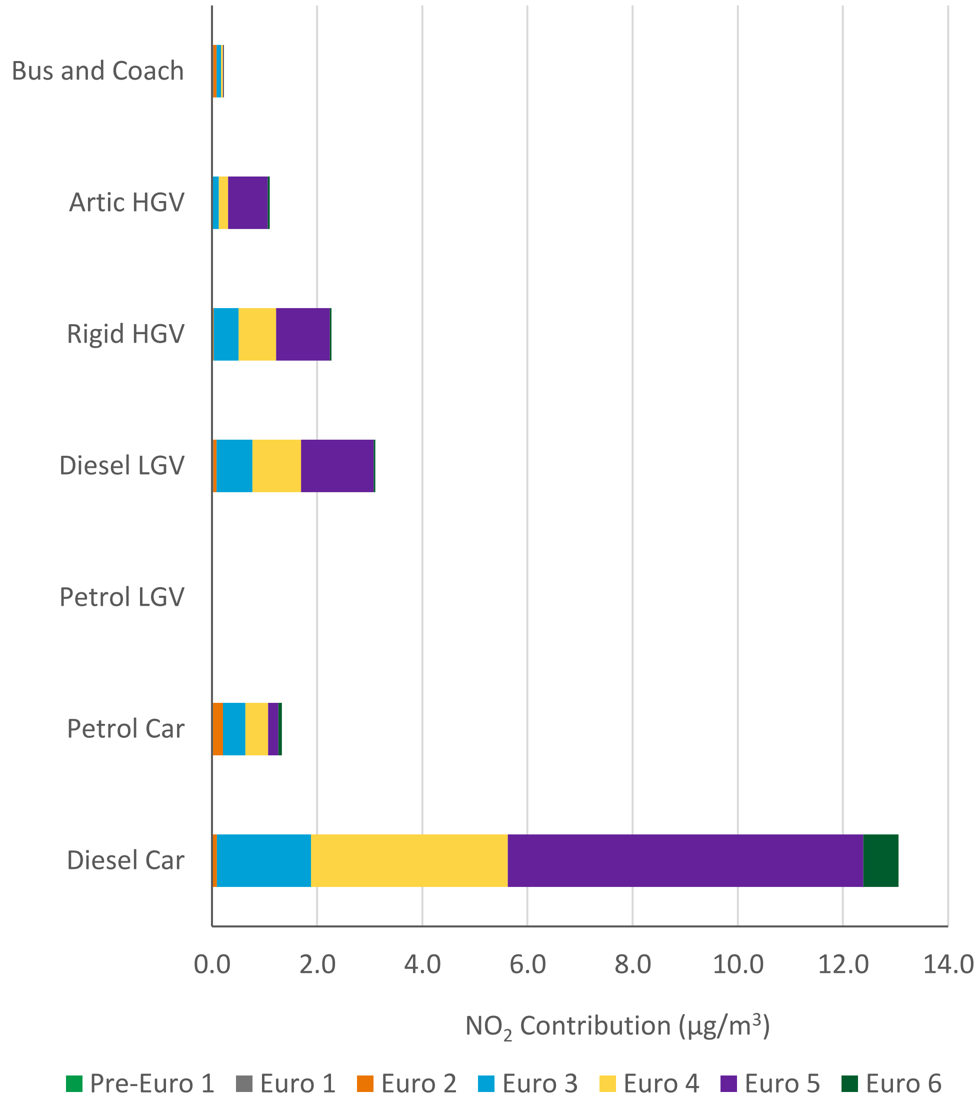

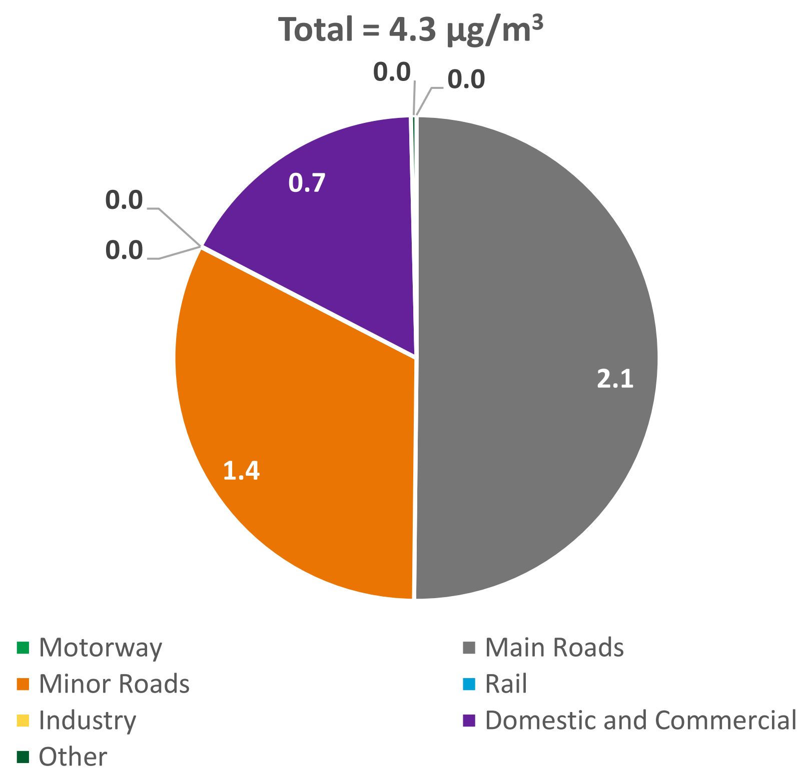

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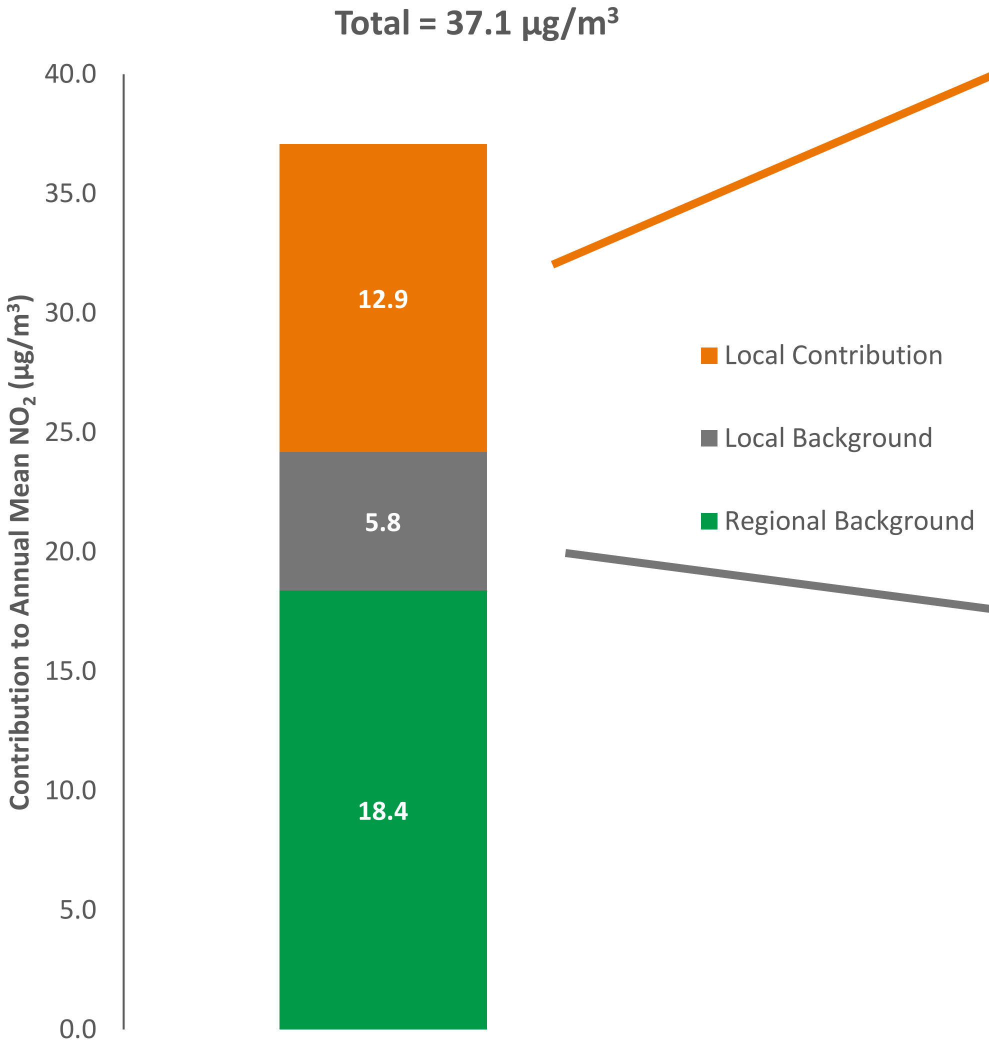

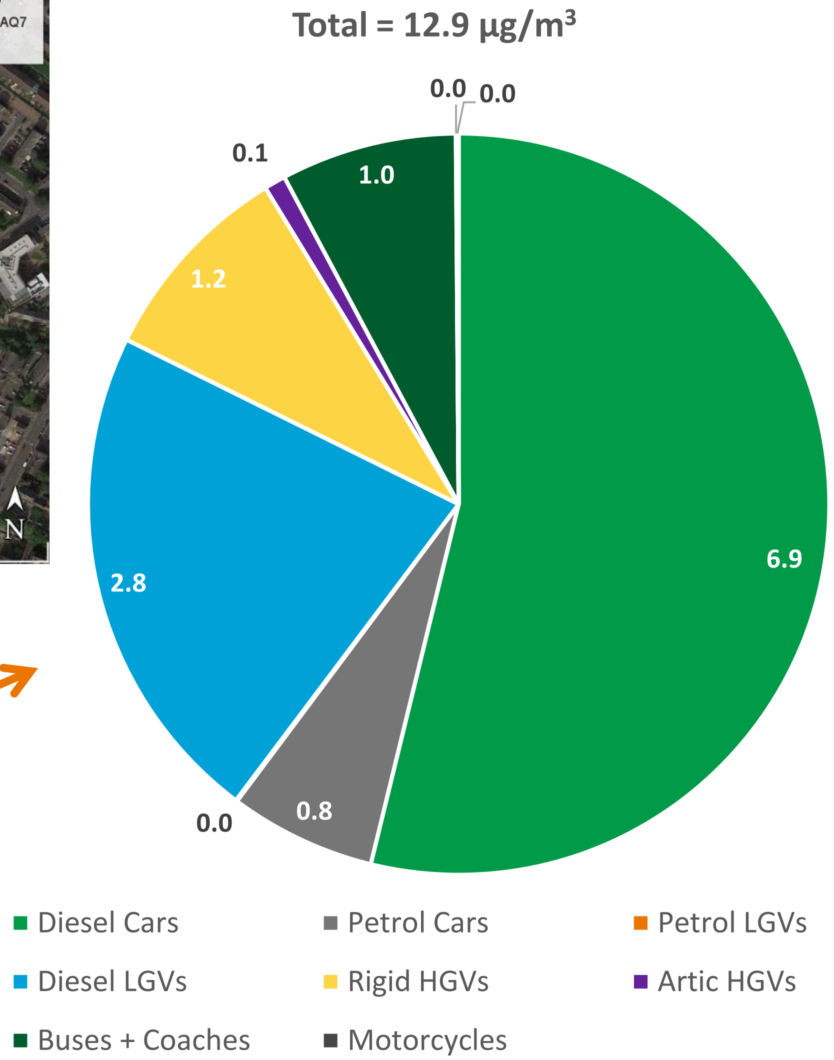

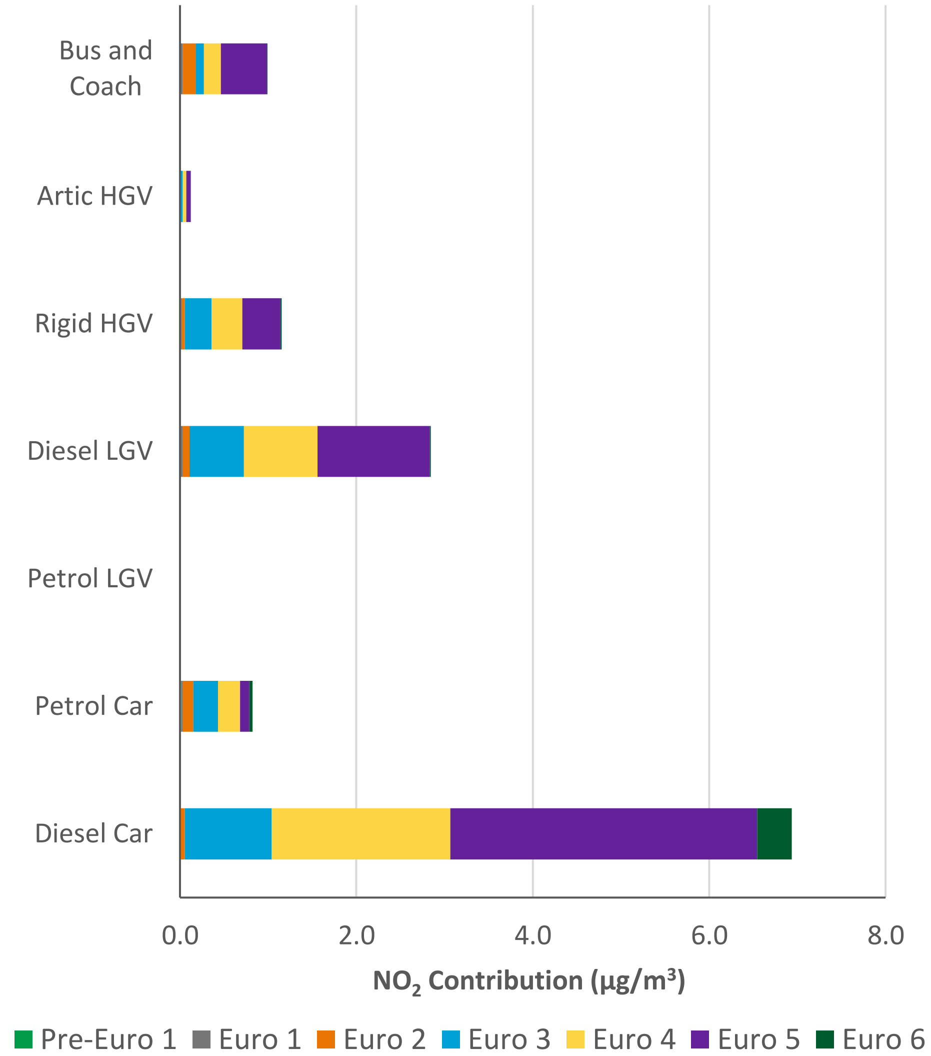

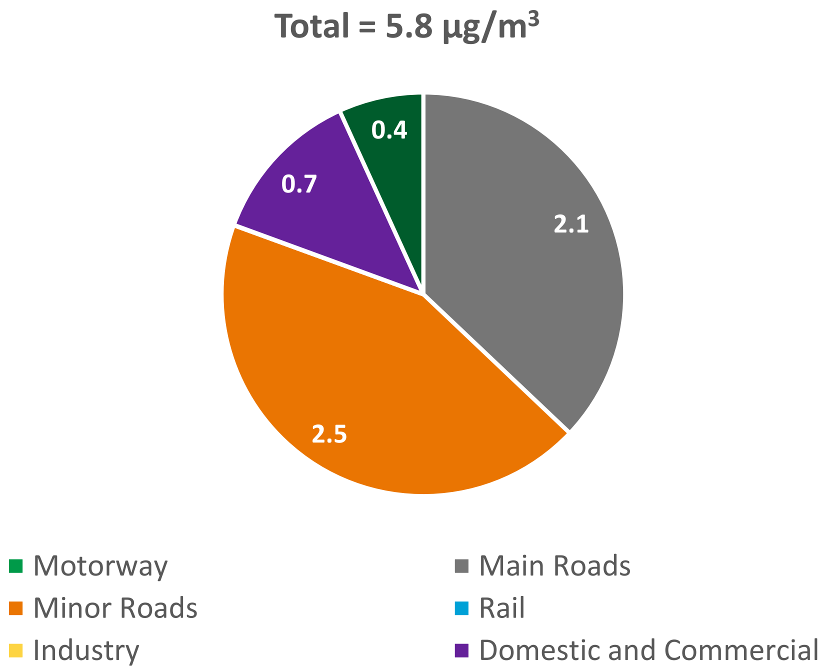

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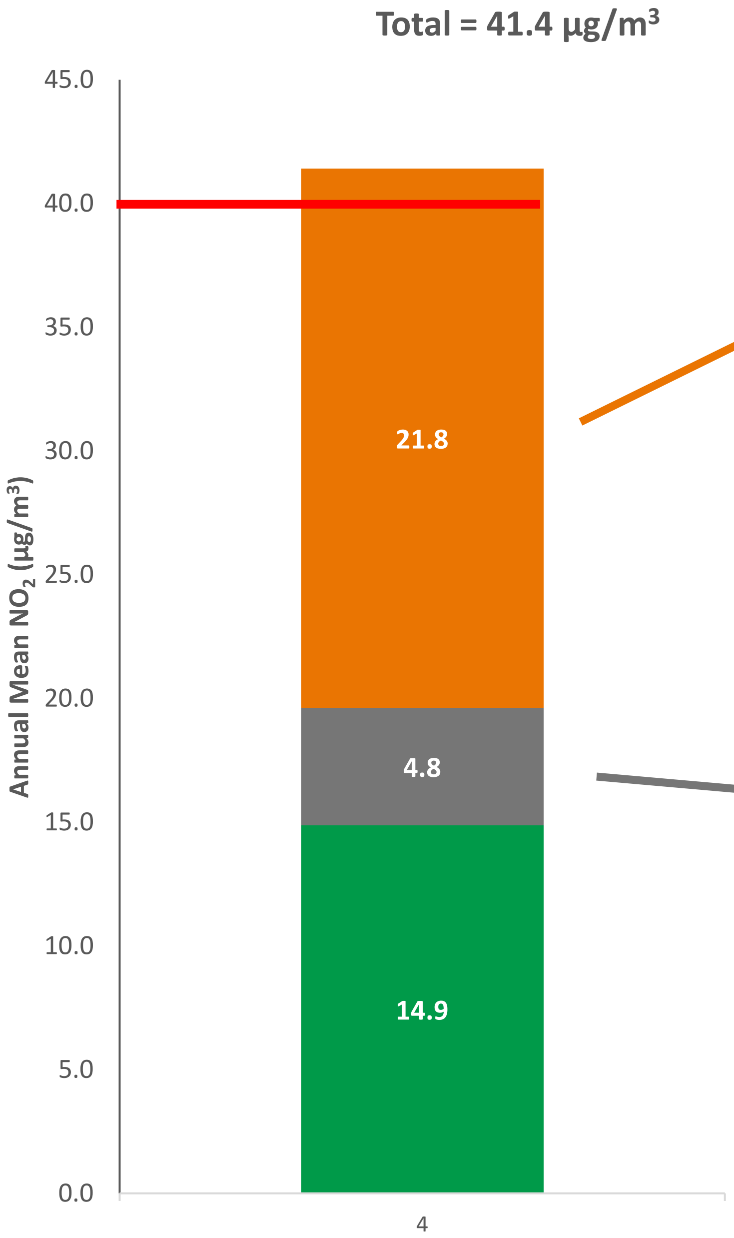

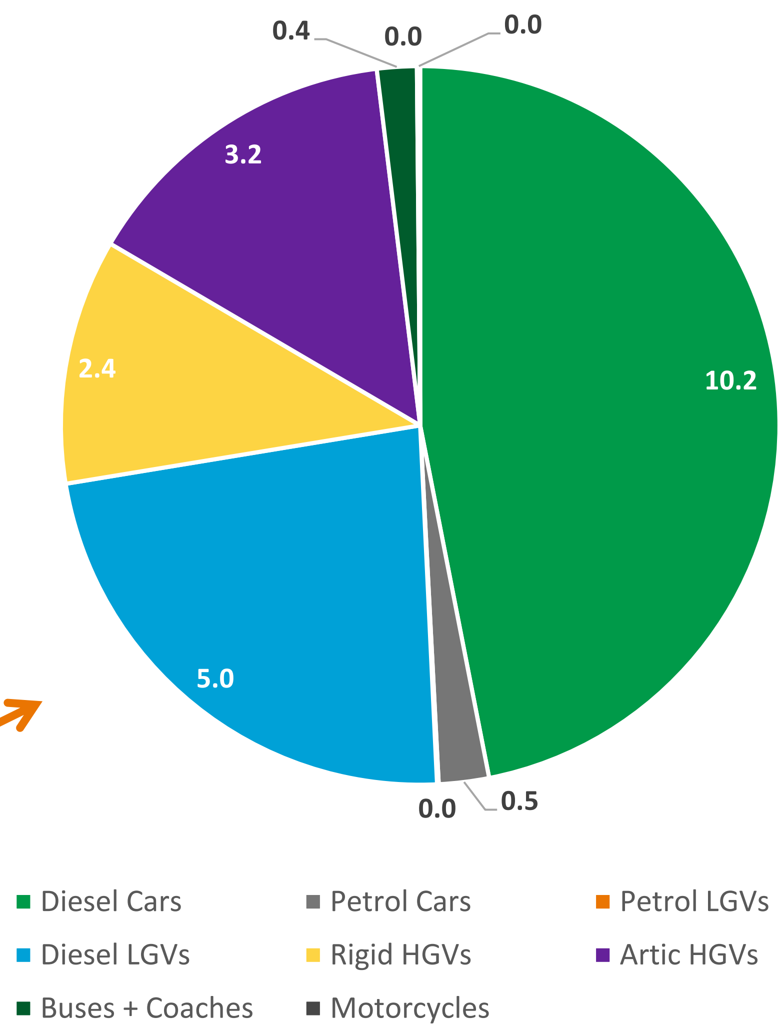

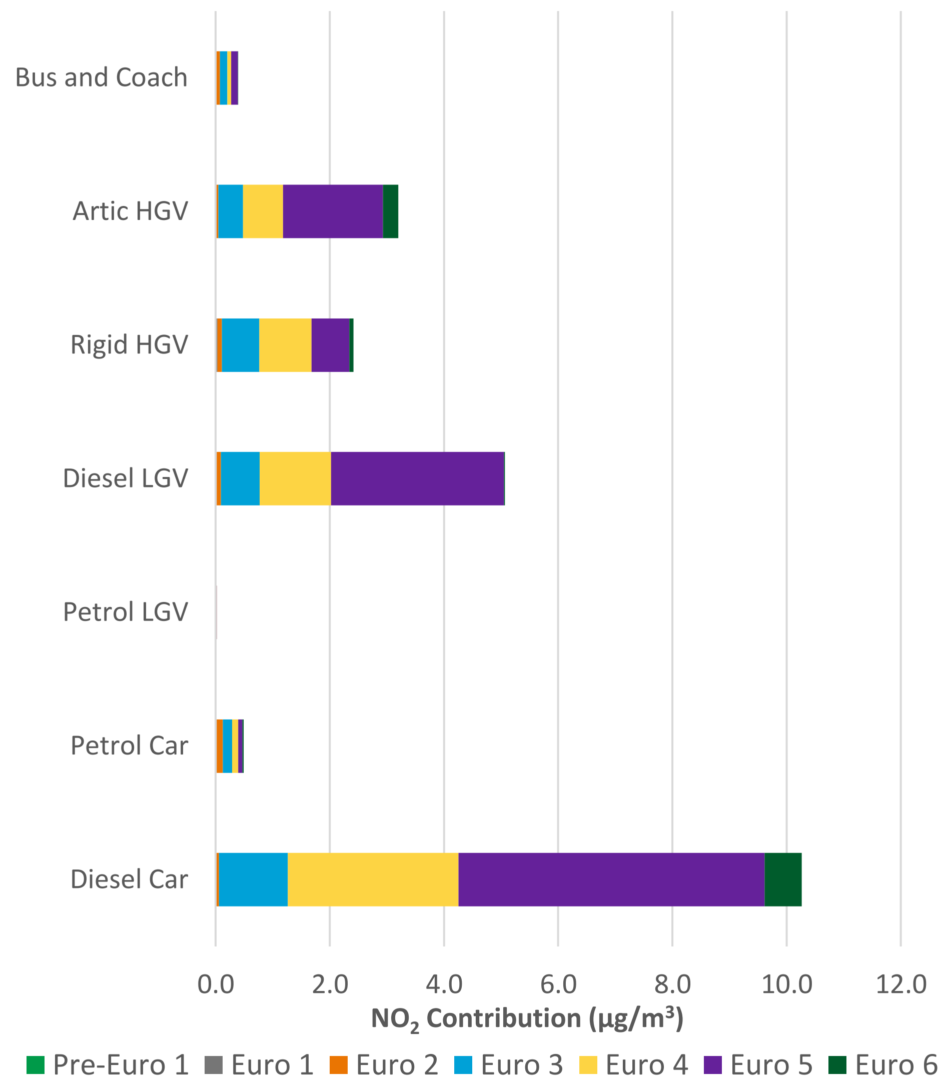

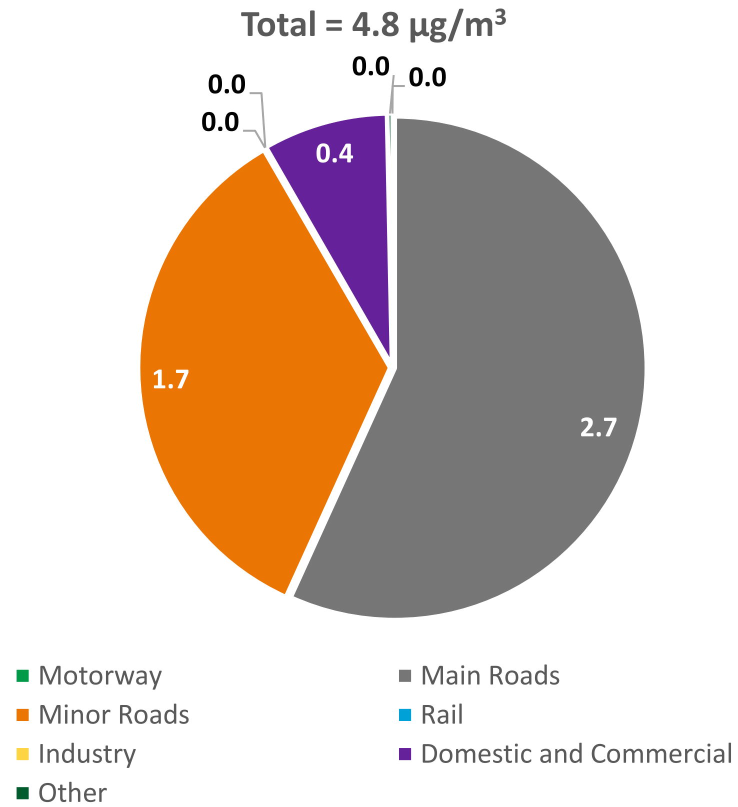

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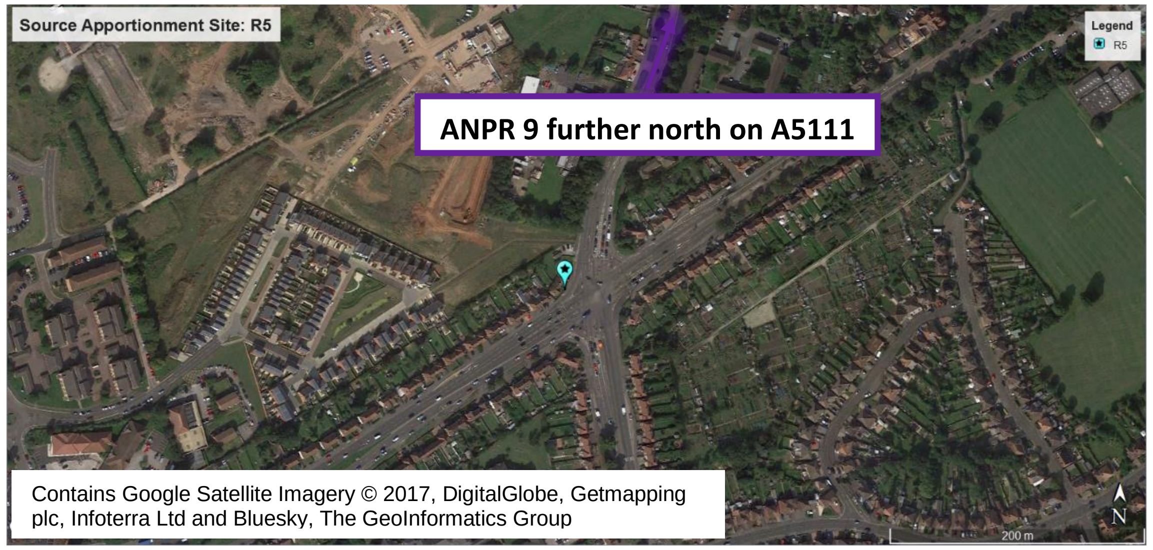

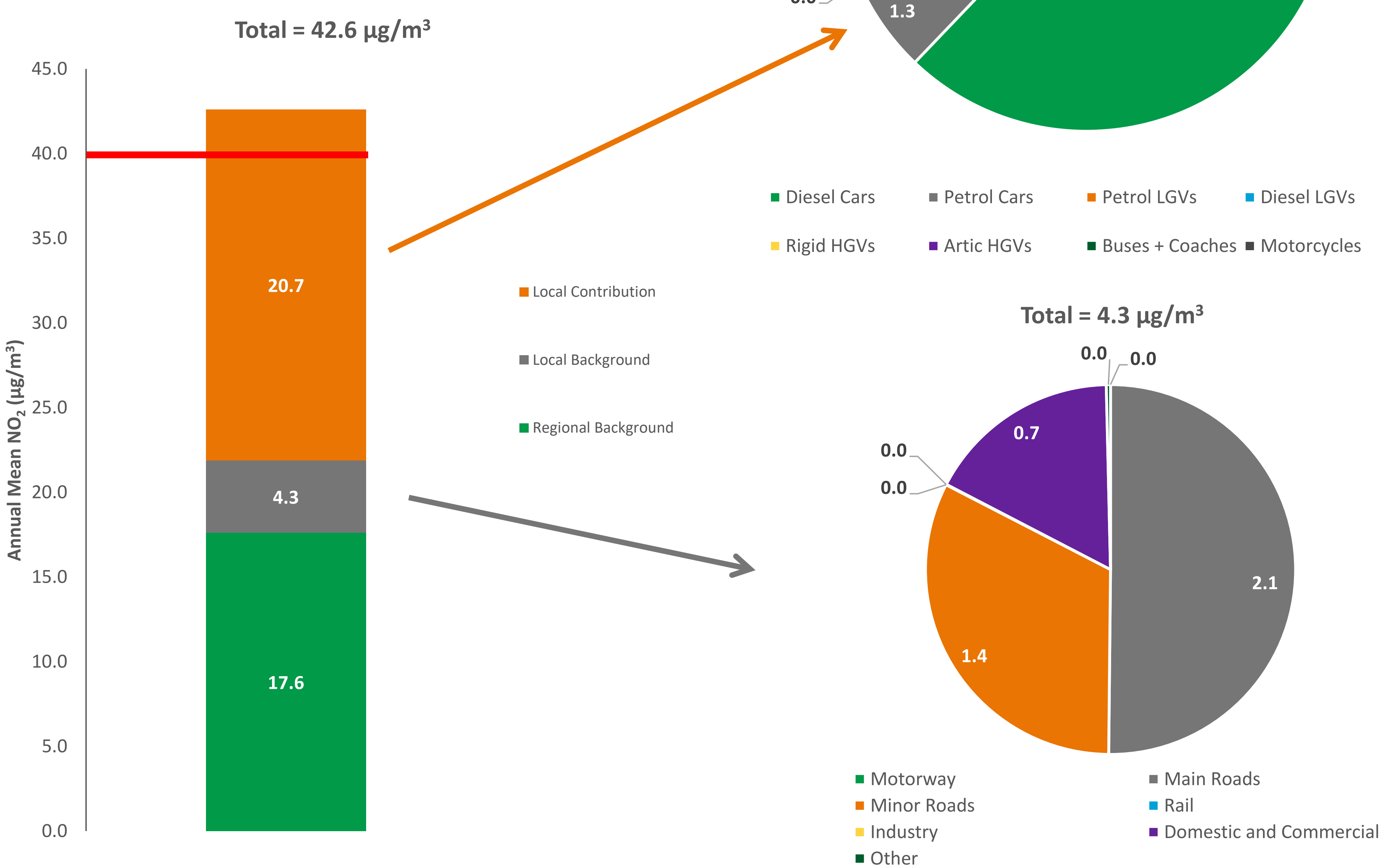

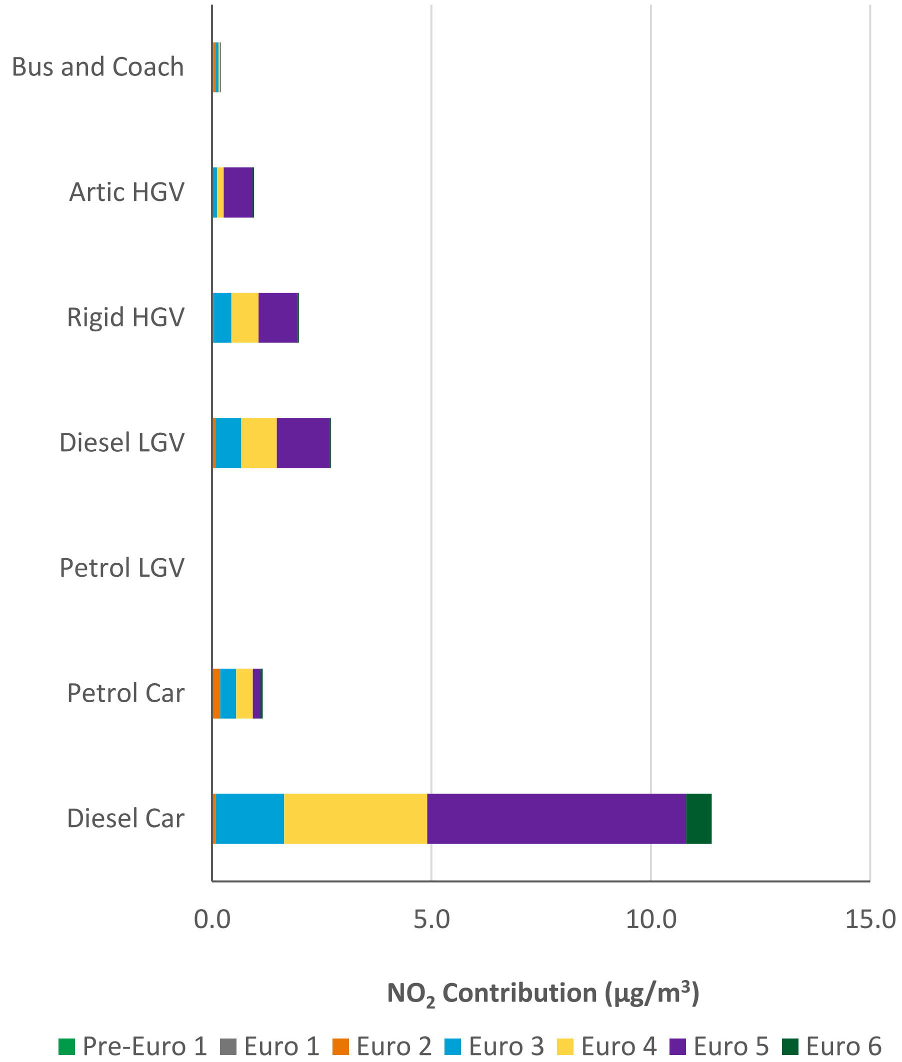

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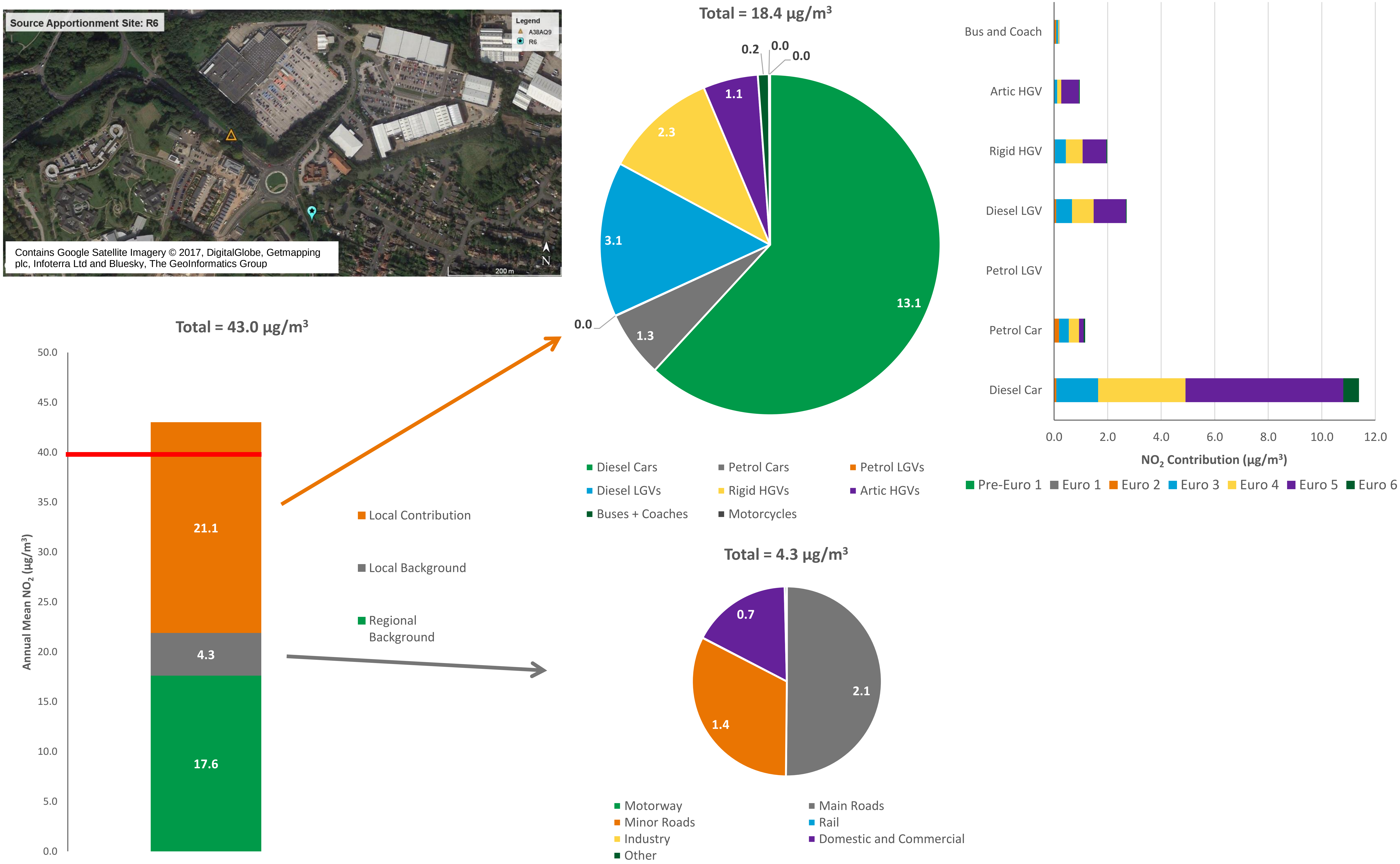

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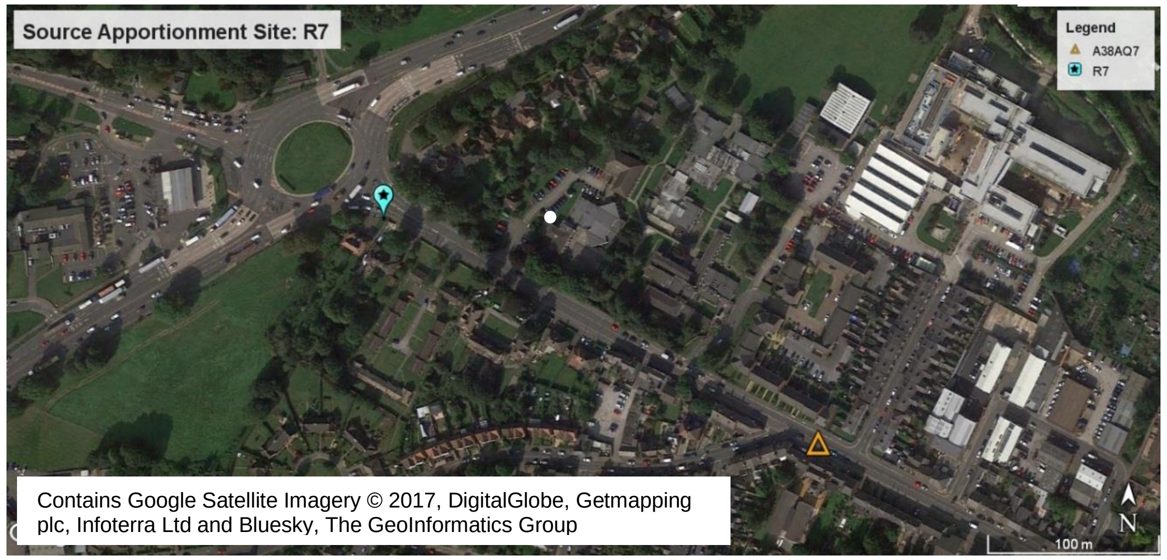

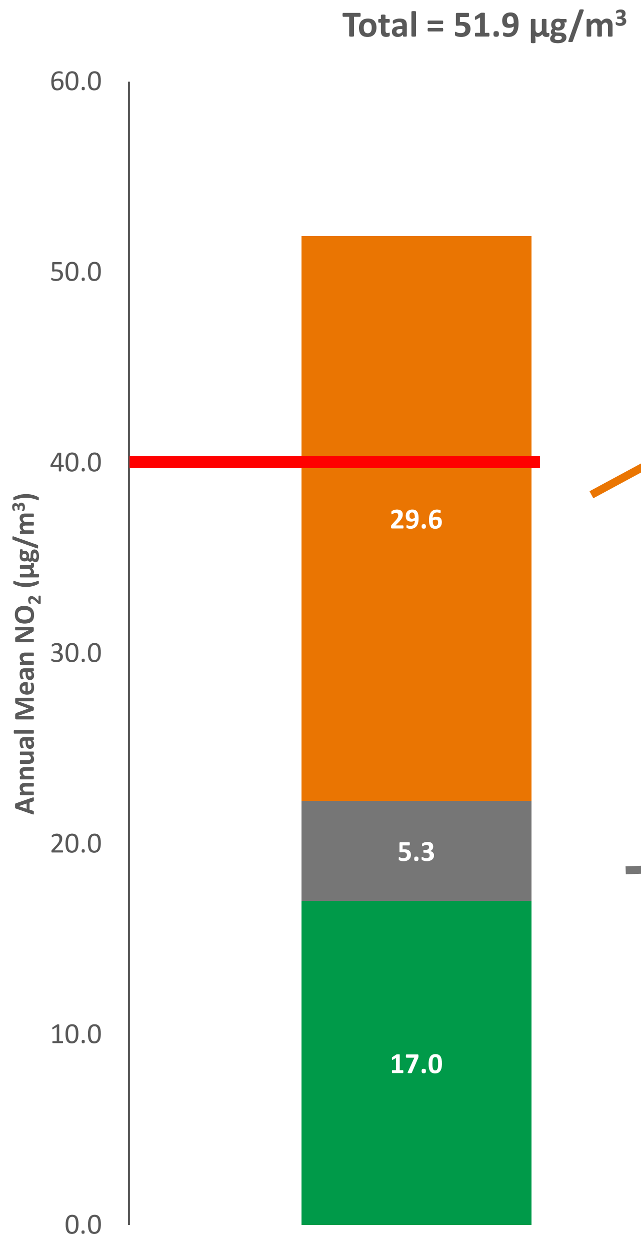

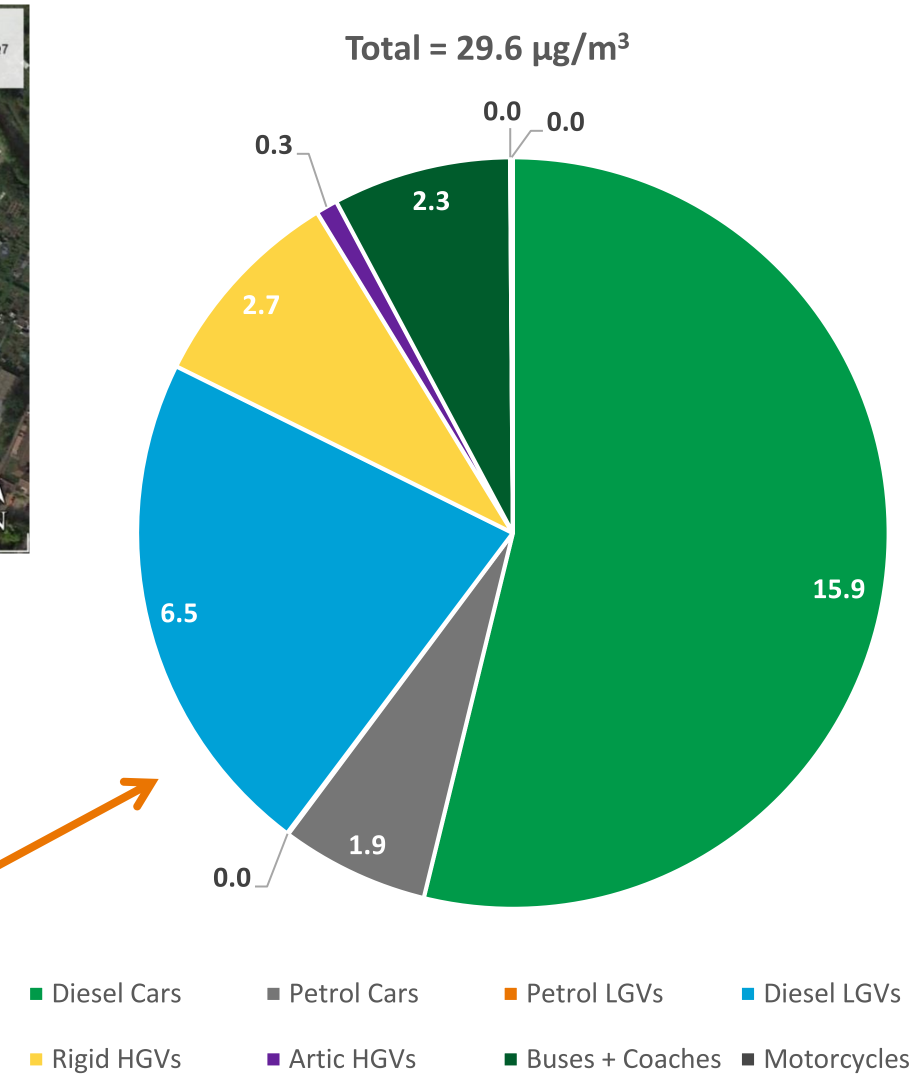

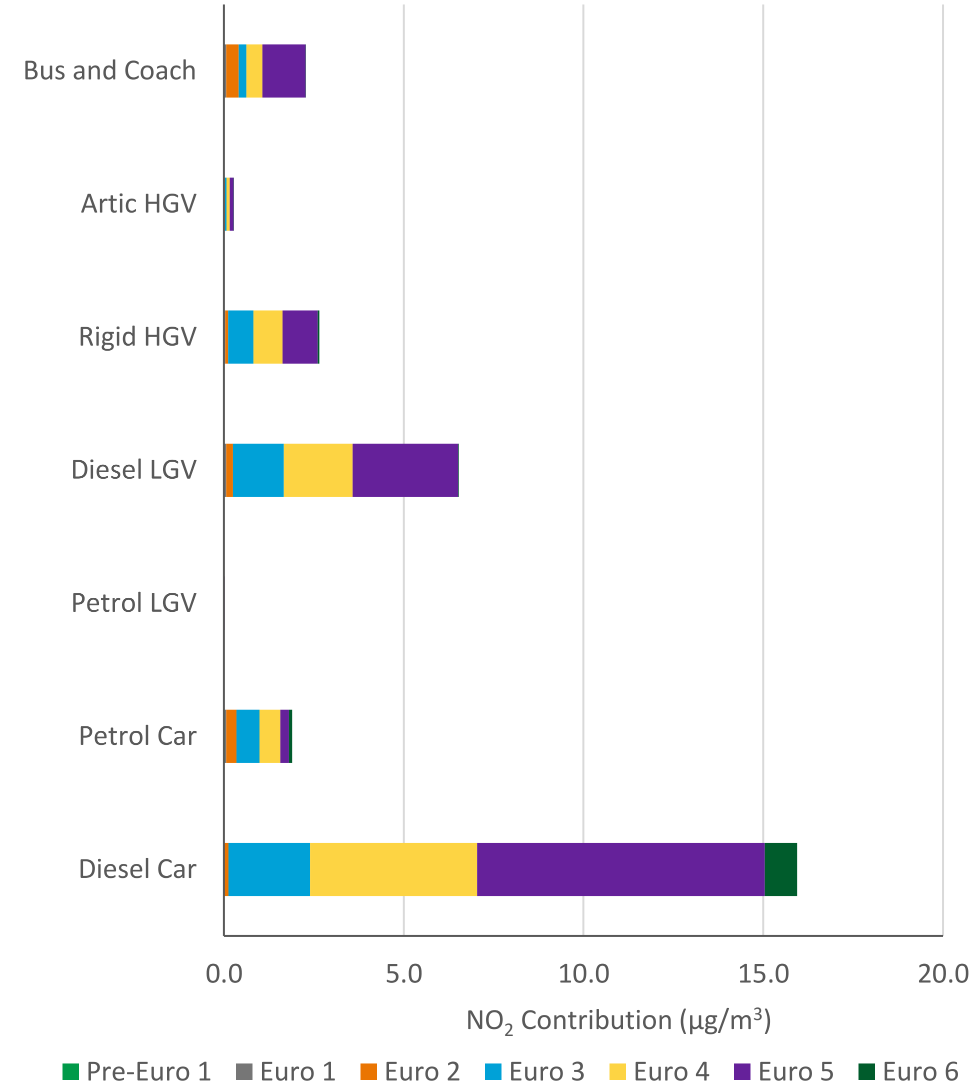

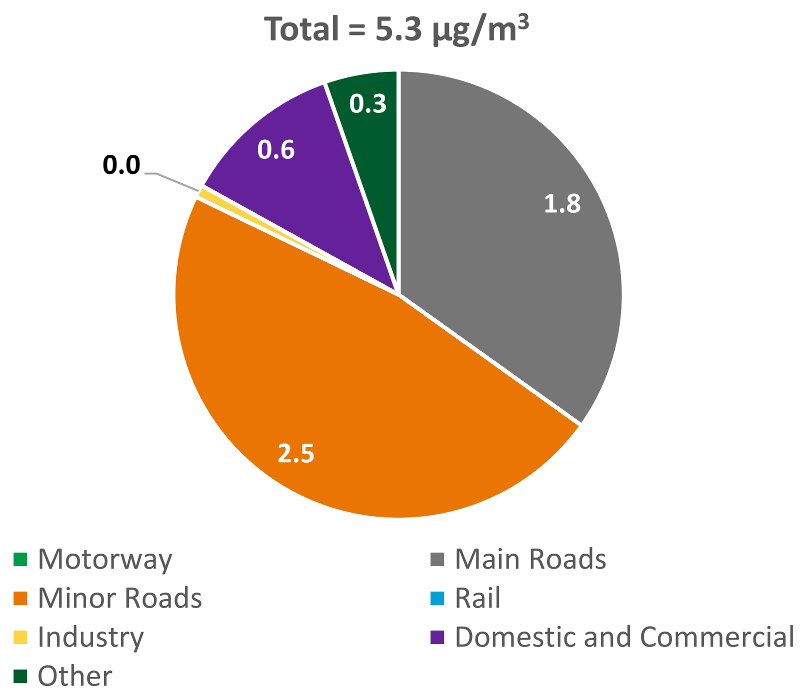

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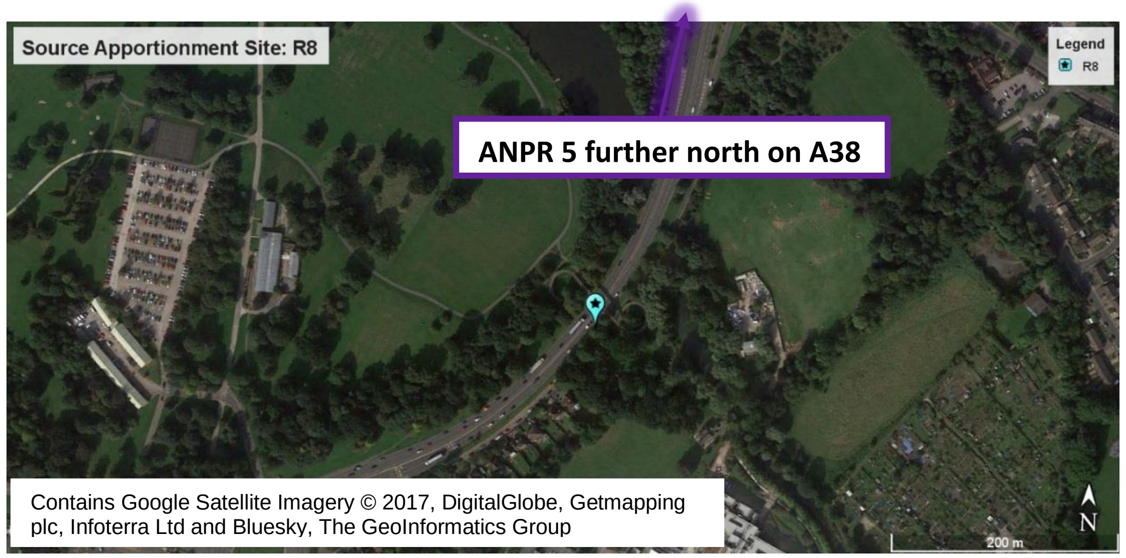

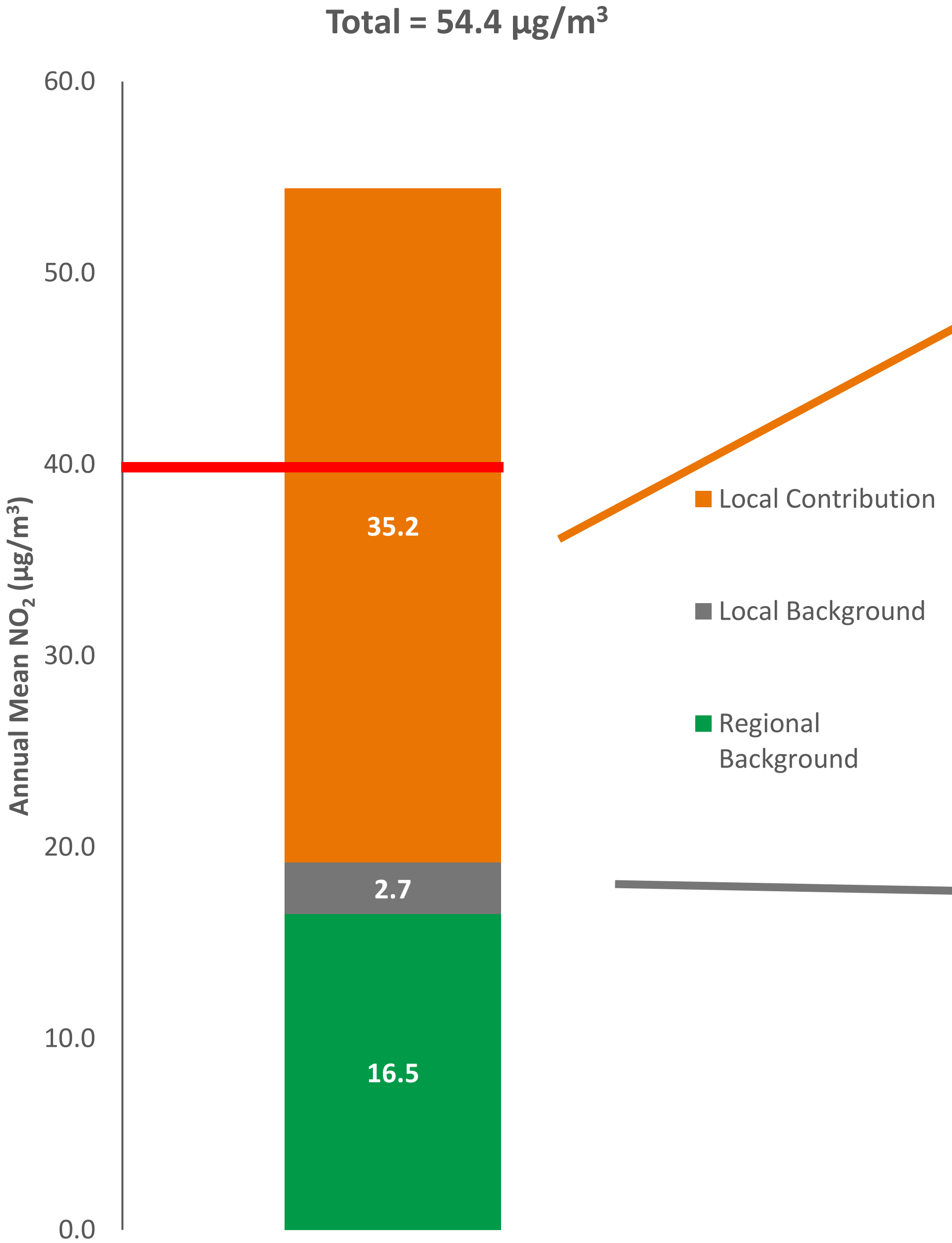

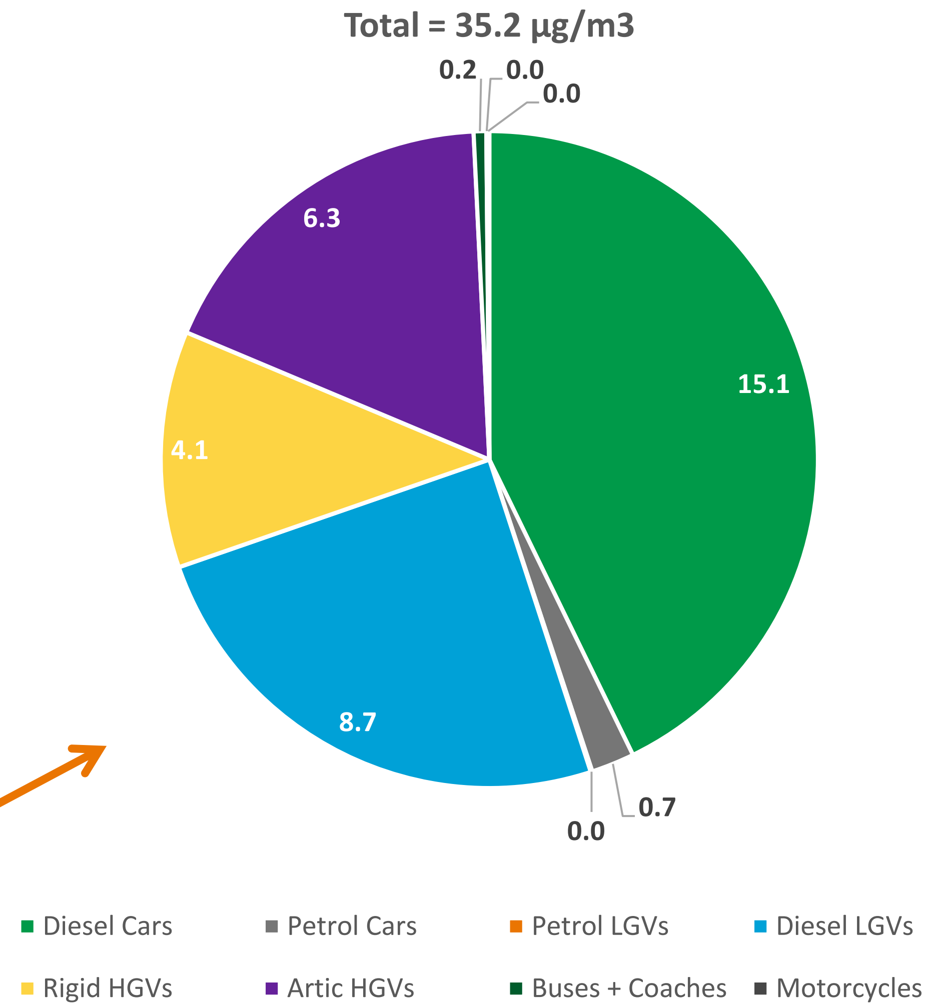

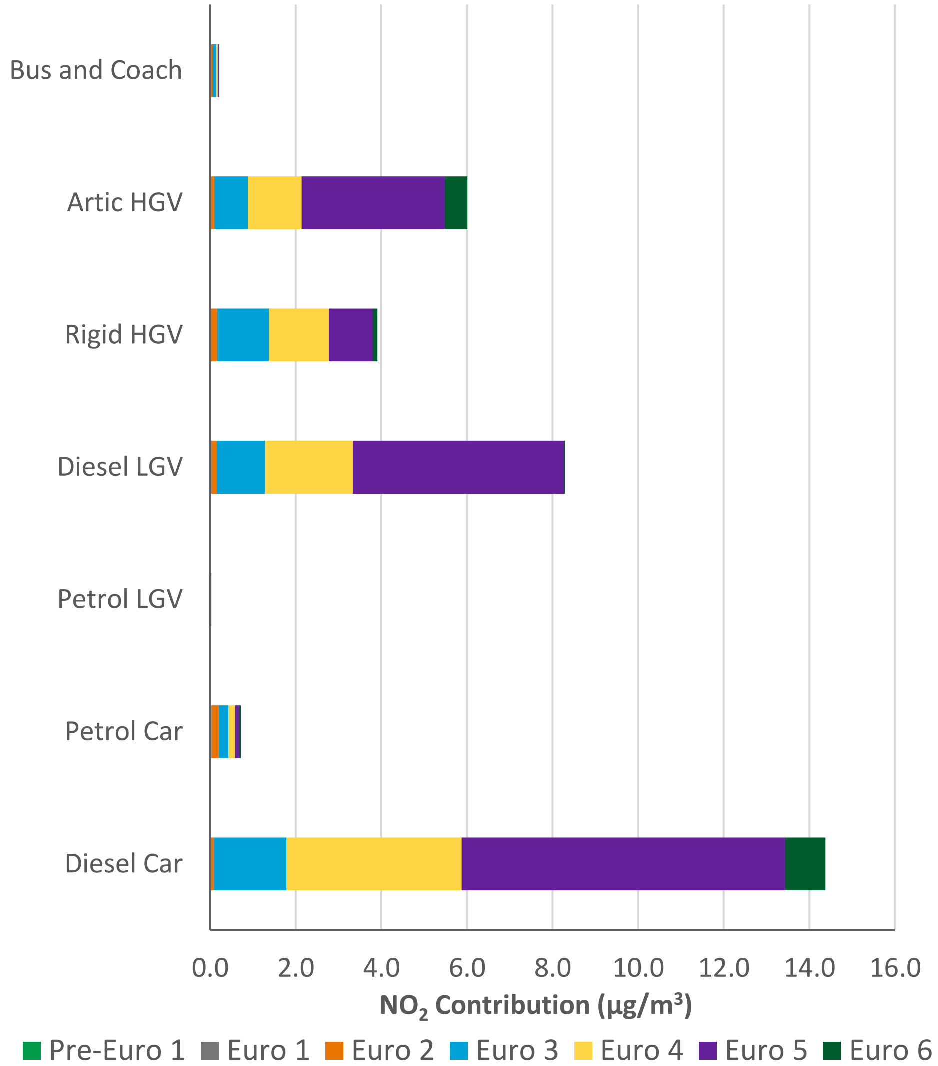

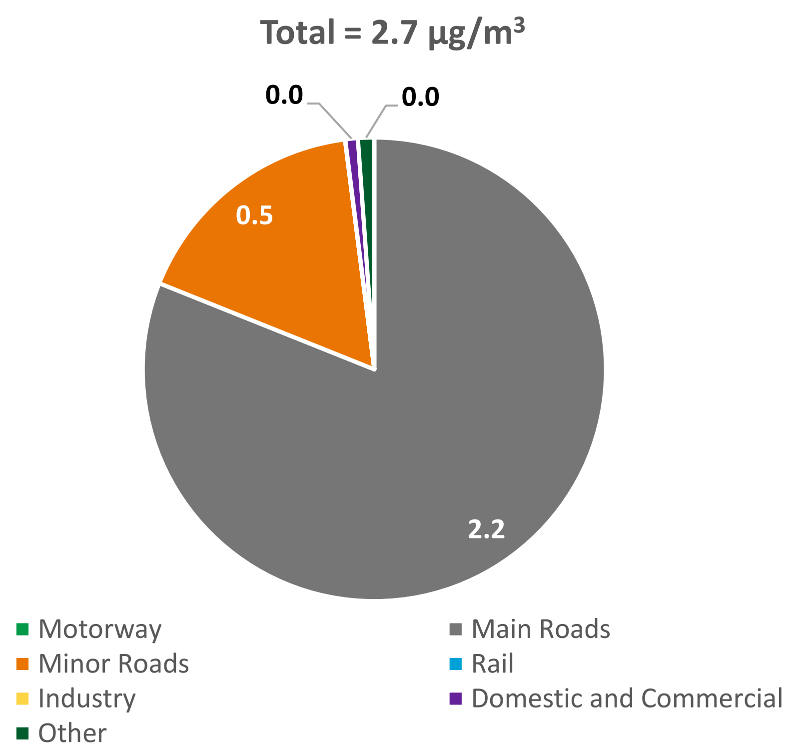

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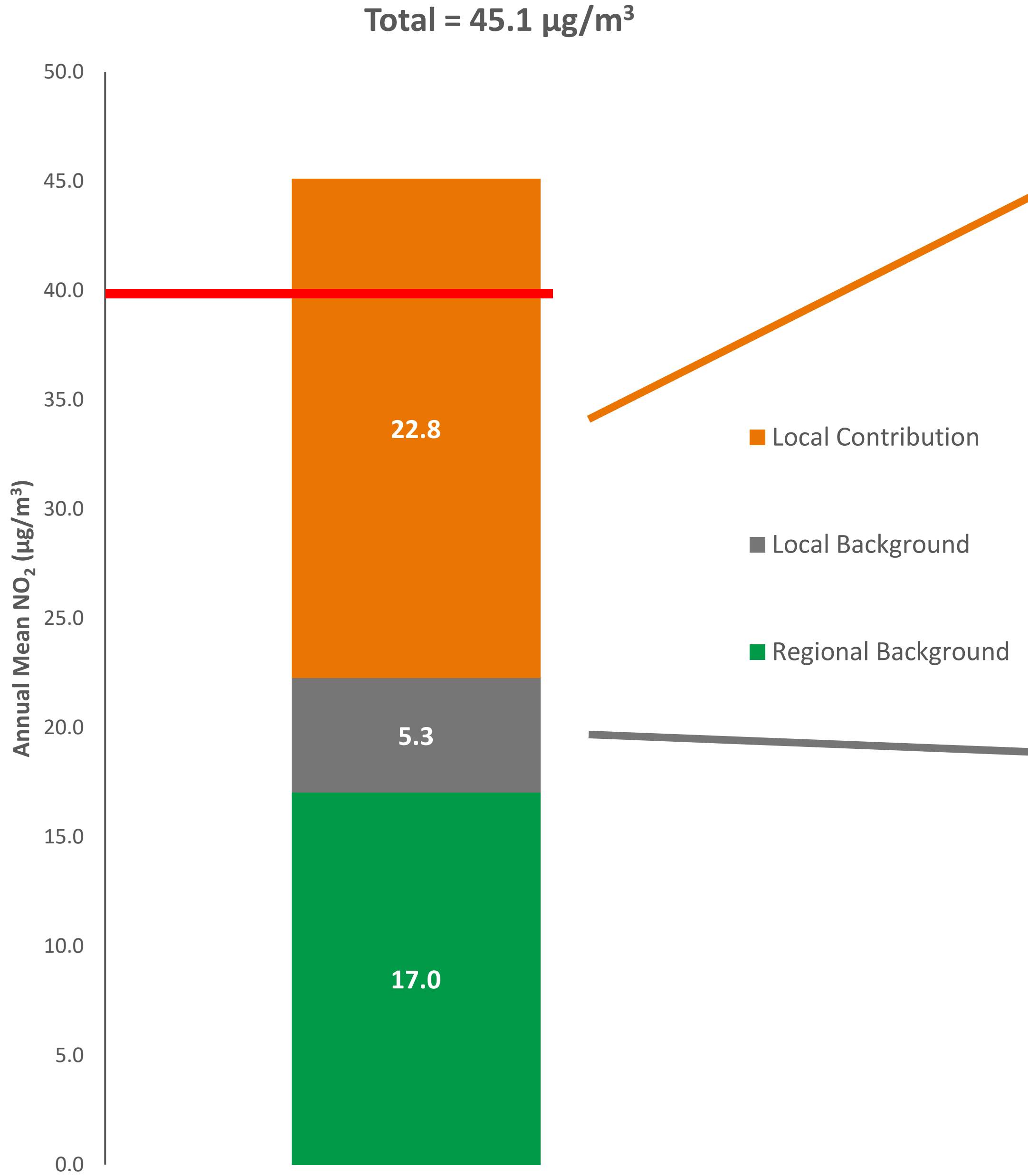
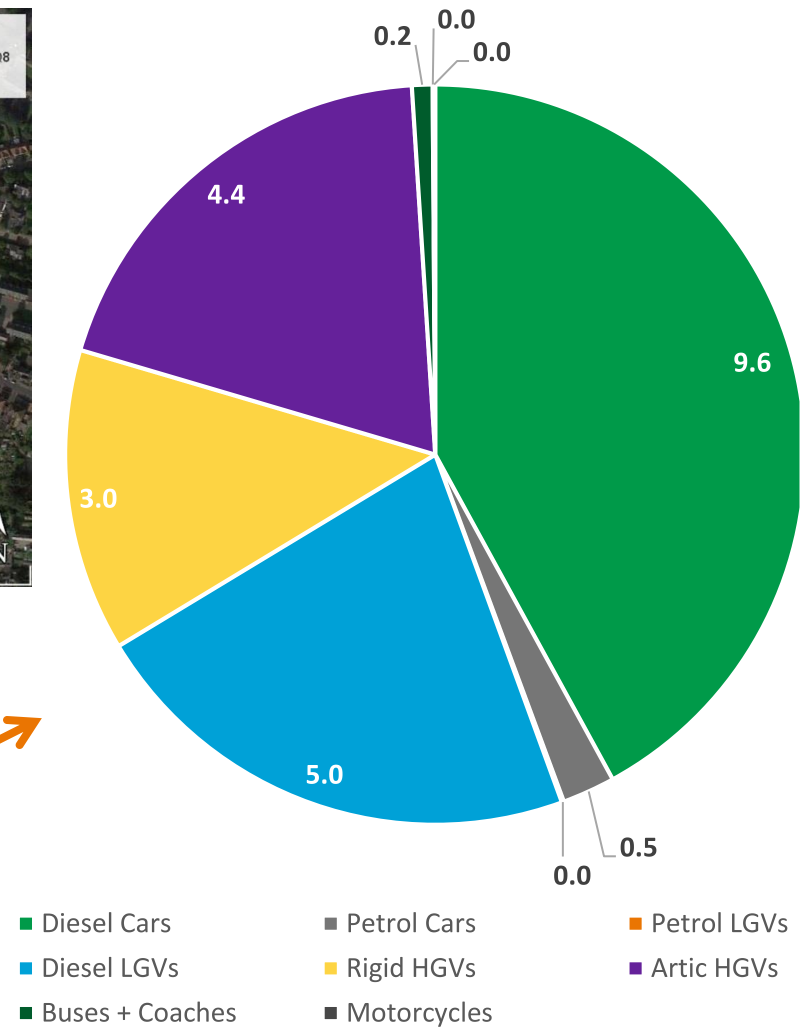
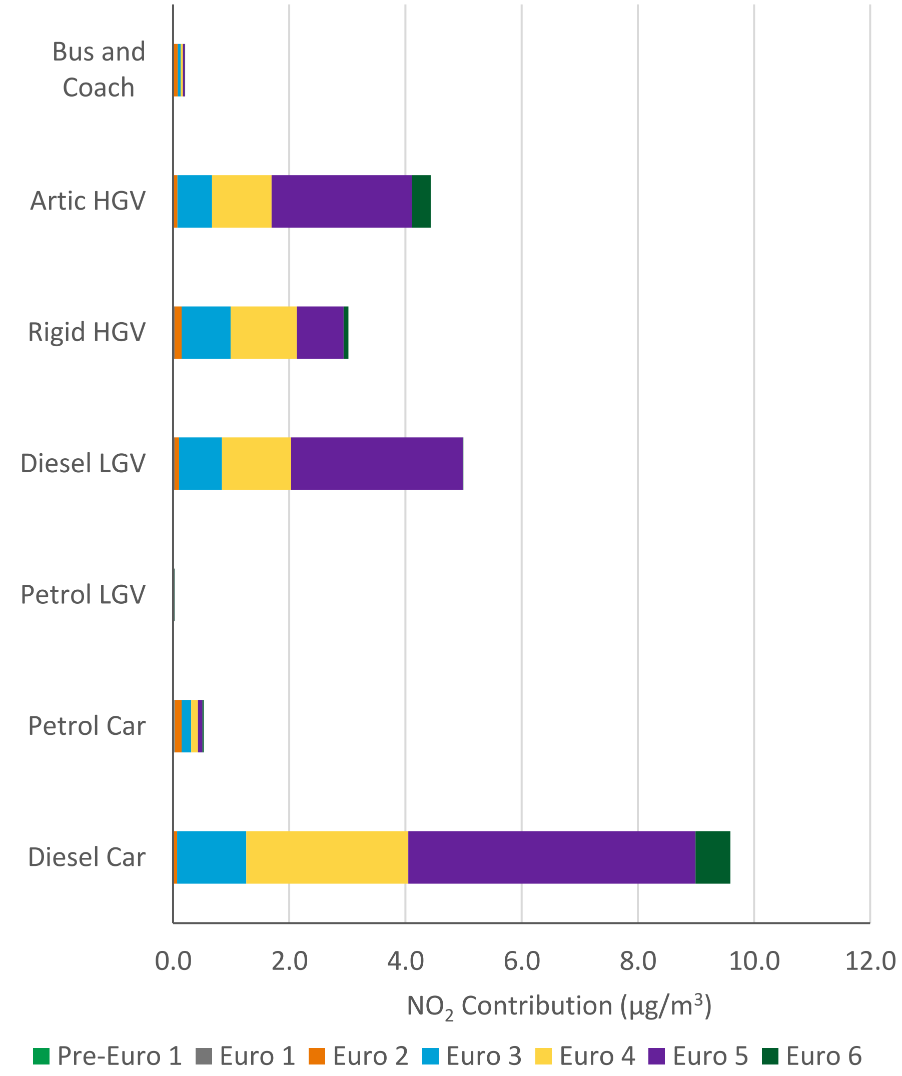
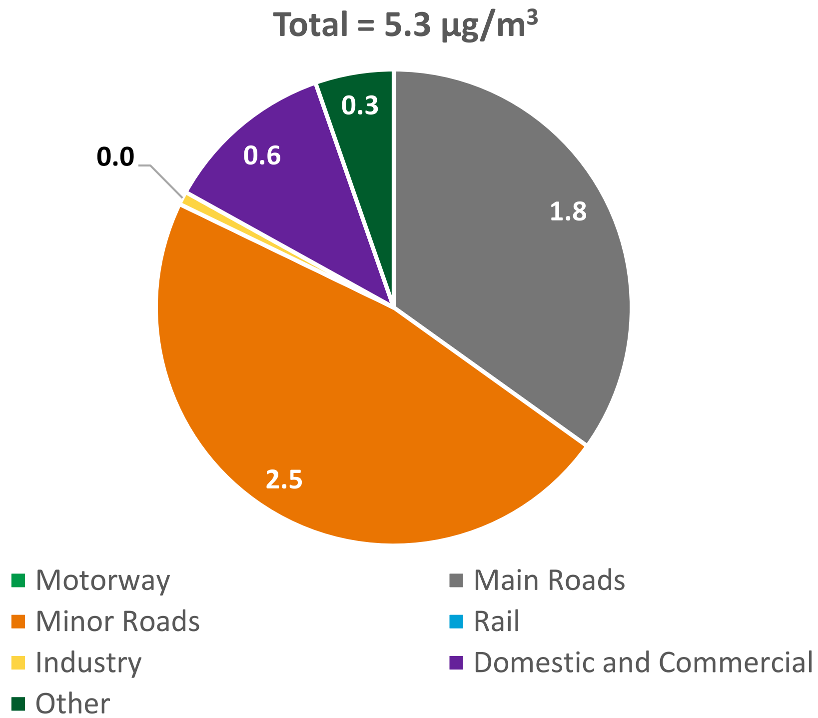








Appendix 8 - Detailed Traffic Analysis

PREPARED BY:	Rebecca Rankin
DATE:	16 June 2017
PROJECT NUMBER:	683270 / Task 61 Lot 2
REVISION NO.:	1
APPROVED BY:	Luke Farrugia

Overview

Select Link Analysis (SLA) is useful for examining a transport model to determine where trips that traverse a link (road) are starting and ending within the model. The results can be presented as either bandwidths or in matrix format. The bandwidth analysis allows routing of trips before/after the selected link to be visualised and the matrix format allows the ultimate origins and destinations of trips using the selected link to be viewed via a thematic map. This note presents a combination of bandwidth analysis and origin/destination thematic maps.

The purpose of the analysis is to determine whether A38 traffic routes to/from the A38 via local roads, or is more likely to be strategic in nature (i.e. already on the A38 and stays on the A38 after the SLA). Several local roads have also been considered in the analysis to determine if the traffic on these links has routed via the A38 or other more local roads. Ultimately, the traffic analysis contributes to the air quality exercise by indicating whether the air quality issues on the A38 and in the Derby area are a result of strategic traffic, local traffic or a combination of the two.

A typical AM peak hour (0700-0800) and PM peak hour (1600-1700) were analysed. This method was considered to be adequate for the purposes of understanding the influence of the A38 on the wider road network around Derby.

Select Link Analysis Details

The A38 Derby Junctions base model was provided for the purpose of this analysis. Full details of the base model can be found in the Local Model Validation Report (LMVR). The model has a 2015 base year and has been signed off as being sufficiently calibrated/validated for the purposes of the A38 Derby Junctions appraisal. The A38 Derby Junctions corridor covers the study area considered in this study and the model is therefore appropriate for this analysis.

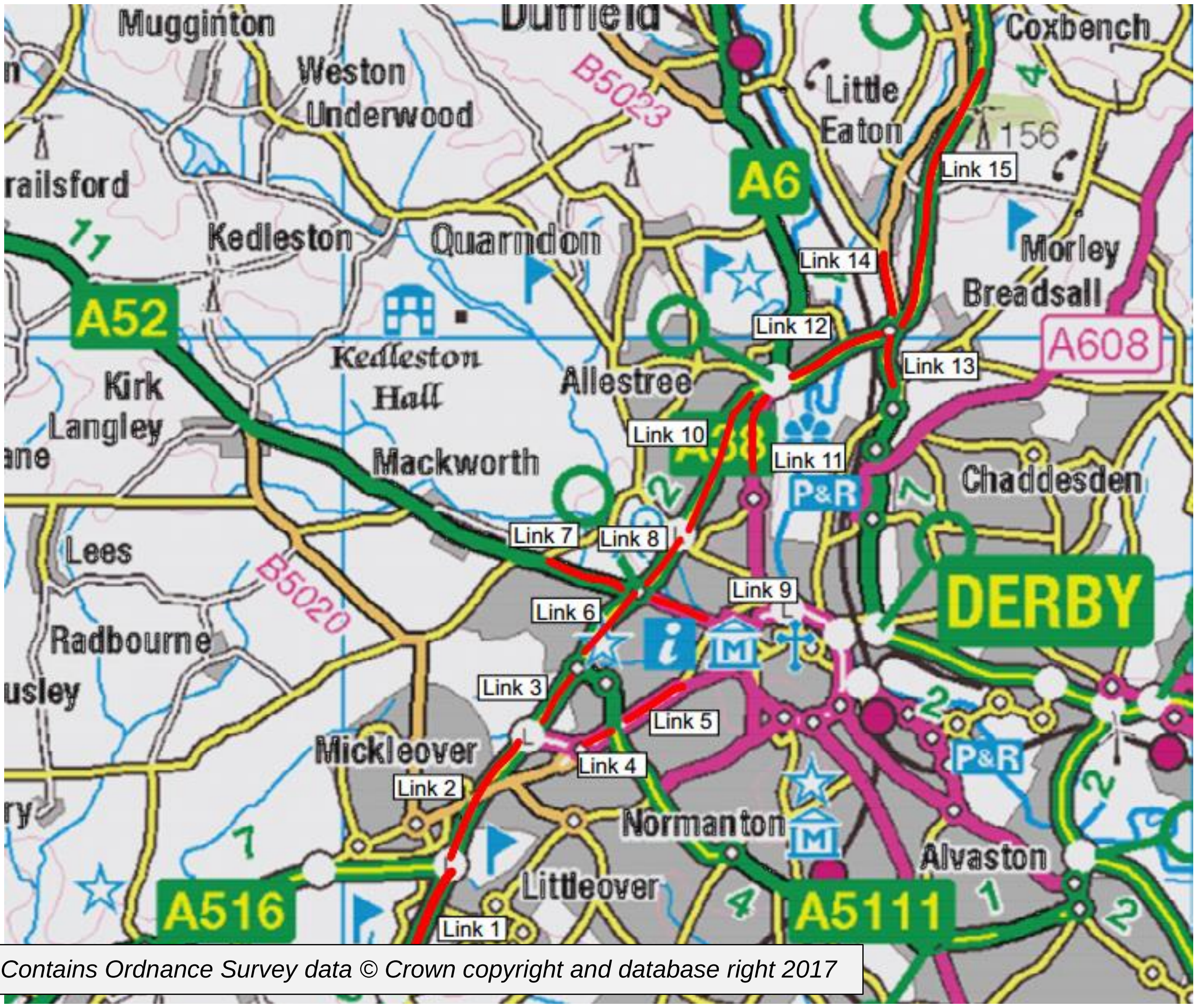
Fifteen select links (listed in

Table 1 and shown in **Figure 1**) have been identified to cover as much of the Derby road network as thought relevant to this study.

Table 1: SLA Locations

SLA	Description
1	The main carriageway south of the junction with the A516.
2	The main carriageway between the two junctions with the A516.
3	Main A38 carriageway between the north junction with the A516 and the roundabout with Kingsway
4	A516 (Uttoxeter New Road) south of the cross roads with Manor Road
5	A516 (Uttoxeter New Road) north of the cross roads with Manor Road
6	A38 (Kingsway) south of A52.
7	A52 (Ashbourne road) west of A38
8	A38 (Queensway) north of A52 (Ashbourne Road). This link boarders Markeaton Park.
9	A52 (Ashbourne Road) east of A38
10	A38 (Queensway) south of Palm Court Island
11	A6 (Duffield Road) south of Palm Court Island
12	A38 (Abbey Hill) north of Palm Court Island
13	A61 (Alfreton Road) south of Little Eaton Island
14	B6179 (Alfreton Road) north of Little Eaton Island
15	A38 north of Little Easton Island

Figure 1: Location of SLAs



The Local Model Validation Report for the A38 Derby Junctions Scheme was consulted to ensure that the areas used in this analysis were sufficiently validated for the different vehicle types. SLAs were exported for cars, Heavy Good Vehicles (HGV) and Light Goods Vehicles (LGV).

The findings are reported for each Select Link Analysis (SLA) link based on the IDs shown in **Figure** 1. The relevant outputs are presented in **Appendix 8A**. It should be noted that whilst the traffic model was calibrated and validated in accordance with guidance, not all movements will have been individually validated. As always, traffic models should be considered as a tool to assist analysis rather than providing and exact and identical replication of real world situations.

Results summary

The results discussed here consider six out of the 15 SLA locations (as highlighted in

Table 1) in detail, namely:

- The A38 at the northern and southern extents of the study area (IDs 1 and 15).
- Uttoxeter New Road, north and south of the Manor Road (IDs 4 and 5)
- The A52 to the west and east of the A38 (IDs 7 and 9).

Summaries of the other locations can be found in **Appendix 8B**. The detailed analysis considers whether traffic using the selected locations are routing via local or strategic roads. This analysis is done by vehicle type (car, LGV and HGV). It should be noted that the figures presented to support this analysis have different scales in the key, this is to allow the routing of traffic to be clearly visible in each figure.

The figures are presented in **Appendix 8A**. Figures for the SLA locations not discussed in detail are available on request.

SLA 1 – A38 South of study area

This SLA is located along the main A38 carriageway between the roundabout (joining the A38 with Rykneld road and Staker lane) and the southern junction with the A516.

The SLAs show similar routing in the AM and PM peak. HGV traffic comes from/goes to the A38 north and south of the select link, with minimal trips using local routes. A similar pattern can be seen with LGVs, though the lighter bandwidths to the north of the SLA indicate that some local LGV trips also use the A38.

In contrast, cars are also influenced from the A516 roundabout adjacent to the Royal Derby Hospital into Uttoxeter New Road/A5111, and to a lesser extent from the B5008 leading to Willington. These are likely to be attributed to the hospital or residents around the area preferring this route to either get to the M1 (via the A50) or commute to Burton-upon-Trent.

SLA 15 – A38 North of study area

SLA 15 is located on the A38 between Little Eaton Island in the south and the junction leading onto the B6179 in the north. There are large flows of car traffic from A38 (north) and A38 (west) with similar proportions for LGV and HGV. It is also noteworthy that there is a significant amount of car traffic travelling on the A61 (south). The figures clearly show the routing of local Derby trips to/from the A38.

Similar distributions of trips can be seen in the AM and PM peak, though the actual numbers of trips themselves are of course different.

SLA 4 – Uttoxeter New Road, South of Manor Road

SLA 4 is located on the A516 (Uttoxeter New Road) between the roundabout with the A5020 and the crossroads with Manor Road. The traffic along this link is largely dominated by cars, with lower volumes of LGVs and fewer HGVs. The distributions of the direction of cars and LGVs are similar with the majority originating from the A516 Uttoxeter New Road and A5111 Manor Road, with the B5020 and A38/A516 Northbound Junction also being a significant route.

More than half of the Eastbound A516 car traffic is directing via the Ring Road to A601. Westbound A516 traffic coming from Manor Road and Uttoxeter New Road moves either via the B5020 (c.35%) or along the A516 Southbound (65%). The largest inputs are from the A5111 Manor Road and the A516 via the A38.

SLA 5 – Uttoxeter New Road, North of Manor Road

SLA 5 is located along A516 (Uttoxeter New Road) between the crossroads with Manor road and the roundabout with the A601 (Mercian way/ Derby ring road). The majority of car movements (75%) are originating from local roads adjacent to Uttoxeter New Road/A516 along to the inner ring road and B5020, with some influence from the A516 merging with the A38 or continuing on the A516 (<25%). HGV and LGV movements are fed from the B5020 and the Derby Inner Ring Road, with little contribution from other directions. The A5111 is a minor contributor for all vehicle types along this link.

SLA 7 – A52 West of A38

SAL7 is located on the A52 (Ashbourne road) between a roundabout linking with the Kingsway and Queensway in the east and turning to Markeaton Lane in the west. The majority of car traffic routing along SLA 7 is following the West-East direction through to the A52 via the Derby Inner Ring Road, with some routing to the A5111 via the A38 Kingsway Northbound (15%).

LGVs follow similar routing to cars with the exception that there are some movements along the A38 Queensway. The majority of HGV movements are in the West-East direction, with minimal trips routing to/from the A38 in both the AM and PM peaks. This supports the conclusions of the A38 SLAs i.e. that HGV traffic on the A38 is largely strategic and routes through the study area.

SLA 9 – A52 East of A38

SLA9 is located on the A52 (Ashbourne Road) between the A38 Kingsway and Queensway in the west and Ford Street in the east. Car movements are dominated by local movements via the A52. There is little influence from the A38 with less than 10% of the total car traffic routing via the A38 Kingsway northbound route on this link. A similar pattern is seen for both HGV and LGV movements along this link.

Origin and Destination Analysis

The select link analyses discussed above consider the routing of traffic either side of the selected link. It is also useful to consider the ultimate origin and destination of these trips. This requires exporting the data from the traffic model in a slightly different format, allowing the number of trips traversing the selected link to be viewed as a thematic map by origin and destination. **Figure 2** to **Figure 5** below show this analysis for the A38 at SLA15 for total traffic in the AM peak.

The purpose of this analysis is to demonstrate that the ultimate origins/destinations of trips on the A38 are generally longer distance rather than within Derby itself. The bandwidth SLA figures discussed above do not readily show the ultimate origin/destination of trips.

Origin/destination analysis for the locations and time periods not presented here are available on request.

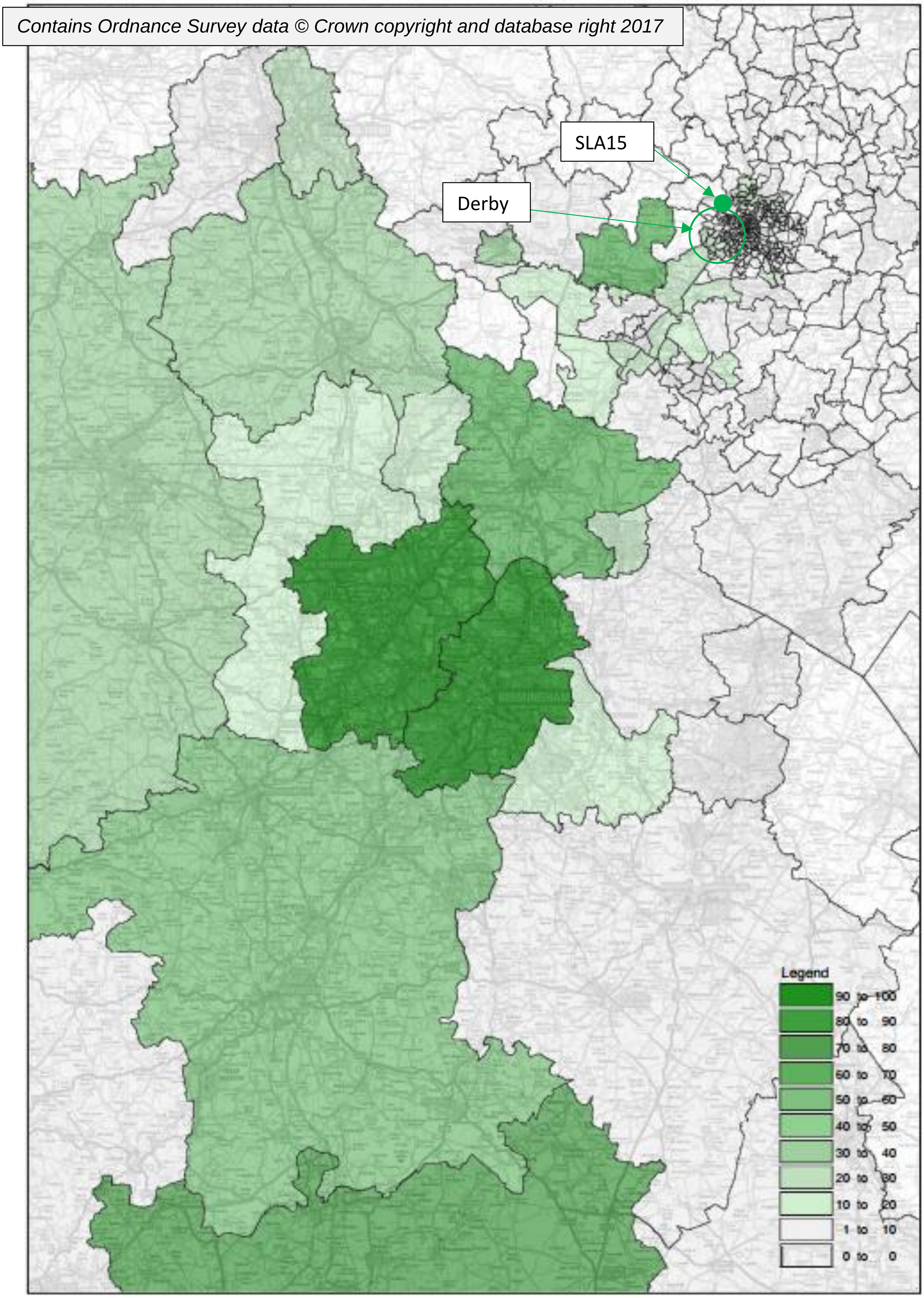


Figure 2: AM Peak A38 north of study area, northbound SLA origins

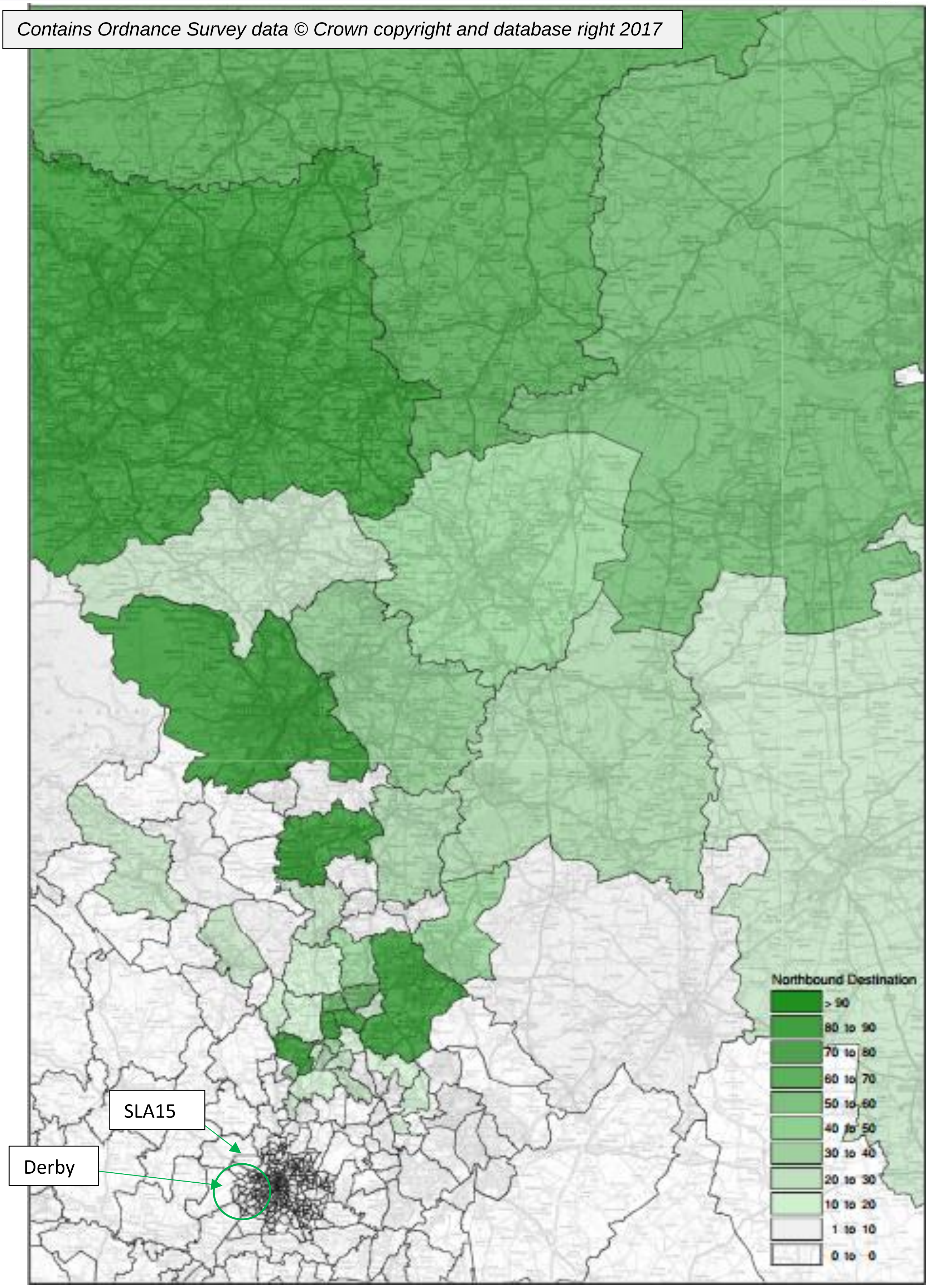


Figure 3: AM Peak A38 north of study area, northbound SLA destination

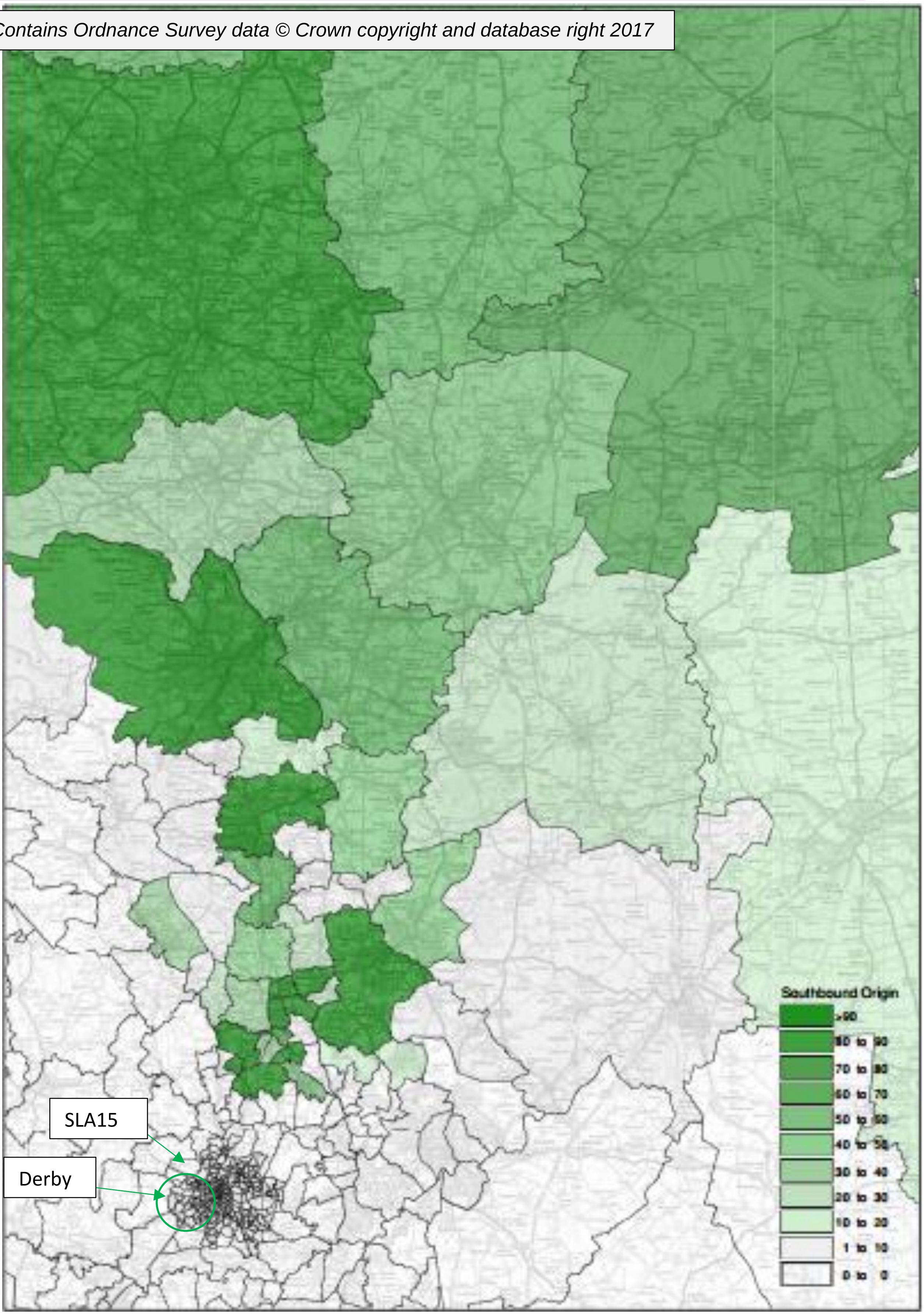


Figure 4: AM Peak A38 north of study area, southbound SLA origins

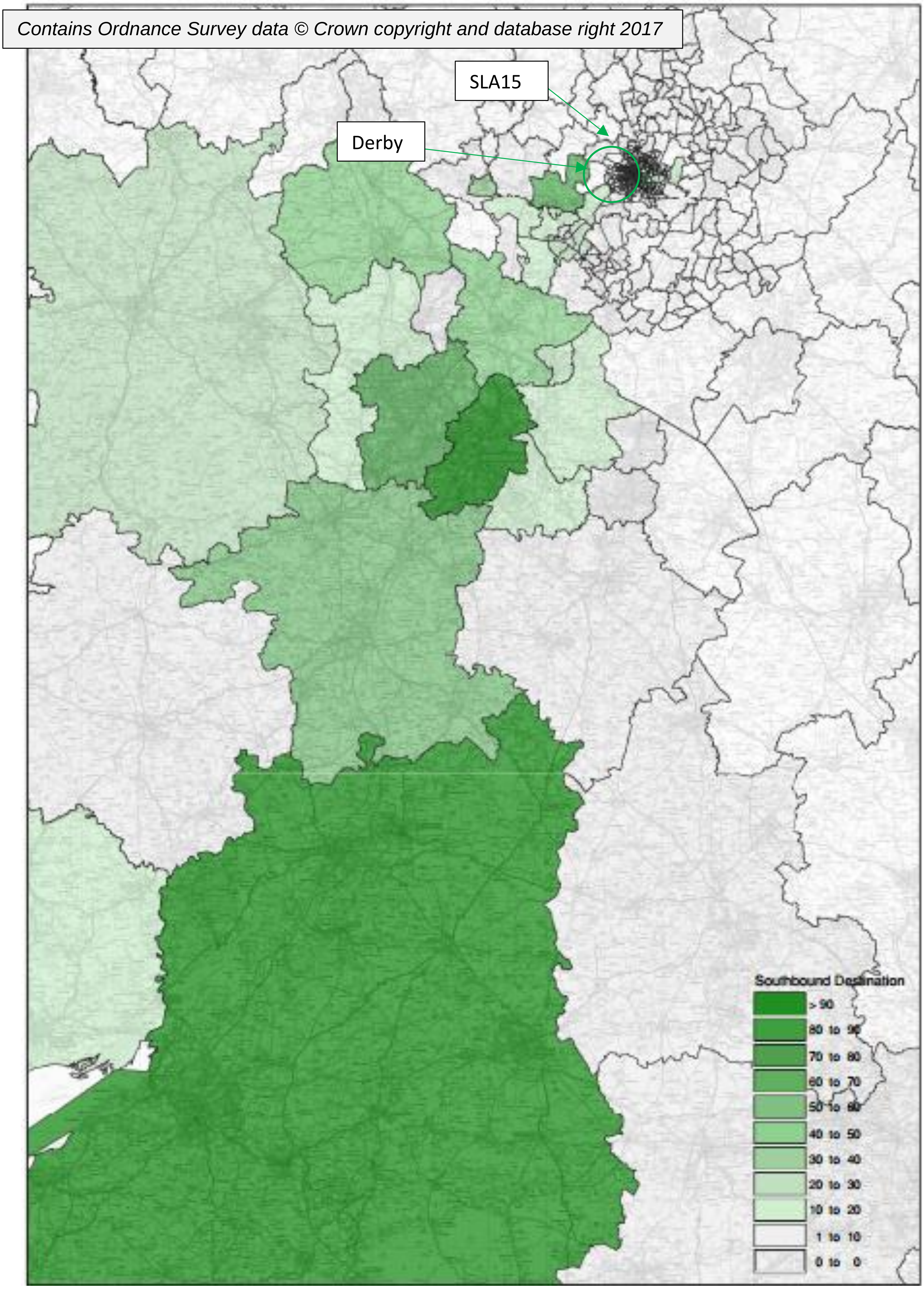


Figure 5: AM Peak A38 north of study area, southbound SLA destination

Appendix 8A – AM Peak and PM Peak SLA Figures

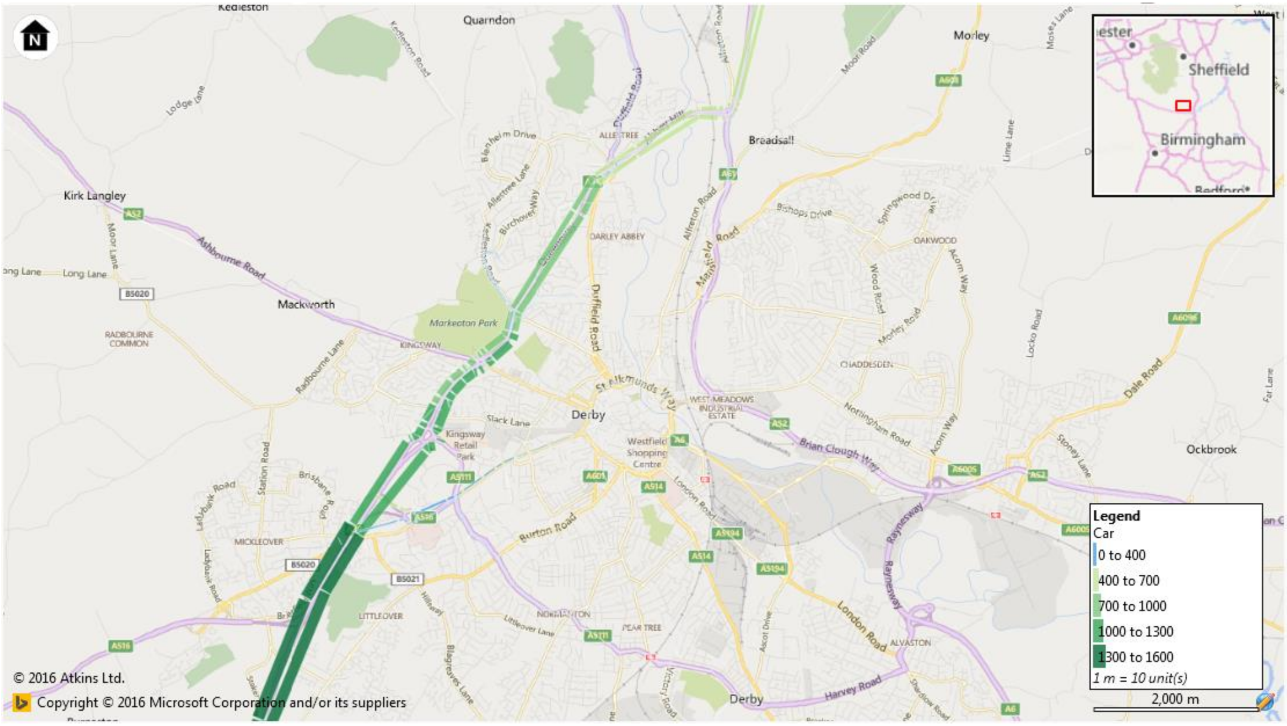


Figure 6: AM Select Link 1 Car

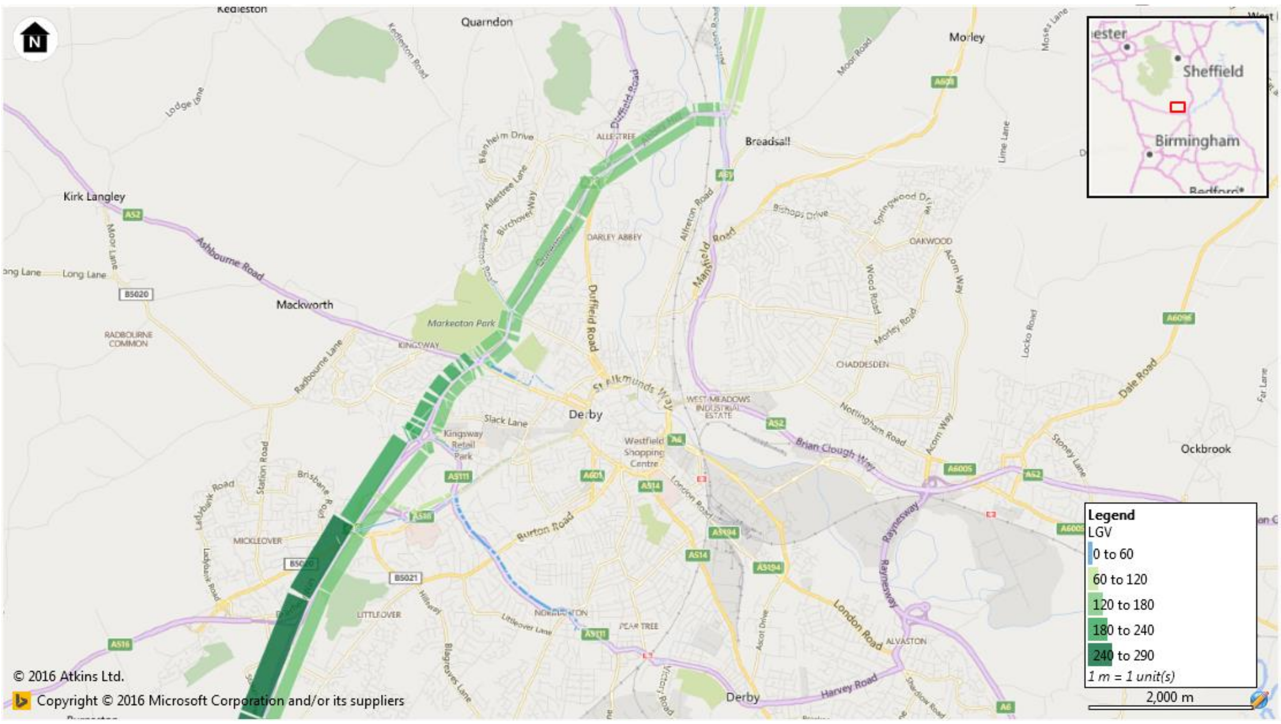


Figure 7: AM Select Link 1 LGV

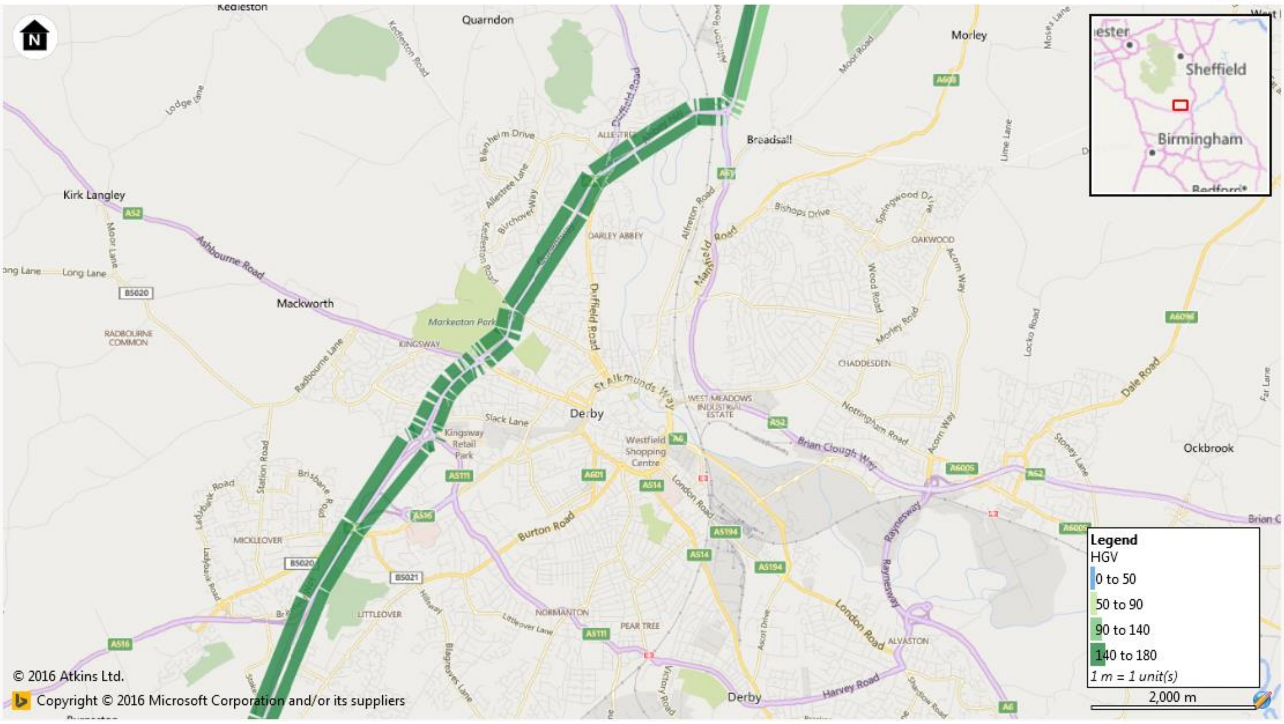


Figure 8: AM Select Link 1 HGV

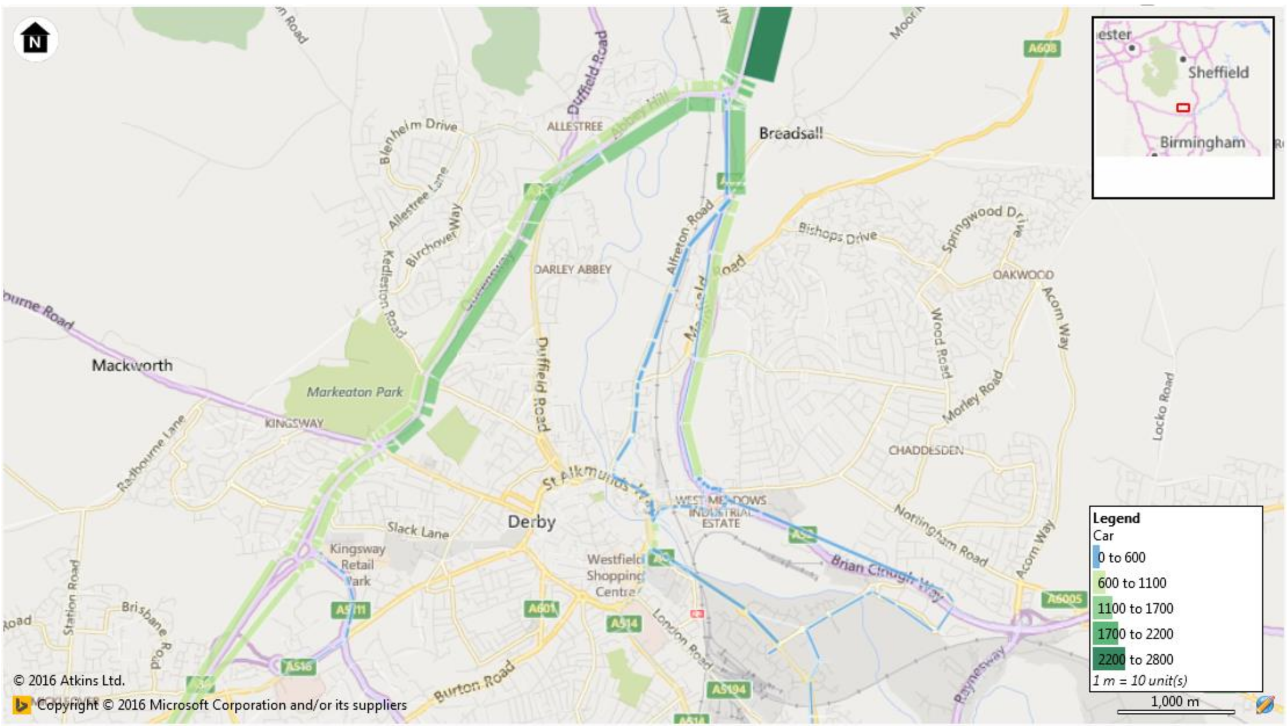


Figure 9: AM Select Link 15 Car

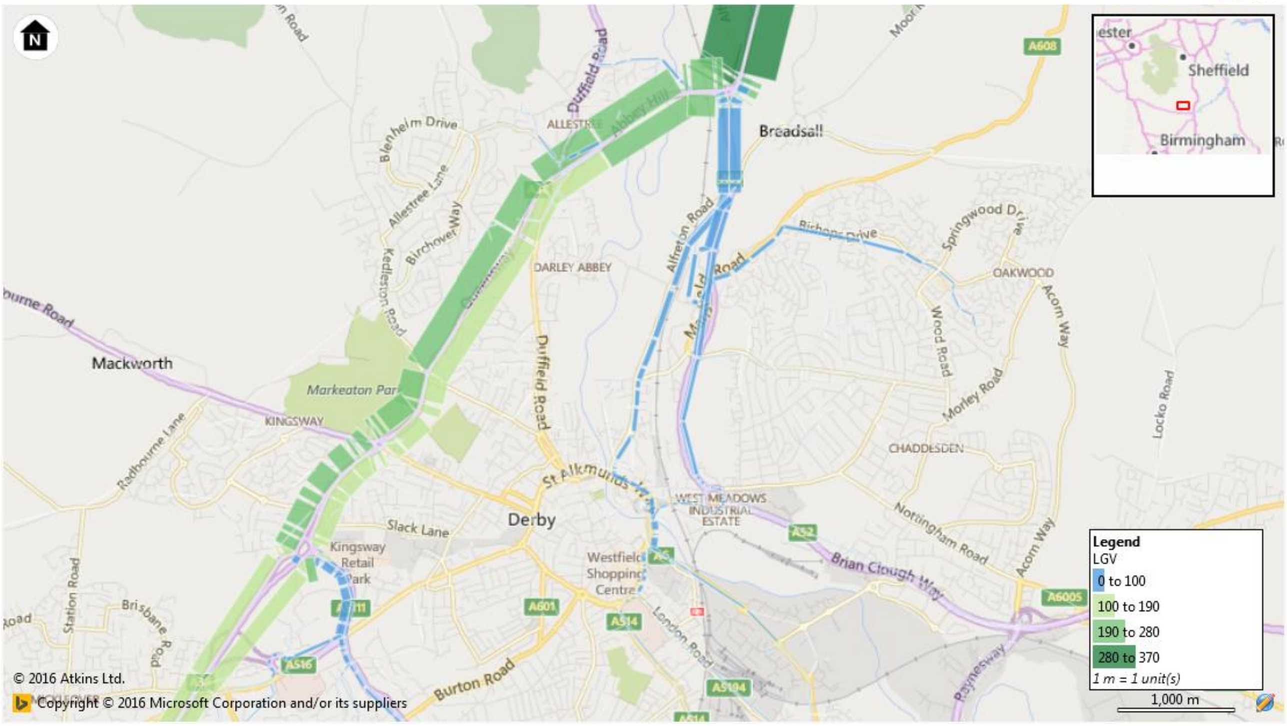


Figure 10: AM Select Link 15 LGV

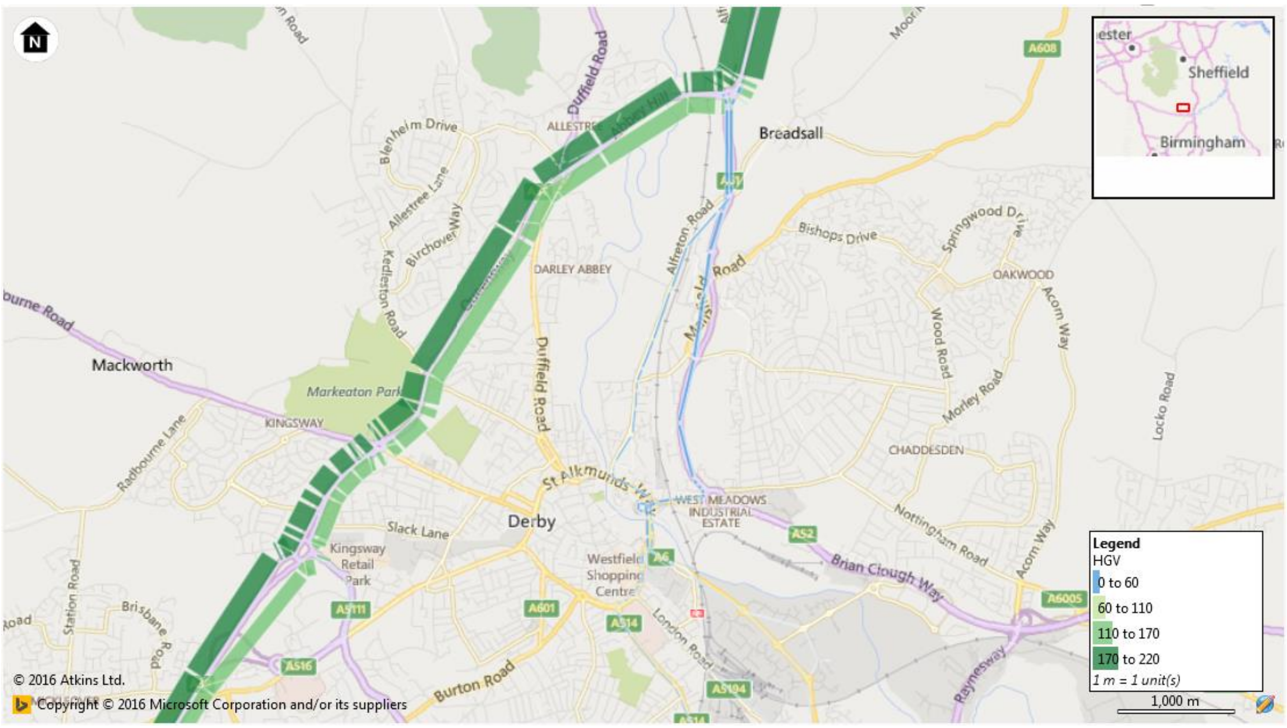


Figure 11: AM Select Link 15 HGV

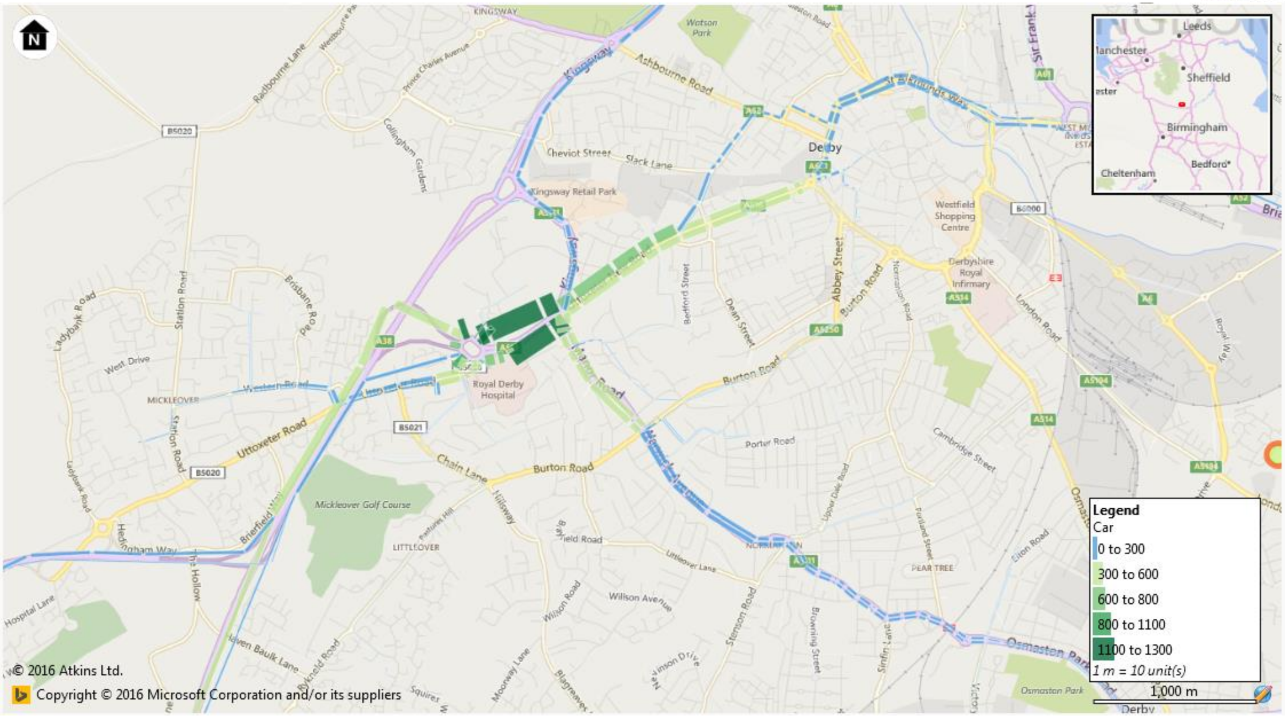


Figure 12: AM Select Link 4 Car

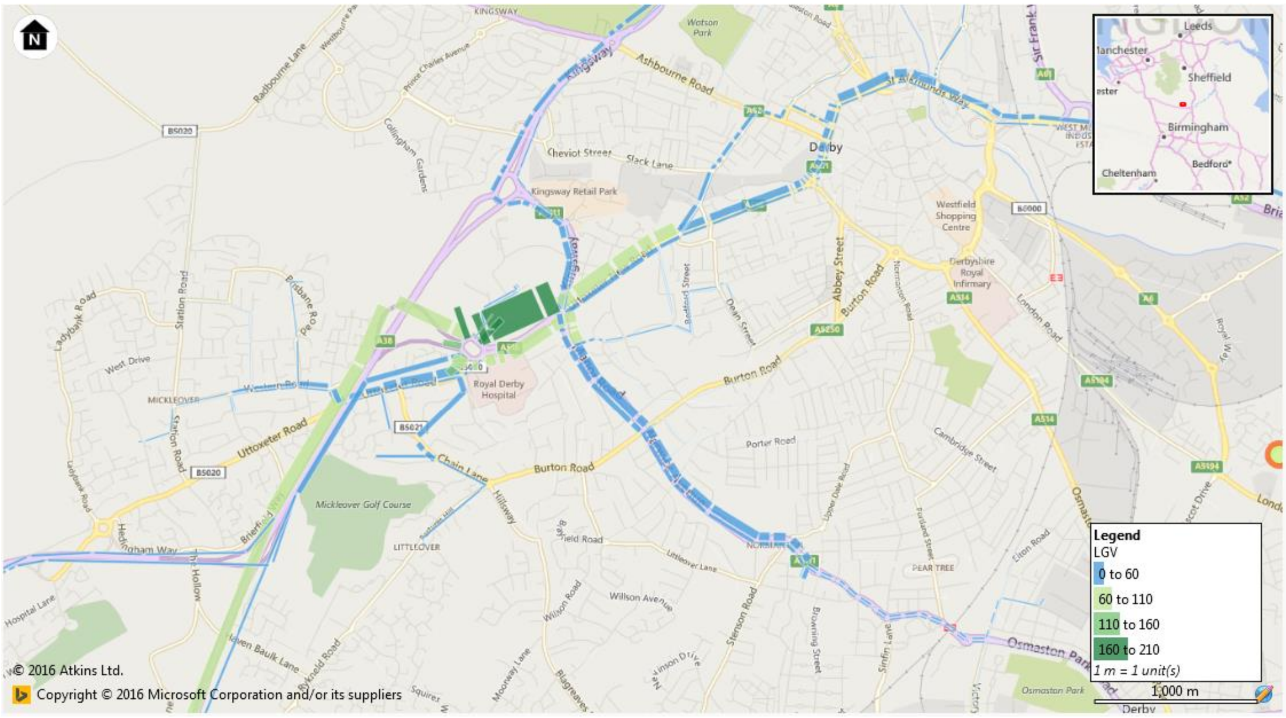


Figure 13: AM Select Link 4 LGV

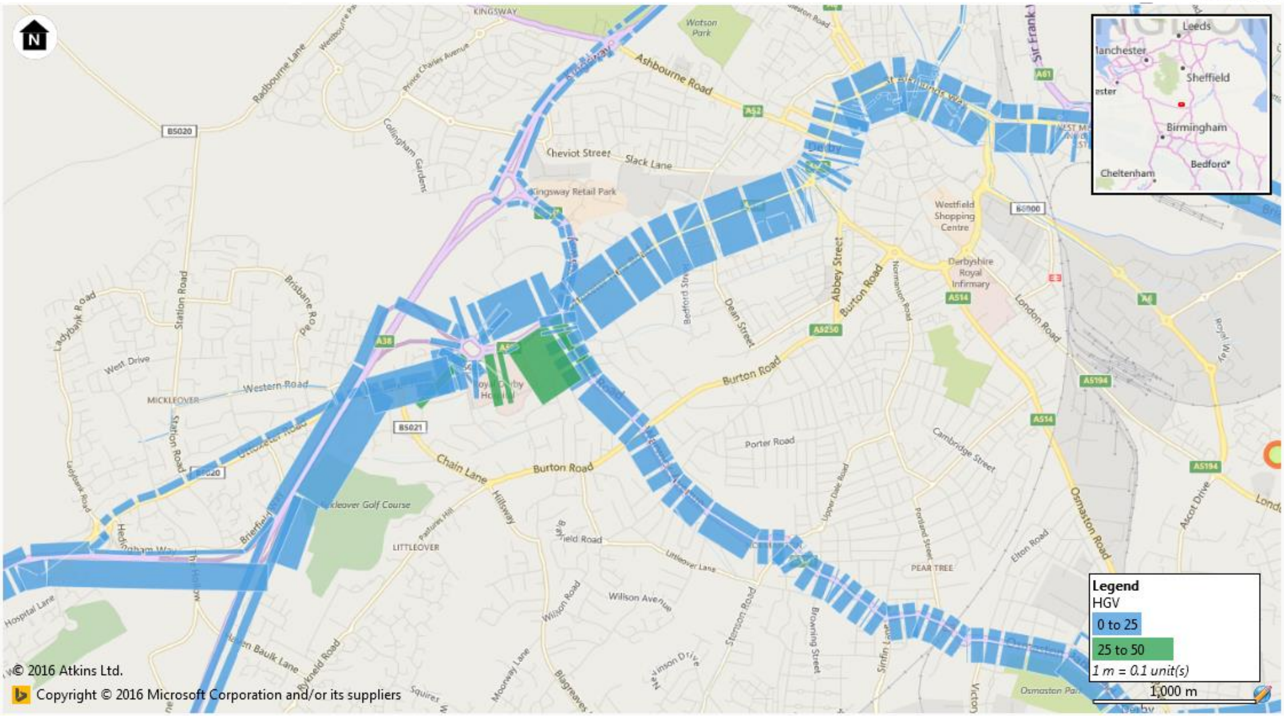


Figure 14: AM Select Link 4 HGV

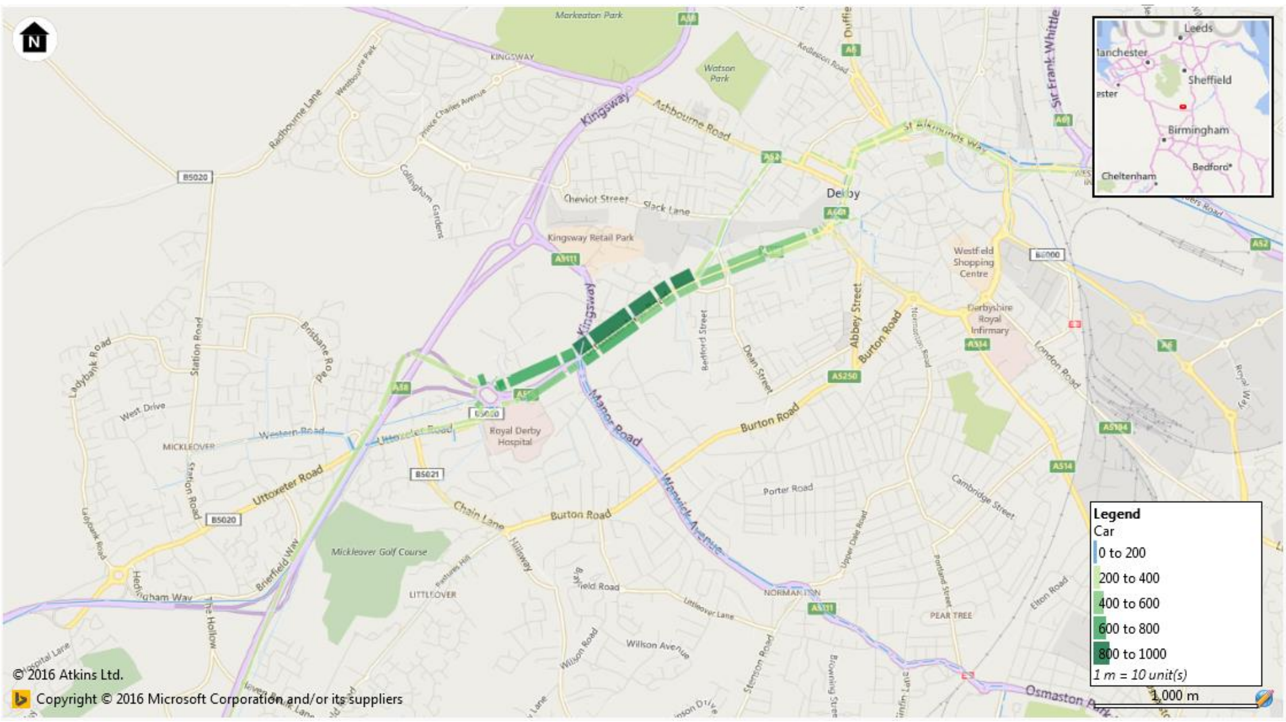


Figure 15: AM Select Link 5 Car

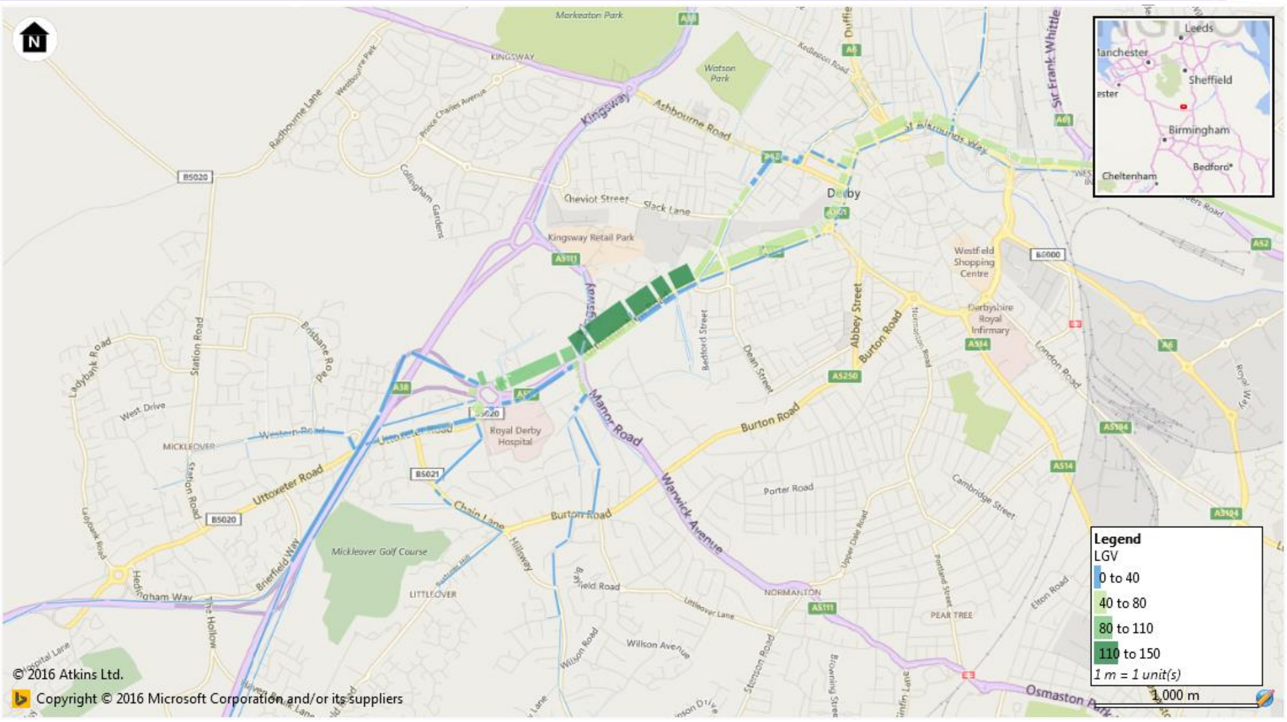


Figure 16: AM Select Link 5 LGV

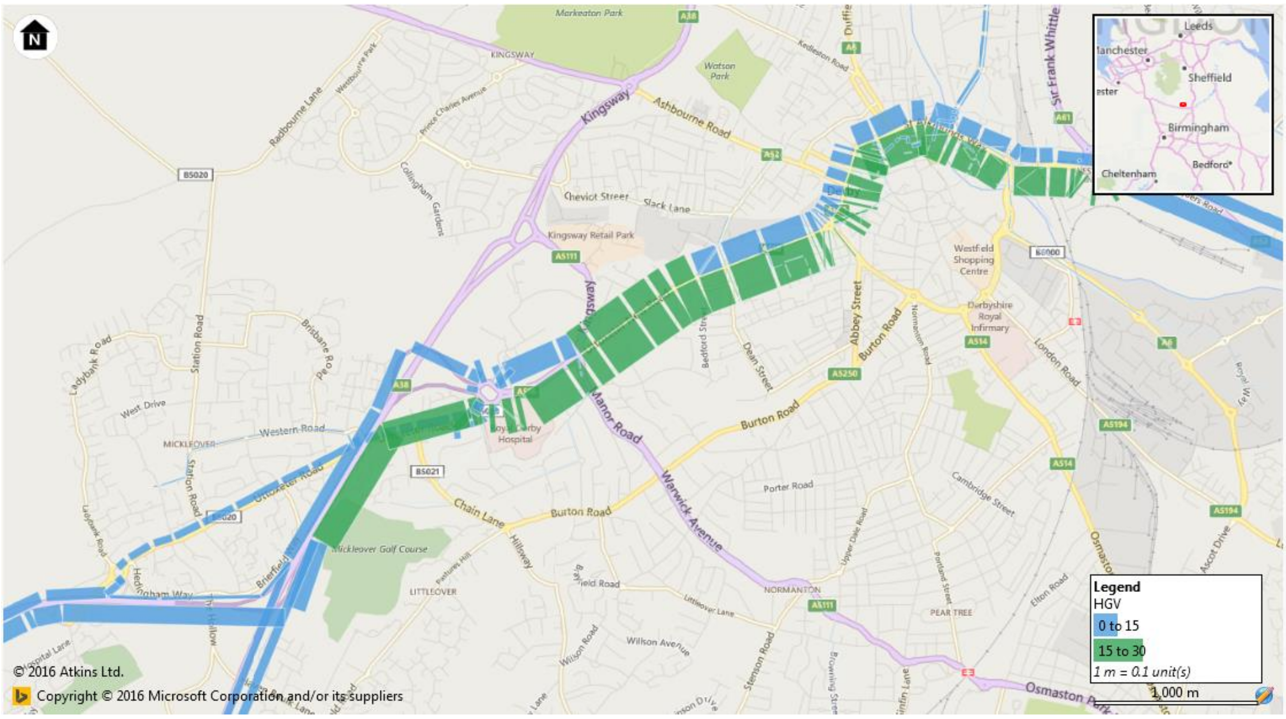


Figure 17: AM Select Link 5 HGV

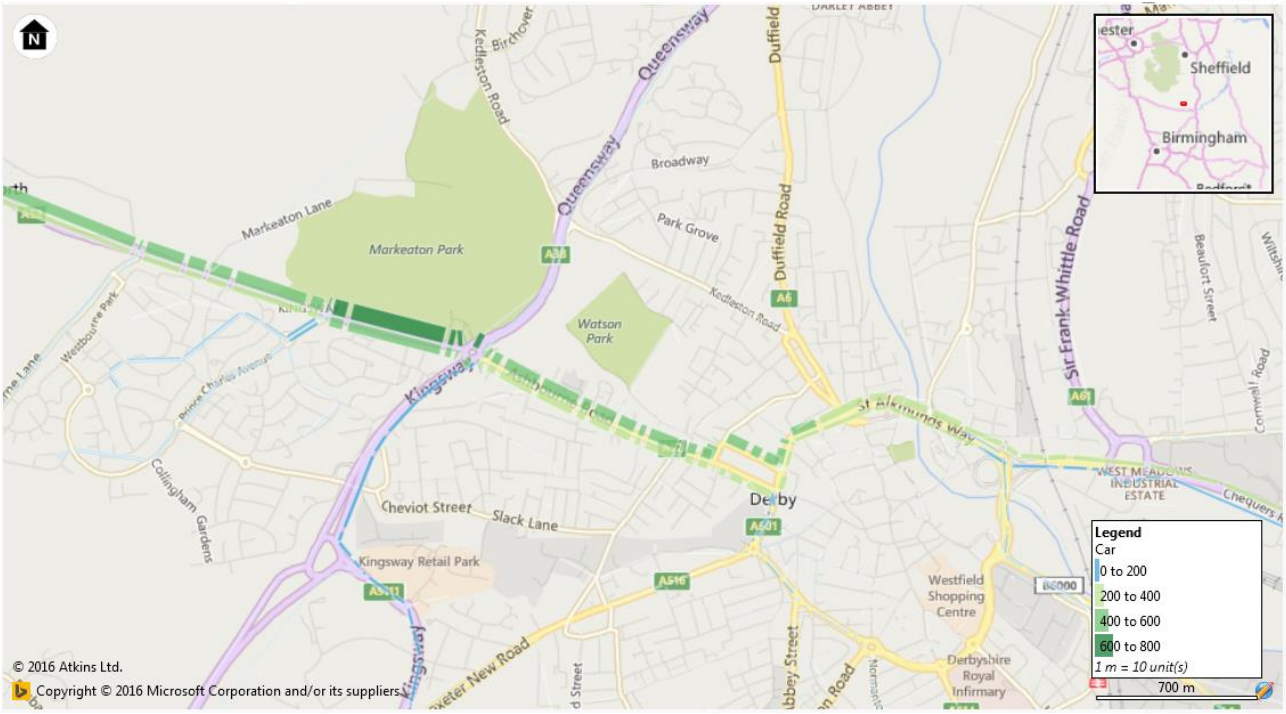


Figure 18: AM Select Link 7 Car

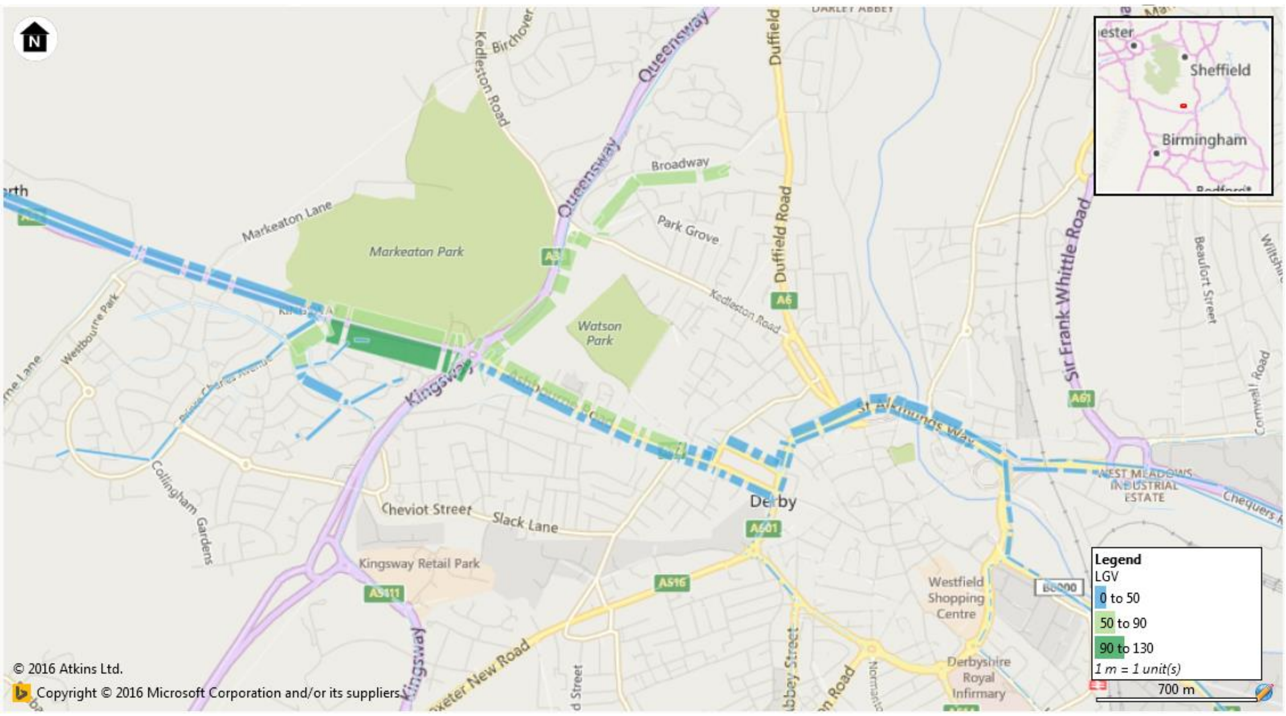


Figure 19: AM Select Link 7 LGV

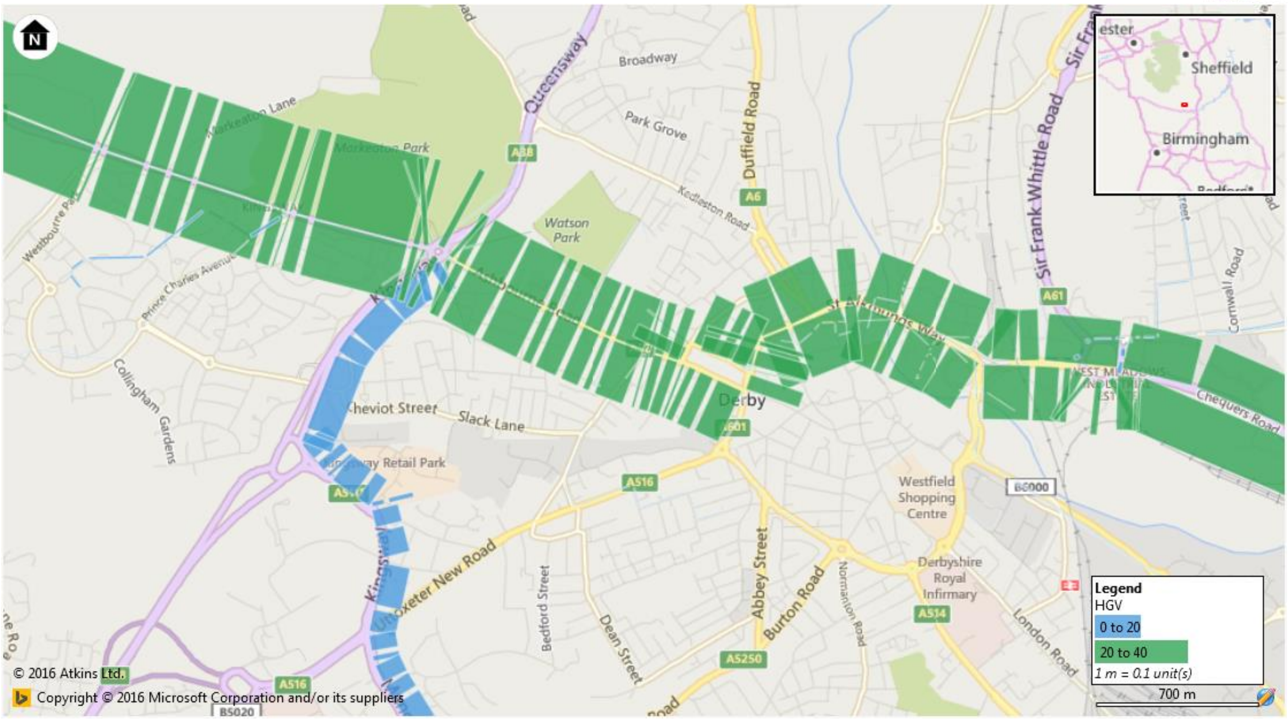


Figure 20: AM Select Link 7 HGV

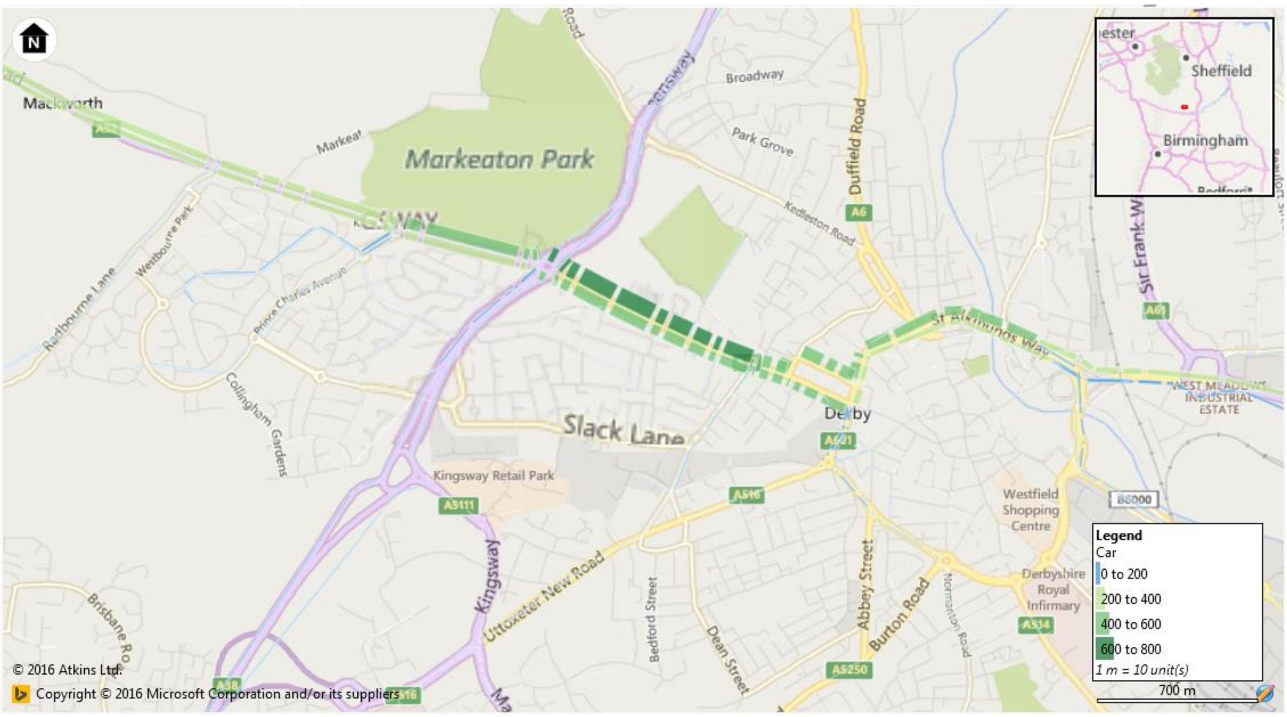


Figure 21: AM Select Link 9 Car

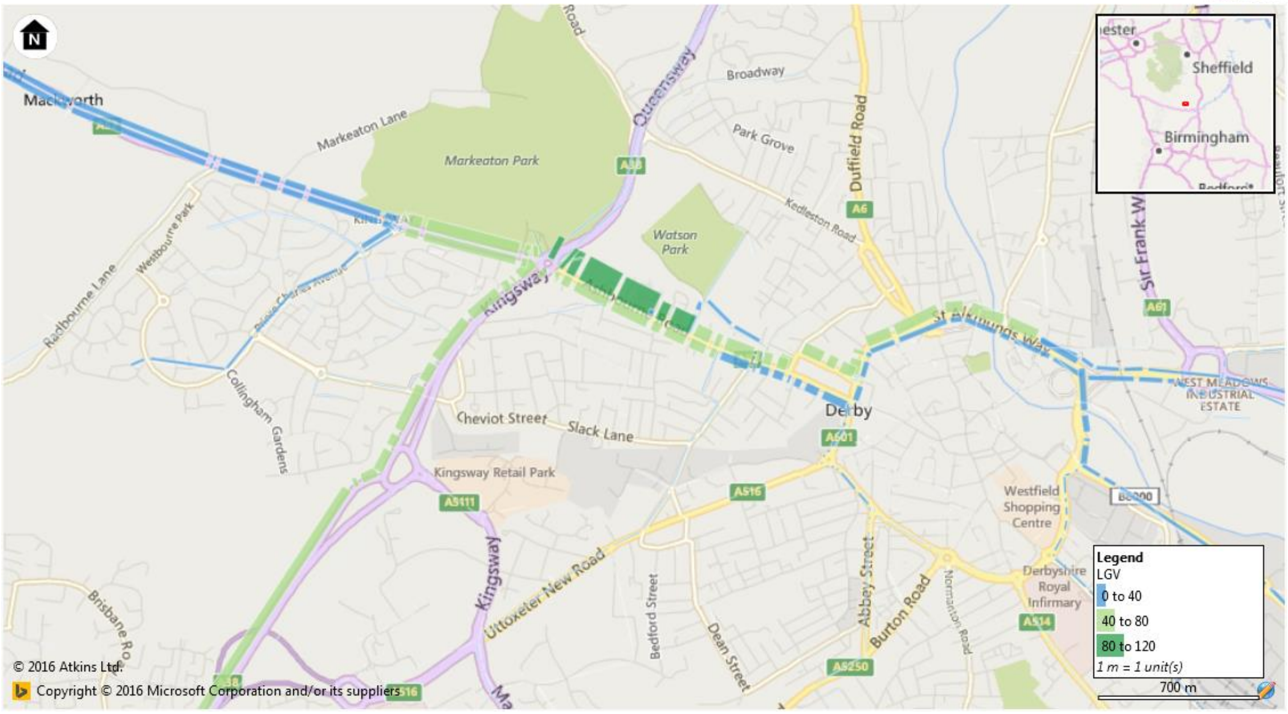


Figure 22: AM Select Link 9 LGV

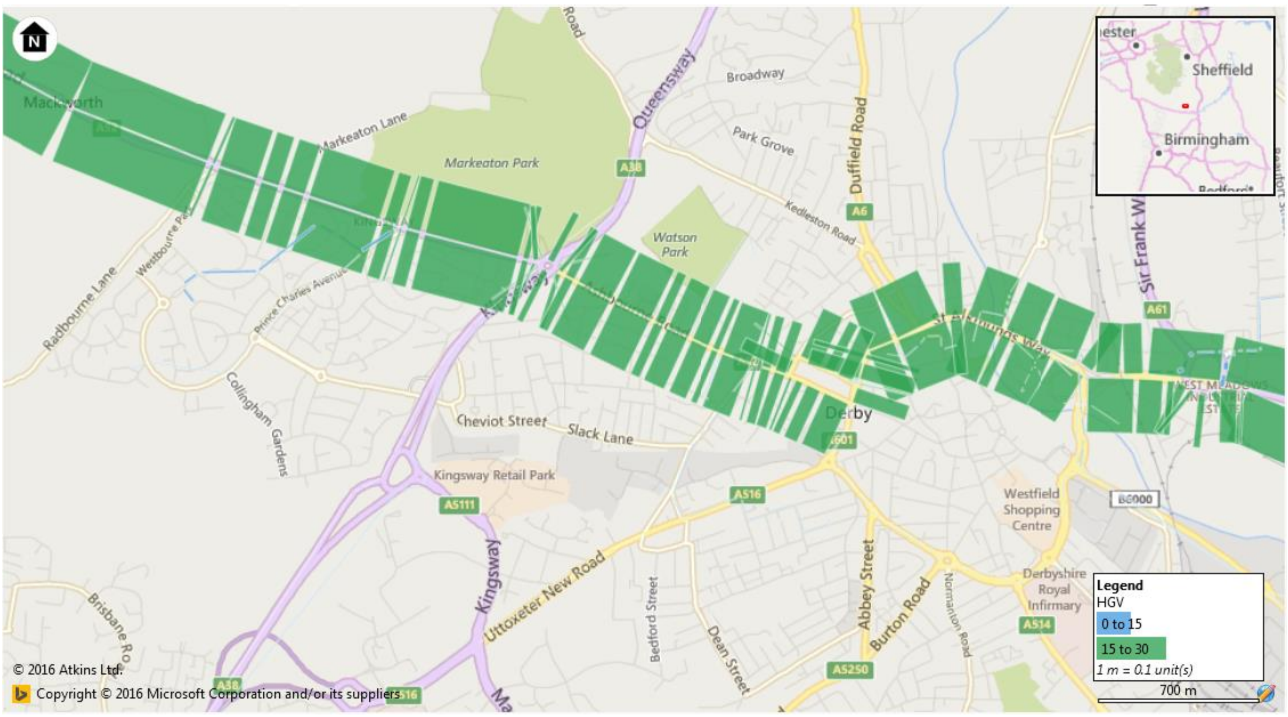


Figure 23: AM Select Link 9 HGV

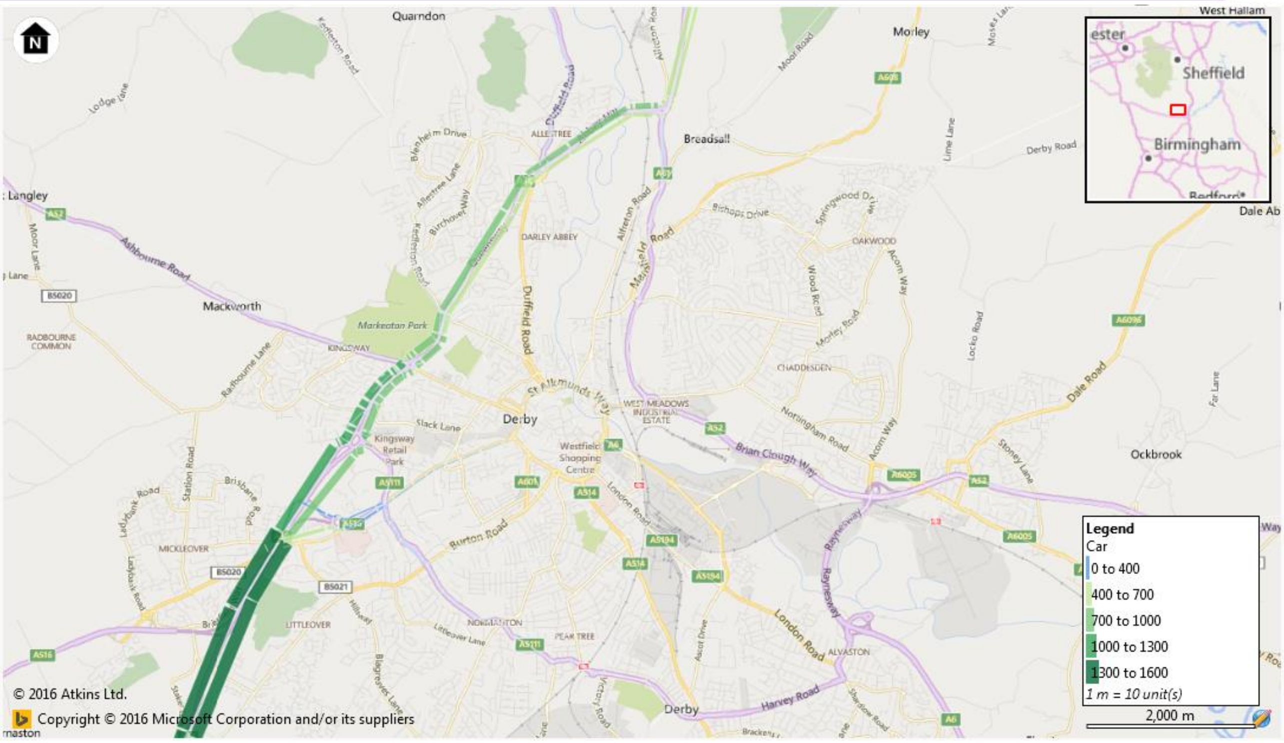


Figure 24: PM Select Link 1 Car

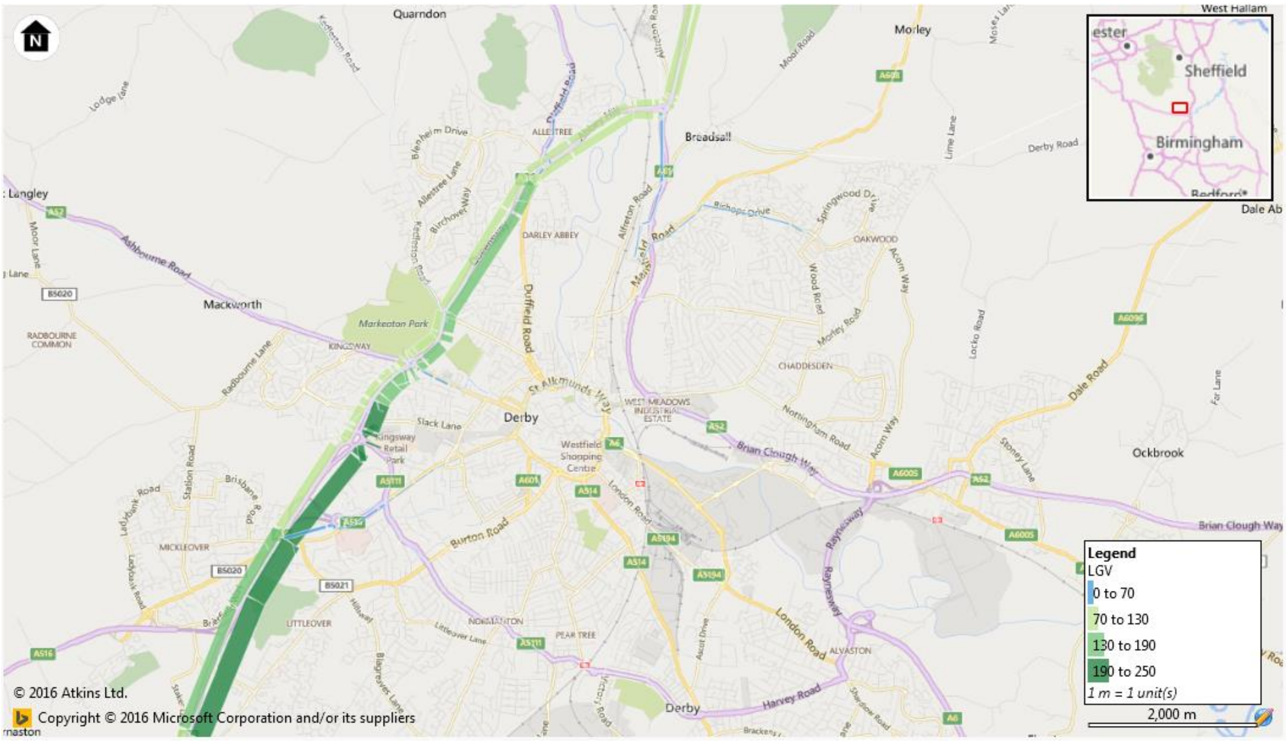


Figure 25: PM Select Link 1 LGV

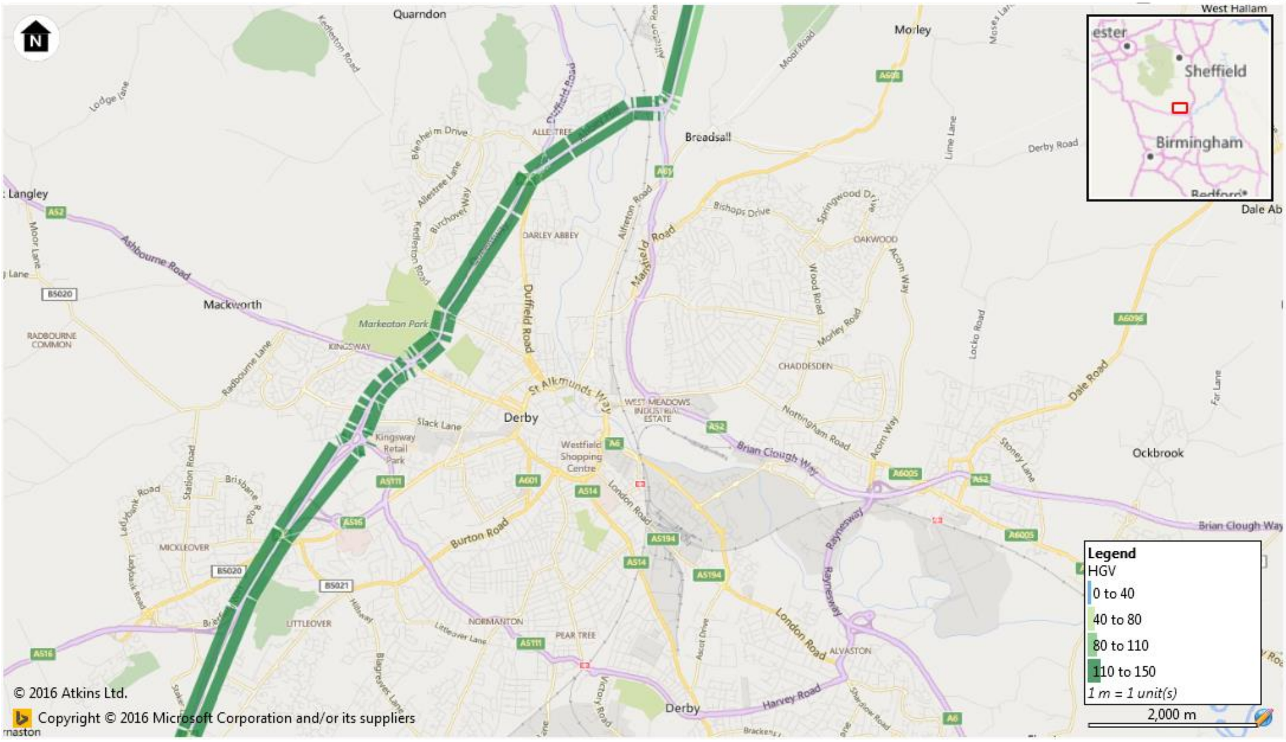


Figure 26: PM Select Link 1 HGV

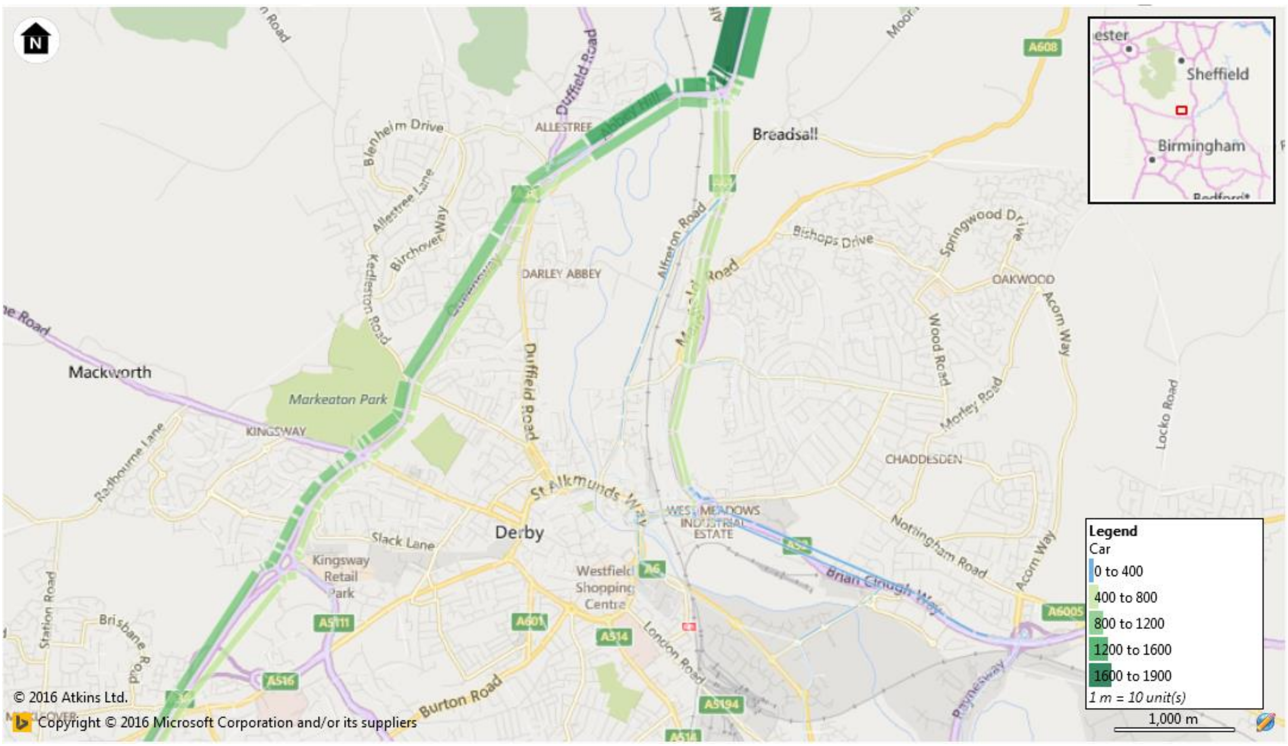


Figure 27: PM Select Link 15 Car

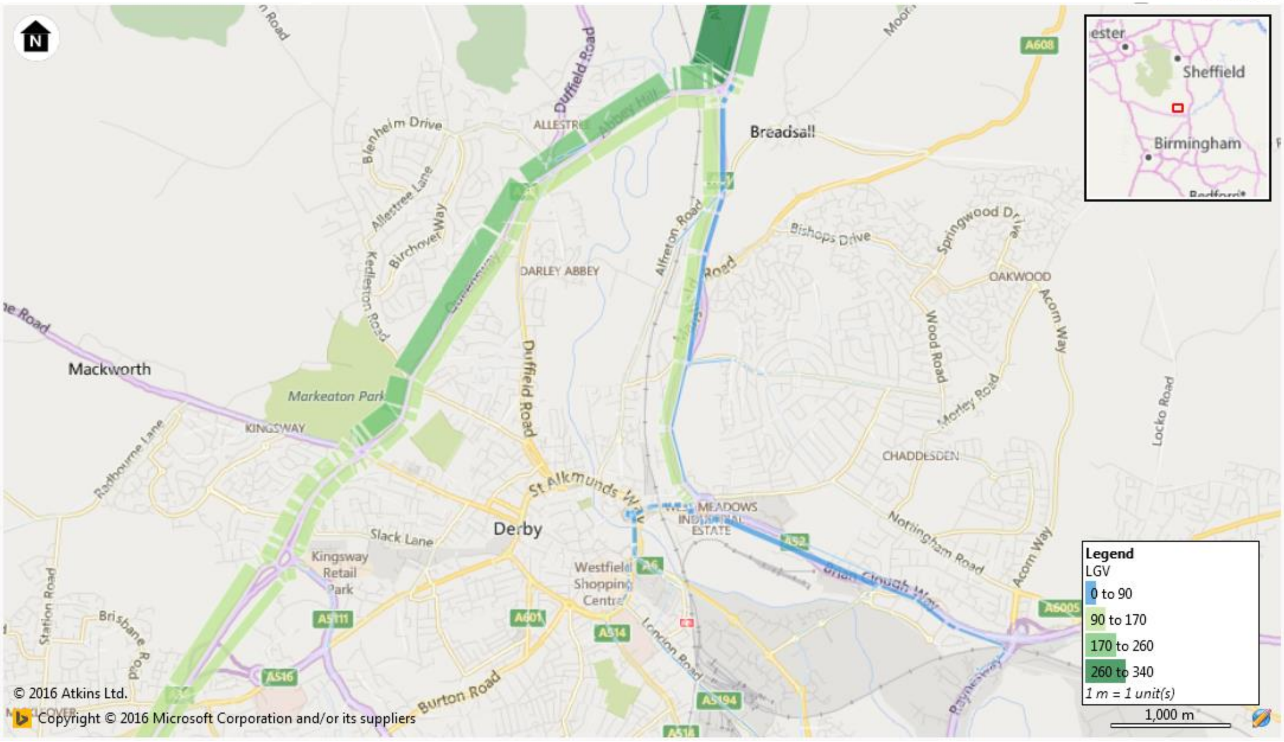


Figure 28: PM Select Link 15 LGV

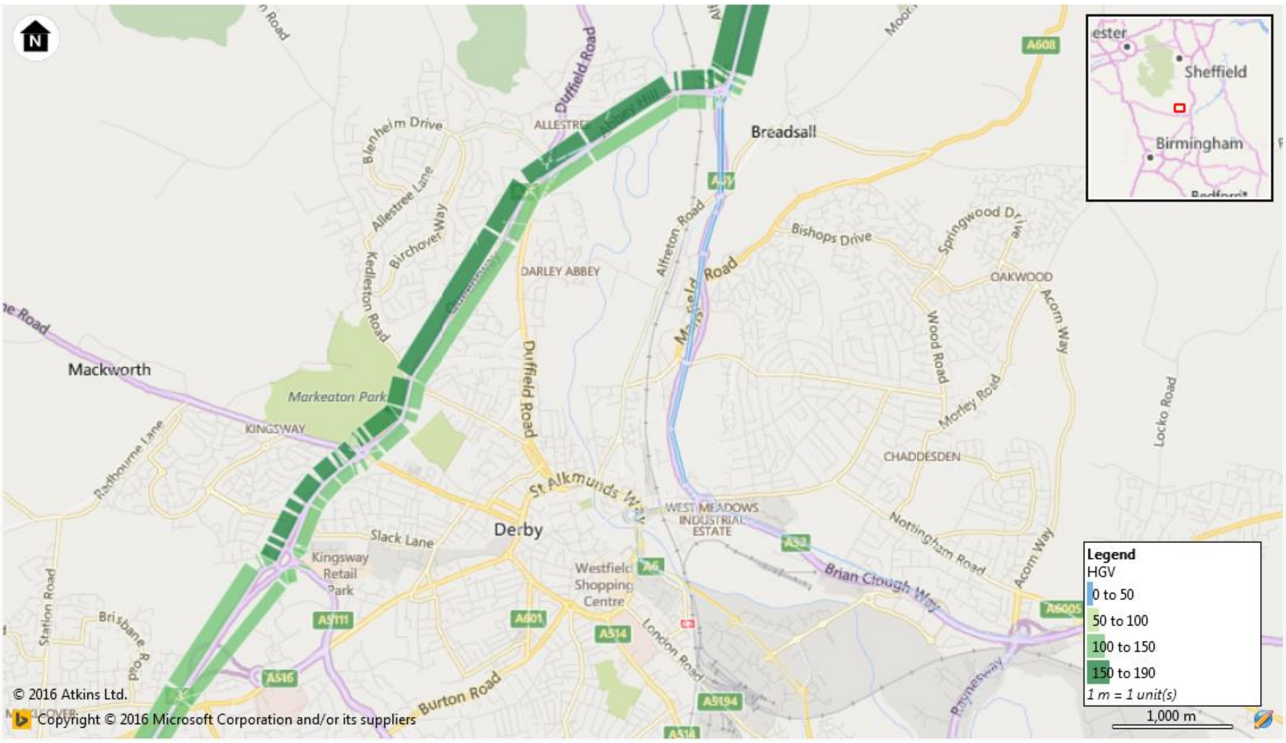


Figure 29: PM Select Link 15 HGV

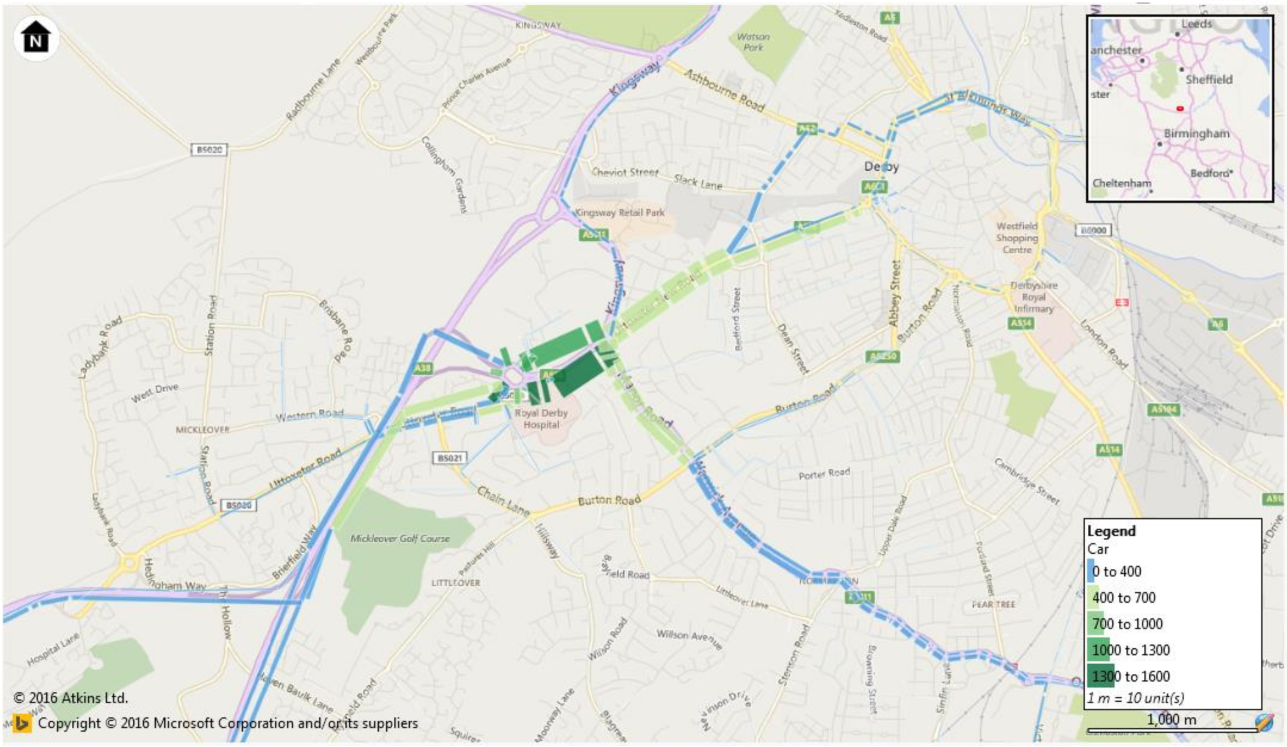


Figure 30: PM Select Link 4 Car

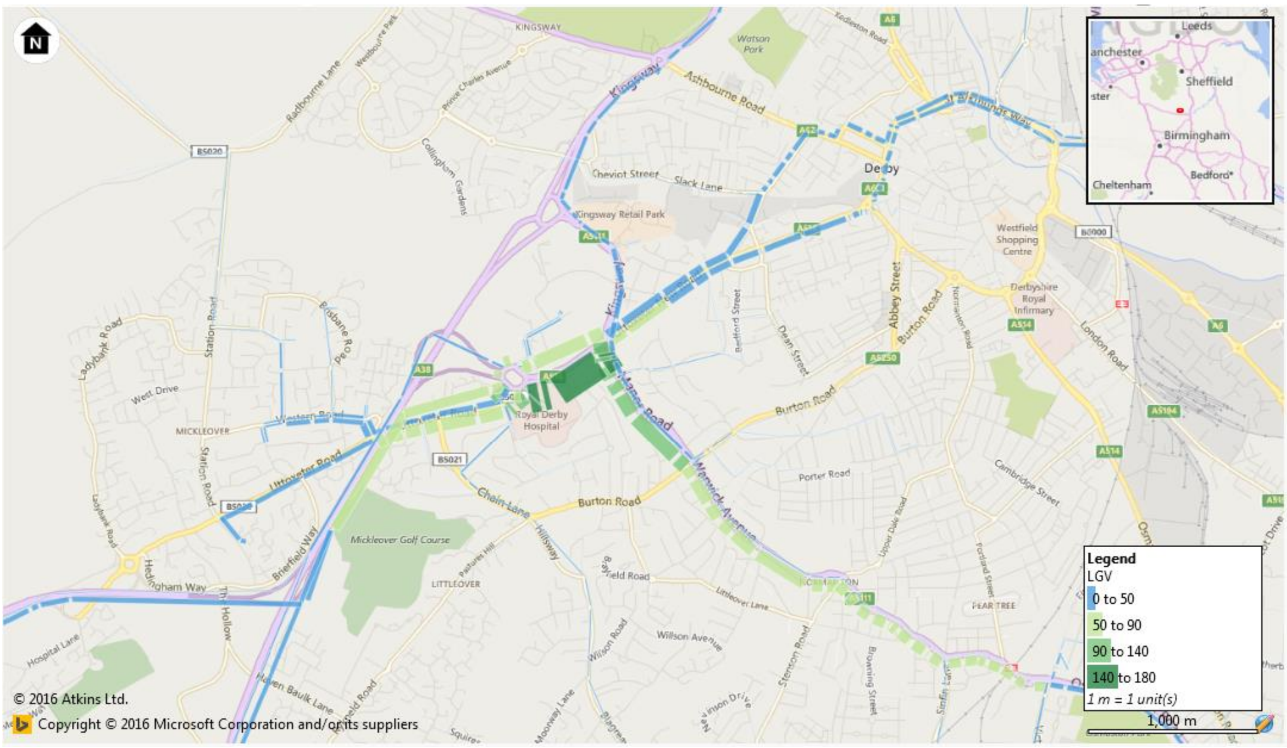


Figure 31: PM Select Link 4 LGV

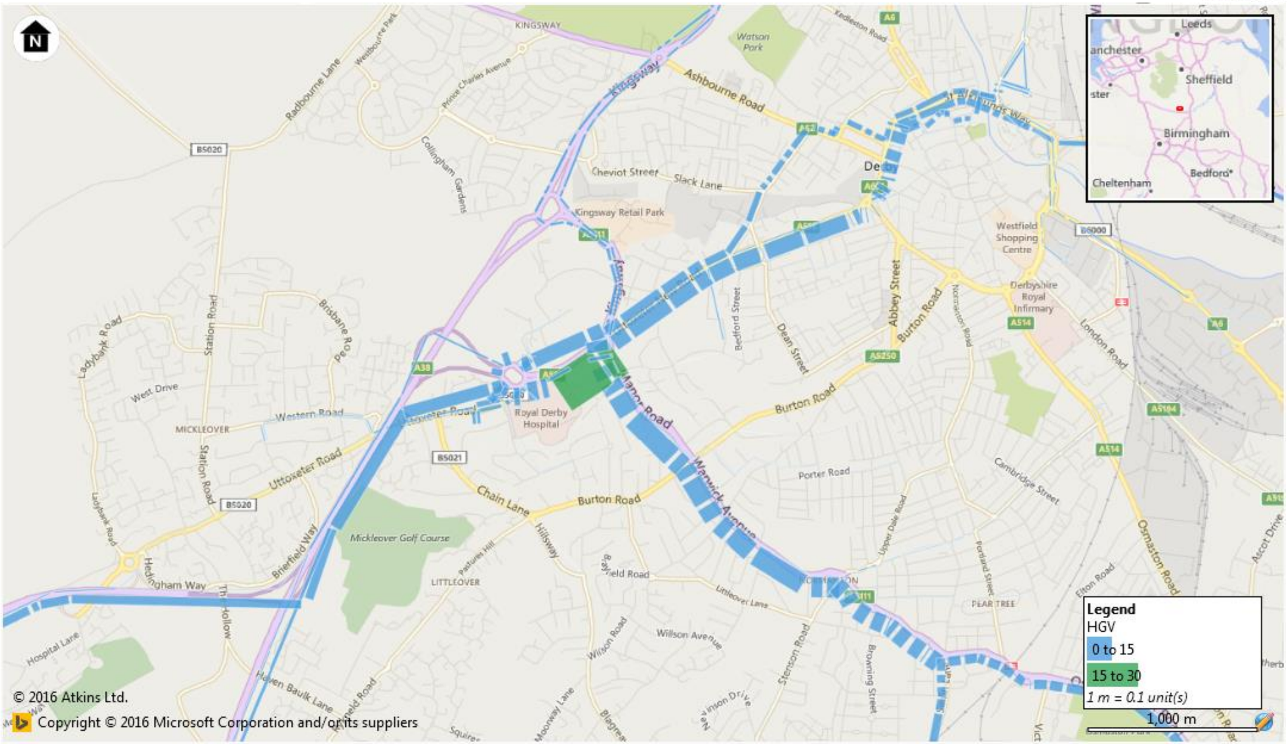


Figure 32: PM Select Link 1 Car

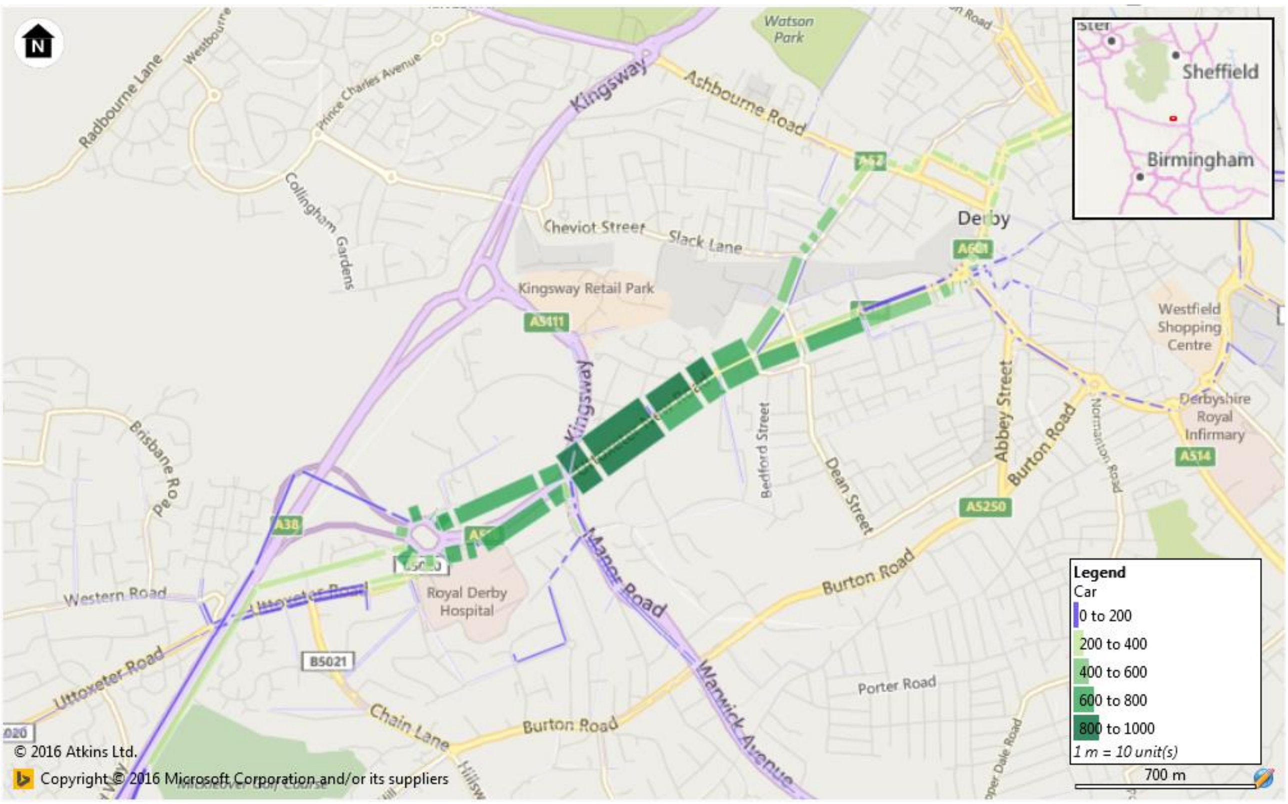


Figure 33: PM Select Link 1 Car

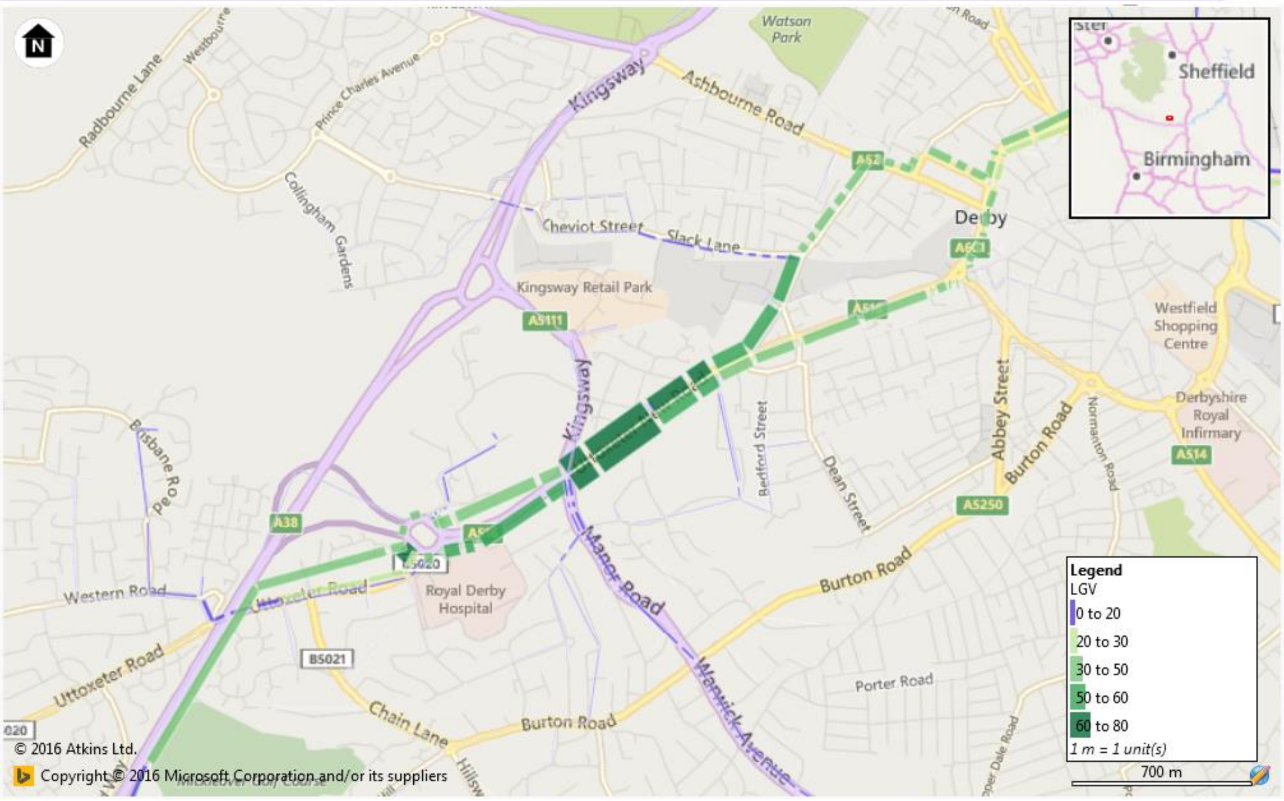


Figure 34: PM Select Link 5 LGV

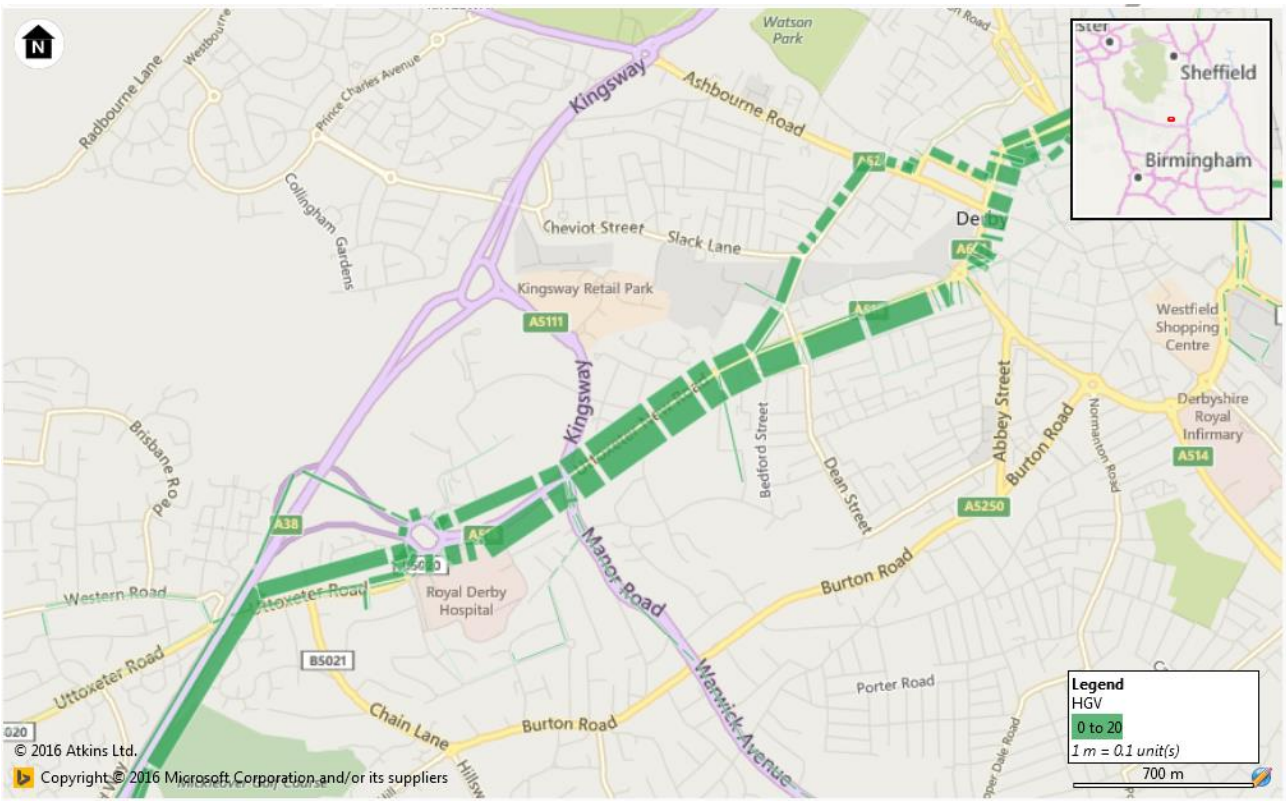


Figure 35: PM Select Link 5 HGV

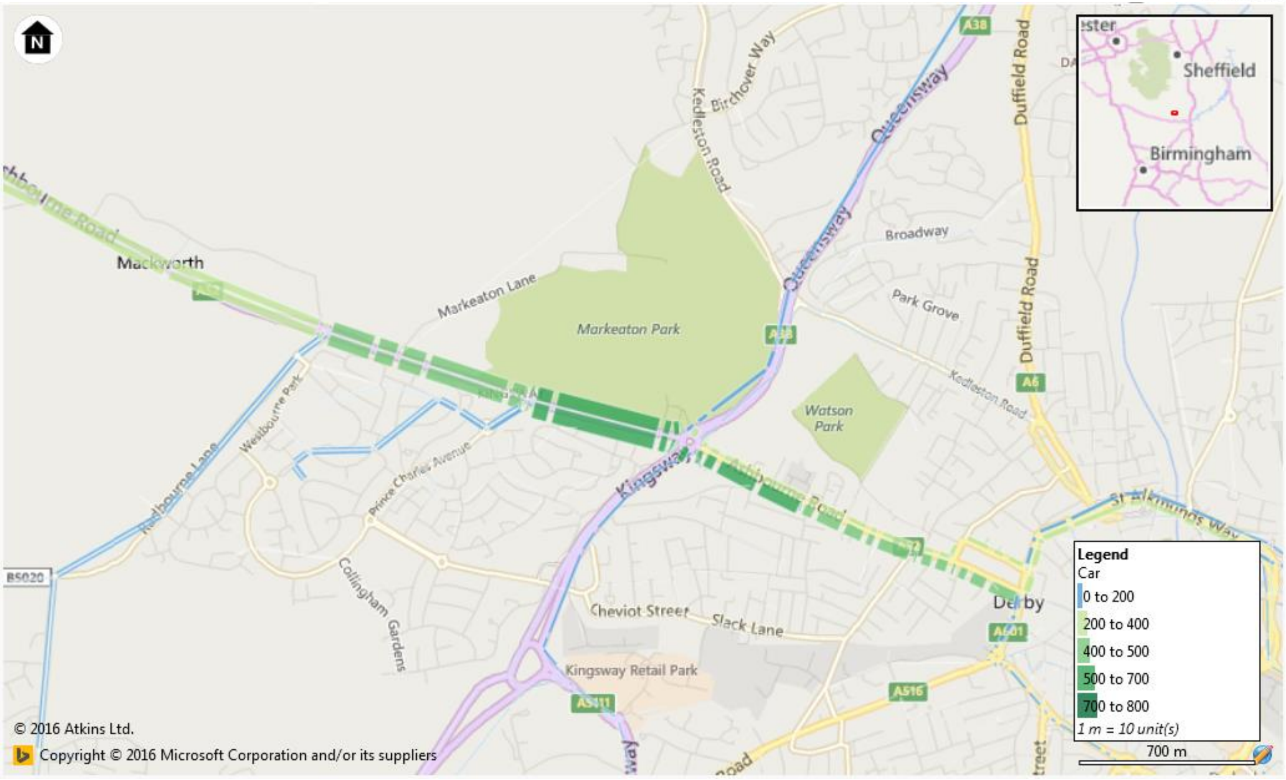


Figure 36: PM Select Link 7 Car

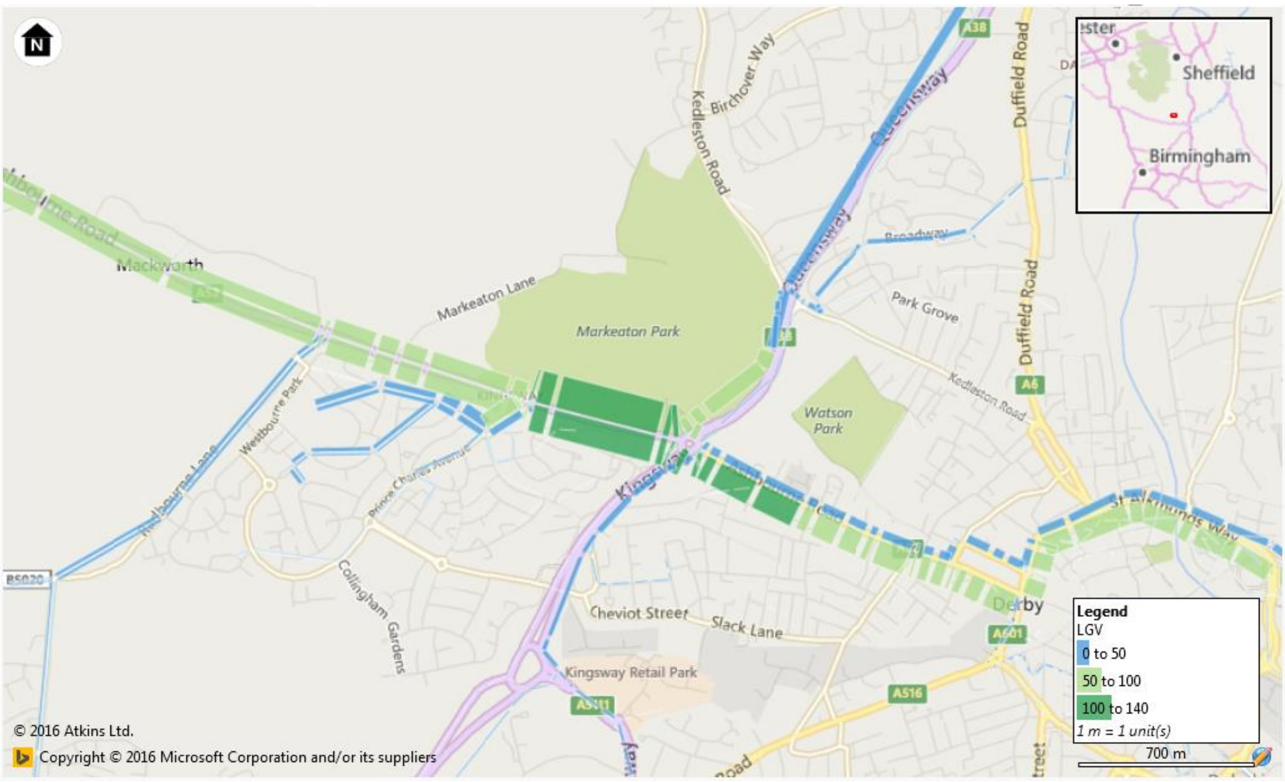


Figure 37: PM Select Link 7 LGV

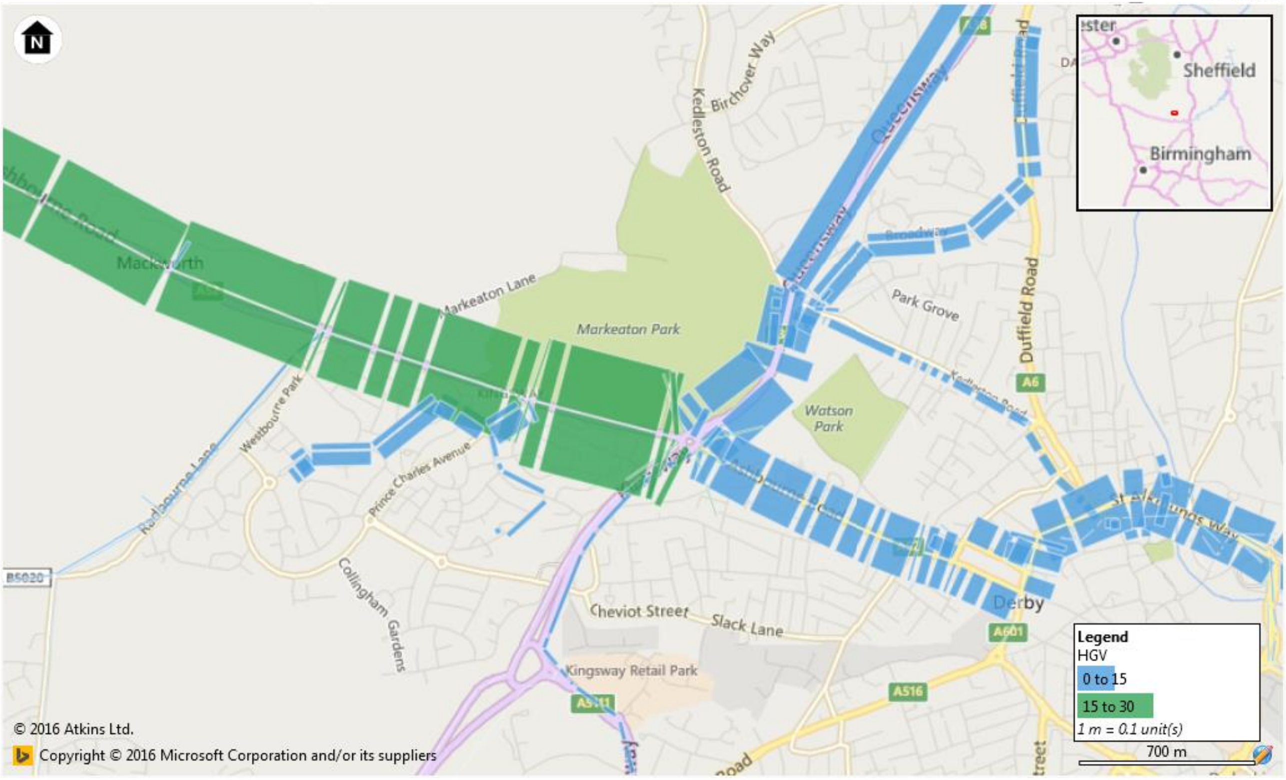


Figure 38: PM Select Link 7 HGV

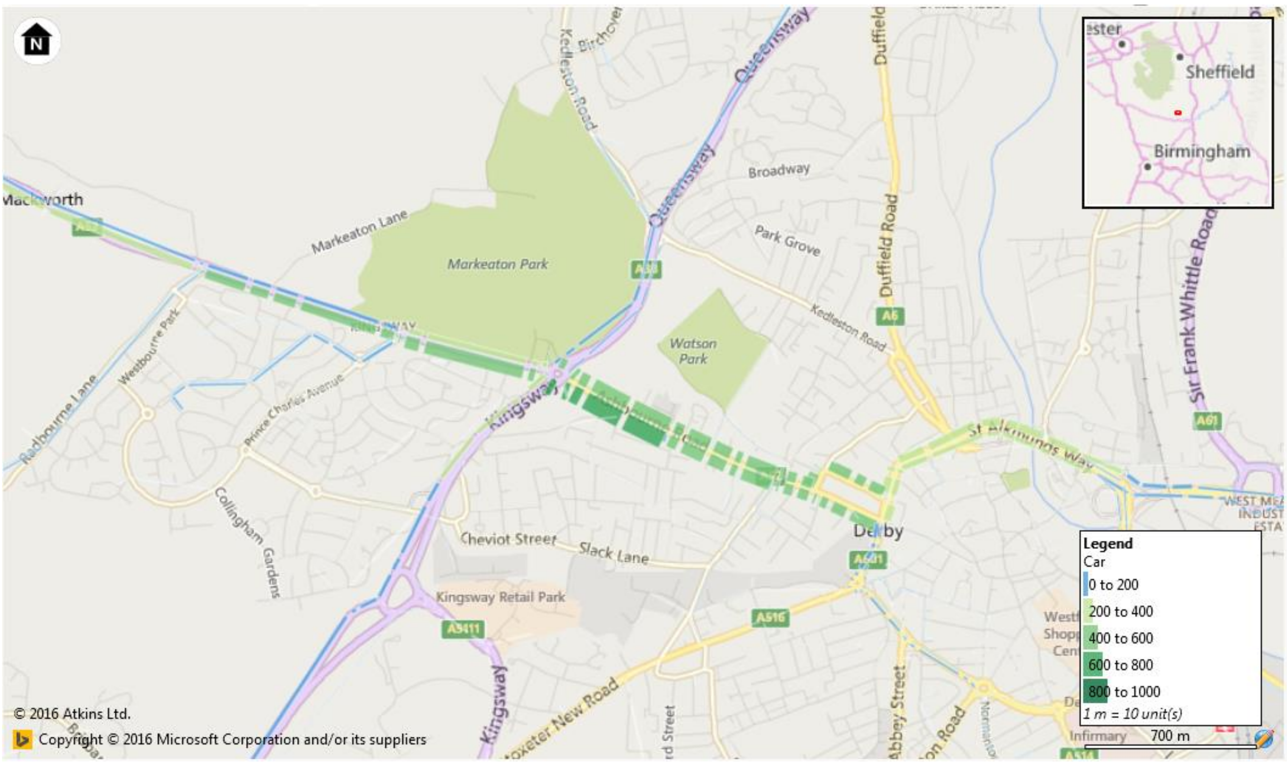


Figure 39: PM Select Link 9 Car

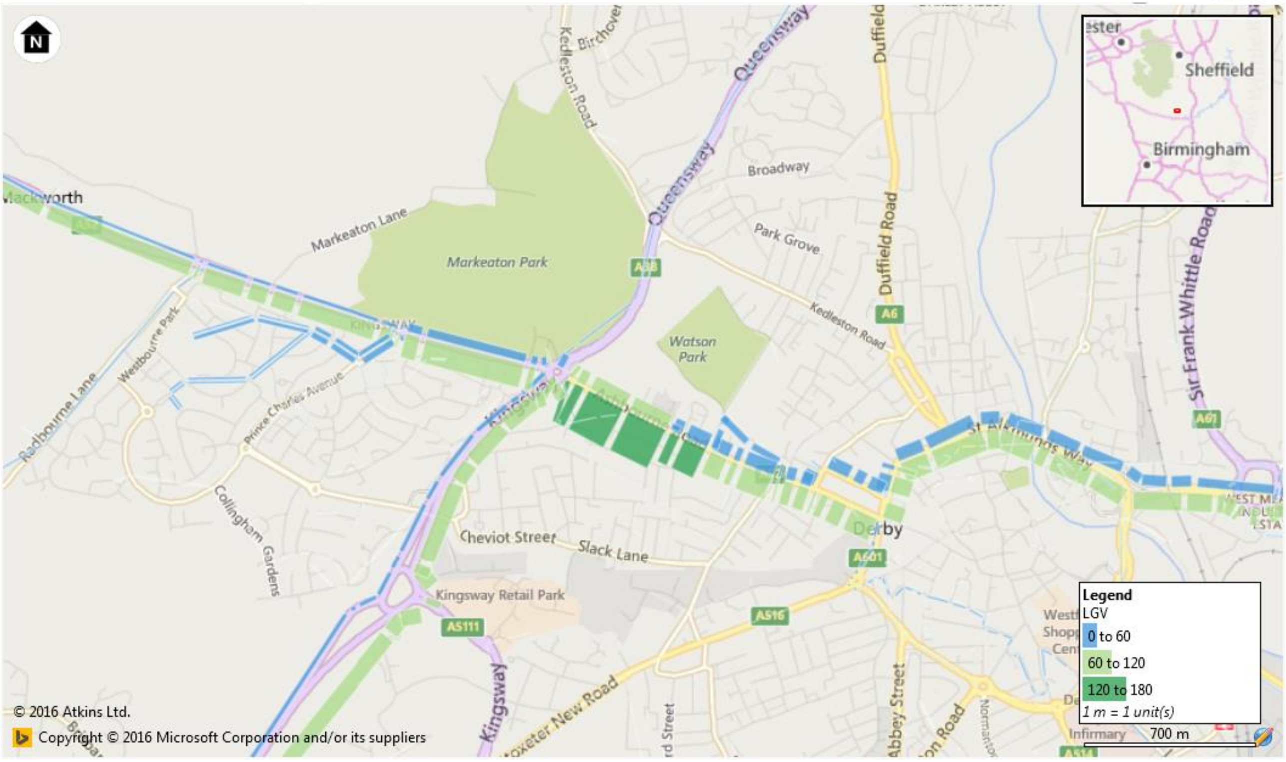


Figure 40: PM Select Link 9 LGV

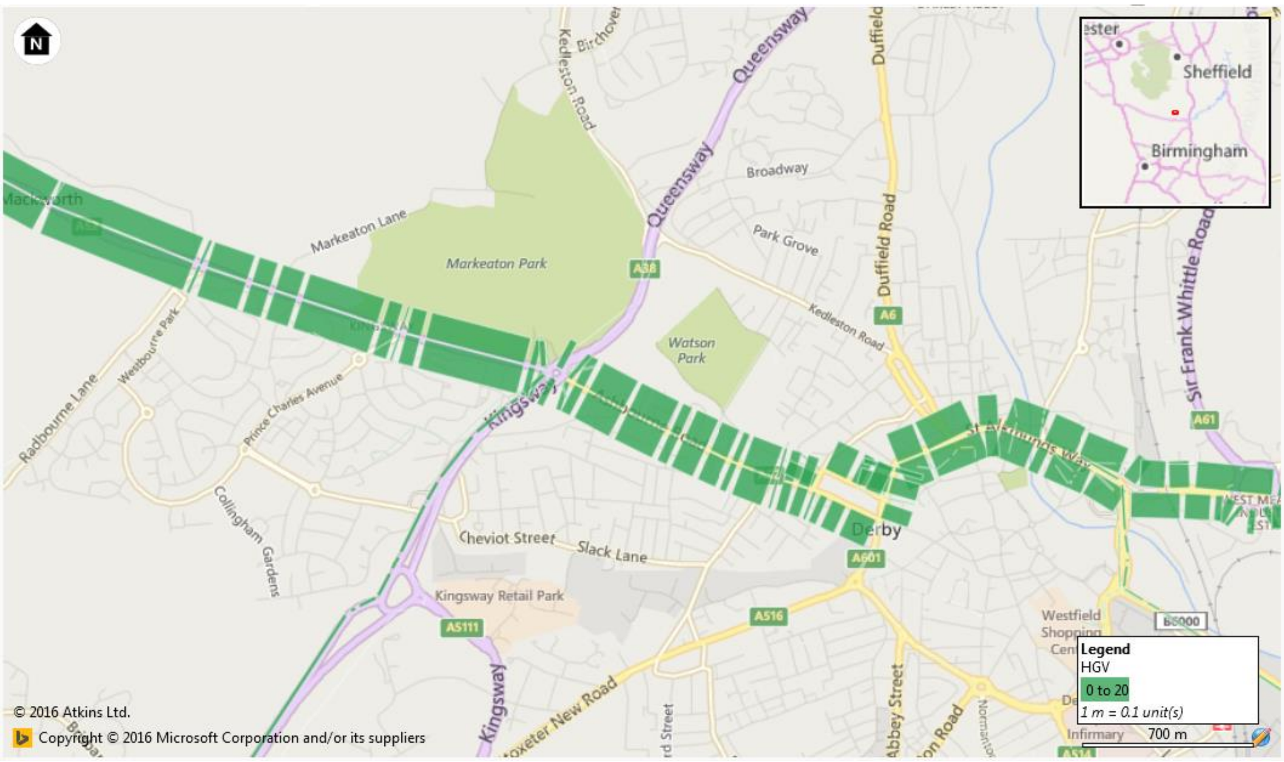


Figure 41: PM Select Link 9 HGV

Appendix 8B – Additional SLA AM Peak Analysis

SLA 2 (A38)

This SLA is on the main carriageway between the two junctions with the A516. Cars are mainly using the A38 main carriageway with other routing from the A516 onto the A38 main carriageway from both the west and east also influencing the cars at SLA 2. HGVs are mainly strategic A38 traffic at this section with some influence coming from the west from the A516 route. LGV movement is mostly strategic with the A38 and the A516 (both East and Westbound direction) being the only movements influencing LGV volumes at SLA 2.

SLA 3 (A38)

The SLA is located along the main A38 carriageway between the northern junction with the A516 and the roundabout with Kingsway. Similar to SLA 1 and 2, the majority of movements for cars, LGVs and HGVs are routing north and southbound on the main A38 carriageway. There is some input of cars and LGVs from the A516 onto the Northbound A38 carriageway. These first three Select Links indicate that the A38 is a strategic route and is not influenced as much by local traffic movements around the Derby area.

SLA 6 (A38)

SLA 6 is on the A38 Kingsway between the roundabout with the A38 in the south and a roundabout between the A38 (Queensway) and the A52 (Ashbourne Road). The link analysis suggests the majority of car and LGV movements is through traffic along the A38, with some minor inputs (15%) from each of the A5111 Kingsway and A516 routes. HGV traffic at SLA 6 generally appears to be strategic through-traffic.

SLA 8 (A38)

SLA 8 is located on the A38 (Queensway) between a roundabout with the Kingsway and the A52 (Ashbourne Road) in the south and the junction with Kedleston Road in the north. This link is adjacent to Markeaton Park. The majority of car traffic along this link proceeds along the A38 in both directions, with less than 5% coming off the A52 and roughly 15% off both the A5111 Kingsway link and A516.

HGVs are all directing along the A38 and LGVs are also predominantly originating from the A38 main carriageway, with similar routes to cars along the A5111 Kingsway.

SLA 10 (A38)

SLA10 is located along the A38 (Queensway) between the junction with Kedleston Road in the south and Palm Court Island in the north. The majority of cars, HGVs and LGVs are routing through the A38 main carriageway in both directions. Minor routing of car and LGV traffic is also seen on A5111 Kingsway towards the Royal Derby Hospital and A516 West.

SLA 11

This SLA is located on the A6 (Duffield Road) between Palm Court Island in the north and the roundabout with Darley Park Drive in the south. Cars are the predominant vehicle type on this route as both LGV and HGV proportions are significantly lower than on the A38. The direction of car movements along this SLA tend to favour the northern direction from Duffield and Milford, and southern direction along the A6/A52 via the Derby Inner Ring Road.

SLA 12 (A38)

SLA 12 is located on the A38 (Abbey Hill) between Palm Court Island in the south and Little Eaton Island in the North. Cars dominate as the main vehicle type and LGVs and HGVs feature significantly less. The flow of HGVs and LGVs through SLA12 is very focused on the A38 with very minimal traffic leaving or joining within the wider area and continuing north or south.

SLA 13

SLA 13 is located on the A61 (Alfreton Road) between Little Eaton Island in the north and the roundabout of Croft lane and Alfreton Road to the south. In terms of the flows there are similarities across all user classes; in particular, movements from the A38 (north) which shows comparatively high levels of traffic. In terms of car flows there is also significant travel from SLA13 to Alfreton Road and from SLA13 south on the A61.

SLA 14

SLA 14 is located on the B6179 (Alfreton Road) between Little Eaton Island in the south and the junction with Duffield Road in the north. The car flows are equally spread north and south of the SLA; in particular, equal flows to and from Alfreton Road (North) and to and from the A61 (south). There is also a significant flow from the SLA to A38 (west). The LGV flows are relatively low although no clear pattern is visible in terms of the routing of these vehicles.