Dundee Emissions Analysis Report

Main Points to Note

- Following the cyber-attack that significantly impacted SEPA's internal IT systems, an alternative approach for carrying out the modelling of proposed LEZs was agreed. This focuses on identifying changes to traffic emissions inside and outside the boundary of the proposed LEZ.

- The highest concentrations of annual-average NO_2 occur in the City Centre where vehicle emissions are dominated by buses. Diesel car emissions dominate other key routes around the city.

- Implementation of the proposed LEZ will reduce NOx emissions on key bus routes inside the LEZ boundary by an average of 70%. Emissions on Lochee Road outside of the LEZ boundary experience a reduction in NO_x emissions by an average of 20%. There is an overall reduction of annual NOx emissions within the LEZ of 78%.

- The proposed LEZ results in low levels of traffic displacement, except for an increase in car flow on the inner ring road and surrounding car parks, and a small increase in Goods vehicles on the Kingsway. This is linked to very localised increases in NOx emissions on small sections of road around the edge of the LEZ boundary. These occur on roads that currently have low traffic levels.

- The next steps will focus on areas of the city that see an increase in vehicle emissions by developing the air-quality model to predict changes in roadside concentrations. This will include detailed work on Lochee Road and the LEZ area.

Scope of Report

Air Quality (AQ) modelling in Dundee is ongoing as part of the National Modelling Framework (NMF) in support of the Scottish Government's Cleaner Air for Scotland Strategy (CAFS). This report summarises work carried out to calculate tail-pipe emissions of Nitrogen Oxides (NO_x) using outputs from the Dundee traffic model which has been used to inform the planning of a Low Emission Zone (LEZ) for Dundee City Council (DCC). This work has been carried out in line with the NMF, which has the aim to deliver a detailed and consistent approach to assessing AQ in Scotland's major cities. This report provides an early indication of where traffic-related emissions are likely to increase or decrease following the implementation of the LEZ.

This report follows on from previous reports by SYSTRA to which SEPA contributed detailed AQ modelling information. SEPA's model helped to inform the testing of early LEZ scenarios.

It is important to note that this is an interim report due to technical issues described below. Further detailed AQ modelling will resume during the summer of 2021 to inform the final LEZ design and will focus on the changes in Nitrogen Dioxide (NO_2) concentrations associated with the changes in traffic patterns summarised below. Particulate Matter (PM) modelling will be included in further work.

SEPA Cyber Attack – and the Alternative Approach Taken

On Christmas Eve, the Scottish Environment Protection Agency (SEPA) was subject to a serious and complex criminal cyber-attack that significantly impacted our internal systems and our AQ modelling capabilities.

As part of SEPAs recovery plan a phased rollout to restore critical services to re-establish communication in order to continue providing priority regulatory, monitoring, flood forecasting and warning services. This included the delivery of our NMF obligations to assist in the final assessments of the LEZ options for each city.

Due to SEPAs inability to carry out full AQ modelling, an alternative approach to allow for local authorities to report to their relevant committees in Spring 2021 was discussed at the LEZ Leadership Group meeting held on the 3rd of February 2021. The following steps were recommended by Scottish Government and SEPA on a way forward:

- Continuation of traffic modelling to define a small number of potential LEZ options or a preferred LEZ option for each city.
- SEPA to carry out emissions analysis on the traffic model outputs using the established NMF methodology. This will assess the impact of the LEZ by comparing traffic and emissions between the reference/base case and LEZ scenarios.
- SEPA to continue detailed AQ modelling during the consultation phase over the summer of 2021 to support the local authorities in finalising the preferred LEZ scheme for Ministerial approval.

Introduction and Background

Air quality management activities (including AQ monitoring) in Scotland have been primarily driven by the 2008 European Union Directive on ambient air quality and cleaner air for Europe (Directive 2008/50/EC), which was incorporated into Scottish law through the Air Quality Standards (Scotland) Regulations 2010 and 2016. At a domestic level, the Environment Act 1995 and Regulatory Reform (Scotland) Act 2014 set out the Local Air Quality Management (LAQM) regime to assist local authorities in achieving compliance with legal AQ standards and objectives set to protect human health.

The CAFS Strategy, published in 2015, sets out how Scottish Government and its partner organisations propose to further reduce air pollution and improve AQ to protect human health and fulfil Scotland's legal responsibilities as soon as possible. CAFS provides a clear commitment to the NMF to ensure that a consistent approach to modelling AQ in areas associated with the highest levels of poor AQ in all four major cities is taken. The NMF will provide tools and evidence to support the NLEF. The NLEF is an evidence-based appraisal process developed to help local authorities consider transport related actions to improve local AQ.

In September 2017, the Scottish Government's Programme for Government committed to the introduction of LEZs in Scotland's four biggest cities (Glasgow, Edinburgh, Aberdeen and Dundee) by 2020, with the first introduced in Glasgow in 2018. With the advent of COVID-19 and the subsequent lock-down restrictions and recovery measures the decision was made to temporarily pause the implementation of LEZs and the Scottish Government have since set a revised timetable for LEZs to be introduced across all four cities between February and May 2022.

CAFS has been subject to a formal review, with an updated strategy (CAFS2) expected to be published shortly in 2021 (to run to 2026). The initial findings of the review identified that Scotland was performing well on AQ, with the major pollutants continuing to fall as a result of actions taken to date. However, the review also recommended that there is more work to be carried out and Scotland must take a precautionary public health approach to further AQ reductions.

Emissions Analysis

A traffic model has been developed by SYSTRA to assess how traffic patterns could change in response to the implementation of a LEZ in Dundee. The model predicts how non-compliant vehicles could be displaced by the LEZ and may re-route around the LEZ.

A comparison has been made between a 'Reference' case and a LEZ case.

- Reference case traffic flows are based on those observed in 2019, but data about the age of the fleet, e.g. the proportions of vehicles that are compliant, are based on fleet observations in 2017. The proportion of bus journeys being made by the lowest-emitting EURO VI buses in the LEZ was 30%.

- Traffic flows in the LEZ case are based on the Reference case with the added intervention of the LEZ. The vehicle fleet is also based on a fleet observed in

Dundee in 2017, but the proportion of bus journeys being made by EURO VI buses was increased to 100%.

A comparison for a 2017 fleet composition gives a worst-case scenario regarding the amount of traffic that will be displaced by the LEZ. This is a more precautionary approach than projecting how quickly the fleet could upgrade in the years leading up to the full introduction of the LEZ.

Traffic model outputs were firstly processed to make them compatible with the CERC emissions database tool (EMIT) using conversion factors derived from observed traffic data. Emission rates (g/km/s) could then be calculated for every road in the traffic model for the Reference and LEZ scenarios. Comparing emissions between these 2 scenarios enables any changes due to the LEZ to be identified.

The EMIT software used contains the emission factors from the Emission Factor Toolkit (EFT) version 8.

Traffic Pollutants described in this Report

The focus of the LEZ is on reducing local concentrations of Nitrogen Dioxide (NO_2) which is emitted directly from the tailpipe of road traffic. However, NO_2 is also chemically produced in the atmosphere from road traffic emissions of Nitrogen Oxide (NO). These two pollutants are referred to collectively as Nitrogen Oxides (NO_x).

The AQ modelling focused on predicting concentrations of NO_2, which is how compliance against AQ Standards is assessed. However, the AQ model has also been used to estimate the proportions of vehicle pollution that comes from different types of vehicle, e.g. diesel cars vs buses. This type of analysis is usually performed for NO_x, rather than NO_2. It is difficult to calculate the breakdown of NO_2 for different vehicles accurately because of the additional component of NO_2 that is created in the atmosphere. For this reason, the analysis of traffic model output currently focuses on emissions of NO_x only.

LEZ Extent

The extent of the LEZ is shown in Figure 1 inside the inner ring road, which is covered by the AQ and traffic models.

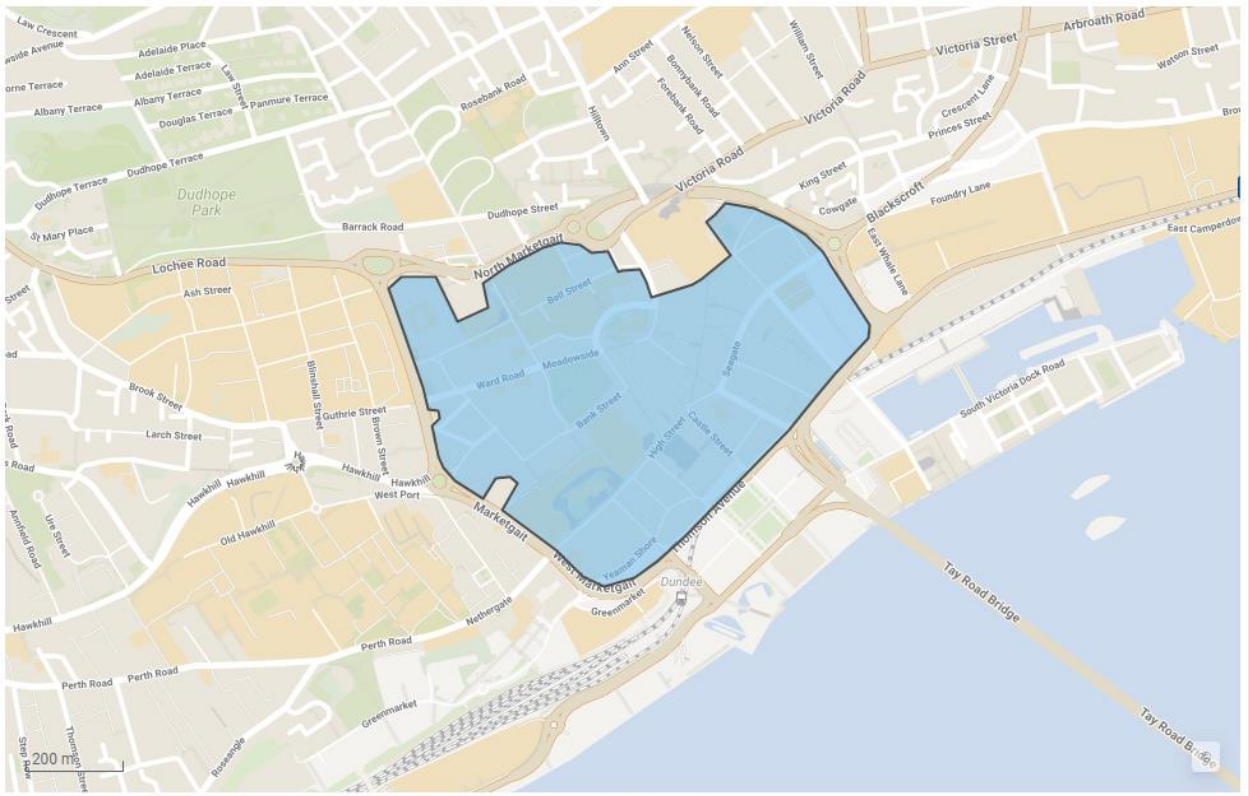

Figure 1 – LEZ extent covering the area of Dundee City Centre within the inner ring road.

Air Quality Model: Pollutant Concentrations

Air quality modelling carried out previously was used to predict concentrations of NO_2 at a network of regular kerbside points across the city. The red markers in Figure 2 show predicted exceedances of the annual average NO_2 limit value of 40µgm^{-3}. Areas of exceedance are focused in the City Centre and in particular along major bus routes. The model results shown here were based on conditions in 2017.

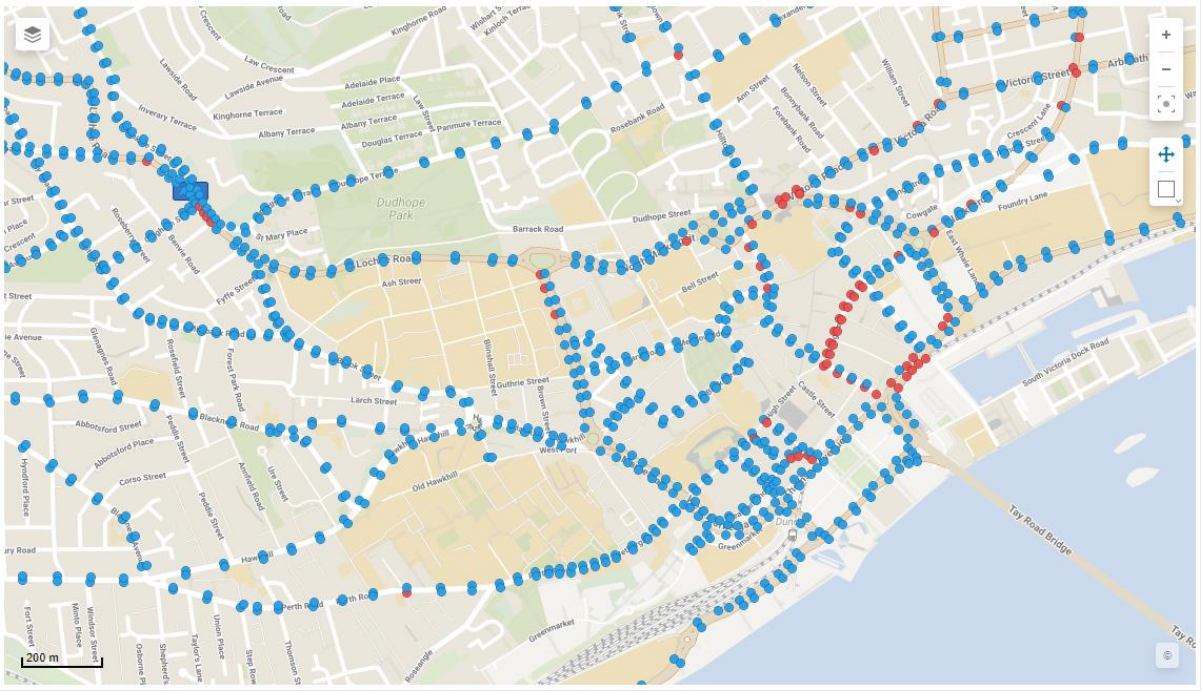

Figure 2 – Modelled concentrations of annual-average NO_2 above (red) and below (blue) the limit value of 40µgm^{-3}.

Air Quality Model: Emissions by Vehicle Type

The AQ model was also used to estimate the relative contribution to total levels of NO_x from different types of vehicles. This analysis showed that the greatest contributors to NO_x across the city are buses and diesel cars. Bus emissions are most dominant on roads inside the City Centre and on key routes in and out of the city. This is where the highest pollutant concentrations are measured and predicted (Figure 3). Diesel car emissions are dominant on other key routes around the city (Figure 4).

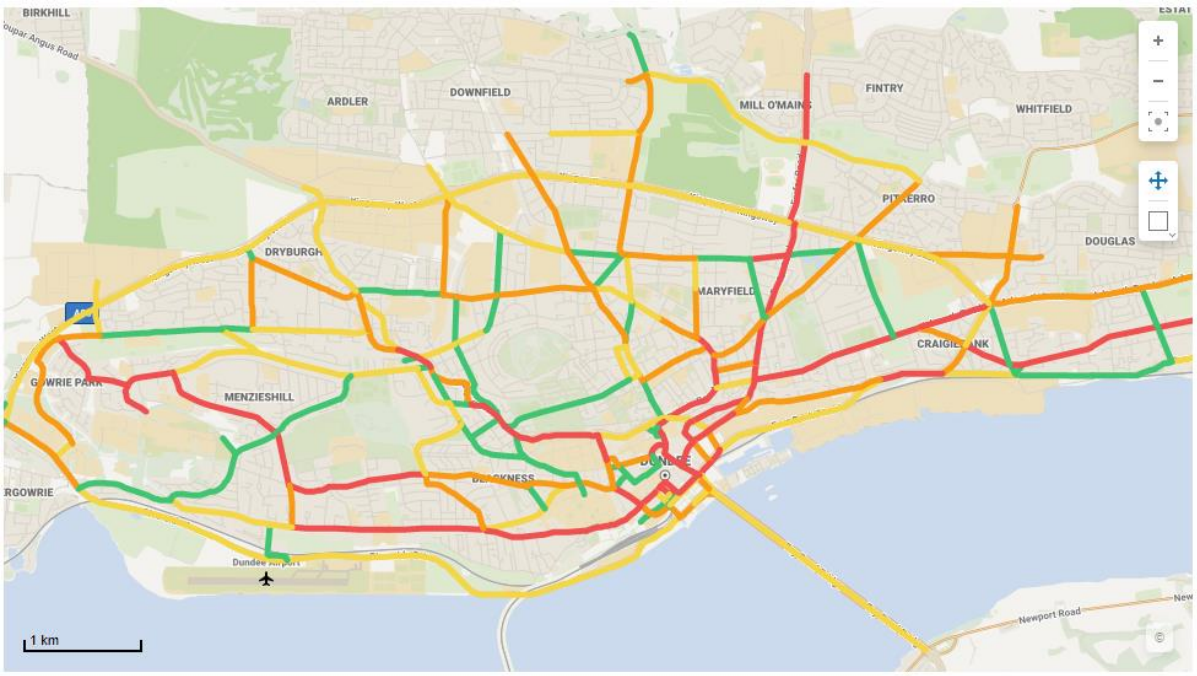

Figure 3 – The roads coloured in red are those dominated by bus emissions (highest 25%).

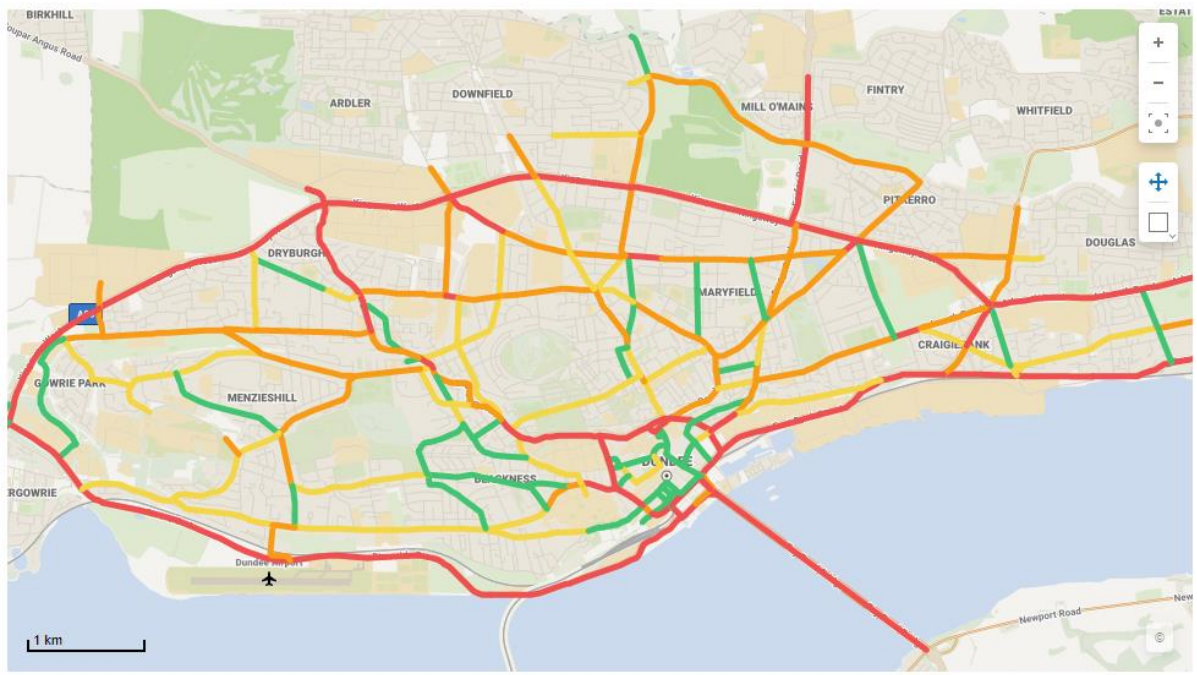

Figure 4 – The roads coloured in red are those dominated by diesel car emissions (highest 25%).

Traffic Model Analysis

The effects of the LEZ have been investigated both inside and outside of the LEZ boundary. The most significant emission reduction occurs inside the boundary where vehicles are required to meet strict emission standards. Some vehicles that do not meet the emission standards of the LEZ re-route around the edges of the LEZ boundary. This displacement of non-compliant vehicles has the potential to increase vehicle emissions.

On key bus routes inside the LEZ there is a significant reduction in NO_x emissions. On the roads highlighted in black in Figure 5 there is an average reduction in total NO_x emissions of over 70%. Those roads highlighted that are outside of the LEZ are mostly associated with lower absolute levels of emission. There is an overall reduction in NO_x emissions on all roads inside the LEZ of 78%.

Many of the roads inside the LEZ that see the greatest reduction in emissions coincide with those highlighted in Figure 2 where the highest pollutant concentrations are experienced.

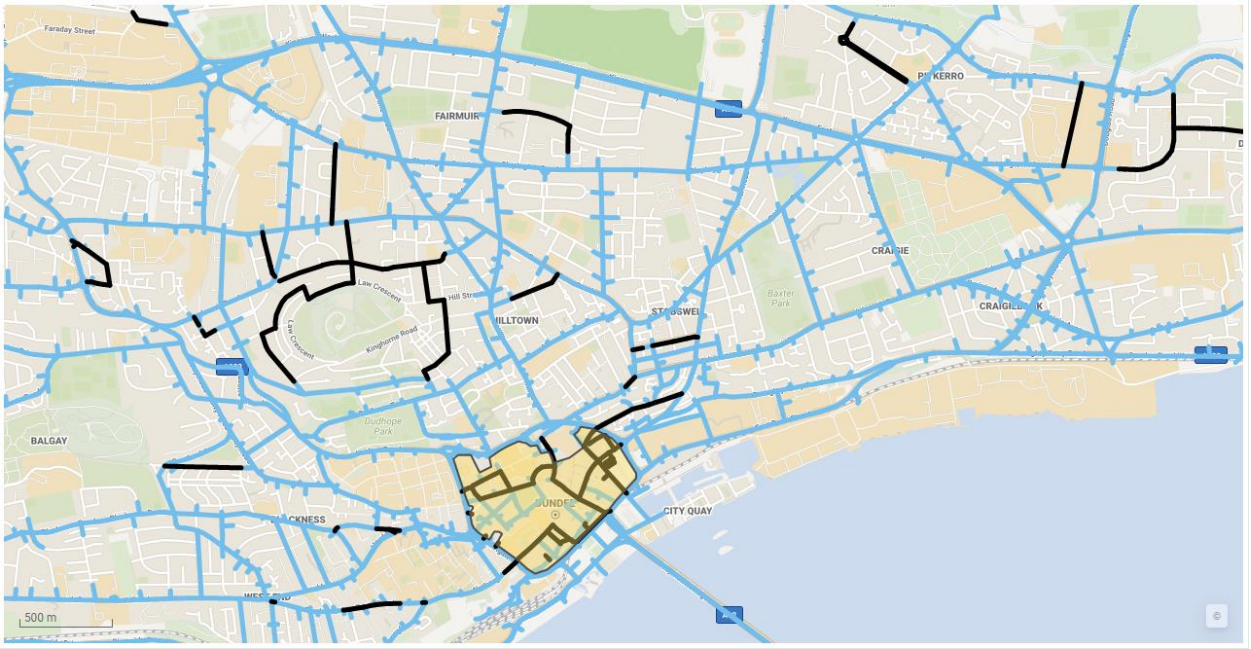

Figure 5 – Areas highlighted in black are predicted to see on average a 70% reduction in NO_x emissions. These are mostly key bus routes within the city City Centre which coincide with high pollutant concentrations and exceedances of the NO_2 annual limit value. The extent of the LEZ is shown in yellow.

There is an average reduction in NO_x emissions along Lochee Road of 20%, along the section of road highlighted in Figure 6. The air-quality model has shown that emissions in this area are linked to a wider mix of vehicle categories than those within the LEZ that tend to be dominated by buses.

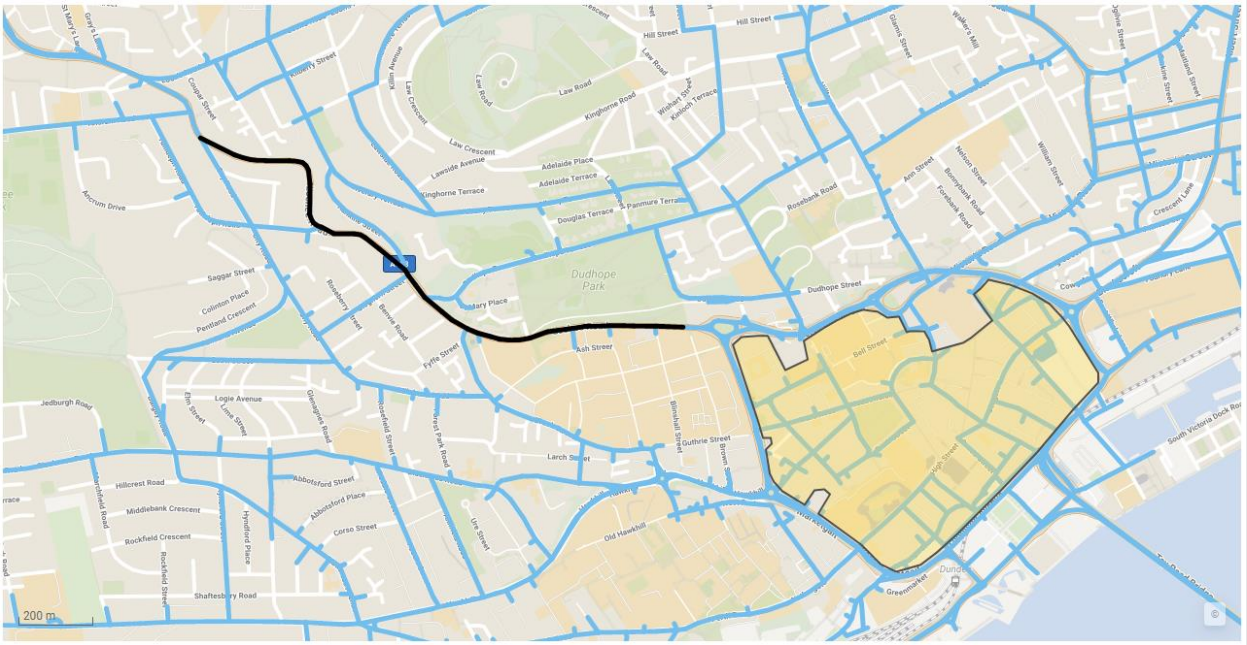

Figure 6 – Section of Lochee Road highlighted in black where NO_x emissions are reduced by 20% following implementation of the LEZ.

There is an increase in car flow around the edge of the LEZ when compared against the Reference case. On the roads highlighted in black in Figure 7 there is an increase of over 100 cars per day. The largest increases in car flow are associated with parts of Marketgait and nearby car parks, as highlighted in red. On these roads there is an increase of between 1000 and 2000 cars per day. A small link leading to the NCP Marketgait car park on the edge of the LEZ boundary sees an increase of around 4000 cars per day.

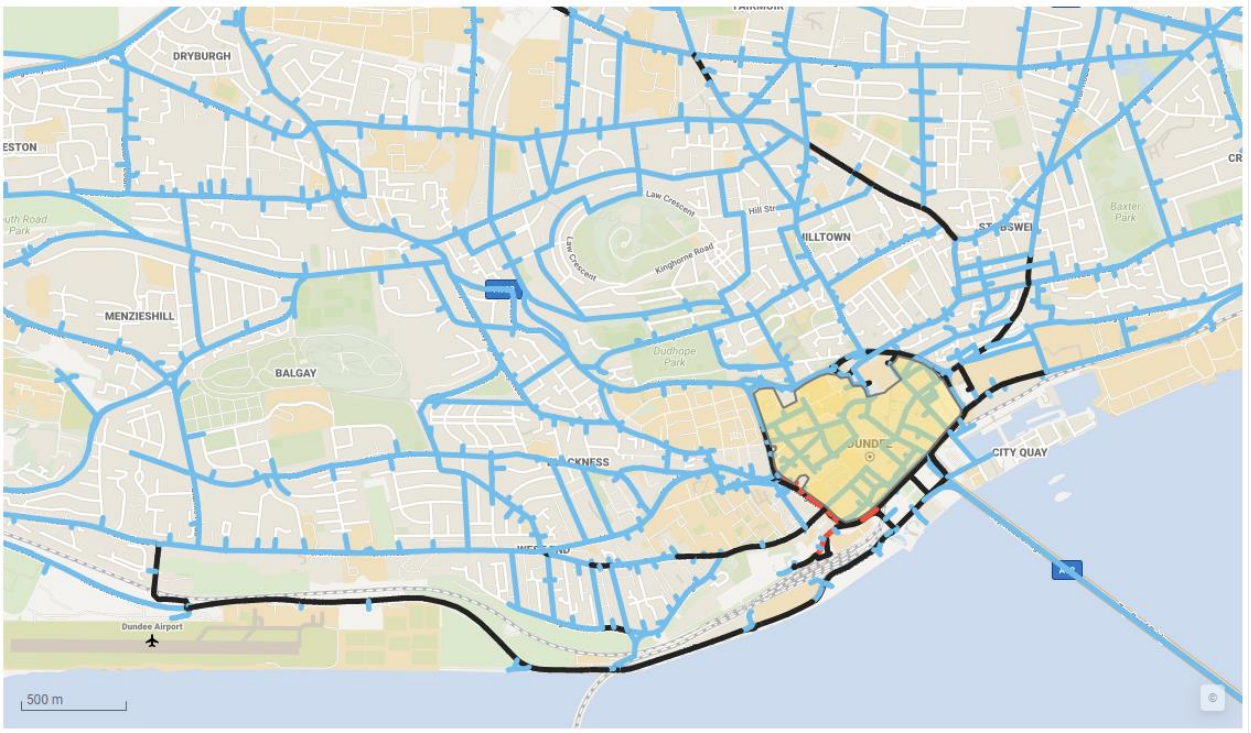

Figure 7 – Areas highlighted in black and red are predicted to see an increase in car traffic flow due to displacement of journeys around the edge of the LEZ. The extent of the LEZ is shown in yellow.

There are only small increases in other vehicle types due to the implementation of the LEZ. Roads highlighted in black in Figure 8 are those where the daily number of LGV's increases by over 25, to a max of 60. The roads highlighted black in Figure 9 show where the daily number of Rigid Heavy Goods Vehicles (HGVs) increase by over 25, to a max of 85.

Figure 8 – Roads highlighted in black experience an increase of over 25 LGVs per day.

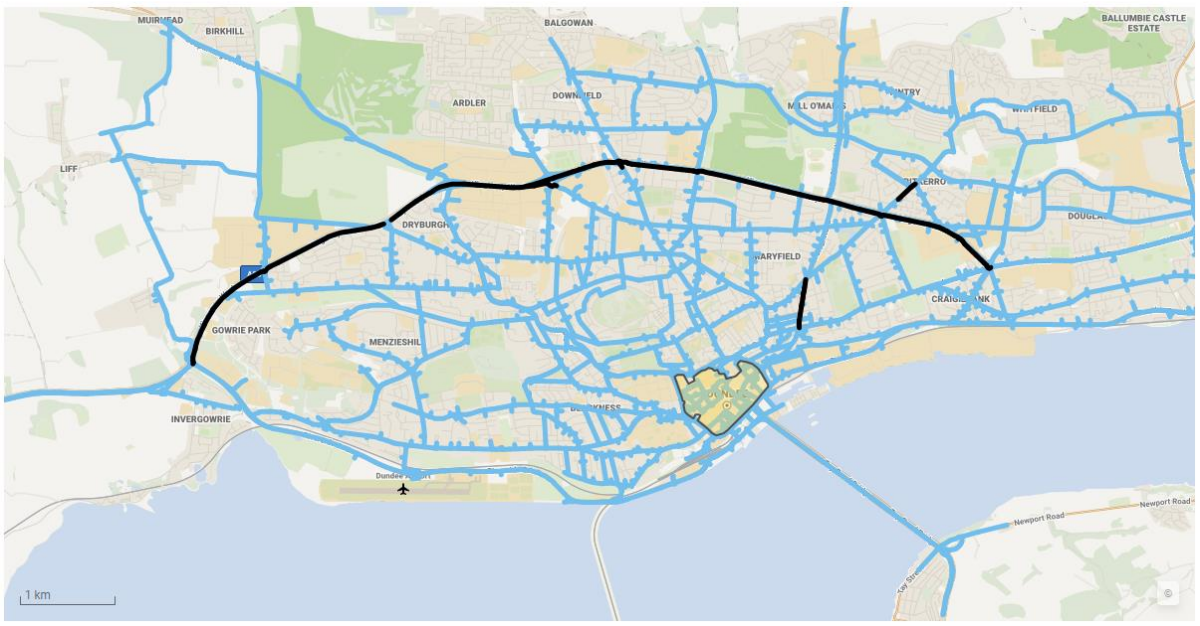

Figure 9 – Roads highlighted in black experience an increase of over 25 Rigid HGVs per day.

Areas of the model that see an increase in traffic flow correspond with a small number of roads that are predicted to see an overall increase in emissions of NO_x, due to the implementation of the LEZ. These are highlighted in black in Figure 10, although these often correspond to small increases or very low absolute rates. The increase in NO_x emissions on the Kingsway is less than 10%.

Figure 10 – Areas highlighted in black are predicted to see an overall increase in NO_x emissions due to displacement of journeys around the edge of the LEZ. The extent of the LEZ is shown in yellow.

Areas of the city that experience an increase in NO_x emissions of over 40% are very localised and are highlighted in black in Figure 11. These have an average increase of 125% and relate to the high number of cars accessing car parks on the edge of the LEZ boundary.

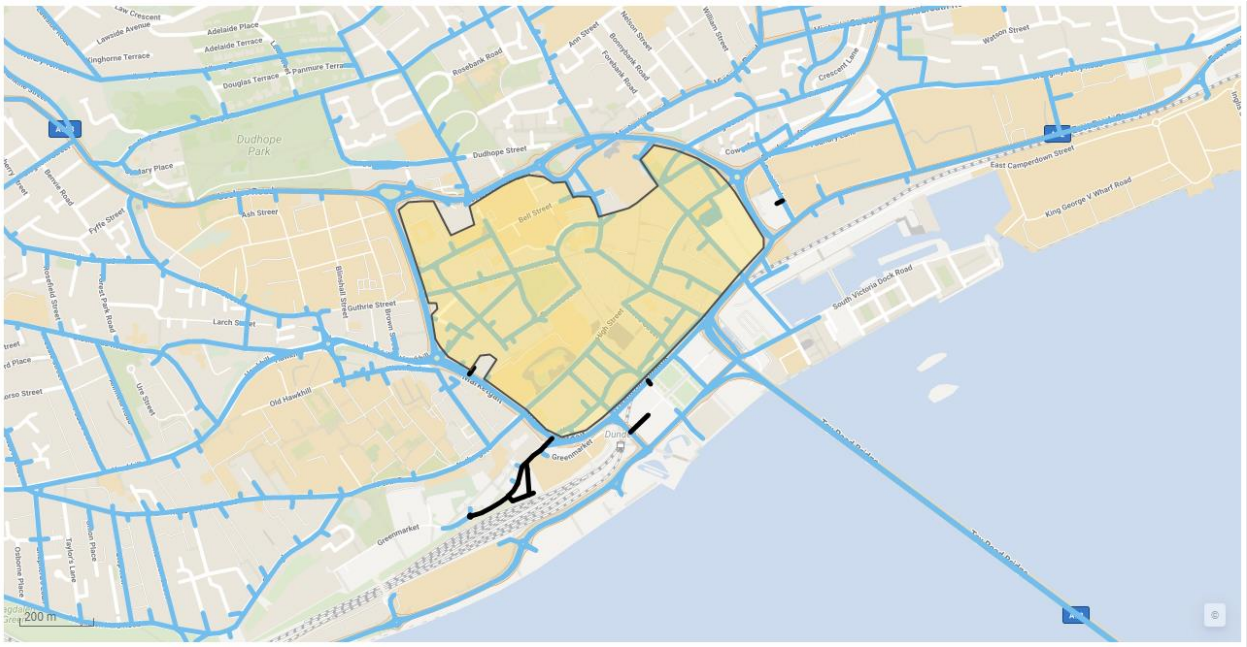

Figure 11 – Roads highlighted in black are predicted to see an increase in NO_x emissions of over 40%, with an average of 125%.

The NO_x emission rates of all roads in the model are ranked in Figure 12, for the Reference and LEZ cases. This emphasises that the overall change in emissions between the two scenarios is relatively small. The roads highlighted in black are those also highlighted in Figure 11 that see an increase in NO_x emissions of over 40%. These roads have low rates of emission and often represent very short sections of road.

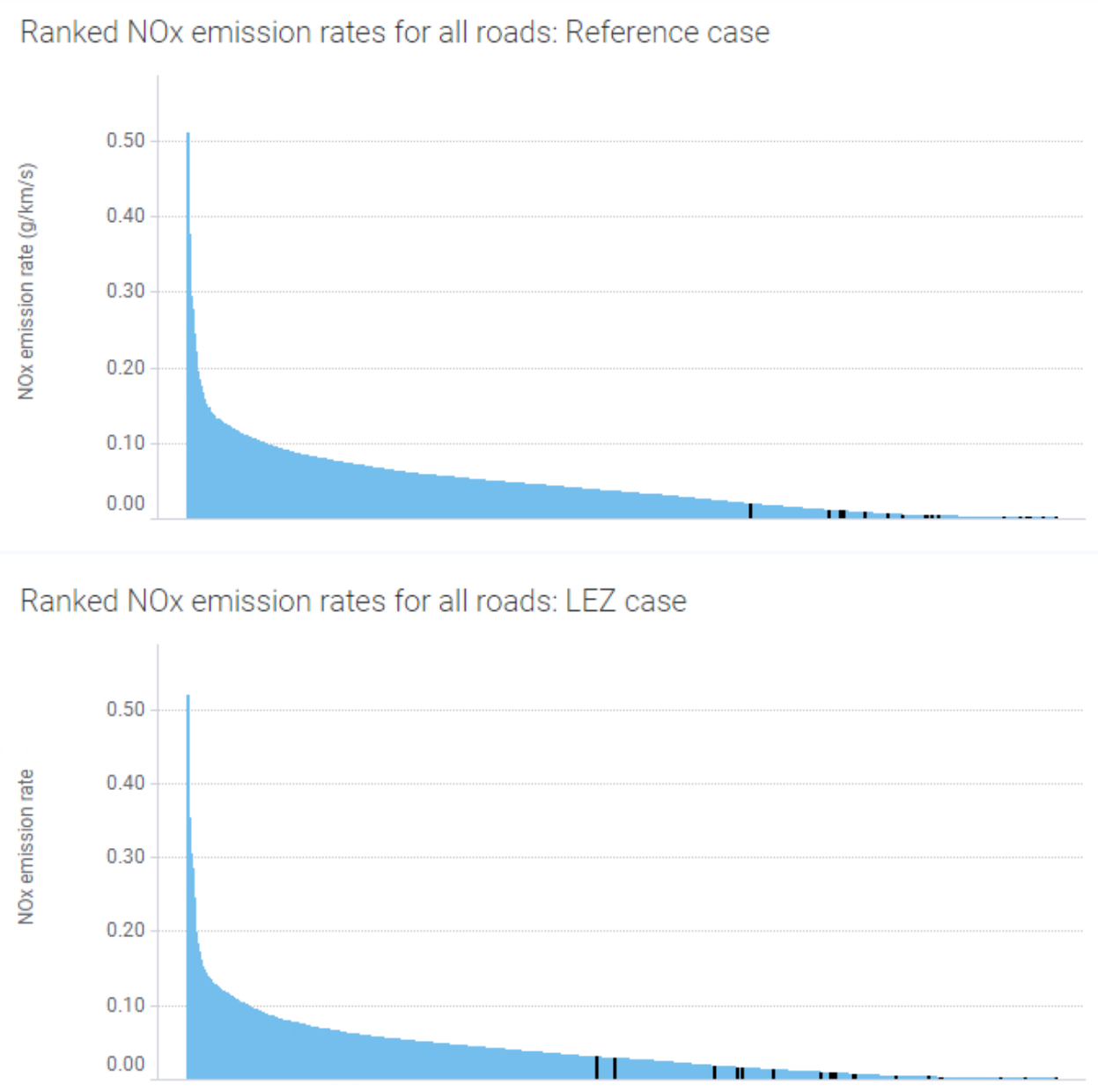

Figure 12 – Ranked NO_x emission rates on all roads in the traffic model for the Reference and LEZ scenarios.

Next Steps

The next stage of the analysis will be to use the predicted emission rates from the traffic model as input to the AQ model. The emission analysis will also inform further development of the AQ model. For example, any roads that see an increase in traffic flow but that were not identified for inclusion in the original model will be added to a more detailed version of the model.

The focus of AQ modelling will be on the area around the edge of the LEZ that sees an increase in car flow. Further detailed work will be focused on Lochee Road, which although is outside of the LEZ boundary continues to experience AQ exceedances.

For this next stage of modelling the emission rates on each of the traffic model links will be mapped onto the larger AQ model links. The results of this modelling will be visualised in a series of interactive maps and charts and made available to the local authority.

There is an additional 'demand reduction' scenario from the traffic modeling that simulates a 10% reduction in traffic flow across all vehicle categories. This scenario which could affect the amount of traffic displacement will also be investigated.