Glasgow's Low Emission Zone

Introduction

In 2016, as part of its Cleaner Air for Scotland – The Road to a Healthier Future Strategy (CAFS), the Scottish Government committed to work with local authorities, to identify and put in place Scotland's first Low Emission Zone (LEZ) by 2018, creating a legacy on which other areas could build. Scotland's first LEZ was also a Programme for Government commitment (2017) and came into effect in Glasgow city centre on 31 December 2018. Glasgow's LEZ is being phased in and Phase 1 only applies to local service buses. When the LEZ is fully implemented, all vehicles entering the zone will have to meet specified exhaust emission standards.

Background

Glasgow City Council operates an extensive automatic analyser and diffusion tube monitoring network across the city that measure a variety of air pollutants including nitrogen dioxide (NO_2) (http://www.scottishairquality.scot/air-quality/pollutants#no2) and particulate matter ($PM_{2.5}$ and PM_{10}). Routine air quality measurements describe pollutant concentrations in terms of micrograms per cubic meter (μgm^{-3}).

Monitoring records show air quality had been steadily improving across the city, although some pockets of the city centre continued to fail to meet the NO_2 annual mean objective required to protect human health. This objective was exceeded at Hope Street and at several nearby locations within the City Centre Air Quality Management Area (AQMA) during 2018 (Figure 1). This data suggested that unsatisfactory roadside NO_2 concentrations that exceed the target objective were likely to be present in other parts of the city centre, particularly along busy routes located within deep and narrow street canyons where the dispersion of pollutants is often poor. As a result, the need for a LEZ covering the city centre area was identified.
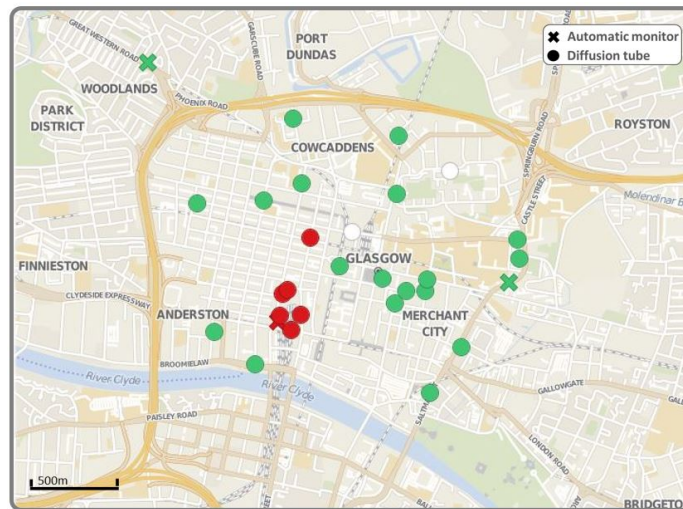
Figure 1. Annual average NO$_2$ concentrations at the automatic monitors and diffusion tubes within the city centre in 2018. Red markers indicate an annual average NO$_2$ concentration greater than 40 µgm^{-3} (unsatisfactory) and green markers indicate a concentration less than 40 µgm^{-3} (satisfactory).

Traffic Data Collection

In 2016, a detailed traffic data collection programme was co-ordinated by Transport Scotland in consultation with Glasgow City Council, Strathclyde Passenger Transport (SPT) and SEPA, with subsequent surveys undertaken during 2017 and 2018. The surveys consisted of 72 Junction Turn Counts (JTC), 38 Automatic Traffic Counters (ATC) and 8 Automatic Number Plate Recognition (ANPR) cameras located on key routes in the city centre and extending out to Byres Road and Dumbarton Road AQMAs (Figure 2).
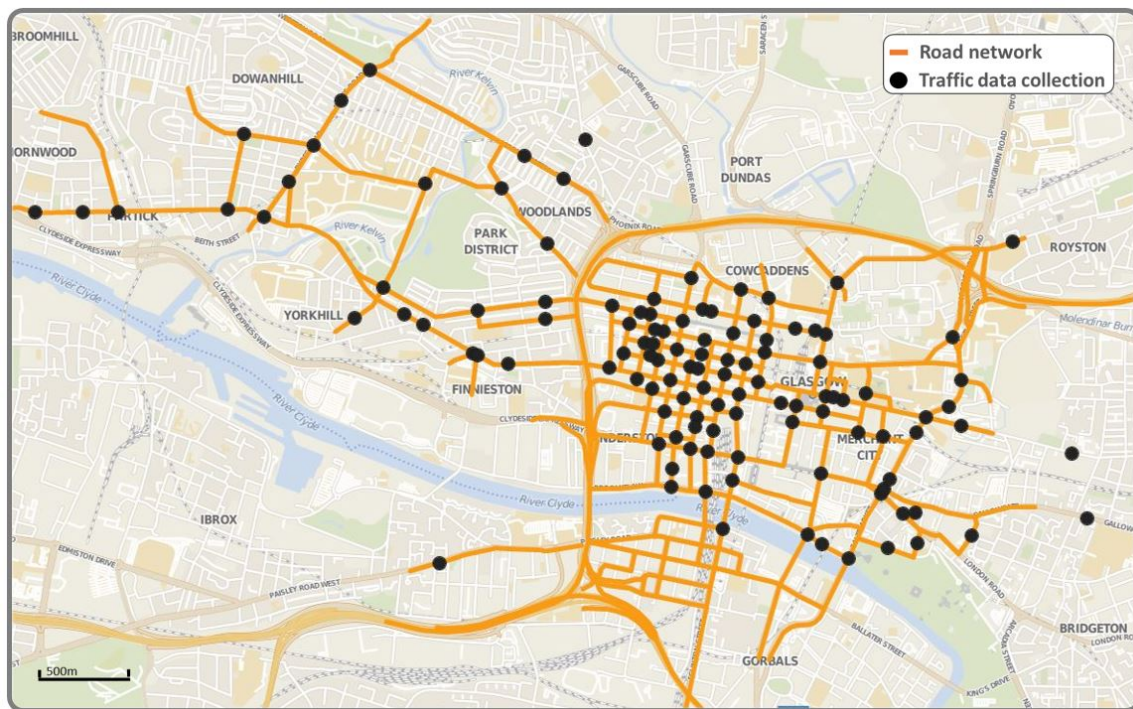
Figure 2. Traffic Data Collection Locations.

Through a mix of survey techniques, a detailed picture of traffic flow and composition across the city was generated, providing traffic flows for 12 vehicle categories which included cars, taxis, buses and coaches, rigid and articulated heavy goods vehicles and pedal cycles.

The National Modelling Framework (NMF) Approach

A national approach to air quality modelling, the NMF, was developed by SEPA to provide the evidence-base to identify the need for, and the extent of, measures required to reduce air pollution in Scotland's four largest cities (and in other urban centres where necessary). This is a requirement of CAFS. SEPA developed this approach basing its methodology on a pilot project using Aberdeen city, and Glasgow was chosen as the first city to go through the formal NMF process.

NO$_2$ Concentrations in the Glasgow NMF Model

Within the Glasgow NMF model, a network of model receptor or "virtual monitoring locations" has been generated along every road in the modelled area. These points are located along the edge of the pavement and may therefore represent greater exposure to traffic pollution than some air quality monitors that are often located further away from the adjacent roads and closer to buildings. These allow us to predict pollutant concentrations and any exceedances of the 40 µgm^{-3} NO$_2$ objective at locations where monitoring data are not available. **Error! Reference source not found.** shows the roadside receptors for the Glasgow City Centre

AQMA with locations where NO$_2$ concentrations exceed the 40 µgm^{-3} objective highlighted in red and black.

The model is based on 2019 conditions, in terms of weather and bus fleet at the time. The model demonstrates that there are continuing areas of exceedance, confirming the need for continual improvements through the LEZ actions. The model results also show that the highest level of exceedances are found along the key bus corridors of Hope Street and Renfield Street.
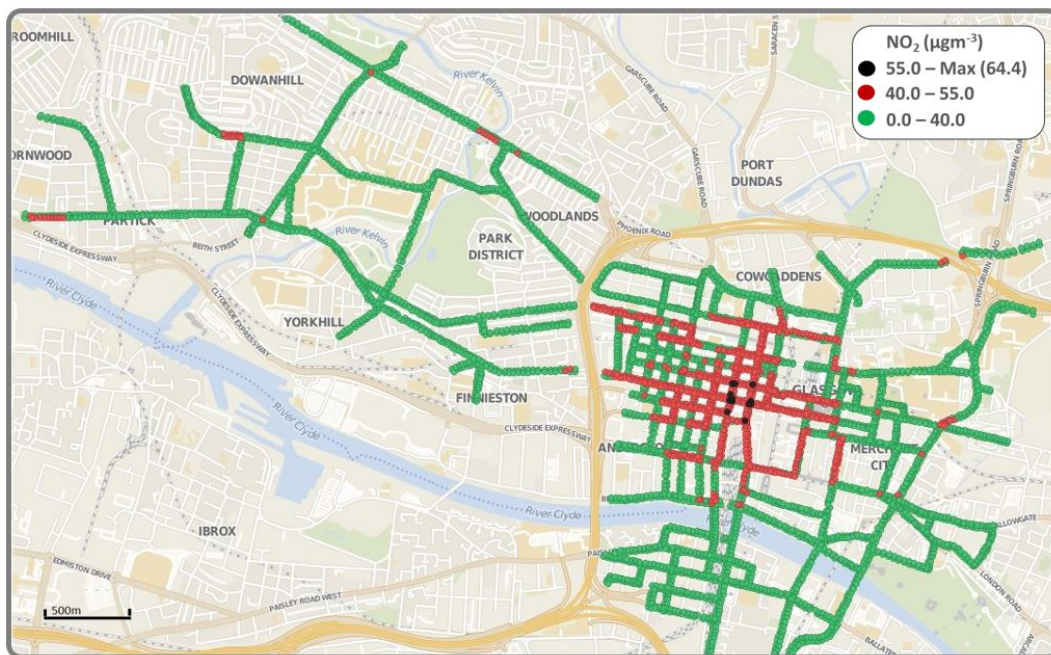

Figure 3. Modelled annual average NO$_2$ (µgm^{-3}) for 2019. Values greater than 40 µgm^{-3} (unsatisfactory) are highlighted in red and black.

Source Apportionment for Nitrogen Oxides (NO$_x$)

Using this framework, we can also explore the relative contribution that each vehicle type makes to total nitrogen oxides (NO$_x$) (both nitric oxide (NO) and nitrogen dioxide (NO$_2$) considered together) at each receptor on an annual basis (Figure 4). This is helpful for identifying high emitters that can be targeted for emission reductions in the future. Source apportionment analysis indicates that along the main bus routes within the city centre NOx from buses and coaches make the biggest contribution to total NO$_x$. Buses and coaches travelling along Hope Street contribute over 70% to total NO$_x$. Along many roads away from the city centre and main bus routes cars are the main source of NO$_x$ emissions. At the monitor on Great Western Road, diesel cars contribute half of all traffic related NO$_x$ emissions.
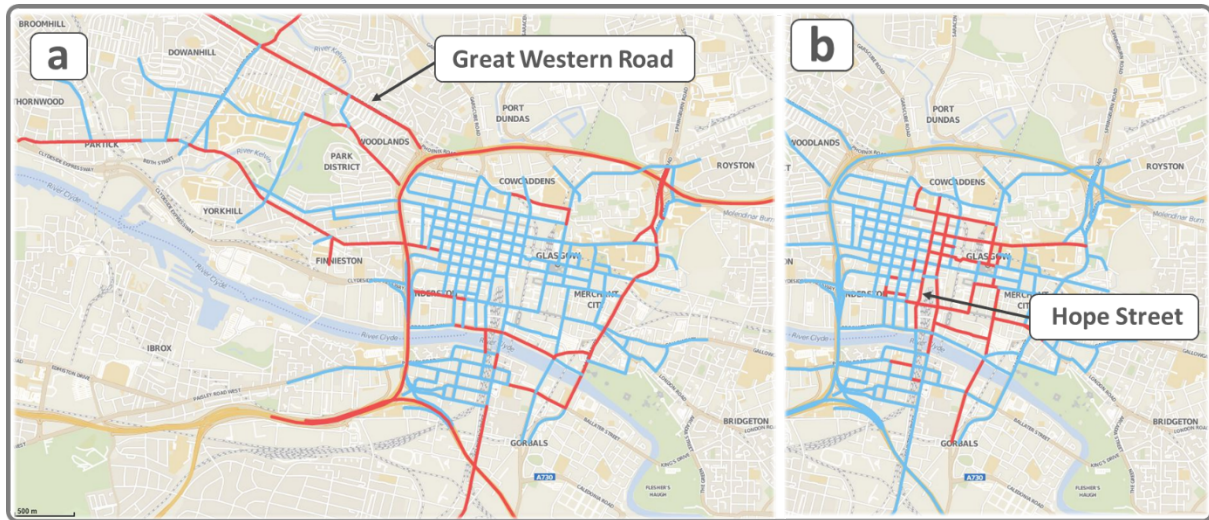
Figure 4. Roads with the highest emissions (top 20%) of NOₓ from (a) Cars and (b) Buses.

Other Sources of Nitrogen Oxides

Glasgow is relatively unique in Scotland as it is bisected by the M8 motorway, a section of which is located very close to the city centre area. It was therefore important to consider the direct emissions from the M8 early on, in order to better understand the relative contribution of NOₓ to roadside concentrations of NO₂ within the city centre. The model demonstrated that the percentage contribution of NOₓ emissions from the motorway to total NOₓ across most of the city centre is less than 5% and this increases to over 10% on roads situated very close to the motorway (Figure 5). It was therefore concluded that the emissions from the M8 had little impact on NO₂ concentrations within the proposed boundary of the LEZ.
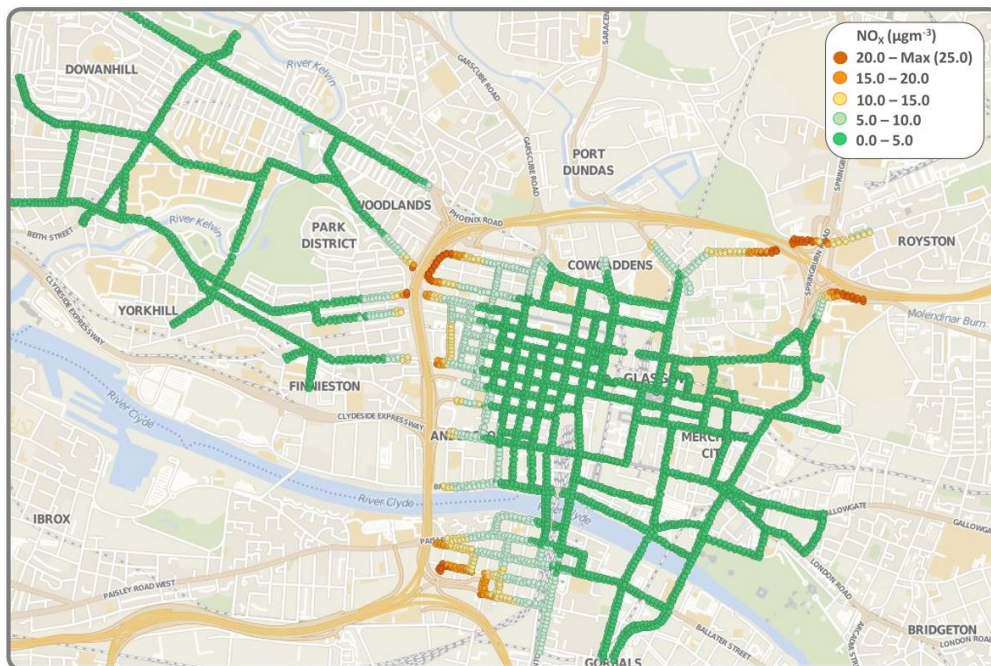
Figure 5. Percentage contribution of NO$_x$ originating from the M8 Motorway to total NO$_x$ at the roadside receptors across the city.

LEZ Phased Approach

The development of Glasgow's LEZ is supported by clear evidence-based data, including the collection of detailed traffic information and the application of a robust modelling approach. Glasgow City Council introduced the proposed LEZ in two phases, with the first phase focusing on improving the public bus services operating through the city centre.

- **Phase 1** of the LEZ which focuses on local service bus movements through the city to reduce emissions and achieve improvements in local air quality. The application of national funding support along with fleet investment within the industry will promote the upgrade of the local bus fleet to Euro VI vehicles or retrofit to existing fleet (to Euro VI equivalent) to improve performance and emission standards.

- **Phase 2** shall apply to all vehicles in order that all harmful sources of air pollutants are reduced further however motorcycles, mopeds, motorised tricycles and quadricycles are likely to be scoped out.

The first phase of the LEZ covers the area of the city centre bound between the M8 corridor to the north and west, the River Clyde to the south, and the Saltmarket and High Street to the east. From the end of December 2018, the LEZ required that 20% of bus journeys through the city centre meet the Euro VI emission standard (Table 1). This target is to be increased by 20% each year, until 100% of buses are compliant by December 2022. The second phase of the LEZ will apply to all vehicle types, including private cars, and will commence in 2023.
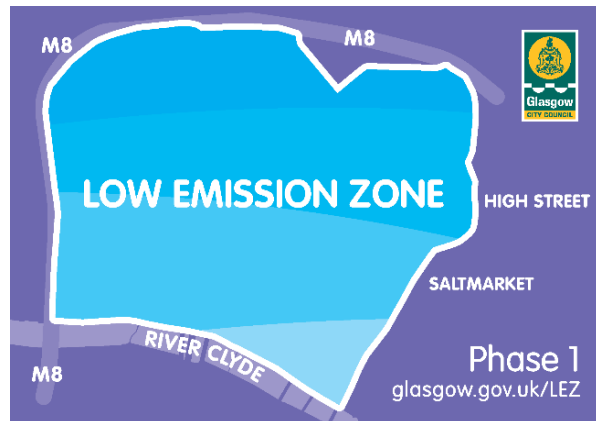
Table 1. Phased approach to upgrading the Glasgow bus fleet to reduce emissions in Phase 1.

YEAR	DATE	EURO VI COMPLIANCE
1	December 2018	20%
2	December 2019	40%
3	December 2020	60%
4	December 2021	80%
5	December 2022	100%

Tools have been developed using bus route and timetable information that allow the number and journey frequency of buses operating along the main bus routes to be visualised with respect to their Euro Class for emission standards. The tools can be used to assess whether there are opportunities to move Euro VI buses that are currently routing along cleaner streets to more polluted streets to increase the compliance and contribute to reducing NO_2 concentrations where this is most needed. These tools are being updated regularly to monitor the changes and improvements to the bus fleet. Figure 6 shows the improvements that had been made to the bus fleet, from pre-LEZ through to the end of 2019, with the fleet achieving compliance with LEZ objectives to date.

Figure 6. Bus fleet composition based on all bus journeys with respect to Euro class up to the end of 2019.

> **As more cleaner buses were introduced in to the city centre fleet observed pollution levels began to decline.**

the necessary emissions reductions targets achieved. Monitoring data collected at the automatic monitor on Hope Street from the beginning of 2018 to the end of August 2020 appear to show that the LEZ was starting to exhibit a positive effect on NO_2 concentrations, pre COVID-19 lockdown measures. This can be seen in the data presented in Figure 7 that demonstrates a reduction in the number of hours each year where NO_2 concentrations peaked over 100 μgm^{-3} during 2019, with a greater reduction in the second half of 2019. This coincides with the progressive changes to bus operator fleets, with an increase in Euro VI vehicles being used on services through Glasgow's LEZ and along Hope Street at that time.
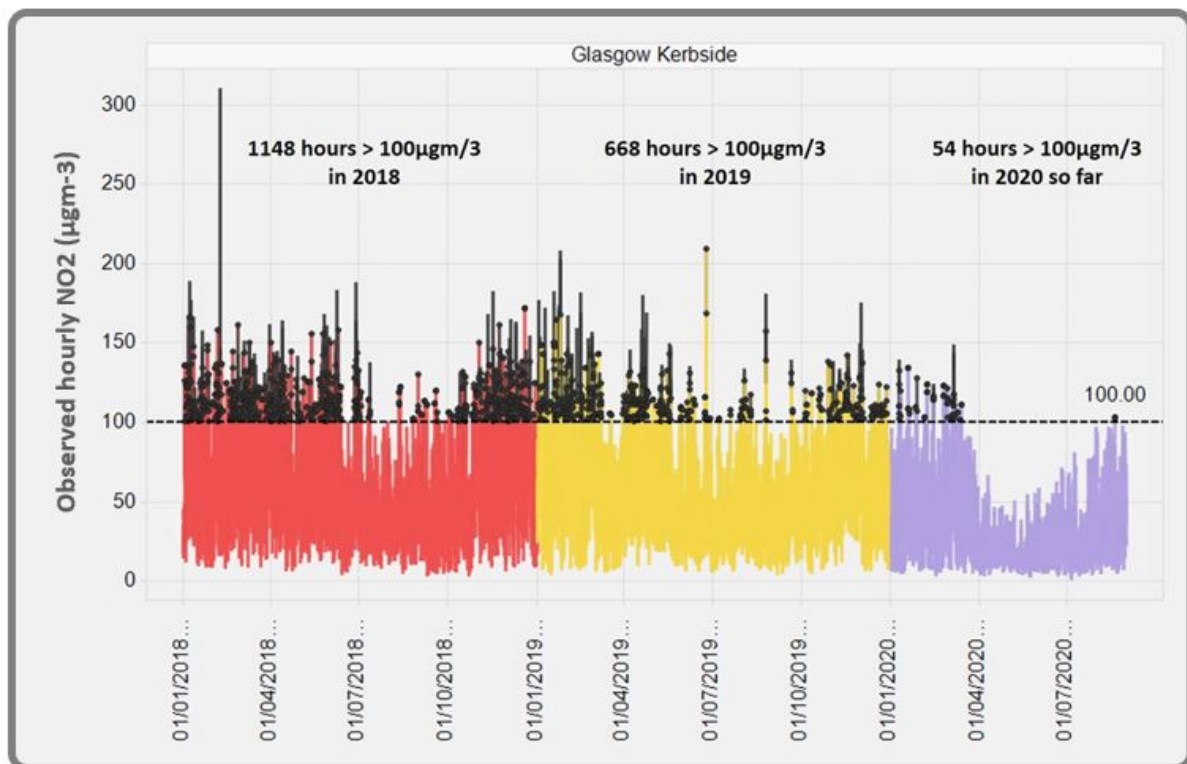

Figure 7. Observed hourly NO_2 (μgm^{-3}) concentrations at the 'Kerbside' automatic monitor on Hope Street from the beginning of 2018 to August 2020.

COVID-19 Lockdown and Recovery

> **The COVID-19 lockdown had a dramatic effect on traffic and air pollution across Glasgow.**

The first case of COVID-19 was confirmed in Scotland in early March 2020. On 16th March everyone across the UK was advised to work from home if possible and avoid visiting social venues. These measures were tightened further on 23rd March when people were directed to stay at home as much as possible and avoid unnecessary travel. This had a dramatic effect upon baseline traffic volumes and air pollution levels across Glasgow. As part of the Scottish Government's Route Map out of the crisis restrictions across Scotland began to be lifted on 28th May and continued beyond that date.

Traffic Data Collection

In response to COVID-19, Transport Scotland in partnership with Glasgow City Council and SEPA began to collect different types of traffic data periodically during the lockdown period that included ATC and ANPR data at key locations around the city. ATC data has been collected at Great Western Road, Hope Street and High Street and this is discussed further below (Figure 8).
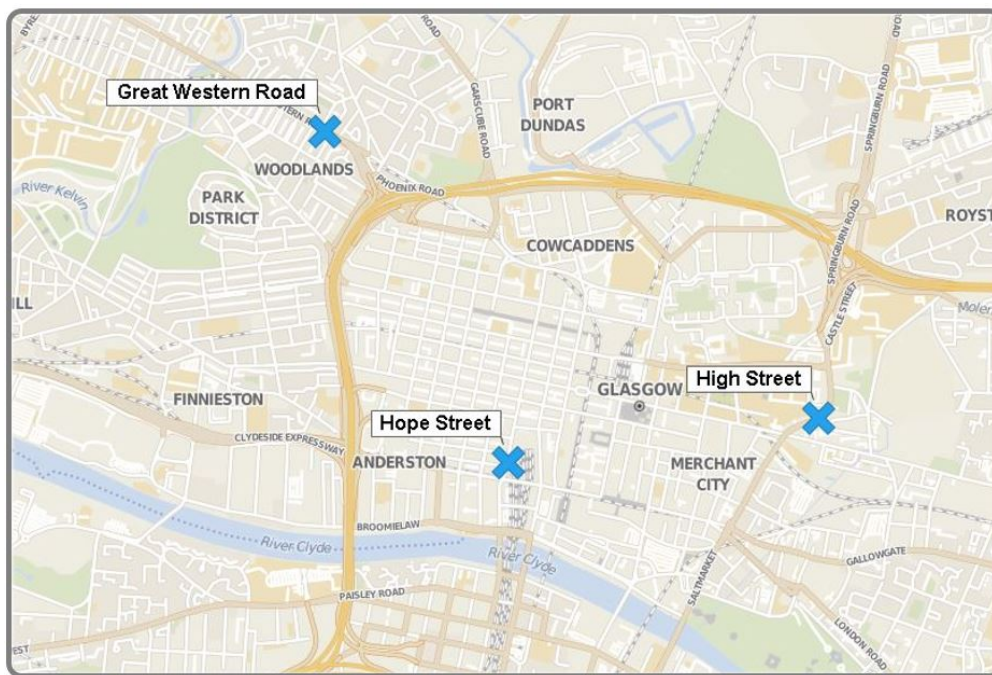

Figure 8. ATC traffic data collection at Great Western Road, Hope Street and High Street during lockdown.

Traffic Flows and Emissions during Lockdown

> **Traffic levels increased steadily as lockdown restrictions were lifted.**
>
> **Along some key commuting routes traffic levels exceeded pre-lockdown levels and the proportion of light vehicles was higher than normal. Traffic levels within the city centre did not recover to the same extent.**

This data provides an opportunity to monitor changes in fleet composition and traffic flows as a result of the pandemic, and identify when flows stabilise across the city, so that any changes in traffic flows can be compared to pre-pandemic levels.

Total traffic flows along these streets decreased to their lowest levels at the beginning of April shortly after the lockdown restrictions came into force with reductions of around 50%, 60% and 85% observed along High Street, Great Western Road and Hope Street respectively. With the lifting of the full lockdown measures at the end of May traffic levels recovered steadily through the period to the end of August along all three streets.

Figure 9 shows the recovery in daily average flows of light duty (cars and light goods vehicles) and heavy duty (buses and coaches, rigid and articulated heay goods vehicles) traffic along High Street. Light duty traffic flows were slightly higher than pre-lockdown levels in August whilst heavy duty traffic flows still remained below pre-lockdown levels at this time. Figure 9 also shows the daily variation of light duty and heavy duty traffic levels by month and it clearly shows the flattening of the morning and late afternoon peaks for light duty vehicles, and the midday peak for heavy duty vehicles when compared to the pre-lockdown profiles shown by the solid black lines.
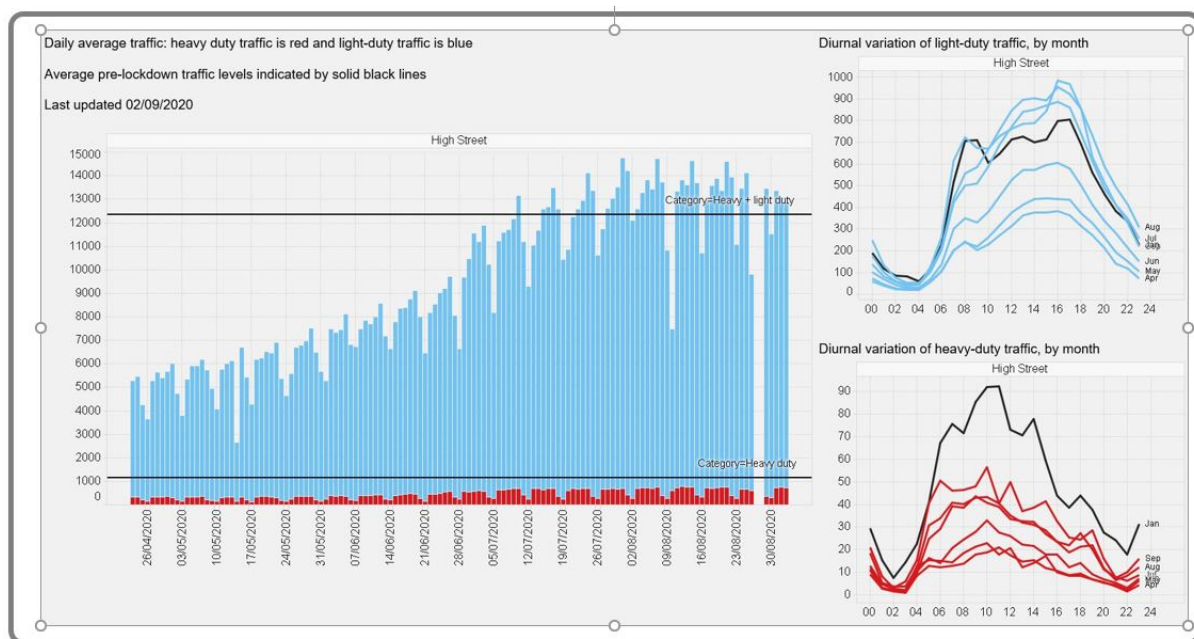

Figure 9. Daily average flows and daily variation of light duty (blue) and heavy duty (red) traffic along High Street compared to pre-lockdown levels indicated by the black lines.

In contrast to High Street daily average flows of both vehicle categories along Great Western Road had recovered to close to pre-lockdown levels by early July. Both these streets are dominated by private car traffic and the increase in light duty vehicles above pre-lockdown levels along High Street may reflect increased car use due to the limitations on passenger numbers on public transport. In contrast, both light and heavy duty traffic flows remained

below pre-lockdown levels on Hope Street at the end of August. Bus services were reduced to between 5% and 15% of pre-lockdown daily services across many streets.

> **Observed levels of pollution in some locations are returning to levels typical for the time of year.**

The Glasgow NMF model has been used to provide an indication of what the NO_2 concentrations would have been at the automatic monitors on Great Western Road, High Street and Hope Street if traffic levels had remained at normal levels without lockdown restrictions during 2020. Figure 10 shows the three-day moving average of observed and modelled timeseries, and average NO_2 concentration data up to the end of August. There is very good agreement between the modelled and observed NO_2 concentrations at all three monitors before the beginning of lockdown at the end of March. The effects of lockdown on traffic-related emissions and observed NO_2 concentrations can be clearly seen at the three sites with concentrations remaining low for much of the period. The bar charts showing the average observed and modelled NO_2 concentrations suggest that traffic related NO_2 concentrations reduced to 60% of normal levels during the period.
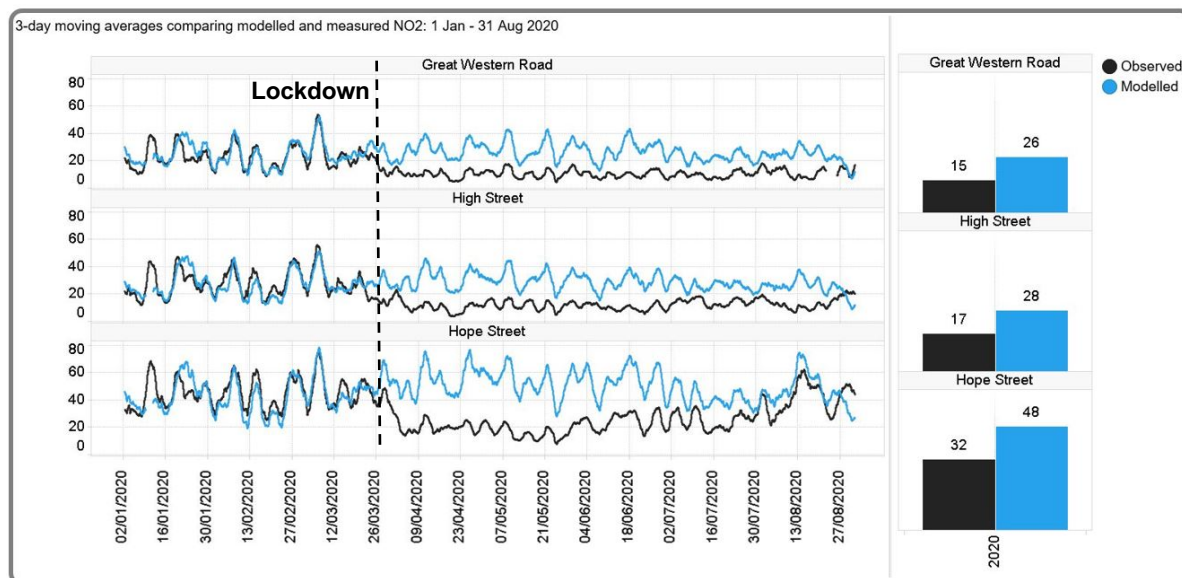

Figure 10. Timeseries showing the three-day moving averages of modelled and observed NO_2 concentrations and bar charts showing the average concentrations for the period at the automatic monitors on Great Western Road, High Street and Hope Street during 2020.

Assessment of NO_x and CO_2 Emissions

> **The LEZ is in place to improve air quality with cleaner vehicles. However, lockdown also demonstrated the clear link between traffic and emissions of greenhouse gases.**

During the start of the lockdown period, total traffic flows and vehicle emissions along many streets dropped considerably compared with January 2018 levels. Figure 11 shows that as we came out of lockdown the proportion of emissions from light duty vehicles were higher than normal. During the stricter lockdown measures (April) emissions had fallen substantially.
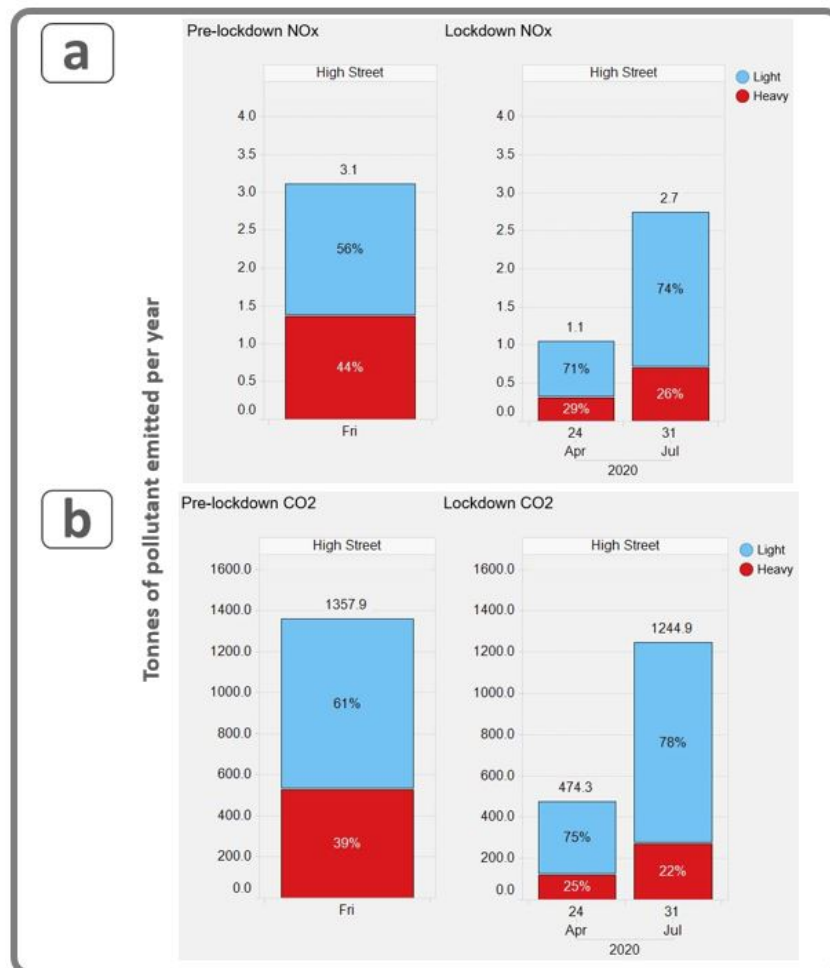

Figure 11. Reductions in a) NO_x and b) CO_2 emission rates (tonnes of pollutant per year along a short stretch of road) along High Street during lockdown and recovery. Charts compare the selected days with the corresponding day of the week before lockdown.

> **The optimum mix of city centre traffic should maximise air quality and climate change benefits.**
>
> **Data from the LEZ suggests that cleaner buses have a positive impact on air quality. The lockdown experience demonstrated that an overall reduction in traffic volume achieves reductions in climate change emissions. We should therefore encourage lower use of private vehicles and continue efforts to clean the bus fleet.**

Going beyond lockdown measures

During lockdown reductions in traffic levels resulted in significant drops in NO_x emissions and CO_2 emissions, whilst the LEZ, on its own, has focused on cleaning the fleet to reduce NO_2 concentrations.

The Spaces for People programme (www.glasgow.gov.uk/spacesforpeople) commenced in May 2020, as part of the city's strategy to provide additional space to maintain physical distancing during the pandemic and subsequent recovery phase. Temporary infrastructure measures were introduced in the city centre, along active travel routes and in surrounding areas and included footway widening, road closures and temporary cycle ways. Kelvin Way was closed to traffic and a pop-up cycle lane was created on the Broomielaw.

> **As we come out of the pandemic it is a good opportunity to reflect on how transport systems can be improved to maximise air quality and climate change benefits.**
>
> **This can be achieved by encouraging people out of private vehicles to use more sustainable and healthier means including walking, cycling and public transport.**

The data displayed here has been provided by SEPA. To see a more detailed analysis of air quality relating to the Glasgow Low Emission Zone and COVID lockdown then please visit these SEPA data tools:

The Glasgow LEZ

https://informatics.sepa.org.uk/GlasgowLez

The impact of the lockdown

https://informatics.sepa.org.uk/GlasgowLockdown