LONDON-WIDE ULTRA LOW EMISSION ZONE – ONE YEAR REPORT

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Executive Summary

Studies have long shown the many adverse health issues associated with elevated pollution levels[1]. The burden of disease attributable to air pollution is estimated to be on par with other major global health risks, such as unhealthy diets and tobacco smoking, and air pollution is now recognised as the single largest environmental threat to human health[2]. Exposure to air pollution is disproportionally higher for those communities that have higher levels of deprivation or a higher proportion of people from Black, Asian and Minority Ethnic backgrounds, further exacerbating existing health inequalities[3].

On 29 August 2023, the Mayor of London expanded the Ultra Low Emission Zone (ULEZ) across all London boroughs. The aim of the ULEZ is to reduce the number of older, more polluting vehicles on the road, therefore reducing emissions and concentrations[4] of harmful pollutants, decreasing the impact of poor air quality on the health of people living and working in London.

Data in this report, the latest in a series evaluating the scheme, shows that the ULEZ has led to Londoners breathing cleaner air. Around 97 per cent of all vehicles seen driving in London are now ULEZ compliant, and it is estimated that harmful roadside nitrogen dioxide (NO_2) concentrations are 27 per cent lower across London, compared to a scenario without the ULEZ.

The latest ULEZ expansion has reduced harmful nitrogen oxides (NO_X) emissions in outer London, which are estimated to be 14 per cent lower in 2024 than they would have been without the ULEZ expansion.

Importantly, London's more deprived communities are seeing greater benefits from the ULEZ[5]; for some of the most deprived communities living near London's busiest roads,

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[1]The Committee on the Medical Effects of Air Pollutants (COMEAP) publishes regular reports and statements on the health effects of air pollution. Available at: COMEAP: reports and statements - GOV.UK (www.gov.uk)

[2] WHO (2021). Global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Available at: WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide

[3] Air quality exposure and inequalities study part 1 – London analysis. Aether Ltd. June 2023. Available at: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/environment-and-climate-change-publications/air-pollution-and-inequalities-london-update-2023

[4] Emissions refers to the discharge of pollutants into the air (e.g. from a vehicle exhaust) whereas concentrations means the amount of pollution found in the air.

[5] In terms of reduced exposure to levels of NO2 pollution exceeding the UK legal limit along the Transport for London Road Network compared to a scenario without ULEZ. Comparing IMD deciles 1-3 as more deprived with IMD deciles 8-10 as less deprived.

there’s been an estimated 80 per cent reduction in people exposed to illegal levels of pollution.

Furthermore, despite potential concerns that the ULEZ expansion would reduce economic activity in outer London, data shows that footfall or retail and leisure spending in outer London has not been impacted by the ULEZ expansion.

This analysis shows that the ULEZ, and its expansion to outer London, is bringing cleaner air to all Londoners.

Context and Key Findings

There is a well-established and growing body of scientific evidence linking exposure to air pollution with a number of adverse health effects across all stages of life. In 2021, the World Health Organization (WHO) updated its air quality guidelines, recommending more stringent targets to protect public health. The updated WHO guidelines are more ambitious than the UK national legal limits and emphasise that no safe level of air pollution exists[6].

On 29 August 2023, the Mayor of London expanded the Ultra Low Emission Zone (ULEZ) across all London boroughs to help tackle air pollution in the capital and improve air quality for Londoners. The ULEZ boundary is now the same as the boundary for the Low Emission Zone (LEZ) for heavy vehicles. The London-wide zone measures 1,500 km^2 and covers nine million people, making it the largest zone of its kind in the world.

This report evaluates the impact of the ULEZ in the first year following the London-wide expansion. The data shows that the ULEZ has been highly effective at reducing the proportion and number of older, more polluting vehicles on London's roads. The impact of the London-wide expansion started ahead of the formal start of the scheme, with many people making changes in advance to prepare. Key dates in advance of the formal start date were the launch of the consultation in May 2022, the announcement of the Mayor's decision to proceed with the expansion in November 2022, and the launch of the scrappage scheme in January 2023. This pre-emptive behaviour has also been observed by independent experts, including in other cities with similar schemes[7].

This report provides the "compliance rate"[8] of vehicles travelling in the zone that are subject to the ULEZ standards – that is cars, vans, minibuses, and motorcycles. This report also provides analysis of pollutant emissions, carbon emissions, concentrations, population exposure, vehicle traffic, footfall and economic spend.

The ULEZ is delivering cleaner air to Londoners, and this report demonstrates sustained improvements in air quality across the whole of London.

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[6] The Mayor's Transport Strategy was revised in 2022 to reflect the updated WHO Guidelines. Mayor's Transport Strategy | London City Hall.

[7] As demonstrated in previously published ULEZ reports available here: Environment and Climate Change publications | London City Hall, as well as in other cities such as Leeds: Leeds' Clean Air Zone has achieved its aims early and is no longer required, joint review finds.

[8] The compliance rate is the percentage of vehicles detected in the zone that meet the ULEZ standards. The higher the compliance rate the more successful the scheme has been in accelerating the transition to cleaner vehicles.

Key Findings

Key findings from the first year of operation since the ULEZ was expanded London-wide, as well as the impact of all phases of the ULEZ are outlined in this section.

Air pollutant concentrations – general trends

Overall improvement in air quality has been observed across London. These trends are not attributable to ULEZ, however schemes and policies such as the ULEZ contribute towards accelerating these improvements.

- **Average nitrogen dioxide (NO_2) concentrations in 99 per cent of all monitoring locations[9] included in the analysis have improved between 2019 and 2024**, with 80 per cent of monitoring locations showing reductions of more than 10 µg/m^3.
- **Long term trends indicate that average NO_2 concentrations over all London zones improved at a faster rate than the rest of England** average over the same time period (2017 – 2024). This is particularly notable in outer London where concentrations have improved more rapidly over recent years and are now similar to the rest of England average which has historically been lower than London[10].

Air pollutant concentrations – ULEZ impacts

Due to the London-wide ULEZ expansion:

- In the first year of operation, roadside NO_2 concentrations in outer London were on average up to **4.8 per cent lower** than would have been expected without the London-wide ULEZ expansion.

[9] 92 roadside and urban background NO_2 monitoring sites were used for this analysis, which includes sites that have data in both 2019 and 2024.

[10] 44 µg/m^3 compared to 32 µg/m^3 in 2017, and 22 µg/m^3 compared to 21 µg/m^3 in 2024 for outer London and the rest of England respectively.

Due to all phases of the ULEZ:

- All phases of the ULEZ have had an impact on improving air quality across the capital. In 2024, compared to a scenario without the ULEZ, harmful roadside NO_2 concentrations are estimated to be:
    - **27 per cent lower across the whole of London** than they would have been without the ULEZ and its expansions.
    - **54 per cent lower in central London** than they would have been without the ULEZ and its expansions.
    - **29 per cent lower in inner London** than they would have been without the ULEZ and its expansions.
    - **24 per cent lower in outer London** than they would have been without the ULEZ and its expansions.
- **London's more deprived communities are seeing greater benefits from the ULEZ[5];** for some of the most deprived communities living near London's busiest roads, there's been an estimated 80 per cent reduction in people exposed to illegal levels of pollution[11].
- **Areas outside London are also seeing the impacts of the ULEZ**, with roadside NO_2 concentrations within 5 km of the Greater London boundary on average **14 per cent lower** in 2024 than an estimated "No ULEZ" scenario.

Air pollutant and carbon emissions

Due to the London-wide ULEZ expansion:

- **Air pollutant emissions in 2024 were lower** than expected compared to a scenario without the ULEZ expansion. Specifically:
    - **Nitrogen oxides (NO_X) emissions from cars and vans in outer London are estimated to be 13 per cent and 16 per cent lower** respectively.

[11] The UK legal limit for NO_2 is 40 µg/m^3 as an annual average: Air_Quality_Objectives_Update_20230403.pdf

- **Particulate Matter 2.5 ($PM_{2.5}$) exhaust emissions from cars and vans in outer London** are estimated to be **31 per cent lower**.
- **Outer London boroughs are seeing the largest impacts from the London-wide expansion**. NO_X emissions are estimated to be between **nine per cent and 15 per cent lower across all boroughs** than would have been expected without the London-wide ULEZ expansion.

Due to all phases of the ULEZ:

- Cumulatively over a six-year period (2019 – 2024), air pollutant and carbon emissions across London are lower due to all phases of the ULEZ, compared to a scenario without the ULEZ. Specifically:
  - NO_X emissions are estimated to be **24 per cent lower**.
  - $PM_{2.5}$ exhaust emissions are estimated to be **29 per cent lower**.
  - CO_2 emissions are estimated to be **two per cent lower**.
- In 2024 alone, NO_X emissions are estimated to be between **33 per cent and 39 per cent lower across all boroughs** than they would have been without the ULEZ and its expansions.

Vehicle compliance

- **A larger proportion of vehicles recorded driving in London are cleaner**. The London-wide compliance rate for vehicles subject to the ULEZ standards after the first year of the expansion (as of September 2024) was **96.7 per cent.** For reference, compliance was 91.6 per cent in June 2023 prior to the expansion and 39 per cent in February 2017, when changes associated with the ULEZ began.
- In the **expanded outer London area, ULEZ vehicle compliance is now 96.7 per cent**, up from 90.9 per cent in June 2023. This is the same level of compliance as seen in inner and central London, with 96.9 per cent and 96.7 per cent respectively. **Van compliance in outer London is over 90 per cent for the first time,** an increase of 11.4 percentage points since June 2023.
- **There are fewer older, more polluting ULEZ vehicles seen driving in the zone.** There were nearly **100,000 fewer** non-compliant vehicles detected in London on an

average day in September 2024 compared to June 2023. This is a **58 per cent reduction** in non-compliant vehicles between those dates.

Footfall and economic spend

- Despite some concerns that economic activity in outer London may be reduced as a result of the London-wide ULEZ expansion, the expansion has had no negative impact on footfall and spend in the outer London area, or at a London-wide level. The following trends were observed although the changes were not statistically significant:
    - Visitor footfall in outer London increased 1.87 per cent in the year after the London-wide ULEZ expansion, compared to an increase of 0.08 per cent across all of London.
    - Worker footfall in outer London increased by 8.89 per cent compared to 8.54 per cent across all of London.
    - Spend in outer London decreased by 3.17 per cent compared to 3.42 per cent across all of London and 3.36 per cent across the rest of England[12].

[12] The per cent change in spend for Outer London was calculated using a different data source (Mastercard Retail Location Index (MRLI)) compared to the per cent changes reported here for London and England (Mastercard Spending Pulse). See Appendix 7 for more detail on these data sources.

What to expect in this report

Scope and aims of this report

The aim of the ULEZ scheme is to reduce the number of older, more polluting vehicles on the road, therefore reducing emissions and concentrations of harmful pollutants, with associated health benefits for people living and working in London. Publishing an evaluation of the ULEZ is important as it provides information on the effectiveness of the policy in achieving these desired outcomes.

A set schedule of reporting has been followed in order to update the public on the effectiveness of the scheme since the London-wide expansion at three main milestones: a First Month Report, a Six Month Report, and this One Year Report. Future reporting on the ULEZ will be included in TfL's annual Travel in London reporting[13]. The London-wide expansion of the ULEZ came into effect on 29 August 2023. This report covers the first full year of its operation (September 2023 to September 2024) and provides analysis of air pollutant emissions and concentrations, as well as vehicle compliance, traffic, population exposure and economic impact, building on the previously published London-wide ULEZ Six Month Report[14].

Analysis in this report is primarily undertaken by the Greater London Authority (GLA) and Transport for London (TfL), with extensive support from an international advisory group of independent experts, who provided invaluable expertise on air pollution analysis methods and extensively reviewed the results. The advisory group consists of six members who brought a range of professional analytical skills, diverse experiences of air quality expertise (including from non-UK based experts) and knowledge of data analysis techniques. Further information on this process can be found on the London-wide ULEZ One Year Report webpage.

To measure the impact of the scheme, in this report the following areas have been analysed:

[13] Travel in London reports - Transport for London

[14] All previous reports can be found on the Greater London Authority (GLA) website.

- Vehicle compliance. This report provides an update to the "compliance rate"[8] of vehicles detected travelling in the zone that are subject to the ULEZ – that is cars, vans, minibuses, and motorcycles. This is a fundamental measure of success of the scheme as it shows how emissions standards within the fleet has changed. Data for this section has been taken from TfL's Automatic Number Plate Recognition (ANPR) camera network[15], which detects vehicles as they enter the ULEZ and when they travel within it. Compliance is assessed by comparing September 2024 (one year after the expansion of the London-wide ULEZ) against previous milestone dates including June 2023 (a typical baseline month to represent pre-launch of the London-wide ULEZ).

- Emissions. The ULEZ directly influences emissions reductions from the vehicle fleet. This section presents analysis of the impact of the London-wide ULEZ expansion and all phases of the ULEZ on air pollution emissions of NO_X and Particulate Matter with a mean size of less than 2.5 µm ($PM_{2.5}$), as well as carbon emissions. Data for this section has been collated and analysed from various sources including the London Atmospheric Emissions Inventory 2019[16], Automatic Traffic Count (ATC) sites across London, as well as Department for Transport (DfT) manual traffic counts[17]. Emissions are assessed by comparing annual estimates for 2024 with an estimated "No ULEZ" and "No London-wide ULEZ expansion" scenario (further detail on this methodology is provided in the Emissions section).

- Air pollution concentrations. Due to the impact on emissions, the ULEZ helps to reduce NO_2 concentrations in the zone. This should in turn reduce the health impacts associated with exposure to NO_2, which is the key aim of the scheme and its expansion London-wide. $PM_{2.5}$ measured concentrations have also been presented as this is a key pollutant of health concern. Data for this section collates ongoing long-term measured concentrations from hundreds of air quality monitoring stations across England, which are funded and operated by a variety of different organisations. The data used from these monitoring stations is publicly available online from sources including the Department for Environment, Food and Rural Affairs (Defra). This section also provides population exposure analysis, looking at the intersection between different levels of deprivation and roadside NO_2 concentrations along London's busiest roads.

- Traffic. The ULEZ was not designed as a traffic congestion management tool, but it does influence travel behaviour and can affect traffic levels. This section presents analysis of traffic trends. Data in this section was sourced from available ATC sites across London. Traffic is assessed by comparing data before and after the London-wide expansion of the ULEZ.

- Footfall and economic activity. This section presents analysis of footfall and economic activity in the expanded zone to assess if the expansion has had a wider impact[18]. Aggregated and anonymised data was sourced from BT Group for footfall and Mastercard for economic spend. Footfall and economic activity are assessed by comparing data before and after the London-wide expansion of the ULEZ.

This report does not aim to quantify the health impacts of the ULEZ. The wider aim of the ULEZ is to reduce emissions from road transport in order to reduce the health impacts of air pollution and the related cost to the NHS, social care and the economy. It is well-documented that exposure to air pollution has serious health effects across all stages of life, including prior to birth. Short-term exposure to raised pollution levels causes acute health harms including worsening of asthma symptoms and is associated with increases in hospital admissions and deaths from heart and lung disease and stroke. Long-term exposure increases the risk of developing lung cancer, heart and lung disease (including asthma), stroke, and early death[19,20]. There is growing evidence linking air pollution exposure to an increased risk of developing dementia in older people[21]. Since many of the health impacts are due to long-term exposure to pollution[22,23] longer term analysis is needed to quantify the impact of the ULEZ on public health.

Emissions and concentrations

Air pollutant emissions in this report means the discharge of pollutants into the air, for example, from a vehicle exhaust. Air pollutant concentrations means the amount of pollution found in the air, expressed as the mass per cubic metre. Vehicle emissions are

[15] For more information on how TfL gathers data, how it is used and protected visit: https://tfl.gov.uk/corporate/privacy-and-cookies/road-user-charging
[16] London Atmospheric Emissions Inventory (LAEI) 2019. Available at: London Atmospheric Emissions Inventory (LAEI) 2019 - London Datastore
[17] Road traffic statistics - Download data (dft.gov.uk)
[18] Liu et al. (2022). The effect of air pollution on consumer decision making: A review. Available at: The effect of air pollution on consumer decision making: A review - ScienceDirect
[19] The Royal College of Physicians (2016). Every breath we take: The lifelong impact of air pollution.
[20] Chief Medical Officer's Annual Report 2022: Air pollution (2022). Available at: https://www.gov.uk/government/publications/chief-medical-officers-annual-report-2022-air-pollution
[21] COMEAP (2022). Cognitive decline, dementia and air pollution. Available at: https://www.gov.uk/government/publications/air-pollution-cognitive-decline-and-dementia
[22] Committee on the Medical Effects of Air Pollutants (2009) Long-term exposure to air pollution: effect on mortality. Available at: Long-term exposure to air pollution: effect on mortality - GOV.UK (www.gov.uk)
[23] Imperial College London (2023). Impacts of air pollution across the life course – evidence highlight note. Available at: Impacts of air pollution across the life course

estimated based on average vehicle fleet composition and vehicle kilometres per vehicle type across London. Air pollutant concentrations are measured at monitoring stations located across London[24].

Reducing emissions, where policy makers, such as the GLA, can mainly influence, has a direct impact on the amount of pollution in the air and in turn on the associated health burden. There are, however, other important factors that affect concentrations, including the impact of weather, natural seasonal variations and, for NO_2, significant atmospheric chemistry processes involving other pollutants (e.g. ozone) and sunlight.

Pollutants

Nitrogen oxides (NO_X) refers to nitric oxide (NO) and nitrogen dioxide (NO_2), which are produced during combustion processes such as in vehicle engines. NO can react with gases in the atmosphere to form NO_2. NO_2 is a toxic gas and the highest concentrations in London are recorded at roadside locations. NO_2 aggravates respiratory diseases – particularly asthma – and stunts the development of children's lungs[25]. In this report, emissions are reported in tonnes of NO_X, and concentrations are reported in micrograms of NO_2 per cubic metre of air ($\mu g/m^3$).

$PM_{2.5}$, also known as fine particulate matter, refers to particles or liquid droplets in the air that have a diameter less than 2.5 micrometres across (that is one 400^{th} of a millimetre, about three per cent of the diameter of a human hair). $PM_{2.5}$ has been linked to a range of perinatal[26] health outcomes, asthma, cardiovascular disease, and reduced cognitive abilities in children[25]. Some $PM_{2.5}$ is naturally occurring, such as dust and sea salt, and some is man-made, such as particulates from vehicle exhausts. In this report, emissions are reported in tonnes of $PM_{2.5}$, and concentrations are reported in micrograms of $PM_{2.5}$ per cubic metre of air ($\mu g/m^3$).

[24] Supplementary Data Sheet 2 - Concentrations has been published alongside this report which includes the full list of monitoring sites considered within this report.
[25] Imperial College London (2023). Impacts of air pollution across the life course – evidence highlight note. Available at: Impacts of air pollution across the life course – evidence highlight note (london.gov.uk)
[26] The time period that includes pregnancy and the year following birth

Introduction

Health impacts of air pollution

As outlined in the Scope and aims of this report section, this report does not aim to assess the health impacts associated with the ULEZ. However, this section describes the well-documented health impacts associated with air pollution and, therefore, why schemes such as the ULEZ are important.

Studies have long shown the many adverse health issues associated with elevated pollution levels[27]. Exposure to air pollution has negative health effects throughout the life course, including prior to birth. Whilst air pollution affects everyone, there are inequalities in exposure and some populations who are disproportionately impacted, including those above 65 years of age, children, pregnant people and those with existing health conditions, such as cardiovascular and respiratory diseases[28]. Exposure to air pollution can impair normal foetal development in the womb and affects children's lung growth. It increases the risk of developing lung cancer, heart and lung disease, stroke, and early death[29]. The latest evidence shows adverse health effects following long-term exposure to relatively low levels of pollution, below those experienced in London.

The burden of disease attributable to air pollution is estimated to be on par with other major global health risks, such as unhealthy diets and tobacco smoking, and air pollution is now recognised as the single largest environmental threat to human health[30].

Long-term exposure to air pollution in England in 2019 was estimated to contribute to the equivalent of between 26,000 to 38,000 premature deaths a year[31]. Air pollution was the subject of the 2022 Chief Medical Officer's Annual Report[20], which set out the effects of air

[27]The Committee on the Medical Effects of Air Pollutants (COMEAP) publishes regular reports and statements on the health effects of air pollution. These can be found here: COMEAP: reports and statements - GOV.UK (www.gov.uk)

[28] Public Health England (2018) Health matters: air pollution. Available at: Health matters: air pollution - GOV.UK

[29] The health effects across the life course are also summarised in "Impacts of air pollution across the life course – evidence highlight note." Imperial College London (April 2023). Available at: Impacts of air pollution across the life course – evidence highlight note (london.gov.uk)

[30] WHO (2021). Global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Available at: WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide

[31] Mitsakou C et al. Updated mortality burden estimates attributable to air pollution. In UK Health Security Agency. *Chemical hazards and poisons report*; Issue 28. Reducing health harms associated with air pollution; 2022. Available from: https://www.gov.uk/government/collections/chemical-hazards-and-poisons-reports

pollution on health and inequalities, as well as solutions to tackling it. The report highlighted that central and local government, alongside many industries and sectors, should go further to reduce air pollution.

In London, independent research using mortality burden calculations has shown that toxic air contributed to the premature deaths of the equivalent of around 4,000 Londoners in 2019[32]. Over 480,000 Londoners have been diagnosed with asthma and are more vulnerable to the impacts of air pollution, with more than half of these people living in outer London[33]. Asthma prevalence in London is highest in outer London, with approximately 4.9 per cent of the population in outer London boroughs diagnosed with asthma, compared to approximately 4.4 per cent in inner London boroughs[34]. In London in 2022/23, there were 2,705 emergency hospital admissions for asthma in children under 19 years[35]. Exposure to air pollution is disproportionally higher for those communities that have higher levels of deprivation or a higher proportion of people from Black, Asian and Minority Ethnic backgrounds, further exacerbating existing health inequalities[36].

Road traffic is one of the main sources of air pollution, and long-term exposure to traffic-related air pollution has adverse health effects across different age groups[37]. In 2019, road transport was the single largest source of certain air pollutant emissions in London, accounting for 43 per cent of NO_X emissions and 31 per cent of $PM_{2.5}$ emissions[38]. The ULEZ aims to reduce levels of such air pollutants on London's roads. The expansion of the ULEZ to outer London means that 1,752 schools and other educational establishments are

[32] Imperial College London. (2021). London Health Burden of Current Air Pollution and Future Health Benefits of Mayoral Air Quality Policies. Available at: Health burden of air pollution in London | London City Hall
[33] NHS England Quality and Outcomes Framework (QOF) data, published in the Public Health Outcomes Framework reports the number of patients aged 6 years plus included on a GP register of patients with asthma, by borough, in 2022/23.
[34] NHS England Quality and Outcomes Framework (QOF) data, published in the Public Health Outcomes Framework reports the percentage of patients aged 6 years plus included on a GP register of patients with asthma, by borough. The average prevalence has been calculated for outer London and inner London. This does not include undiagnosed or unrecorded cases of asthma.
[35] NHS England and Office for National Statistics data, published in the Public Health Outcomes Framework
[36] Air quality exposure and inequalities study part 1 – London analysis. Aether Ltd. June 2023. Available at: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/environment-and-climate-change-publications/air-pollution-and-inequalities-london-update-2023
[37] Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution. Health Effects Institute. June 2022. Available at: Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution | Health Effects Institute
[38] London Atmospheric Emissions Inventory (LAEI) 2019. Available at: London Atmospheric Emissions Inventory (LAEI) 2019 - London Datastore. 2019 is the latest available baseline data at the time of writing.

now included in the ULEZ area, bringing cleaner air to the around 880,000 attendees of these schools and establishments[39].

The ULEZ primarily aims to reduce NO_2, however $PM_{2.5}$ levels are also impacted, as previous ULEZ reports have shown. Reductions in $PM_{2.5}$ concentrations brings important health benefits to Londoners. Worldwide, nearly a third of all asthma cases are linked to long-term exposure to $PM_{2.5}$[40]. $PM_{2.5}$ reductions are associated with reduced acute respiratory and cardiovascular hospital admissions, incidences of heart disease and stroke and reduced levels of all-cause mortality[41].

The World Health Organization (WHO) emphasises that no safe level of exposure to air pollution exists, therefore reductions in air pollution are important for the health of Londoners. In 2021, the WHO updated its health-based guidelines for air quality, the first update since 2005[30]. The WHO air quality guideline for NO_2 is an annual mean concentration of 10 $\mu g/m^3$ and for $PM_{2.5}$ it is 5 $\mu g/m^3$. These are more ambitious than the current national legal limits of 40 $\mu g/m^3$ for NO_2 and 20 $\mu g/m^3$ for $PM_{2.5}$ in England[42,43].

The WHO's recommendations continue to be recognised globally as the targets that should be met to protect public health. Despite substantial improvements in air quality over recent years, the new WHO guidelines were not achieved anywhere in London in 2019, the latest date for which modelled London-wide data is available[16]. The Mayor has commissioned comprehensive analysis to determine how and when London can meet the new WHO guidelines; this report will be available later in 2025.

What is the ULEZ?

The expansion of the ULEZ London-wide in August 2023 is the latest world-leading policy delivered in London under this Mayoralty, aimed at tackling harmful air pollution emissions

[39] Air Quality Factsheet (2024). Available at: Schools, Hospitals and Care Homes in the ULEZ Expansion Area

[40] Ni, Ruijing et al. (2024). Long-term exposure to PM2.5 has significant adverse effects on childhood and adult asthma: A global meta-analysis and health impact assessment. Available at: Long-term exposure to PM2.5 has significant adverse effects on childhood and adult asthma: A global meta-analysis and health impact assessment: One Earth (cell.com)

[41] COMEAP (2022) Summary of COMEAP recommendations for the quantification of health effects associated with air pollutants. Available at: COMEAP summary of qualification recommendations (publishing.service.gov.uk)

[42] UK-Air (2023) UK Air Quality Limits. Available at: UK Air Quality Limits - Defra, UK

[43] The Environment Act (2021) also provides two further targets for $PM_{2.5}$ to be achieved by 2040. England Fine Particulate Matter Targets - Defra, UK

from road transport, specifically NO_X and $PM_{2.5}$. The ULEZ disincentivises the use of older, more polluting vehicles within the city through applying a daily charge to vehicles that do not meet certain emissions criteria. The emissions criteria are based on the Euro standards[44], which regulate the emissions of pollutants from road vehicles before they can be put on the market. The emissions levels permitted by each new Euro standard has progressively reduced, meaning new vehicles have become less polluting over time.

Although not a primary aim, schemes like the ULEZ have also been shown to reduce the number of vehicles that are on the road, for example, by encouraging people to switch to walking, cycling or public transport, and reduce air pollution and carbon emissions in this way.

Importantly, the ULEZ builds upon previous emissions-based charging zones in London. London's Low Emission Zone (LEZ) was launched in 2008 and is the oldest of the capital's emission control schemes. The LEZ applies to large and heavy diesel vehicles, including lorries, buses, minibuses[45] and vans[46] and operates 24 hours a day, every day of the year. For most vehicles, they are not separately subject to LEZ and ULEZ standards.

In October 2017, the Mayor introduced the Toxicity Charge (T-Charge) in central London, the first vehicle emissions control scheme in the UK to include cars and small vans. This was replaced by the introduction of the ULEZ in central London in April 2019, the enforcement of higher emissions standards for the LEZ in March 2021, the expansion of the ULEZ to inner London in October 2021, and the London-wide expansion of the ULEZ in August 2023. As such, Londoners and those who drive in London have been taking action to comply with the schemes affecting lighter vehicles since the confirmation of the T-Charge in February 2017. This date was, therefore, used as a reference for measuring the impact of the schemes over a longer-term period. This assumption has been examined in Table 65 and Table 66 in Appendix 3.

The timeline of emissions-based charging schemes in London are set out in Figure 1. These schemes have been transformational in improving air quality in London.

[44] More information on Euro Standards can be found on the RAC website: Euro 1 to Euro 6 – Vehicle Emissions Standards | RAC Drive

[45] over 5 tonnes Gross Vehicle Weight

[46] over 3.5 tonnes Gross Vehicle Weight

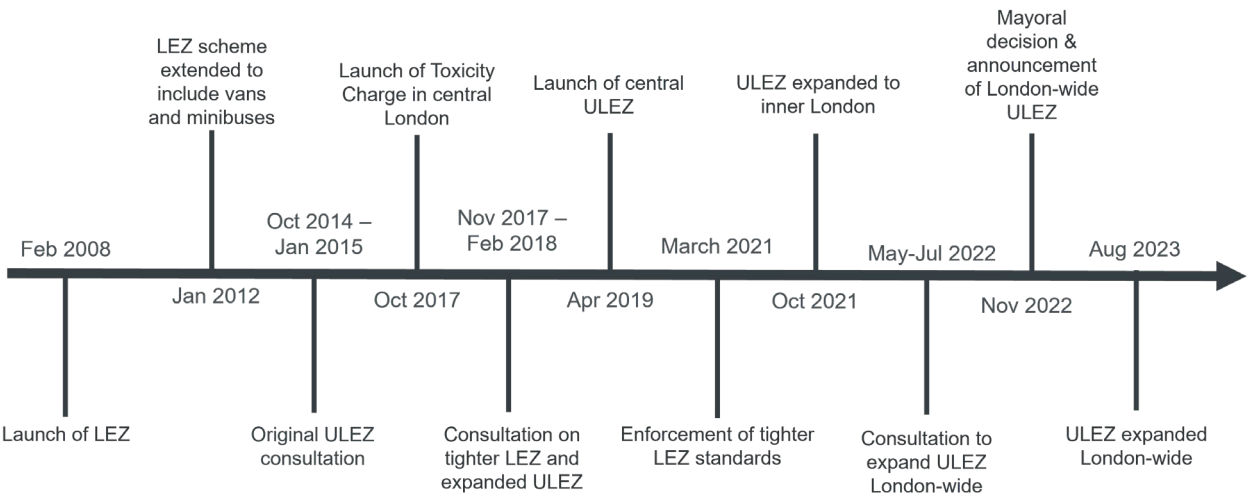

Figure 1: Timeline of vehicle emissions charging schemes in London

The ULEZ operates 24 hours a day, every day of the year except Christmas Day[47] (25 December). Vehicles must meet strict emissions standards to drive in the ULEZ area, as set out in Table 1.

Table 1: ULEZ Standards

Vehicle type	ULEZ standard	Date from which manufacturers had to sell new vehicles meeting the ULEZ emissions standards[48]
Motorcycles, mopeds, and other L category vehicles	Euro 3	From 1 July 2007
Cars and light vans	Euro 4 (petrol) Euro 6 (diesel)	From 1 January 2006 From 1 September 2015
Larger vans (≤3.5 tonnes Gross Vehicle Weight) and	Euro 4 (petrol)	From 1 January 2007

[47] On 25 December there are significantly reduced public transport options in operation meaning there are fewer alternatives available to those with non-compliant vehicles.

[48] Some manufacturers were early adopters of the relevant standards, meaning some vehicles manufactured before these dates will meet the ULEZ standards.

Vehicle type	ULEZ standard	Date from which manufacturers had to sell new vehicles meeting the ULEZ emissions standards[48]
minibuses (≤5 tonnes Gross Vehicle Weight)	Euro 6 (diesel)	From 1 September 2016

As summarised in Table 1, all petrol cars registered new from 1 January 2006 and all diesel cars registered new from 1 September 2015 will comply with the ULEZ emissions standards, however for some vehicles these dates may be even earlier[49]. Vehicles that do not meet these standards must pay a charge of £12.50 per day to travel in the ULEZ if they are not otherwise subject to a grace period[50], discount, or exemption. The charge is set to disincentivise frequent trips in non-compliant vehicles, which would otherwise contribute more to air pollution. This incentivises people to change their travel behaviour or replace their vehicle, whilst allowing occasional visitors and infrequent drivers an alternative.

Figure 2 shows a map of the area covered by the London-wide ULEZ (LWULEZ). The ULEZ is complemented by the London-wide LEZ. The LEZ standards are aligned with the ULEZ standards, however LEZ standards have been in place London-wide since March 2021[51].

[49] Some vehicle manufacturers were early adopters of the relevant standards, meaning some petrol cars manufactured before 2006 and some diesel cars manufactured before 2015 will meet the ULEZ standards
[50] Also known as “temporary exemptions” For more information on grace periods: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/discounts-and-exemptions
[51] Diesel vans between 1.2 T and 3.5 T and minibuses under 5 T are subject to both the LEZ (if they do not meet the Euro 3 standard for PM) and the ULEZ (if they do not meet the Euro 6 standard).

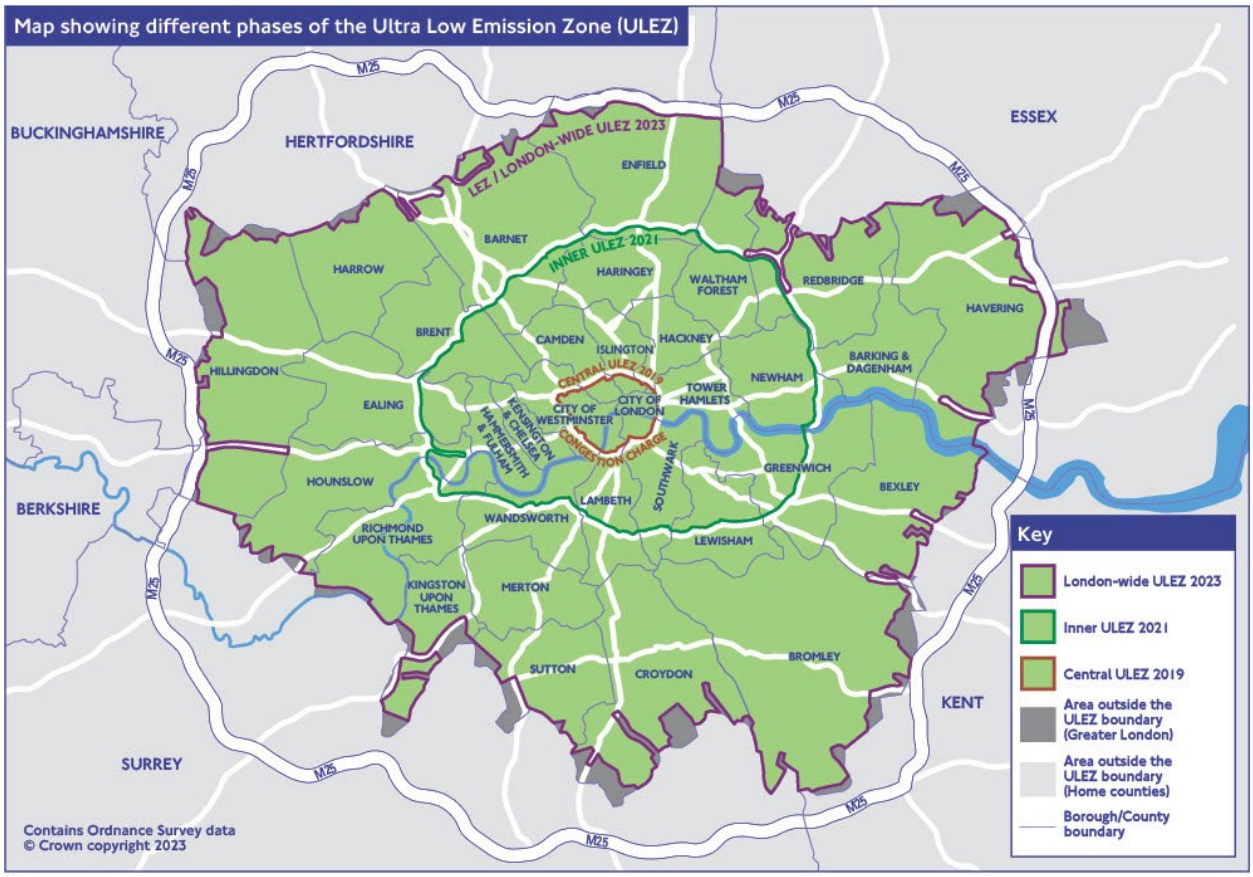

Figure 2: Map of the ULEZ

Importantly, the ULEZ and the LEZ sit within a wider suite of policies aimed at reducing air pollution in London. These policies include cleaning up the bus, taxi and Private Hire Vehicle (PHV) fleets, including introducing more than 1,800 zero-emission buses and introducing taxi and PHV age limits and emissions-based licensing requirements. As well as working with the London boroughs and the private sector to increase the provision of electric vehicle charge points in London, and making it easier and safer to walk, cycle, and use public transport in the city. All of these policies contribute to improvements in air pollution concentrations. Further detail on the air quality policies implemented and delivered by the Mayor of London during the current Mayoralty is detailed in the Air Quality in London 2016 – 2024 report.

Providing support

There is, and has been, a range of support available for people and organisations with non-compliant vehicles. This includes the scrappage scheme, temporary exemptions, a

reimbursement scheme for certain NHS patients, and third-party offers on alternative transport options.

The package of support measures for the London-wide ULEZ was designed to build on previous successful scrappage schemes and other support provided for earlier iterations of the ULEZ and to respond to points raised in the public consultation and stakeholder engagement about the Mayor's decision to expand the ULEZ London-wide. This led to the extension of existing grace periods by two years, the launch of new grace periods to help more disabled people, and new retrofit and wheelchair accessible vehicle grants under the scrappage scheme. Please refer to the London-wide Ultra Low Emission Zone First Month Report, where information on these support measures was provided in detail.

In January 2023, the Mayor-funded scrappage scheme launched, providing financial assistance to help more eligible Londoners scrap their non-compliant vehicles. Scrappage scheme support was initially targeted at low-income and disabled Londoners with eligible non-compliant cars, motorcycles and wheelchair accessible vehicles (WAV), and London-registered sole traders, micro businesses and charities with eligible non-compliant vans or minibuses. The scheme was later expanded to cover all Londoners with eligible non-compliant cars, motorcycles and WAVs and small businesses with eligible non-compliant vans and minibuses. From March 2024, an option was added for successful scrappage scheme applicants to choose to donate vehicles to support humanitarian and medical needs in Ukraine instead of scrapping them, and still receive the same grant payment[52]. Following the decline of application volumes and high measured compliance with the ULEZ standards, the scrappage scheme closed to new applications on 8 September 2024. A full evaluation of the scrappage scheme will be published in spring 2025. To mitigate a potential impact of the closure of the scrappage scheme, the temporary exemption for not-for-profit minibuses was extended by two years to 24 October 2027. The third-party offers ended on 8 November 2024, two months after the closure of the scrappage scheme.

How the ULEZ delivers change

Long-term exposure to air pollution, over years, increases the risk of developing lung cancer, heart and lung disease (including asthma), stroke, and early death. The WHO's recommendations continue to be recognised globally as the targets that should be met to protect public health, and schemes such as the ULEZ are a vital step towards achieving these limits in London. Schemes such as the ULEZ seek to create long-term

[52] TfL regularly reports on the scrappage scheme. See the "Finance, operations & performance" section here: https://tfl.gov.uk/corporate/publications-and-reports/ultra-low-emission-zone

transformative change, and ensure benefits are realised over many years, which began even before the scheme was launched.

The ULEZ requires vehicle users with non-compliant vehicles to take action and either replace a non-compliant vehicle or change how they regularly travel. To help vehicle users prepare for the London-wide ULEZ, an extensive public information campaign commenced in January 2023. This was in addition to significant stakeholder and local borough engagement and press activity. Communication activity included raising awareness of the scrappage scheme and third-party support available. Stakeholder and press activity also engaged non-UK drivers, and third-party mapping apps, such as Google, Apple, and Waze to provide information on the ULEZ boundary when route planning for users.

There were also a number of changes to the vehicle scrappage scheme that were announced in the lead up to the launch of the expansion. These changes are likely to have acted as a further prompt by enabling more people to access scrappage grants and adding to the media coverage about the ULEZ expansion.

Therefore, we expected to see people starting to change their vehicles and travel behaviour in the build-up to the launch date. However, there are still immediate impacts that can be observed directly before and after launch.

Vehicle compliance

The focus of this report is the London-wide ULEZ, which came into effect on 29 August 2023. As such, the compliance figures reported only relate to vehicles that are subject to the ULEZ standards (see Table 2). Lorries, vans and specialist vehicles over 3.5 tonnes Gross Vehicle Weight, and buses and minibuses over 5 tonnes Gross Vehicle Weight are required to meet Euro VI emissions standards through the separate LEZ[53]. Updated information on compliance for the LEZ is provided in Appendix 6.

Licensed London taxis are not subject to the ULEZ as they have different emissions requirements as part of their licensing conditions and, therefore, are not included in the ULEZ compliance figures. Transport for London (TfL) has used its licensing powers to introduce tighter age limits and, since 1 January 2018, all newly licensed taxis have needed to be zero-emission capable (ZEC). As of December 2024, over 79 per cent of London licensed taxis are compliant with the ULEZ standards, including over 8,800 ZEC taxis[54]. This is up from less than 20 per cent in 2018 when the ZEC licensing requirement was introduced (when only 14 taxis were ZEC).

[53] Vans or specialist diesel vehicles from 1.205 tonnes unladen weight up to 3.5 tonnes gross vehicle weight are required to meet Euro 3 (Particulate Matter) emissions standards through the LEZ. They are additionally subject to the ULEZ.

[54] Latest licensing information can be found on TfL's website: Licensing information - Transport for London (tfl.gov.uk)

Table 2: Vehicle types included and excluded from compliance figures

Vehicle type	Included in ULEZ compliance?	Emissions limits requirement	Relevant scheme
Motorcycles	Yes	Euro 3	ULEZ
Cars	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ
Smaller vans	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ
Larger vans and minibuses (vans up to and including 3.5 tonnes, minibuses up to and including 5 tonnes)	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ
Heavy diesel vehicles (including buses and coaches over 5 tonnes and HGVs and other heavy diesel vehicles over 3.5 tonnes)	No (Appendix 6)	Euro VI	LEZ
Taxis (Black cabs)	No	All newly licensed taxis required to be “Zero-Emission Capable” since 2018 and are subject to age limits and other restrictions to reduce emissions.	Taxi licensing

TfL buses are subject to the LEZ, including the tighter standards enforced from March 2021. The entire fleet met the standards for this scheme by January 2021, well ahead of the enforcement of the tighter LEZ standards. Following his re-election in May 2024, the Mayor stated his ambition to deliver a fully zero-emission bus fleet by 2030. London has the largest zero-emission bus fleet in western Europe, with over 1,800 (one in five) TfL buses now zero-emission[55].

[55] Zero-emission refers to tailpipe emissions. See: https://www.c40.org/case-studies/london-powers-ahead-with-zero-emission-buses/

There are a limited number of ULEZ exemptions, discounts, and grace periods. These vehicles are still recorded as non-compliant in these figures. Drivers of vehicles that qualify for these do not need to pay if their vehicles do not meet the required emissions standards.

ULEZ compliance data

The data in this section has been taken from TfL's ANPR camera network[56], which detects vehicles as they enter the ULEZ and when they travel within it. Drivers of vehicles that do not comply and are not subject to a grace period, discount or permanent exemption must pay the daily charge or may be liable for enforcement action.

Compliance levels in London are measured through ANPR data derived from anonymised daily camera detections. To check if a vehicle meets the ULEZ standards or not, TfL cross-references this data with available Driver and Vehicle Licensing Agency (DVLA) records, including information on vehicle type, age, Euro standards, and emissions. This gives daily data that is averaged over a month to give a daily average compliance rate for each month for central, inner, and outer London.

Camera installations for the London-wide ULEZ commenced in December 2022, following the Mayoral decision to expand the ULEZ across all London boroughs[57]. By May 2023, a network of new cameras was in place, which continued to evolve following the launch of the London-wide expansion in August 2023. To date, around 3,900 cameras are in place across the London-wide zone and an active programme of camera repairs and replacements is in place, including to address instances of vandalism. These day-to-day changes in the camera network can lead to minor fluctuations in data in addition to usual variations in vehicular activity.

Compliance rates based on ANPR data from the camera network are provided for the whole London-wide zone. A subset of zonal compliance estimates for the central London ULEZ (the same area as the Congestion Charge zone), the inner London ULEZ (the entire area bounded by the North and South Circular Roads, including central London), and the

[56] For more information on how TfL gathers data, how it is used and protected visit: https://tfl.gov.uk/corporate/privacy-and-cookies/road-user-charging
[57] https://www.london.gov.uk/who-we-are/governance-and-spending/promoting-good-governance/decision-making/mayoral-decisions/md3060-london-wide-ultra-low-emission-zone-ulez-scheme

expanded outer London area (excluding the central and inner London ULEZ area) are also provided.

Compliance rates and vehicle detections up to November 2022 are based on the camera network in place for the LEZ at the time and do not include any cameras installed in preparation for the London-wide ULEZ. In outer London, this camera network detected unique vehicle numbers in the high hundreds of thousands per day and provided a suitable level of confidence for the assessment of compliance levels in that area before the network evolved.

General overview of London-wide ULEZ compliance

Table 3 summarises the London-wide ULEZ compliance rates at the following stages:

- February 2017 – confirmation of the T-Charge, the predecessor to the ULEZ
- May 2019 – the first month after the central London ULEZ was introduced
- November 2021 – the first month after the inner London ULEZ was introduced on 25 October
- June 2023 – baseline month for this report (includes data from new camera network rollout in outer London)
- September 2023 – the first month after the London-wide expansion of the ULEZ
- February 2024 – six months after the London-wide expansion of the ULEZ
- September 2024 – one year after the London-wide expansion of ULEZ

Table 3: Daily average proportion of ULEZ compliant vehicles detected in the London-wide ULEZ area

Vehicle type	Feb-17*	May-19	Nov-21	Jun-23	Sep-23	Feb-24	Sep-24
All ULEZ vehicles	39.0%	67.9%	87.0%	91.6%	95.3%	96.2%	96.7%
Cars (incl. PHV)	44.0%	72.8%	89.2%	93.0%	96.4%	97.1%	97.4%
Vans (up to and incl. 3.5 tonnes)	12.0%	34.7%	70.8%	80.2%	86.2%	88.9%	90.7%

Vehicle type	Feb-17*	May-19	Nov-21	Jun-23	Sep-23	Feb-24	Sep-24
Minibuses (up to and incl. 5 tonnes	12.0%	45.0%	72.1%	76.0%	79.1%	80.3%	82.9%
Motorcycles	50.0%	88.7%	95.6%	96.0%	96.6%	97.0%	96.6%
All vehicles (LEZ, ULEZ, taxis)	38.0%	67.5%	86.9%	91.6%	95.2%	96.1%	96.6%

*February 2017 based on data from the London Atmospheric Emissions Inventory, except for motorcycles which is based on Defra fleet composition data. Minibuses compliance estimate in 2017 is assumed to be the same as vans.

Table 3 shows an overview of changes in ULEZ compliance over time. These figures are calculated based on detected vehicles from the camera network, and they show there has been a continuing and rapid improvement in the proportion of ULEZ compliant vehicles driving in London since 2017.

The average compliance for all vehicles subject to the ULEZ in 2017 was approximately 39 per cent. In September 2024, one year after the London-wide expansion of the ULEZ, this figure has increased to 96.7 per cent for all vehicles and to 97.4 per cent for cars and PHVs. For the first time, compliance for vans has exceeded 90 per cent.

The fleet in outer London is estimated to be approximately three to four years ahead of the national (UK) fleet composition. This estimate is based on comparisons of outer London vehicle kilometre proportions of cars and vans that are Euro 5 and Euro 6 petrol, Euro 6 diesel and zero-emission vehicles, compared to the most recently published Defra vehicle kilometre fleet compositions[58]. The Defra projections suggest that the levels now achieved in outer London would not be achieved until 2027 for cars and 2028 for vans.

[58] Published in 2024 for 2022 NAEI, available at: Air Pollutant Emissions Data | National Atmospheric Emissions Inventory

Combining information on heavy vehicles also subject to the LEZ means that after the first year of the London-wide ULEZ nearly 97 per cent of all vehicles seen driving in the London-wide zone are now compliant with ULEZ and LEZ standards.

Assessment of the impact of the London-wide ULEZ on compliance

This One Year Report compares volumes of vehicles detected in September 2024 (one year after the London-wide expansion) to September 2023 and June 2023[59]. Whilst the London-wide ULEZ came into operation on 29 August 2023, for data clarity, whole monthly comparisons have been undertaken for this report.

All tables in this section show compliance rates for the entire London-wide ULEZ. Further sections provide more information on compliance rates in the expanded outer London area, and discussion of compliance rates across different areas of London over time. More detail on zonal compliance is available in Appendix 1.

The tables provide the average daily number of unique vehicles[60] seen by the camera network each month, along with compliance rates[61] for the different vehicle types. From May 2023, in outer London, there is an increase in the number of vehicles detected by the camera network in this area as this is when the data from new cameras installed for the expansion first became available. This also affects London-wide data as it includes new data from outer London cameras. Vehicle volume comparisons prior to this date are unsuitable for assessing scheme impacts because the development of the camera network over time has increased the rate of vehicle detections.

Whilst the biggest impact of the scheme is reducing the number of non-compliant vehicles being driven, it is worth noting that the number of unique vehicles detected (both compliant and non-compliant) in the London-wide ULEZ has increased further since the scheme was expanded. This is expected for various reasons. Usual typical variation in traffic activity is one reason (for example, during school holidays), and the other main reason is having an

[59] June 2023 has been used as a pre-expansion comparator as it is a typical month that does not include bank holidays or school holidays, and also uses available data from the new cameras installed for the London-wide ULEZ expansion.
[60] A daily unique vehicle means a vehicle that has been detected by at least one camera in the zone at least once per day.
[61] Compliance rate is calculated dividing the total number of vehicles which are compliant by the total overall number of vehicles.

increased camera network with a better spatial distribution, which increases the likelihood of a given vehicle being captured.

This report is based on the further developed camera network and allows a longer-term comparison using one year's worth of data, including typical variations in traffic levels and patterns across the year.

Overall, vehicle numbers went down from just over two million in June 2023 (a month after the camera network was first expanded in preparation of the scheme) to 1.97 million in September 2023, just after the launch of the ULEZ expansion. The number of detections has since increased, reaching two million again in February 2024 and 2.1 million one year after the scheme went live, in September 2024. Whilst the number of overall detections currently sits at 2.1 million vehicles (average day in September 2024), the proportion of non-compliant vehicles has continued to reduce.

> Table 4 shows that overall compliance with the ULEZ is now 96.7 per cent. This is an increase of 1.4 percentage points (ppt) from September 2023, and an increase of 5.1 percentage points from June 2023 before the scheme went live.

Of the 3.3 per cent of non-compliant vehicles in September 2024, some vehicles will be non-chargeable, and the remainder will pay the charge or may have enforcement action taken against them. Non-chargeable vehicles include those with exemptions or benefitting from extended grace periods, as well as vehicles that were detected on a diversion route[62]. TfL publishes quarterly factsheets that provide a breakdown of the daily average number and proportion of vehicles detected in the ULEZ that were non-compliant broken down by those who paid the charge, received a penalty charge notice or warning notice or were non-chargeable[63].

As seen in Table 4, the average number of non-compliant vehicles detected daily in the zone has fallen in the first year of the scheme. Non-compliant vehicles have dropped from a daily average of 170,000 in June 2023, prior to the expansion, to a daily average of 93,000 in September 2023, 80,000 in February 2024 and 71,000 in September 2024.

[62] Available information indicates there were 555 traffic diversions from 29 August 2023 to 28 August 2024.

[63] https://tfl.gov.uk/corporate/publications-and-reports/ultra-low-emission-zone

> In the London-wide ULEZ, there were nearly 100,000 fewer non-compliant vehicles seen driving in London on an average day in September 2024 compared to June 2023 (a 58 per cent reduction).

Table 4: Daily average number and proportion of ULEZ compliant vehicles detected in the London-wide ULEZ area per month (rounded to the nearest 1,000 vehicles)

Date	Unique vehicles detected in zone	Number of non-compliant vehicles	Number of Compliant vehicles	Proportion of Non-compliant vehicles	Proportion of Compliant vehicles
Jun-23	2,022,000	170,000	1,852,000	8.4%	91.6%
Sep-23	1,974,000	93,000	1,881,000	4.7%	95.3%
Feb-24	2,098,000	80,000	2,018,000	3.8%	96.2%
Sep-24	2,144,000	71,000	2,072,000	3.3%	96.7%
Change between June 2023 and September 2024	121,000	-99,000	220,000	-5.1 ppt	+5.1 ppt
% Change in vehicles between June 2023 and September 2024	6%	-58%	12%	N/A	N/A

Table 5 to Table 6 show the monthly average compliance rates and unique vehicles detected driving in the zone for cars subject to the ULEZ. Table 5 reports compliance rates for all cars, while Table 6 focuses on diesel cars only.

Table 5: Daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. taxis) detected in the London-wide ULEZ area per month (rounded to nearest 1,000 vehicles)

Date	Unique cars detected in zone	Number of Non-compliant cars	Number of Compliant cars	Proportion of Non-compliant cars	Proportion of Compliant cars
Jun-23	1,747,000	123,000	1,624,000	7.0%	93.0%
Sep-23	1,710,000	61,000	1,649,000	3.6%	96.4%
Feb-24	1,825,000	53,000	1,771,000	2.9%	97.1%
Sep-24	1,868,000	49,000	1,820,000	2.6%	97.4%
Change between June 2023 and September 2024	121,000	-75,000	196,000	-4.4 ppt	+4.4 ppt
% Change in vehicles between June 2023 and	7%	-61%	12%	N/A	N/A

Date	Unique cars detected in zone	Number of Non-compliant cars	Number of Compliant cars	Proportion of Non-compliant cars	Proportion of Compliant cars
September 2024					

Comparing June 2023 and September 2024, the average number of non-compliant cars detected in the zone has fallen by approximately 61 per cent, with around 75,000 fewer non-compliant cars seen on an average day. Out of all cars detected in London, only 2.6 per cent are now non-compliant. The compliance rate increased by 4.4 percentage points between June 2023 and September 2024 reaching a compliance rate of 97.4 per cent in September 2024.

Table 6: Daily average number and proportion of ULEZ compliant diesel cars (M1, excl. PHVs and taxis) detected in the London-wide ULEZ area per month (rounded to nearest 100)

Date	Unique diesel cars detected in zone	Number of Non-compliant diesel cars	Number of Compliant diesel cars	Proportion of Non-compliant diesel cars	Proportion of Compliant diesel cars
Jun-23	378,100	111,500	266,600	29.5%	70.5%
Sep-23	326,300	55,300	270,900	17.0%	83.0%
Feb-24	330,900	48,000	282,900	14.5%	85.5%
Sep-24	326,400	43,200	283,200	13.2%	86.8%
Change between June 2023	-51,700	-68,200	16,000	-16.2 ppt	+ 16.2 ppt

Date	Unique diesel cars detected in zone	Number of Non-compliant diesel cars	Number of Compliant diesel cars	Proportion of Non-compliant diesel cars	Proportion of Compliant diesel cars
and September 2024					
% Change in vehicles between June 2023 and September 2024	-14%	-61%	6%	N/A	N/A

Of the 74,000 fewer non-compliant cars detected in the zone, the vast majority (over 68,000) are diesel cars. This is similar to the pattern seen following the previous iterations of the scheme as only newer diesel cars meet the strict ULEZ emissions standards. The data from Table 6 indicates a 14 per cent reduction in the number of diesel cars seen overall. Compliance rates for diesel cars have increased by over 16 percentage points to 86.8 per cent between June 2023 and September 2024.

Table 7: Daily average number and proportion of ULEZ compliant vans (N1) detected in the London-wide ULEZ area per month (rounded to nearest 100 vehicles)

Date	Unique vans detected in zone	Number of Non-compliant vans	Number of Compliant vans	Proportion of Non-compliant vans	Proportion of Compliant vans
Jun-23	225,600	44,700	180,900	19.8%	80.2%
Sep-23	214,900	29,700	185,200	13.8%	86.2%

Date	Unique vans detected in zone	Number of Non-compliant vans	Number of Compliant vans	Proportion of Non-compliant vans	Proportion of Compliant vans
Feb-24	226,800	25,200	201,600	11.1%	88.9%
Sep-24	233,400	20,800	202,600	9.3%	90.7%
Change between June 2023 and September 2024	-2,200	-23,900	21,700	-10.5 ppt	+10.5 ppt
% Change in vehicles between June 2023 and September 2024	-1%	-53%	12%	N/A	N/A

Comparing June 2023 and September 2024, the average number of non-compliant vans detected in the zone has fallen by 53 per cent, with around 23,900 fewer non-compliant vans being seen on an average day. The compliance rate for vans has increased by 10.5 percentage points between June 2023 and September 2024, and compliance is now 90.7 per cent, one year after the scheme went live. For comparison, the average compliance rate for all vehicles between June 2023 and September 2024 has increased by 5.1 percentage points. The compliance rate for vans remains lower than that for cars. However, it is still high and crucially it has risen at a quicker pace than the average for all vehicles. The scrappage scheme has helped drive this transition.

Table 8: Daily average number and proportion of ULEZ compliant minibuses detected in the London-wide ULEZ area per month (rounded to nearest 10 vehicles)

Date	Unique minibuses detected in zone	Number of Non-compliant minibuses	Number of Compliant minibuses	Proportion of Non-compliant minibuses	Proportion of Compliant minibuses
Jun-23	3,130	750	2,370	24.0%	76.0%
Sep-23	2,760	580	2,180	20.9%	79.1%
Feb-24	2,770	540	2,220	19.7%	80.3%
Sep-24	2,850	490	2,360	17.2%	82.8%
Change between June 2023 and September 2024	-270	-260	-10	-6.8 ppt	+6.8 ppt
% Change in vehicles between June 2023 and September 2024	-9%	-35%	-0.5%	N/A	N/A

Fewer than 3,000 minibuses are detected in the London-wide ULEZ on an average day. Compliance levels have increased by 6.8 percentage points since June 2023 to 82.8 per cent in September 2024. The compliance level for minibuses is lower than for other ULEZ vehicle types. This may be because minibuses owned by not-for-profit organisations for

community transport are eligible for a grace period from the scheme until 24 October 2027. As the number of minibuses seen travelling in London is low, a reduction of a few hundred vehicles equates to a larger percentage reduction than for other vehicle types. However, the number of minibuses seen fluctuates considerably during the year and data covering more months will be required to fully assess any trends due to the small volumes detected.

Table 9: Daily average number and proportion of ULEZ compliant motorcycles (L) detected in the London-wide ULEZ area per month (rounded to nearest 10 vehicles)

Date	Unique motorcycles detected in zone	Number of Non-compliant motorcycles	Number of Compliant motorcycles	Proportion of Non-compliant motorcycles	Proportion of Compliant motorcycles
Jun-23	46,170	1,850	44,310	4.0%	96.0%
Sep-23	45,700	1,580	44,130	3.4%	96.6%
Feb-24	44,210	1,340	42,870	3.0%	97.0%
Sep-24	48,830	1,650	47,180	3.4%	96.6%
Change between June 2023 and September 2024	2,660	-200	2870	-0.6 ppt	+0.6 ppt
% Change in vehicles between June 2023 and	6%	-11%	7%	N/A	N/A

Date	Unique motorcycles detected in zone	Number of Non-compliant motorcycles	Number of Compliant motorcycles	Proportion of Non-compliant motorcycles	Proportion of Compliant motorcycles
September 2024					

The compliance rate for motorcycles remains high and has increased by 0.6 percentage point since June 2023 to reach 96.6 per cent in September 2024.

ULEZ compliance by zone

Table 10 shows the compliance levels for the central London ULEZ area, the inner London ULEZ area, and the expanded outer London area for September 2019 (the first month where monitoring across all areas separately is available). Table 11 presents the same for September 2024 (one year after the London-wide ULEZ). This shows that, based on available data for 2019, there were large differences in the compliance levels for all vehicles subject to the ULEZ across London, with central London having much higher levels of compliance following the earlier introduction of the central London ULEZ.

Compliance rates in outer London in September 2019 were about 10 percentage points lower for cars and nearly 20 percentage points lower for vans than in central London.

> By September 2024, compliance rates for vehicles using London's roads are nearly the same across all areas for all vehicles subject to the ULEZ.

Vans still have 3.4 percentage point difference between central and outer London, however this is expected to keep reducing over time.

This shows the substantial impact of the London-wide expansion, which operates across a wide geographical area and brings changes to a large number of vehicles, helping to reduce emissions and improve air quality across the city.

Table 10: Daily average proportion of ULEZ compliant vehicles detected in different areas of London in September 2019[64]

Vehicle type	Central London ULEZ	Inner London ULEZ	Expanded outer London area	Percentage point difference between central and outer London
All ULEZ vehicles	79.0%	71.2%	68.6%	-10.4 ppt
Cars (incl. PHV, excl. taxis)	84.0%	76.0%	73.5%	-10.5 ppt
Vans (up to and incl. 3.5 tonnes)	56.5%	43.2%	37.7%	-18.9 ppt
Motorcycles	84.0%	76.0%	73.5%	-10.5 ppt
Minibuses (up to and incl. 5 tonnes)	62.1%	50.2%	48.6%	-13.5 ppt
All Vehicles (ULEZ, LEZ, Taxis)	76.3%	70.6%	68.3%	-7.9 ppt

[64] September 2019 is the first month where monitoring across all ULEZ zones separately is available.

Table 11: Daily average proportion of ULEZ compliant vehicles detected in different areas of London in September 2024

Vehicle type	Central London ULEZ	Inner London ULEZ	Expanded outer London area	Percentage point difference between central and outer London
All ULEZ vehicles	96.7%	96.9%	96.7%	-0.0ppt
Cars (incl. PHV, excl. taxi)	97.3%	97.6%	97.5%	0.2ppt
Vans (up to and incl. 3.5 tonnes)	94.3%	92.6%	90.9%	-3.4ppt
Motorcycles	98.1%	97.5%	96.8%	-1.3ppt
Minibuses	84.4%	85.0%	83.0%	-1.4ppt
All vehicles (ULEZ, LEZ, Taxis)	96.1%	96.8%	96.7%	0.6ppt

Compliance rates in the expanded outer London area

This section provides information on compliance rates in the expanded outer London area, which is now part of the London-wide ULEZ. The number of vehicles detected as provided in these tables are those seen in the outer zone (the area from, and including, the North and South Circular Roads, to the London-wide ULEZ boundary based on available cameras). However, it is important to note that many of these vehicles are also seen in the inner London and central London ULEZ areas – these are not vehicles travelling solely in the expanded outer London area.

> Table 12 shows that the compliance rate for all vehicles subject to the ULEZ seen in outer London in September 2024 is 96.7 per cent and has increased by 5.8 percentage points since June 2023.

Compliance in outer London has reached the same level as London-wide compliance for all vehicles subject to the ULEZ. Tables in Appendix 1 for the expanded outer area show that, on an average day, there were 95,000 fewer non-compliant vehicles in the expanded outer London area – a reduction of nearly 61 per cent between June 2023 and September 2024. Whilst the number of non-compliant vehicles has reduced, overall traffic trends remained consistent. More detail on traffic trends is provided in the Traffic section of this report.

The compliance rate for cars seen in the expanded outer London area has increased to 97.5 per cent in the first year of the scheme, an increase of 5.1 percentage points compared to June 2023, with 72,000 fewer non-compliant cars seen on an average day, a reduction of 64 per cent.

The compliance rate for vans seen in the expanded outer London area is now over 90 per cent for the first time – an increase of 11.4 percentage points since June 2023 and over 21.8 percentage points since May 2022. The number of non-compliant vans in the expanded outer London area has reduced by 55 per cent.

Table 12: Daily average proportion of ULEZ compliant vehicles detected in the expanded outer area

Vehicle type	Feb-17*	Nov-21	Jun-23	Sep-23	Feb-24	Sep-24
All ULEZ vehicles	39%	82.3%	90.9%	95.2%	96.2%	96.7%
Cars (incl. PHV)	44%	85.2%	92.4%	96.4%	97.1%	97.5%
Vans (up to and incl. 3.5 tonnes)	12%	65.2%	79.5%	86.2%	89.0%	90.9%
Minibuses (up to and incl. 5 tonnes	12%	67.8%	75.4%	78.7%	80.4%	83.0%
Motorcycles	50%	75.6%	95.6%	96.6%	97.0%	96.8%
All vehicles (LEZ, ULEZ, taxis)	38%	82.5%	90.5%	95.2%	96.1%	96.7%

*February 2017 is based on data for all of London from the London Atmospheric Emissions Inventory, except for motorcycles which is based on Defra fleet composition data. Minibuses compliance estimate in 2017 is assumed to be the same as vans.

**Compliance figures on any month before May 2023 are based on the camera network in place before additional new cameras were installed for the London-wide ULEZ. Figures from June 2023 include data available from an evolving camera network.

Compliance rates across London

ULEZ compliance rates have increased across the whole of London over time, however the rate of increase and level has varied over the years due to the successive phasing of the scheme.

Vehicles travel between different areas of London and outside of the capital and this means that the ULEZ and LEZ can bring air quality benefits to a wider area and larger population than directly within the charging area[65]. The benefits of these effects have been shown in previous monitoring reports. For example, analysis by the Environmental Defense Fund (EDF) showed that HGVs meeting the LEZ standards were driven on average for twice the distance outside the LEZ than within, with many of them driving substantially further outside the capital and, therefore, bringing the benefits of the London LEZ to 95 per cent of major towns and cities in England and Wales[66].

Figure 3 confirms that benefits could be seen outside the direct charging areas. While compliance rates increased faster in the areas that would be charged, increases in compliance occurred outside these areas as well. There is yet again a substantial step up in the compliance of vehicles in the expanded outer London area (and London-wide) as drivers responded to the launch of the London-wide scheme. The step up in compliance is smaller than for previous phases of the ULEZ but this is expected as the gap to a fully ULEZ compliant fleet is much smaller. This is due to the natural replacement of the vehicle fleet over time, and, crucially, the positive effects of the central and inner ULEZ on increasing vehicle compliance even for those based outside of the previous charging zones. Importantly, at the time of launching the London-wide ULEZ, the increase in compliance levels in the expanded outer London area affected over three times the number of vehicles than were covered by the inner London ULEZ (Table 4 and Table 37).

The London-wide expansion of the ULEZ led to a rapid rate of increase in compliance in outer London in 2023 as Londoners and businesses prepared for the scheme. As such, compliance rates across different areas of London are now similar, and nearly 97 per cent of all vehicles meet the standards. The dotted lines in the graphs relate to changes in the camera network, in preparation for the ULEZ expansion.

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[65] Future information on the make-up of the fleet outside of London becomes available periodically through the National Atmospheric Emissions Inventory, published by the UK Government.
[66] Full report here: EDF-Europe-Examining-the-reach-of-Greater-Londons-Clean-Air-Zone.pdf (globalcleanair.org). Data used in the report was procured from INRIX. INRIX has no affiliation with the analysis or results.

Further tables in Appendix 1 provide compliance rates for the central London ULEZ and inner London ULEZ areas over similar dates.

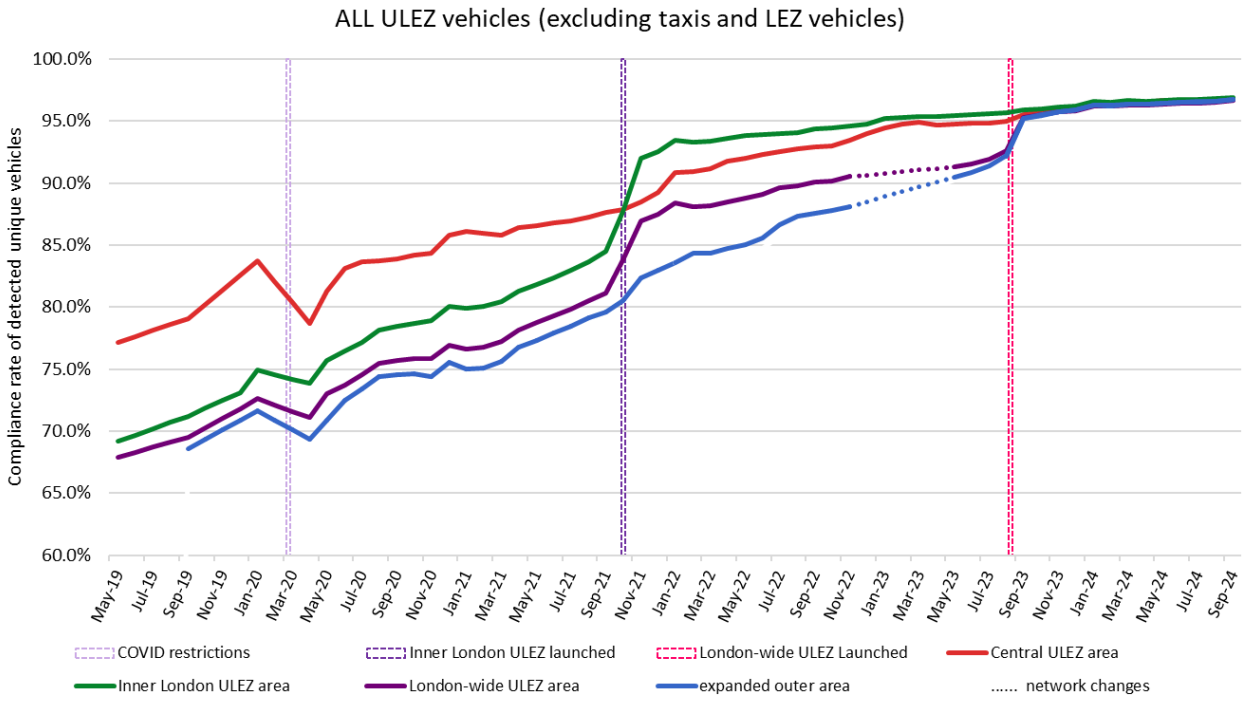

Figure 3: Monthly average ULEZ compliance rates split by zone – all ULEZ vehicles

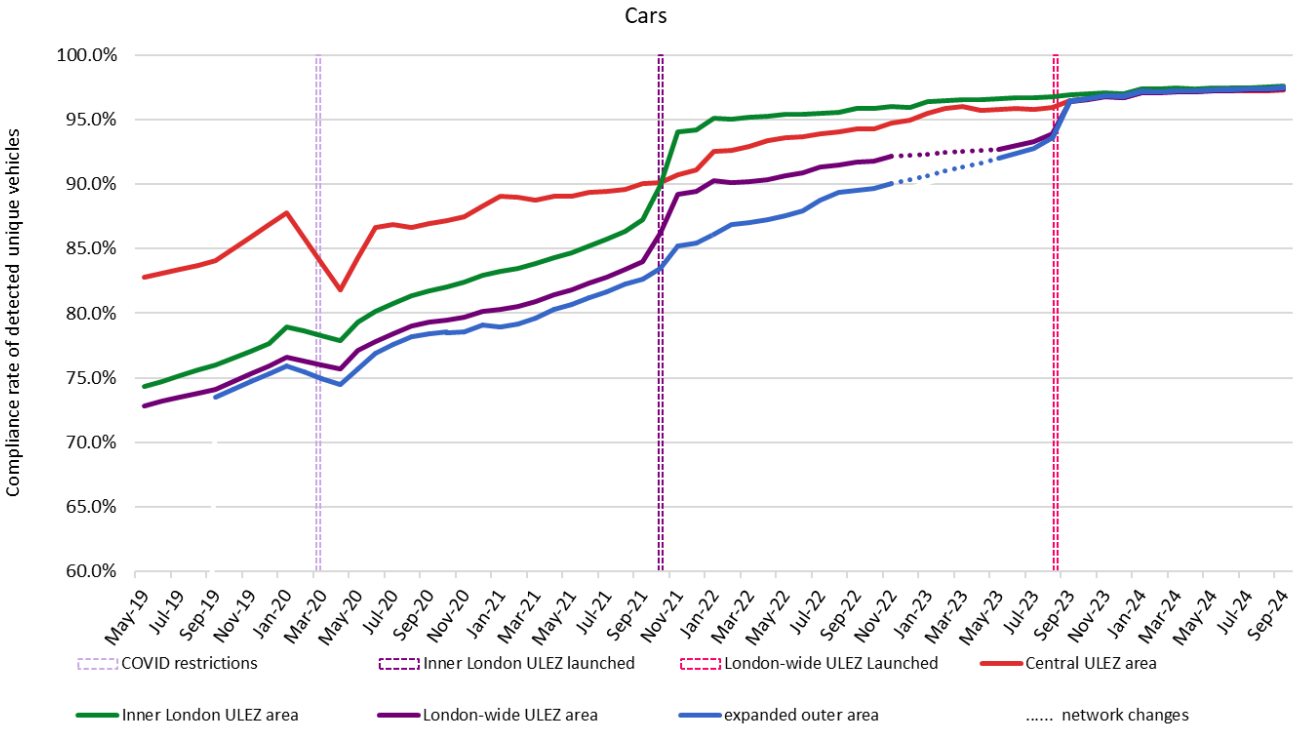

Figure 4: Monthly average ULEZ compliance rates split by zone – cars

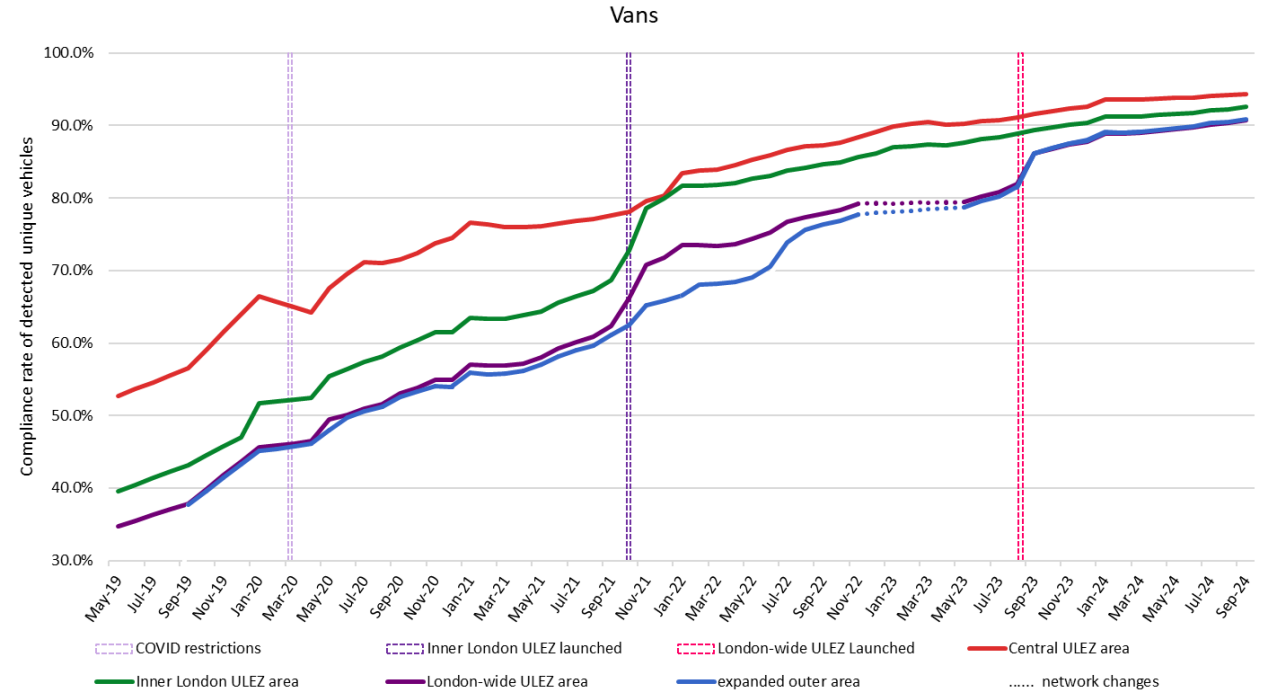

Figure 5: Monthly average ULEZ compliance rates split by zone – vans

Emissions

The ULEZ is based on road vehicle engine emissions standards and disincentivises the use of older vehicles with higher pollutant emissions in the zone. Therefore, the ULEZ directly influences emissions reductions from vehicles.

Reducing emissions of pollution is essential to reduce levels of harmful concentrations of pollution in the air, and ultimately improve the health of all Londoners.

This report presents analysis of the impact of the London-wide ULEZ expansion, as well as all phases of the ULEZ, on air pollution emissions. Exhaust emissions of NO_X, $PM_{2.5}$ and CO_2 have been estimated for 2024 under two sets of scenarios: with and without the London-wide ULEZ expansion; and with and without all phases of ULEZ.

The emissions for each year are estimated based upon the average vehicle fleet composition and vehicle kilometres of different vehicle types across the zones in the ULEZ area excluding the M25 and areas outside London.

Further information on the method, as well as trends comparing emissions between 2023 and 2024 are included in Appendix 2.

Data sources and methodology

Annual vehicle kilometre estimates on road links in each zone, as represented in the London Atmospheric Emissions Inventory 2019[16], were used for this analysis. Data from available Automatic Traffic Count (ATC) sites across London, as well as Department for Transport (DfT) manual traffic counts[67] providing annual average traffic flows by vehicle type, have been used to calculate the growth in traffic on roads in London which then provide annual vehicle kilometres travelled for vehicles in 2023. As DfT data is not available for 2024, the overall change between 2023 and 2024 has been based on TfL ATC data, and the proportion of flows by vehicle have been assumed the same as in 2023. Annual average speeds from the LAEI 2019[16] have been used, providing wider coverage of speeds across the network than individual traffic count point information.

[67] Road traffic statistics - Download data (dft.gov.uk), data updated on an annual basis for the preceding year.

The quantity of pollutants emitted is estimated by multiplying the vehicle kilometres for each vehicle type by the average emission rate for each vehicle type.

The expansion of the London-wide ULEZ was expected to lead to small changes in total traffic in outer London (changes in the order of +/- one per cent) based on traffic modelling undertaken for the consultation. In order to estimate emissions for 2024 without the expansion of the London-wide ULEZ, vehicle kilometres have been adjusted in that scenario to remove the impact that the ULEZ was expected to have. Further information on how vehicle kilometres have been adjusted to account for ULEZ impacts in central and inner London are provided in Appendix 2.

The average fleet composition for circulating traffic has been derived from camera detections across each zone up to September 2024. This allows changes in proportion of fuel types and Euro Standards to be calculated for traffic. Speed related emissions factors (COPERT[68]) for NO_X, $PM_{2.5}$, and CO_2 for each vehicle type are then calculated using the fleet information. The average speeds are lowest in central London, and highest in outer London[13].

Emissions for 2019 to 2024 represent observed traffic and fleet compositions. To estimate the impact of the ULEZ, a “no ULEZ” scenario for fleet compositions with only natural churn in the vehicle fleet and vehicle kilometres without ULEZ impacts has been used. The resulting emissions represent what they would have been without the ULEZ in place.

For this report an additional set of emissions has been estimated representing 2023 and 2024 without the London-wide ULEZ expansion, but with previous phases of the ULEZ in place, and assuming some natural churn between 2023 and 2024. The resulting emissions represent what they would have been without the London-wide ULEZ in place.

The difference between the emissions based on observed data and the “no ULEZ” scenario represents the estimated impact of all phases of the ULEZ, whilst the difference between the observed data and the “no London-wide ULEZ expansion” scenario represents the estimated impacts of only the expansion of the ULEZ London-wide. Further detail on how the “no ULEZ” and “no London-wide ULEZ expansion” emissions scenarios have been assessed is provided in Appendix 2.

This section quantifies the estimated impact of the ULEZ and the London-wide ULEZ expansion on NO_X, $PM_{2.5}$ and CO_2 emissions. The overall trend in emissions between

[68] COPERT | Calculations of Emissions from Road Transport

2023 and 2024, which includes the natural churn of the vehicle fleet and overall changes in vehicle kilometres that are not attributable to the ULEZ, are provided in Appendix 2.

It is worth noting that when providing the impact on emissions from all phases of the ULEZ, this provides the overall impact of the ULEZ package of measures which includes the London-wide LEZ (for heavy vehicles) and complementary policies such as introducing over 1,800 zero-emission buses and emissions based licencing requirements for taxis.

All data tables used for this analysis are provided in the Supplementary Data Sheet 1 - Emissions.

NO_X emission impacts

London-wide ULEZ expansion

Table 13 shows the estimated annual NO_X emissions for cars (including PHVs) and vans[69] in 2024 with and without the London-wide ULEZ expansion for each zone.

Table 14 shows the change in these emissions.

When looking at London as a whole, it is estimated that NO_X emissions from cars and vans are 13 per cent lower (cars are 11 per cent and vans are 14 per cent lower respectively) than would have been expected without the London-wide ULEZ expansion. This equates to a NO_X emission saving of 690 tonnes across London in 2024.

Across central, inner and outer London, the biggest impact on emissions from cars and vans as a result of the London-wide expansion have occurred in outer London. This is to be expected as the ULEZ was already in operation in central and inner London.

> When looking at outer London, it is estimated that NO_X emissions from cars and vans are 14 per cent lower (cars are 13 per cent and vans are 16 per cent lower respectively), than would have been expected without the London-wide ULEZ expansion. This equates to a NO_X emission saving of 540 tonnes in this area in 2024.

[69]Only cars and vans have been included as these are the specific vehicle types affected by the London-wide ULEZ expansion (as opposed to all ULEZ phases which for example includes the LEZ).

NO_X emission savings have also been calculated for each London borough. All London boroughs have seen positive impacts from the London-wide ULEZ expansion, with the greatest impacts seen in outer London boroughs. The London boroughs that have seen the highest emission savings due to the expansion are Sutton, Merton, Croydon, Harrow, and Bromley[70]. All borough-level data is provided in Supplementary Data Sheet 1 - Emissions.

> Comparing against a "No London-wide ULEZ expansion" scenario, NO_X emissions are estimated to be between nine per cent and 15 per cent lower across all boroughs in 2024 due to the expansion.

Table 13: Estimated annual NO_X emissions (tonnes) for cars and vans in 2024 with and without the London-wide ULEZ expansion for each zone[71]

London Zone	Without LWULEZ - Cars[72]	Without LWULEZ - Vans	Without LWULEZ - Cars and Vans	LWULEZ - Cars[72]	LWULEZ - Vans	LWULEZ - Cars and Vans
Central	35	54	89	33	45	78
Inner	730	740	1,470	680	650	1,330
Outer	2,070	1,820	3,880	1,800	1,540	3,340
London-wide	2,830	2,610	5,440	2,510	2,230	4,750

[70] In 2024, emissions are estimated to be 15.4% lower in Sutton, 15.3% lower in Merton, 15.3% lower in Croydon, 15.2% lower in Harrow and 15.2% lower in Bromley compared to a scenario without the London-wide ULEZ expansion.
[71] Tonnes are rounded to the nearest 10 (except central London which is rounded to the nearest 1), percentages are rounded to 1 per cent. Due to rounding there may be differences in totals when adding values.
[72] Including motorcycles and PHVs

Table 14: Change in cars and vans NO_X emissions (tonnes and per cent) in 2024 with the London-wide ULEZ compared to the 2024 scenario without the London-wide ULEZ[71]

London Zone	Change in Emissions (Tonnes) - Cars[72]	Change in Emissions (Tonnes) - Vans	Change in Emissions (Tonnes) - Cars and Vans	Change in Emissions (%) - Cars[72]	Change in Emissions (%) - Vans	Change in Emissions (%) - Cars and Vans
Central	-2	-9	-11	-6%	-16%	-12%
Inner	-60	-80	-140	-8%	-11%	-9%
Outer	-260	-280	-540	-13%	-16%	-14%
London-wide	-320	-380	-690	-11%	-14%	-13%

All phases of ULEZ

Figure 6 shows the estimated annual NO_X emissions between 2019 and 2024 across London, with and without all phases of the ULEZ, split by vehicle type. Associated data for 2024 is provided in Table 15, as 2024 represents the first full year when all phases of the ULEZ have been in place. Data for previous years (2019 – 2023) as well as 2024 is provided in Table 61, in Appendix 2 which shows how the phasing of the ULEZ has impacted emissions over time, with increased NO_X savings each year. This means that across the six-year period of 2019 to 2024 there have been substantial cumulative NO_X emissions savings, which is shown in Table 16.

Figure 6 shows the progression of all phases of the ULEZ, visualised by the changing emission reductions in tonnes by vehicle type over time. The shaded areas in Figure 6 effectively represent the proportion of savings attributed to each vehicle type year to year. This particularly shows how the contribution in reduction from both cars and vans has grown over time, demonstrating the effectiveness of the phased expansions of the ULEZ.

> NO_X emissions are estimated to be 36 per cent lower across London in 2024 due to all phases of the ULEZ, compared to a scenario without the ULEZ. This is a saving of 3,460 tonnes of NO_X.

> Cumulatively since 2019, NO_X emissions are estimated to be 17,770 tonnes lower (24 per cent) across London due to all phases of the ULEZ.

NO_X emission savings have also been calculated for each London borough, data is provided in Supplementary Data Sheet 1 - Emissions.

> All London boroughs have seen positive impacts from the ULEZ. Comparing against a "No ULEZ" scenario, NO_X emissions are estimated to be between 33 per cent and 39 per cent lower across all boroughs in 2024 due to all phases of the ULEZ.

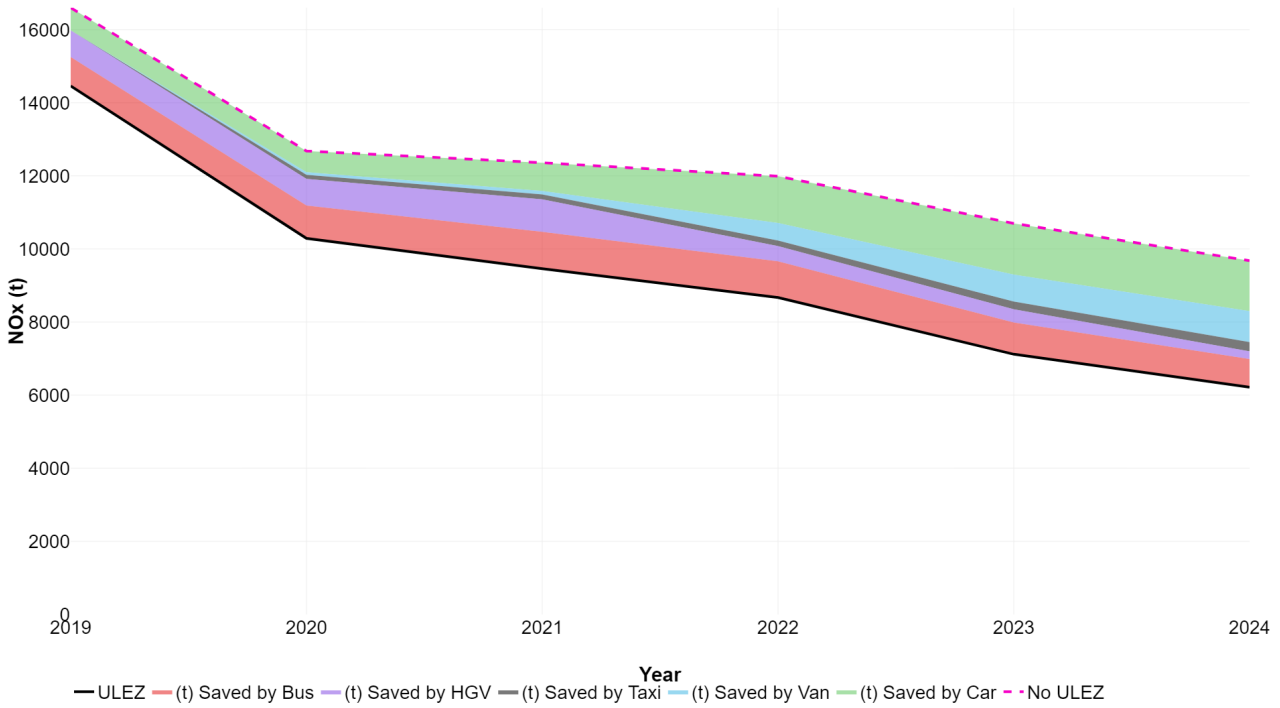

Figure 6: Estimated annual NO_X emissions (tonnes) across London split by vehicle type between 2019 and 2024 with and without the ULEZ and its expansions.

Table 15: Estimated annual NO_X emissions (tonnes) across London split by vehicle type in 2024 with and without all phases of the ULEZ.

Scenario	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	9,680	3,900	3,090	450	1,270	980
ULEZ	6,220	2,510	2,230	200	1,050	210
Change in emissions (tonnes)	-3,460	-1,380	-850	-250	-210	-760
Change in emissions (per centage)	-36%	-35%	-28%	-56%	-17%	-78%

Table 16: Estimated cumulative NO_X emissions (tonnes) across London split by vehicle type over the 2019 – 2024 period with and without all ULEZ phases.

Scenario	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	73,990	30,060	19,910	3,010	13,520	7,500
ULEZ	56,220	24,030	17,710	2,150	10,140	2,200
Change in emissions (tonnes)	-17,770	-6,040	-2,200	-860	-3,380	-5,300
Change in emissions (per centage)	-24%	-20%	-11%	-29%	-25%	-71%

$PM_{2.5}$ emission impacts

London-wide ULEZ expansion

Table 17 shows the estimated $PM_{2.5}$ exhaust emissions[73] from cars (excluding PHVs) and vans[69] in 2024, with and without the London-wide ULEZ expansion. Table 18 shows the change in these emissions.

When looking at London as a whole, it is estimated that $PM_{2.5}$ exhaust emissions from cars and vans are 25 per cent lower (cars are 23 per cent and vans are 31 per cent lower respectively), than they would have been without the London-wide ULEZ expansion. This equates to a $PM_{2.5}$ emission saving of 9.9 tonnes across London in 2024.

Across central, inner and outer London, the biggest impacts on emissions from cars and vans have occurred in the outer London zone as a result of the London-wide expansion of the ULEZ. This is to be expected as the ULEZ was already in operation in central and inner London.

> When looking at outer London, it is estimated that $PM_{2.5}$ exhaust emissions from cars and vans are 31 per cent lower (cars are 29 per cent and vans are 37 per cent lower respectively), than would have been expected without the London-wide ULEZ expansion. This equates to a $PM_{2.5}$ exhaust emission saving of 9.1 tonnes in outer London in 2024.

$PM_{2.5}$ emission savings have also been calculated for each London borough; data is provided in Supplementary Data Sheet 1 - Emissions.

> All London boroughs have seen positive impacts from the London-wide ULEZ expansion on $PM_{2.5}$ exhaust emissions, with the greatest impacts seen in outer London boroughs.

[73] Non-exhaust PM2.5 emissions have not been included in this analysis. Non-exhaust emissions are a growing proportion of PM2.5 emissions from road transport but would not be affected by the tightening of tailpipe emissions standards for vehicles driving in the ULEZ.

Comparing against a "No London-wide ULEZ expansion" scenario, $PM_{2.5}$ exhaust emissions are estimated to be between six per cent and 32 per cent lower across all boroughs in 2024 due to the expansion.

Table 17: Estimated annual $PM_{2.5}$ exhaust emissions (tonnes) for cars and vans in 2024 with and without the London-wide ULEZ expansion for each zone.

London Zone	Without LWULEZ - Cars[72]	Without LWULEZ - Vans	Without LWULEZ – Cars and Vans	LWULEZ – Cars[72]	LWULEZ – Vans	LWULEZ – Cars and Vans
Central	0.47	0.19	0.66	0.45	0.17	0.62
Inner	6.8	2.6	9.4	6.5	2.2	8.8
Outer	21.4	8.0	29.4	15.2	5.0	20.2
London-wide	28.7	10.8	39.5	22.2	7.4	29.6

Table 18: Change in annual $PM_{2.5}$ exhaust emissions (tonnes and per cent) in 2024 with London-wide ULEZ compared to the scenario without the London-wide ULEZ expansion

London Zone	Change in Emissions (Tonnes) – Cars[72]	Change in Emissions (Tonnes) – Vans	Change in Emissions (Tonnes) – Cars and Vans	Change in Emissions (%) – Cars[72]	Change in Emissions (%) – Vans	Change in Emissions (%) – Cars and Vans
Central	-0.02	-0.02	-0.04	-4%	-11%	-6%
Inner	-0.3	-0.4	-0.7	-4%	-15%	-7%
Outer	-6.2	-3.0	-9.1	-29%	-37%	-31%
London-wide	-6.5	-3.4	-9.9	-23%	-31%	-25%

All phases of ULEZ

Table 19 shows the estimated annual $PM_{2.5}$ exhaust emissions for 2024, representing the first full year when all phases of the ULEZ have been in place. Data for previous years (2019 to 2023) as well as 2024 is provided in Table 62 in Appendix 2, and cumulative data is provided in Table 20.

> $PM_{2.5}$ exhaust emissions are estimated to be 36 per cent lower across London in 2024 due to all phases of the ULEZ. This is a saving of 23 tonnes of $PM_{2.5}$.

> Cumulatively since 2019, $PM_{2.5}$ exhaust emissions are estimated to be 210.4 tonnes lower across London, equivalent to a 29 per cent reduction.

$PM_{2.5}$ exhaust emission savings have also been calculated for each London borough; data is provided in Supplementary Data Sheet 1 - Emissions.

> All London boroughs have seen positive impacts from the ULEZ on $PM_{2.5}$ exhaust emissions. Comparing against a "No ULEZ" scenario, $PM_{2.5}$ exhaust emissions are estimated to be between 30 per cent and 36 per cent lower across all boroughs in 2024 due to all phases of the ULEZ.

Table 19: Estimated annual $PM_{2.5}$ exhaust emissions (tonnes) across London split by vehicle type in 2024 with and without all phases of the ULEZ, and estimated changes in emissions (in tonnes and percentage).

Scenario	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	64.6	35.7	8.1	2.1	11.3	7.4
ULEZ	41.6	22.2	7.4	0.5	9.5	2.1
Change in emissions (tonnes)	-23.0	-13.6	-0.6	-1.6	-1.9	-5.3
Change in emissions (per centage)	-36%	-38%	-8%	-78%	-17%	-72%

Table 20: Estimated cumulative $PM_{2.5}$ exhaust emissions (tonnes) across London split by vehicle type over the 2019 – 2024 period with and without all phases of the ULEZ, and estimated changes in emissions (in tonnes and percentage).

Scenario	All Vehicles	Cars [72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	724.0	402.7	109.7	37.0	119.1	55.5
ULEZ	513.6	275.4	107.0	14.9	96.6	19.7
Change in emissions (tonnes)	-210.4	-127.3	-2.7	-22.1	-22.6	-35.8
Change in emissions (per centage)	-29%	-32%	-2%	-60%	-19%	-65%

CO_2 emission impacts

Whilst the ULEZ is primarily aimed at reducing key air pollutants (namely NO_2 and $PM_{2.5}$), the impact of all phases of the ULEZ does also impact CO_2 emissions. We can see from the results of this report and previous analysis that the ULEZ scheme is leading to clear and rapid improvements in air quality, which is the aim of the scheme, but it is also leading to longer-term reductions in CO_2 emissions. Therefore, this section provides analysis of the impact of the ULEZ on CO_2 emissions.

London-wide ULEZ expansion

Table 21 shows the estimated CO_2 emissions from cars (excluding PHVs) and vans[69] in 2024, with and without the London-wide ULEZ expansion. Table 22 shows the change in these emissions.

When looking at London as a whole, it is estimated that CO_2 emissions from cars and vans are one per cent lower than they would have been without the London-wide ULEZ expansion. This equates to a CO_2 emission saving of 35,000 tonnes across London in 2024.

CO_2 emission savings have also been calculated for each London borough; data is provided in Supplementary Data Sheet 1 - Emissions.

All London boroughs have seen positive impacts from the London-wide ULEZ expansion. Comparing against a "No London-wide ULEZ expansion" scenario, CO_2 emissions are estimated to be between one and two per cent lower across all boroughs in 2024 due to the expansion.

Table 21: Estimated annual CO_2 emissions (tonnes) for cars and vans in 2024 with and without the London-wide ULEZ expansion for each zone.

London Zone	Without LWULEZ - Cars[72]	Without LWULEZ - Vans	Without LWULEZ – Cars and Vans	LWULEZ – Cars[72]	LWULEZ – Vans	LWULEZ – Cars and Vans
Central	36,000	25,000	61,000	35,000	24,000	59,000
Inner	733,000	281,000	1,014,000	729,000	272,000	1,001,000
Outer	1,931,000	589,000	2,520,000	1,930,000	571,000	2,500,000
London-wide	2,701,000	895,000	3,596,000	2,694,000	867,000	3,561,000

Table 22: Change in annual CO_2 emissions (tonnes and per cent), 2024 with London-wide ULEZ compared to the scenario without the London-wide ULEZ

London Zone	Change in Emissions (Tonnes) – Cars[72]	Change in Emissions (Tonnes) – Vans	Change in Emissions (Tonnes) – Cars and Vans	Change in Emissions (%) – Cars[72]	Change in Emissions (%) – Vans	Change in Emissions (%) – Cars and Vans
Central	-1,000	-1,000	-2,000	-2%	-3%	-2%
Inner	-4,000	-9,000	-13,000	-1%	-3%	-1%
Outer	-1,000	-19,000	-20,000	0%	-3%	-1%
London-wide	-6,000	-29,000	-35,000	0%	-3%	-1%

All phases of ULEZ

Table 23 shows the estimated annual CO_2 emissions for 2024, representing the first full year when all phases of the ULEZ have been in place. Data for previous years (2019 to 2023) as well as 2024 is provided in Table 62 in Appendix 2, and cumulative data is provided in Table 24.

> CO_2 emissions are estimated to be six per cent lower across London in 2024 due to all phases of the ULEZ. This is a saving of 332,000 tonnes of CO_2.

> Cumulatively since 2019, CO_2 emissions are estimated to be 813,000 tonnes lower across London, equivalent to a 2 per cent reduction.

CO_2 emission savings have also been calculated for each London borough; data is provided in Supplementary Data Sheet 1 - Emissions.

> All London boroughs have seen positive impacts from the ULEZ. Comparing against a "No ULEZ" scenario, CO_2 emissions are estimated to be between four per cent and 16 per cent lower across all boroughs in 2024 due to all phases of the ULEZ.

Table 23: Estimated annual CO_2 emissions (tonnes) across London split by vehicle type in 2024 with and without all phases of the ULEZ.

Scenario	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	5,356,000	2,793,000	882,000	113,000	1,163,000	406,000
ULEZ	5,023,000	2,694,000	867,000	72,000	1,071,000	320,000
Change in emissions (tonnes)	-332,000	-99,000	-15,000	-41,000	-92,000	-85,000
Change in emissions (per centage)	-6%	-4%	-2%	-36%	-8%	-21%

Table 24: Estimated cumulative CO_2 emissions (thousand tonnes) across London split by vehicle type over the 2019 – 2024 period with and without the ULEZ and its expansions.

Scenario	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
No ULEZ	32,585	17,534	5,103	759	6,823	2,366
ULEZ	31,772	17,244	5,131	600	6,661	2,137
Change in emissions (tonnes)	-813	-291	28	-159	-162	-229
Change in emissions (per centage)	-2%	-2%	1%	-21%	-2%	-10%

Air pollution concentrations

Trend analysis

By reducing the amount of NO_X and $PM_{2.5}$ emitted by vehicles (emissions), the ULEZ helps reduce NO_2 and $PM_{2.5}$ concentrations in the zone. This will reduce the health impacts associated with exposure to NO_2 and $PM_{2.5}$, which is the key aim of the ULEZ and its expansion London-wide.

This section presents an analysis of air pollution data, specifically air pollutants NO_2 and $PM_{2.5}$ from London's extensive automatic monitoring network and data from the rest of England, to assess how pollution levels have changed over time. It includes one full year worth of monitoring data since the London-wide expansion of the ULEZ.

For this analysis, data from air quality monitoring stations are grouped by site type. This analysis focuses on the two most common types of monitoring sites: roadside and urban background. Roadside sites give the best estimate of public exposure on busy roads. Background sites are located further away from the main sources of pollution (e.g. traffic) and are representative of air pollution exposure for the wider population.

In line with previous reports, statistical smoothing has been used to reduce the impacts of weather and seasonal changes in the long-term trend data. Further detail on the methodology is contained in Appendix 3.

In this section, monthly average concentrations were used to calculate trends in the period from 2010 to the end of September 2024. It should be noted that some of the latest measurement data from 2024 has not yet been ratified. As a result, these could be subject to revisions following equipment tests undertaken as part of the routine audit and servicing of air quality monitoring sites[74].

[74] The process of ratifying the data, i.e. undergoing the process of detailed quality assurance and control, can take between six months to a year, varies across monitoring stations, and may depend on network operators. In most cases, ratified monitoring data usually only shows small variations overall from the initial readings. For the purposes of undertaking this analysis, data as available and downloaded at the end of October 2024 has been used.

Context

In addition to the ULEZ and the London-wide LEZ (for heavy vehicles), the Mayor has introduced complementary policies, including the introduction of more than 1,800 zero-emission buses, introducing taxi and PHV age limits and emissions-based licensing requirements, and encouraging active travel and use of sustainable public transport, all of which contribute to changes in pollution concentrations. As such, it is not straightforward to isolate the impact of the ULEZ and its expansions. Therefore, the analysis for the ULEZ shows the impacts of the ULEZ and its expansions in conjunction with other Mayoral policies to reduce emissions from transport, that were happening in each ULEZ zone at the time. These include wider policies within the Mayor's Transport Strategy.

As previously reported, the impacts of the pandemic on air quality in London have been extreme and variable with much deeper and sustained impacts in central London compared with inner and outer London[75]. The pandemic led to large reductions in traffic volumes in London in 2020 and in 2021, with central London being especially affected. This in turn in reduced pollution levels across the city, particularly in central London. Due to the ULEZ and continued efforts to tackle air pollution, it is clear from further air pollution data analysis that concentrations in London are continuing to reduce despite traffic increasing post-pandemic.

For this analysis, long-term monitoring stations which met the minimum data capture requirements were used. Air quality concentration data from 440 NO_2 monitoring stations and 197 $PM_{2.5}$ monitoring stations in London and England have been analysed between 2010 and September 2024. The data has been grouped as follows:

- roadside and urban background sites
- central, inner and outer London as in previous reports and to help describe the impact of the London-wide ULEZ
- a 0-5 km zone around London (referred to as 5 km from the GLA boundary) recognising this area is close to the boundary of the London-wide ULEZ
- a 5-40 km zone around Greater London which provides a control comparison for outer London

[75] Further analysis on the initial impact of the pandemic on air quality in London is available here: https://www.london.gov.uk/sites/default/files/london_response_to_aqeg_call_for_evidence_april_2020.pdf

- Rest of England (sites beyond 40 km from the Greater London boundary) representing wider trends in England, distant from the London ULEZ scheme.

Overview of trends in NO_2 concentrations

Figure 7 shows the trends in NO_2 at roadside and urban background monitoring sites in London zones, the surrounding zones, and the rest of England (beyond 40 km from the Greater London boundary) from January 2014 to September 2024. The graphs show monthly average NO_2 concentrations grouped by zone and site type, statistically smoothed to reduce the impact of weather and seasonality[76].

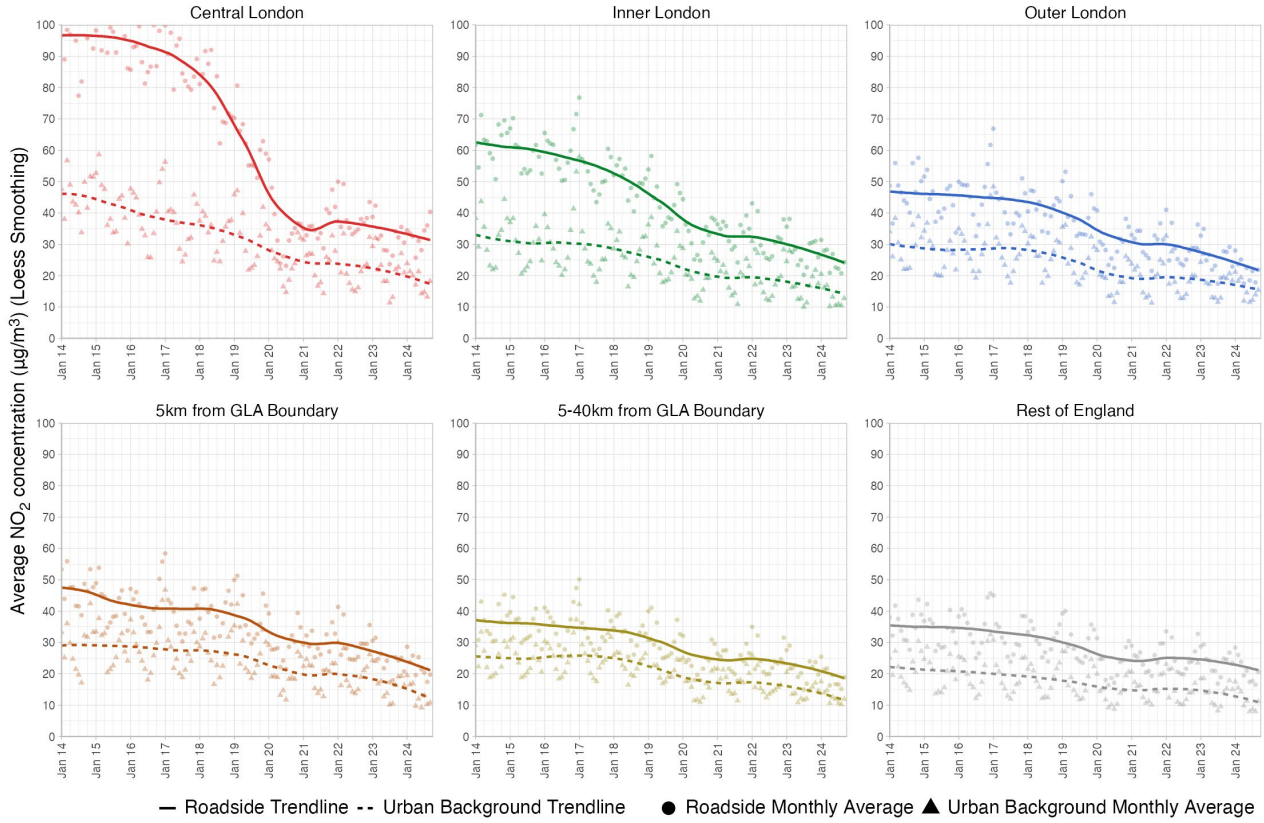

Figure 7: Trends in monthly average NO_2 concentrations in London zones, the surrounding zone, and rest of England from January 2014 to September 2024

[76] Data points representing the average monthly concentrations from which the trend lines have been derived are shown for transparency. Circles are roadside and triangles are urban background monthly concentrations averaged across the available sites each month.

Average annual concentrations derived from data underpinning Figure 7 is also available in Table 68 in Appendix 4. It can be seen from Figure 7 that:

- Since 2017, when the Mayor introduced the T-Charge and people started preparing for the introduction of the central ULEZ, the greatest reductions in both roadside and background average concentrations occurred in central London.
- Average roadside concentrations in outer London are much lower and are now similar to the average for the rest of England (where concentrations have historically been lower). The difference between these areas has reduced more rapidly since 2019.

Average roadside concentrations have reduced in the rest of England to a lesser extent than in outer London, with a generally flat trend over the last four years. Table 68 in Appendix 4 shows that:

> Average roadside concentrations of NO_2 reduced by 63 per cent in central London, 54 per cent in inner London, and 49 per cent in outer London between 2017 and 2024 (as of September). Whereas average roadside concentrations in the rest of England reduced to a much lesser extent, by 33 per cent.

Whilst average concentrations were and continue to be higher in the London zones compared to the rest of England, it is clear from Figure 7 and Table 68 that due to improvements across London, there is now much less difference. It is noteworthy that average concentrations in all London zones are now below the legal limit for NO_2 including in central London. This does not provide formal reporting against legal limits[77]. However, this analysis does show that based on the monitoring sites used in this analysis, there were exceedances of the NO_2 annual mean legal limit at 46 sites in 2017 compared to three in 2024. This shows clear improvement in air quality while highlighting that a few exceedances remain.

Urban background concentrations have reduced in all zones, with similar levels of percentage reductions for all London zones and the surrounding areas. The average for all of London is 49 per cent lower in 2024 when compared with 2017, whereas the average for the rest of England decreased by 40 per cent over the same time period.

[77] This is not official reporting against legal limits as this is an average across all monitoring stations included within this analysis. Some individual sites still record exceedances. Statutory legal compliance is assessed via national reporting which include modelled data, rather than individual monitoring station data.

These overall reductions in concentrations are important for population exposure. There is a clear indication from the trend analysis that nine million Londoners are breathing cleaner air.

Trends at a local level

Figure 8 shows the observed annual mean NO_2 concentration at all the roadside monitoring sites across London used in this analysis (as reported in Table 64 in Appendix 3), from 2010 to 2024[78]. The graph provides a heatmap of concentrations, with the highest concentrations in dark red (annual mean over 100 µg/m^3) and the lowest concentrations in green (annual mean below 20 µg/m^3)[79].

Figure 8 shows how NO_2 concentrations have improved at roadside locations over time across London, with most roadside sites improving from the highest concentrations (reds and oranges) in 2010, to lower concentrations (yellows and greens) in recent years. When looking at all sites, including urban background locations[80]:

> Average NO_2 concentrations in 99 per cent of all monitoring locations have improved between 2019 and 2024.

Of these, 16 sites showed an average improvement in NO_2 within 5 to 10 µg/m^3, whilst 74 sites showed an improvement over 10 µg/m^3, representing respectively 17 per cent and 80 per cent of all sites with available monitoring data for both years.

All data underpinning Figure 8 and the above results, including the full site name for each site, is available in the Supplementary Data Sheet 2 - Concentrations. Maps showing the location of the sites used in this analysis are provided in Figure 24 and Figure 25 in Appendix 3.

[78] Note that the annual mean for 2024 only covers data up to September 2024

[79] Grey squares show years for which no annual mean could be calculated, either because the site was not installed yet, was closed, or data capture was less than 75 per cent. Monitoring sites are grouped by area (from central London at the top, to outer London at the bottom of the chart) and can be identified by their site ID and borough.

[80] 92 roadside and urban background monitoring sites were included in this analysis, only sites where the annual mean concentration was available in both 2019 and 2024 have been included.

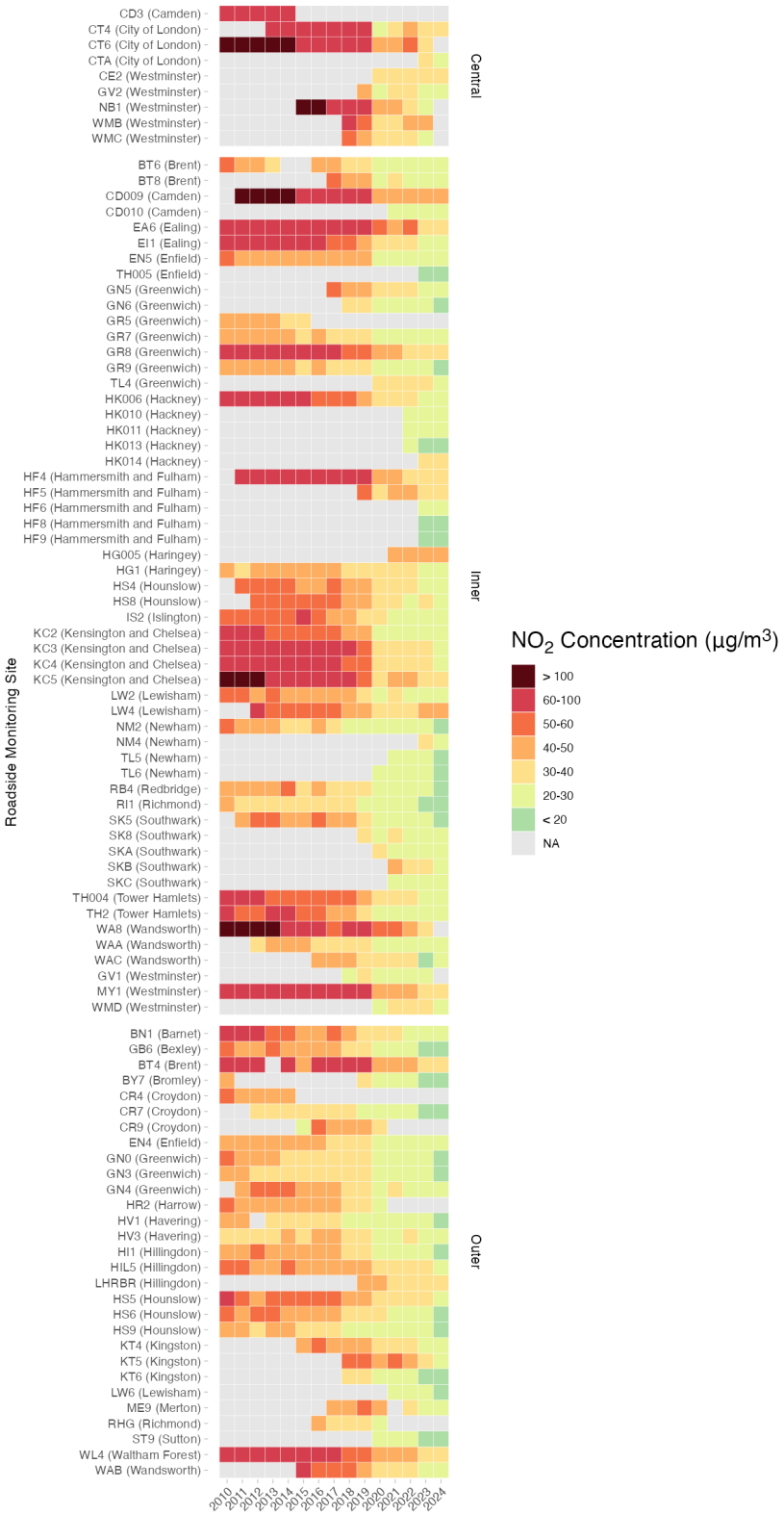

Figure 8: Annual mean NO_2 at London roadside sites 2010 – 2024. Sites are identified by three-digit codes, with London borough in brackets.

Overview of trends in $PM_{2.5}$ concentrations

Road transport is the largest single source of fine particulate matter in London, accounting for around 30 per cent of emissions[16]. However, of the emissions from road transport, nearly 80 per cent of $PM_{2.5}$ emissions are from non-exhaust sources[81], and this proportion is predicted to increase over time to nearly 95 per cent by 2030. Non-exhaust emissions are not affected by the tightening of tailpipe emissions standards for vehicles driving in the ULEZ. There are also important non-road transport sources of $PM_{2.5}$[82] which are not targeted by the ULEZ.

Unlike NO_2, over half of London's concentrations of $PM_{2.5}$ come from regional, and often transboundary (non-UK) sources outside of London[16]. $PM_{2.5}$ concentrations from these sources are also heavily influenced by meteorological conditions, and long-range transport, causing more variation between different years.

For these reasons, the reduction in $PM_{2.5}$ emissions that have occurred due to a cleaner fleet will have a less pronounced impact on concentrations than seen for NO_2, which is dominated by London-based traffic sources.

[81] Non-exhaust emissions include road wear, tyre and brake wear, as well as resuspension of road dust.

[82] Wilson et al. (2024) Mobile monitoring reveals the importance of non-vehicular particulate matter sources in London. Royal Society of Chemistry.

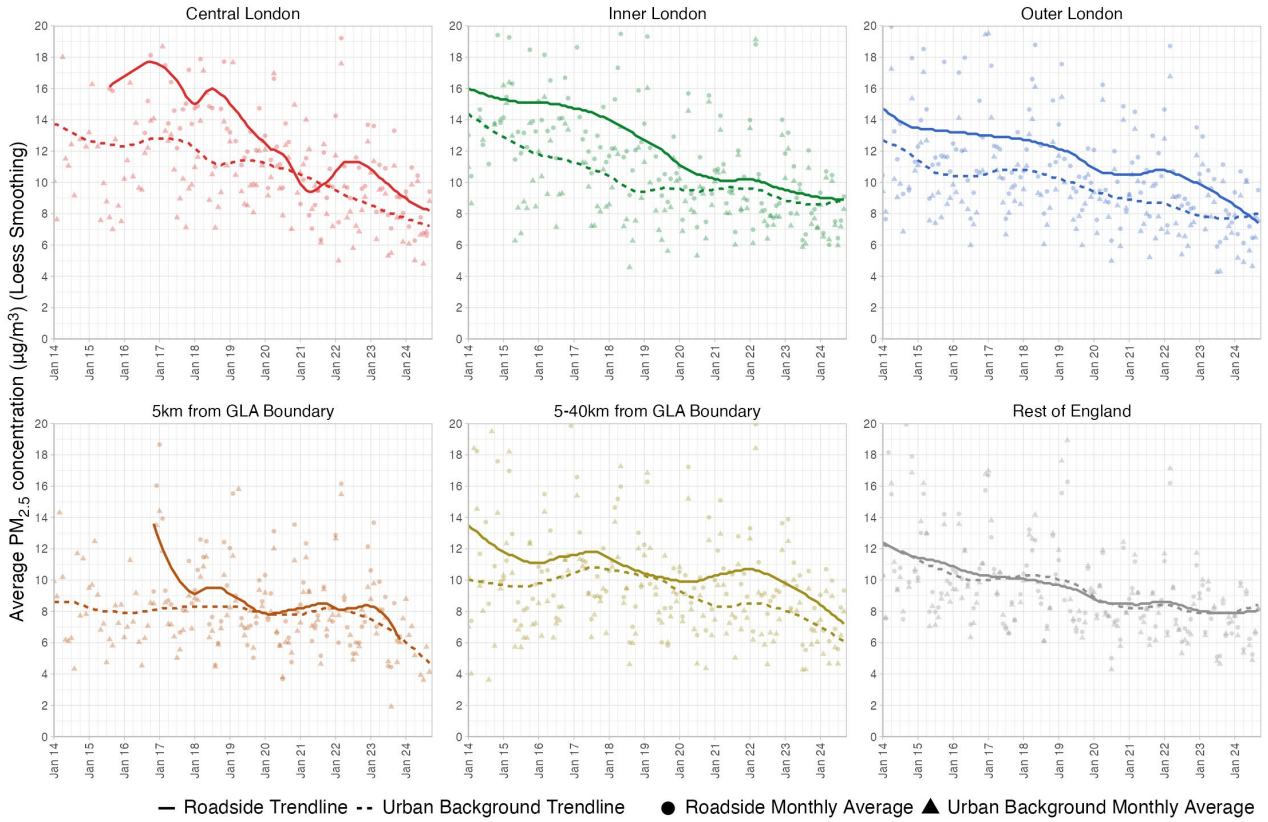

Figure 9: Trends in monthly average $PM_{2.5}$ concentrations in London zones, the surrounding zone, and rest of England from January 2014 to September 2024

Figure 9 shows the trends in monthly average $PM_{2.5}$ concentrations at roadside and urban background sites in London zones, surrounding zones, and the rest of England (beyond 40 km from Greater London boundary) from January 2014 to September 2024. Average annual concentrations derived from data underpinning Figure 9 is also available in Table 69 in Appendix 4.

The graph shows monthly average $PM_{2.5}$ concentrations grouped by zone and site type, statistically smoothed to reduce the impact of weather and seasonality. Concentrations at both roadside and background sites are often similar because of the importance of other non-road transport sources, especially regional and transboundary contributions. There are also considerably fewer monitors for $PM_{2.5}$ than NO_2, (197 compared to 440 used in the analysis, as seen in Table 64 in Appendix 3) which means grouping of sites can produce trends with greater uncertainty.

Average $PM_{2.5}$ concentrations have reduced across all zones, most substanitally in central London, where average roadside concentrations in 2024 were 50 per cent lower than in

2017, equating to a reduction of 8 µg/m^3. Large reductions at the roadside of 39 per cent and 29 per cent respectively have also been seen in inner and outer London, whilst reductions in the rest of England are approximately 26 per cent. Based on trends analysis, average $PM_{2.5}$ concentrations in the London area are now approaching those in the rest of England (which have historically been lower). Background concentrations have also reduced substantially, by approximately 31 per cent across London.

Figure 9 shows that roadside $PM_{2.5}$ concentrations tended to increase in the short-term from spring 2021 across all areas, which may reflect growing activity and increases in traffic post-pandemic. However roadside concentrations have since reduced and are tending towards backround concentrations, especially in London where there was historically a bigger difference between background and roadside.

Trends at a local level

Figure 10 shows the observed annual mean $PM_{2.5}$ concentration at all the roadside monitoring sites across London used in this analysis (as reported in Table 64 in Appendix 3), from 2010 to 2024[78]. The figure provides a heatmap of concentrations, with the highest concentrations in dark red (annual mean over 21 µg/m^3) and the lowest concentrations in green (annual mean below 6 µg/m^3)[85].

The graph visualises the improvement in $PM_{2.5}$ concentrations over time across London. Although the reduction has not been as large as for NO_2 (see Figure 8), $PM_{2.5}$ concentrations have gradually reduced over the period, with most sites in 2024 showing concentrations in the range 6-12 µg/m^3.

Between 2019 and 2024, 22 sites showed an average improvement in $PM_{2.5}$ of up to 5 µg/m^3, whilst 5 sites showed an improvement within 5 to 10 µg/m^3, representing respectively 76 per cent and 17 per cent of all sites with data available for both years.

All data underpinning Figure 10 and the above results, including the full site name for each site, is available in Supplementary Data Sheet 2 - Concentrations. Maps showing the location of the sites used in this analysis are provided in Figure 24 and Figure 25 in Appendix 3.

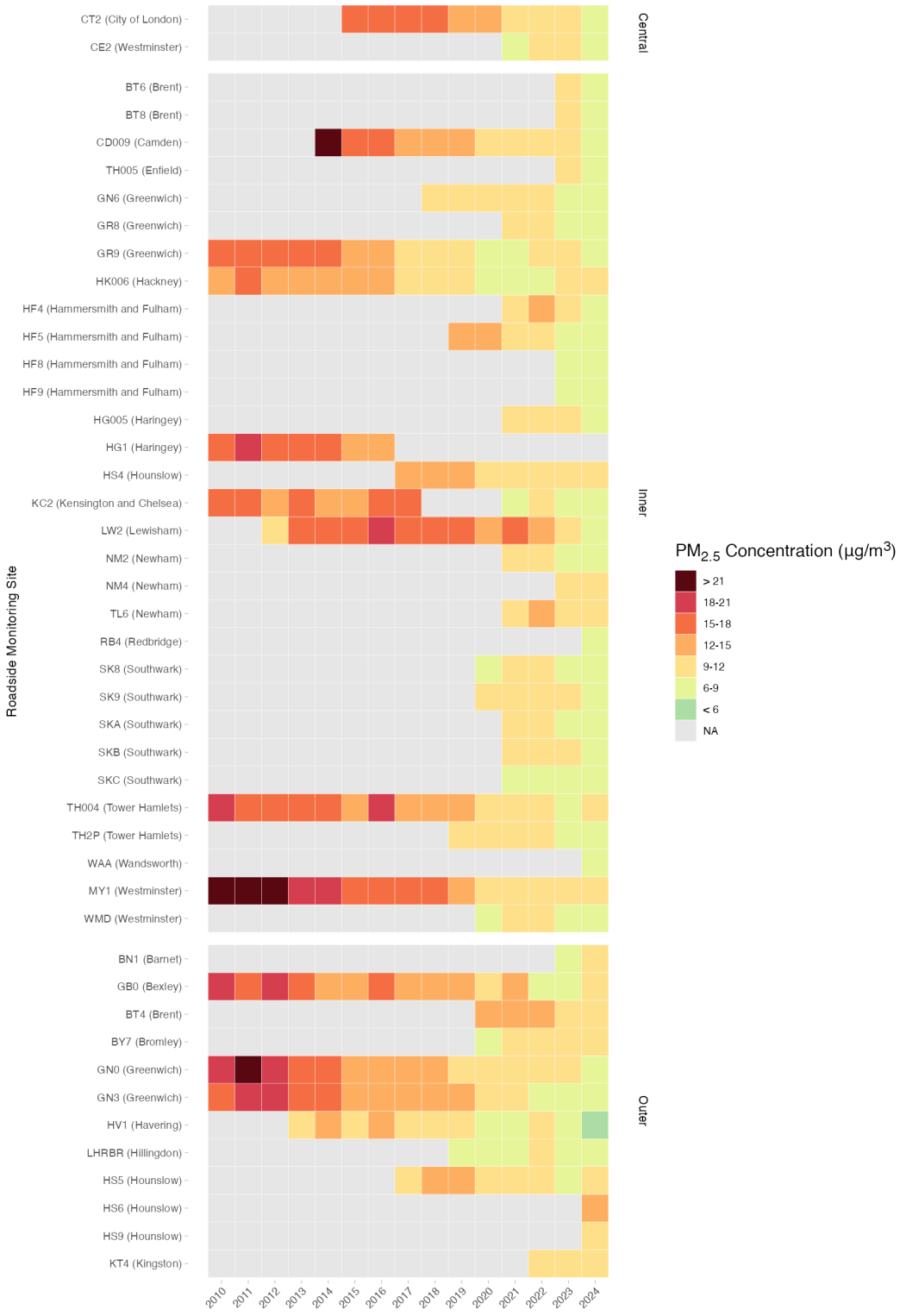

Figure 10: Annual mean $PM_{2.5}$ at London roadside sites - 2010 – 2024. Sites are identified by three-digit codes, with London borough in brackets.

ULEZ impact analysis

The previous section highlights the overall NO_2 and $PM_{2.5}$ concentration trends in London and the surrounding area. Additional analysis has been carried out to assess the impact of the ULEZ and its London-wide expansion. This has been done by comparing the observed (measured) concentrations in each area with a “No ULEZ” or “No LWULEZ” scenario. The “No ULEZ” and “No LWULEZ” scenarios are also based on measurements, but in a distinct separate area away from the ULEZ. This approach controls for the influences of weather and seasonal factors as well as fleet replacement due to vehicle aging that affect the ULEZ and non-ULEZ area in the same way.

Method

The method used in this report is based on a similar approach used in the earlier central and inner London ULEZ reports, and in the London-wide ULEZ Six Month Report. The use of control sites and an estimated “No ULEZ” scenario is fundamentally required, as observed data will always represent the situation with the ULEZ being in operation. This method also recognises that a general trend of improvement in concentrations would be expected even without the ULEZ due to natural fleet churn, whereby older vehicles drop out of the fleet and newer cleaner vehicles come into it over time.

For this report, an international advisory group of independent air quality analysis experts was set up to assist TfL and the GLA to provide independent advice and review of the air quality analysis. The advisory group provided a technical function and confirmed that the methodology employed in previous reporting was robust and appropriate. Additional analysis and sensitivity testing was also undertaken on the advice of the group, to provide further confidence in the results. This analysis is provided in Appendix 3.

Impacts have been assessed in two ways:

- London-wide ULEZ: The impact of the third phase of the ULEZ expansion in outer London, assessed from December 2022 (after the Mayor announced the decision to go ahead with the expansion). This requires the estimation of a “No London-wide ULEZ expansion” scenario from December 2022 against which impacts are assessed by comparing to observed data.
- All ULEZ phases: The overall impact of the ULEZ package of measures from 2017 (when the policy interventions including the introduction of the T-Charge, the announcement of the intention to bring forward the introduction of the ULEZ in central London and the consultation on tightening the LEZ standards and expanding

the ULEZ to inner London were first announced). This requires the estimation of a "No ULEZ" scenario from January 2017 against which impacts are assessed by comparing to observed data.

ULEZ impact analysis applies the following principles:

- measured data from air quality monitoring stations were used as the basis for all analysis
- outer London served as a suitable control area against which to assess the impact of the central and inner London ULEZ
- the changes in road increment of NO_2 in outer London (that is subtracting outer urban background from total roadside concentrations in outer London to represent the changes in traffic related pollution) represented the trend that would be expected without the ULEZ
- concentrations for a "No ULEZ" scenario were estimated, in order to assess observed changes in concentration trends from all phases of the ULEZ
- a zone between 5-40 km of Greater London served as a suitable control area to assess the impacts of the London-wide ULEZ (the expansion to include outer London)
- concentrations for a "No London-wide ULEZ expansion" scenario have also been estimated, in order to assess observed changes in concentration trends from the London-wide ULEZ expansion only

Measured trends from the area between 5-40 km outside of London was considered suitable to assess the impacts in outer London and in the immediate 0-5 km around the boundary. This 5-40 km control zone was chosen because:

- it does not include sites immediately around the boundary of the ULEZ
- it excludes sites in the south of England that are affected by different local meteorological conditions, especially on the coast
- meteorological and regional background influences in this surrounding area are similar to those for London, which is unlikely to be the case for the rest of England

Full details of the methodology can be found in Appendix 3.

Results

Impacts of the London-wide ULEZ expansion

Figure 11 and Figure 12 show the trends in monthly average roadside NO_2 in outer London and in the area 5km from the GLA boundary respectively, comparing the observed trends (based on measured data and shown by the solid lines), with the estimated trends for the "No London-wide ULEZ expansion" scenario (shown by the dashed lines). The shaded area on each graph represents the impact of the London-wide ULEZ. Whilst the previous phases of the ULEZ and LEZ will have led to changes in emissions in outer London, this estimated impact is looking at specifically the London-wide ULEZ expansion and, therefore, only represents a proportion of the overall impacts on NO_2 concentrations in London. Further analysis using a bootstrap method was undertaken to calculate 95 per cent confidence intervals associated with this data, which is presented in Appendix 3.

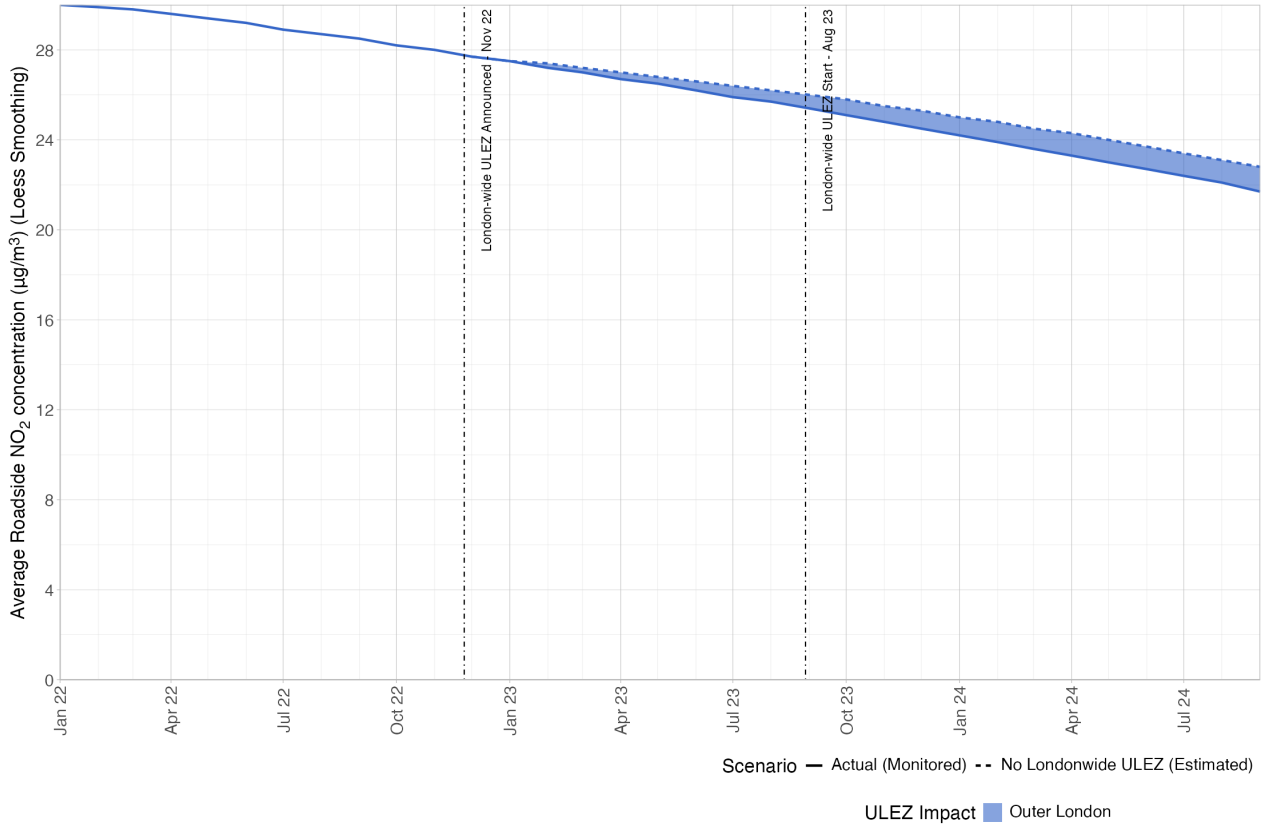

Figure 11: Trends in monthly average roadside NO_2 concentrations in outer London, with and without London-wide ULEZ

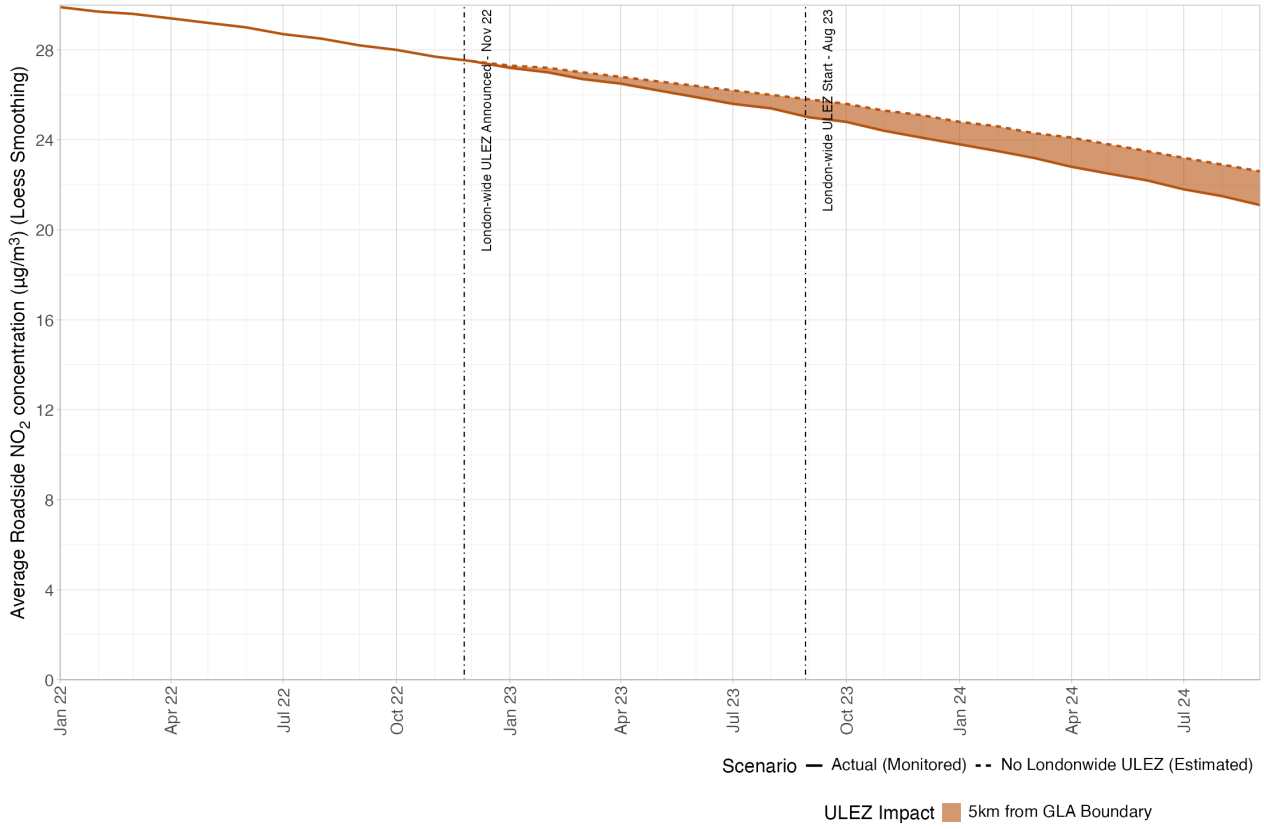

Figure 12: Trends in monthly average roadside NO_2 concentrations in the zone 5 km from the GLA boundary, with and without London-wide ULEZ[83]

These results show a gradual increase of impacts since the start of operation of the London-wide ULEZ, both in outer London and in the zone 5 km from the GLA boundary (where some roads also cross the boundary to the new charging area). Although results for the zone 5 km from the GLA boundary are more uncertain, as discussed in Appendix 3.

In outer London, compared to the estimated "No London-wide ULEZ" scenario, measured roadside NO_2 average concentrations were 0.6 µg/m^3 lower in September 2023, representing a 2.3 per cent reduction. One year on, this reduction is now estimated to be 1.1 µg/m^3, representing a 4.8 per cent reduction (as of September 2024).

[83] The data that underpins Figure 11 and Figure 12 are provided in Table 70 and Table 71 in Appendix 4 respectively.

> After one year of operation of the London-wide ULEZ, our estimates show that roadside NO_2 concentrations in outer London were on average 4.8 per cent lower than would have been expected without the London-wide ULEZ expansion.

The impacts of the London-wide ULEZ for London as a whole are shown in Figure 33 in Appendix 4.

Impacts of all ULEZ phases

Figure 13 shows the trends in monthly average roadside NO_2 concentrations in each zone, comparing the observed trends (based on measured data and shown by the solid lines) with the estimated trends they would have followed based on the “No ULEZ” scenario (shown by the dashed lines). The shaded area on each graph represents the impact of all phases of the ULEZ.

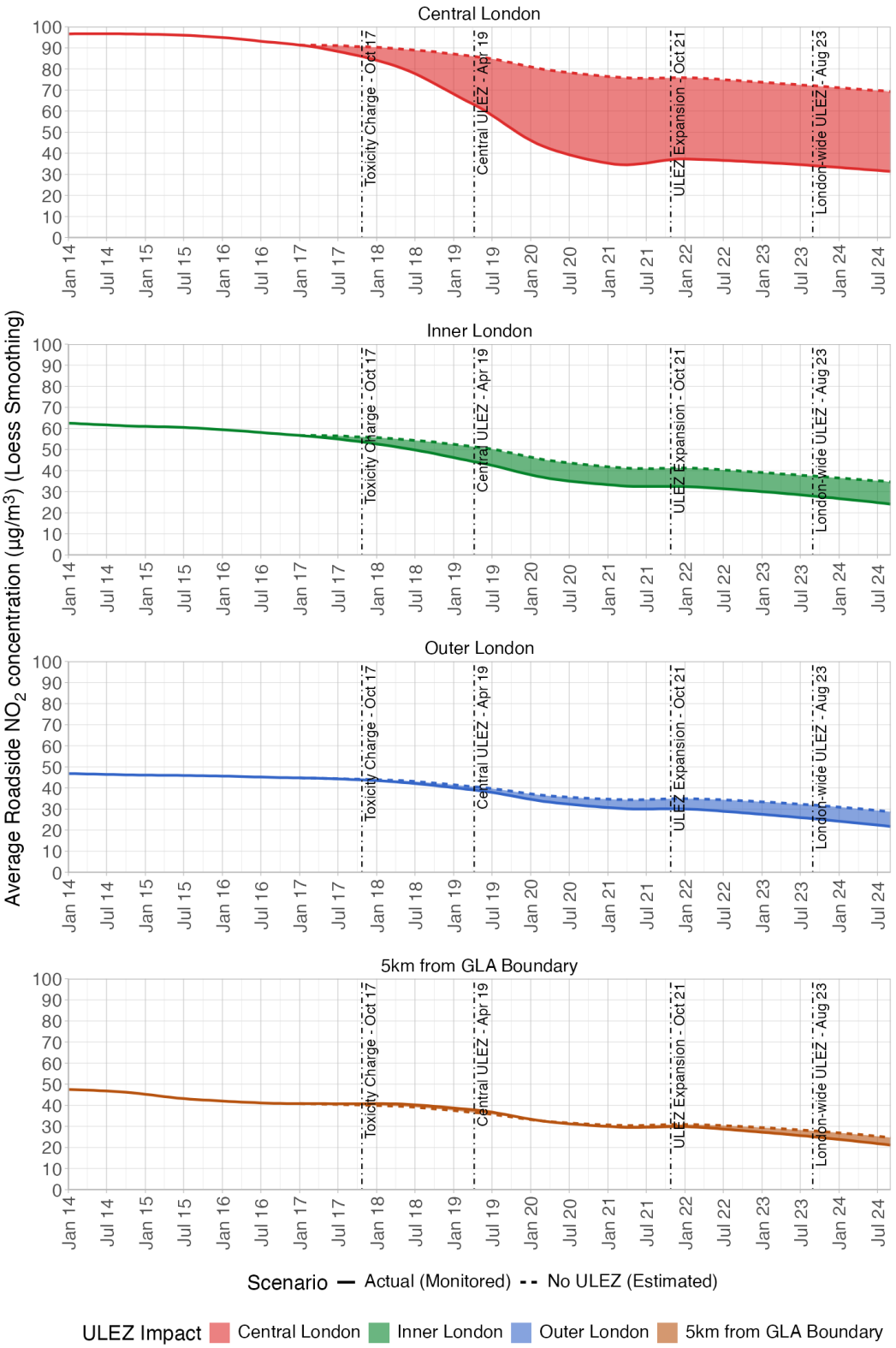

Figure 13: Trends in monthly average NO_2 concentrations in London zones with and without the ULEZ

Figure 13 shows that average concentrations for roadside sites in all London zones have seen accelerated and greater reductions than would be expected without the ULEZ and its expansions. The biggest reductions are in central London, where historically concentrations were much higher and where the earliest phase of the ULEZ was introduced (notably this also included heavy vehicles including London buses). The graphs show how the impacts of the ULEZ can be seen in all London zones, but the magnitude of reductions is greatest in central London, followed by inner London and then outer London. This is a function of the phased introduction of the scheme into different zones of London.

Over five million people live in outer London, compared with under four million in inner London and less than half a million in central London. Therefore, air quality improvements in outer London impact the largest share of London's residents. Table 25 to Table 29 summarise the impacts of all phases of the ULEZ in each zone by comparing the yearly concentrations for the observed trends against the "No ULEZ" scenario, to provide impacts each year since 2017. This can be understood as the impact of the ULEZ in each London zone.

Table 25: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations in central London based on trends analysis

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	ULEZ Impact ($\mu g/m^3$)	ULEZ Impact (per cent)
2016	93	N/A	N/A	N/A
2017	88	91	-3	-3%
2018	78	89	-11	-13%
2019	58	85	-26	-31%
2020	40	79	-38	-49%

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	ULEZ Impact ($\mu g/m^3$)	ULEZ Impact (per cent)
2021	36	76	-40	-53%
2022	37	75	-38	-51%
2023	35	73	-38	-52%
2024 (up to Sept)	32	70	-38	-54%

Table 26: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations in inner London based on trends analysis

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	Impact ($\mu g/m^3$)	Impact (per cent)
2016	58	N/A	N/A	N/A
2017	55	56	-1	-2%
2018	50	54	-4	-8%
2019	43	50	-7	-15%

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	Impact ($\mu g/m^3$)	Impact (per cent)
2020	35	44	-9	-19%
2021	33	41	-9	-21%
2022	31	40	-9	-22%
2023	29	38	-9	-25%
2024 (up to Sept)	25	35	-10	-29%

Table 27: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations in outer London based on trends analysis

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	Impact ($\mu g/m^3$)	Impact (per cent)
2016	45	N/A	N/A	N/A
2017	44	44	0	0%
2018	42	43	-1	-2%

Year	Actual (Measured) (µg/m^3)	No ULEZ (Estimated) (µg/m^3)	Impact (µg/m^3)	Impact (per cent)
2019	38	40	-2	-5%
2020	33	36	-3	-9%
2021	30	35	-4	-13%
2022	29	34	-5	-16%
2023	26	32	-6	-20%
2024 (up to Sept)	23	30	-7	-24%

Table 28: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations in the 0-5 km zone outside London based on trends analysis

Year	Actual (Measured) µg/m^3	No ULEZ (Estimated) µg/m^3	Impact (µg/m^3)	Impact (per cent)
2016	41	N/A	N/A	N/A

Year	Actual (Measured) µg/m^3	No ULEZ (Estimated) µg/m^3	Impact (µg/m^3)	Impact (per cent)
2017	41	40	0	1%
2018	40	39	-1	3%
2019	37	36	-1	3%
2020	32	32	0	-1%
2021	30	31	-1	-3%
2022	29	30	-2	-5%
2023	26	28	-3	-9%
2024 (up to Sept)	22	26	-4	-14%

The difference between the measured trends and the “No ULEZ” scenario is substantial and demonstrates that the ULEZ has had a transformative impact on reducing NO_2 levels.

> In 2024, the average roadside NO_2 concentrations measured in central London, inner London and outer London were 54 per cent lower, 29 per cent and 24 per cent lower, respectively, than the estimated “No ULEZ” scenario.

The impacts on NO_2 concentrations in both inner and outer London are substantial given the size of the population in these areas, representing over 95 per cent of people living in London.

The impacts observed in central London are sustained and have increased slightly from previous years. Impacts in 2024 have increased in both inner and outer London compared with 2022 as a result of the phased expansion of the ULEZ. The NO_2 impact of all phases of the ULEZ in outer London was eight percentage points greater in 2024 than it was in 2022 (24 per cent compared to 16 per cent).

> Areas outside London are also seeing the impacts of the ULEZ. Average roadside NO_2 concentrations within 5 km from the Greater London boundary were 14 per cent lower in 2024 than the estimated “No ULEZ” scenario.

Figure 14 and Table 29 show the impacts of all phases of the ULEZ for London as a whole.

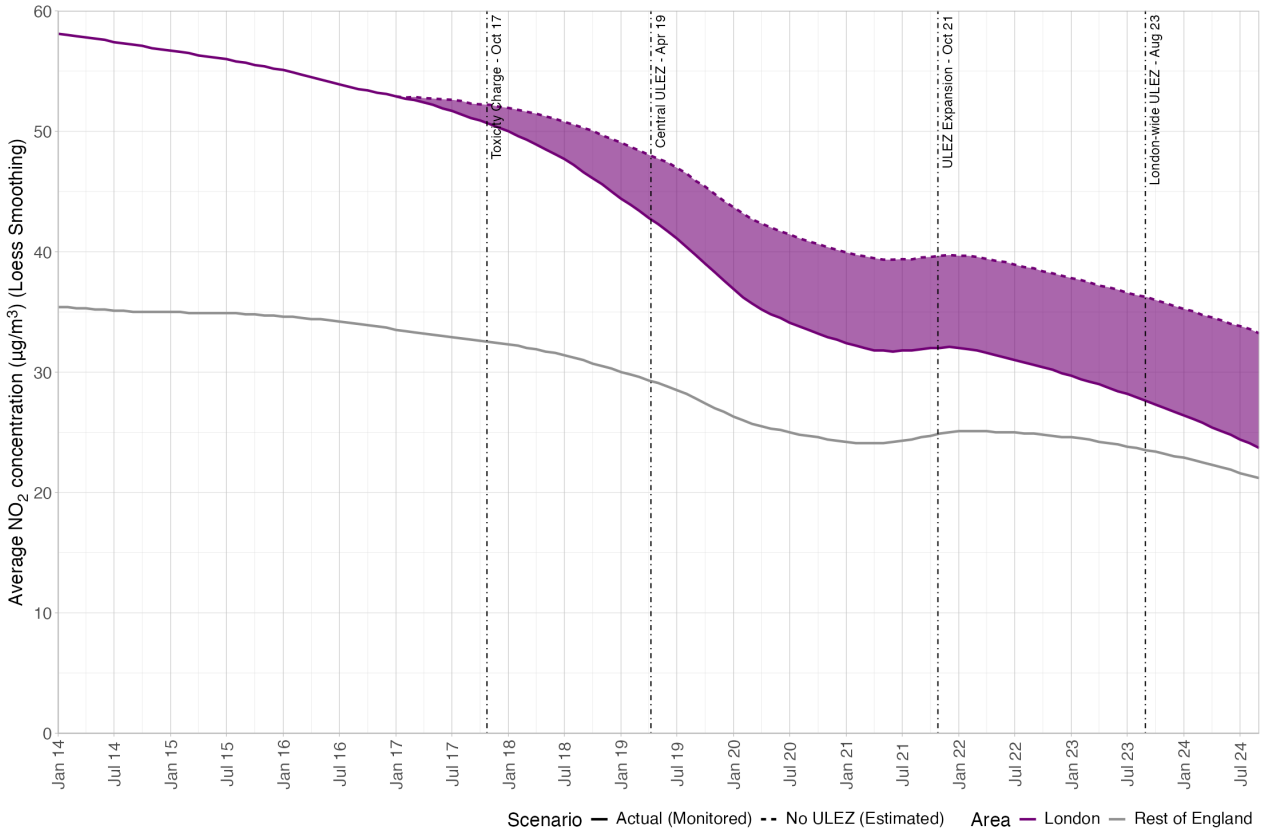

Figure 14: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations for the whole of London based on trends analysis

Table 29: Estimated impact of all phases of the ULEZ on roadside NO_2 concentrations in London as a whole based on trends analysis

Year	Actual (Measured) ($\mu g/m^3$)	No ULEZ (Estimated) ($\mu g/m^3$)	Impact ($\mu g/m^3$)	Impact (per cent)
2016	53	N/A	N/A	N/A
2017	51	52	-1	-2%
2018	47	50	-3	-6%
2019	42	46	-5	-10%
2020	34	41	-7	-18%
2021	32	39	-7	-18%
2022	31	39	-7	-19%
2023	28	36	-8	-23%
2024 (up to Sept)	24	34	-9	-27%

The analysis of trends of average London concentrations (the whole of London) indicates that the ULEZ is estimated to have reduced roadside NO_2 concentrations by 27 per cent in 2024 (equivalent to 9 $\mu g/m^3$) compared to what they would have been without the ULEZ.

When compared to trends of measured data for the rest of England, roadside concentrations in London are declining at a faster rate and, therefore, are closing the gap

between London and the rest of England (see grey and purple solid lines in Figure 14). The rest of England average has always been lower than London due to the inclusion of non-urban areas which are less built-up and have lower population density, therefore demonstrating the success of the ULEZ in achieving similar NO_2 concentrations in a large city of nine million people. In 2014, the gap between London and rest of England was over 20 µg/m^3, this reduced to 13 µg/m^3 in 2019 and in 2024 (average up to September) was less than 3 µg/m^3.

Crucially, this means improving air quality directly for the nine million people living in London and those who come into the area for work, study or leisure.

Population exposure

Previous analysis has highlighted the differential impacts of poor air quality on London's deprived communities[84,85]. The analysis presented here looks at the intersection between levels of deprivation and roadside NO_2 concentrations. It does this through assessing roadside NO_2 concentrations, as well as indices of multiple deprivation (IMD), in those communities living beside the Transport for London Road Network (TLRN).

The UK legal limit value for NO_2 of 40 µg/m^3 (as an annual mean) has been taken as the benchmark for this analysis. Roadside NO_2 concentrations in 2023 along the TLRN were calculated by applying the relative change in roadside NO_2 concentrations between 2019 and 2023 without the ULEZ, and with the ULEZ (as assessed above) to the modelled NO_2 data for 2019 from the latest London Atmospheric Emission Inventory (LAEI 2019)[16].

IMD is assigned to lower layer super output areas (LSOA) with between 400 and 1,200 households, whilst demographic and air quality concentration data are available at the smaller output area (OA) level, which is the smallest geographical unit used for the Census, typically 40 to 250 households[86].

IMD data is broken down into deciles, with the lowest deciles indicating communities who experience higher levels of deprivation. For the purpose of this research, it has been assumed that all output areas within the same LSOA have the same level of deprivation. NO_2 roadside concentrations along the TLRN have been assigned to output areas.

[84] Air quality exposure and inequalities study - part one - London analysis.pdf
[85] Air quality exposure and inequalities study - part two - Comparison with other cities.pdf (london.gov.uk)
[86] Area type definitions Census 2021 - Office for National Statistics

Table 30 shows the London population living by the TLRN and specifically in areas that are also predicted to exceed the UK NO_2 legal limit in scenarios with and without the ULEZ and its expansions.

Over one million Londoners (14 per cent of the London population) live in output areas that intersect the TLRN. In outer London only, over half a million people (10 per cent of the outer London population) live beside the TLRN.

> In a scenario without the ULEZ and its expansions in 2023, of the London population living in output areas intersecting the TLRN, 11 per cent (128,000) would have still been exposed to NO_2 roadside concentrations that exceed the UK annual limit. It is estimated that this has reduced to 24,000 people (two per cent), an 81 per cent reduction, due to the ULEZ.

In 2023, in outer London only and in a scenario without the ULEZ and its expansions, 19,000 Londoners (four per cent of the outer London population) living in areas intersecting the TLRN would have still been exposed to NO_2 roadside concentrations that exceed the UK legal limit. It is estimated that due to the ULEZ and its expansions this has reduced to 3,000 (one per cent of the outer London population), an 84 per cent reduction.

Table 30: London population living by the TLRN and exceeding UK legal NO_2 limit in scenarios with and without the ULEZ in 2023

Zone	Population intersecting TLRN (%)	Population intersecting TLRN exceeding legal limit (without ULEZ)	Population intersecting TLRN exceeding legal limit (%) (without ULEZ)	Population intersecting TLRN exceeding legal limit (with ULEZ)	Population intersecting TLRN exceeding legal limit (%) (with ULEZ)
London	14%	128,000	11%	24,000	2%
Central	33%	36,000	60%	3,000	5%
Inner	17%	73,000	12%	18,000	3%
Outer	10%	19,000	4%	3,000	1%

Figure 15 and Figure 16 indicate the level of deprivation experienced by the population that lives by the TLRN and who are also exposed to NO_2 roadside concentrations above the UK legal limit in 2023.

Of the London population living beside the TLRN and benefiting from the implementation of the ULEZ and its expansions:

- 37 per cent live in areas where IMD is 3 or below (i.e. those living in more deprived areas). The proportion of this population exposed to illegal levels of NO_2 reduced by 80 per cent, compared with a scenario without the ULEZ and its expansions.
- 50 per cent live in areas where IMD is 4-7. The proportion of this population exposed to illegal levels of NO_2 reduced by 83 per cent, compared to a scenario without the ULEZ and its expansions.
- 13 per cent live in areas where IMD is 8 or above (i.e. those living in less deprived areas). The proportion of this population exposed to illegal levels of NO_2 reduced by 76 per cent, compared to a scenario without the ULEZ and its expansions.

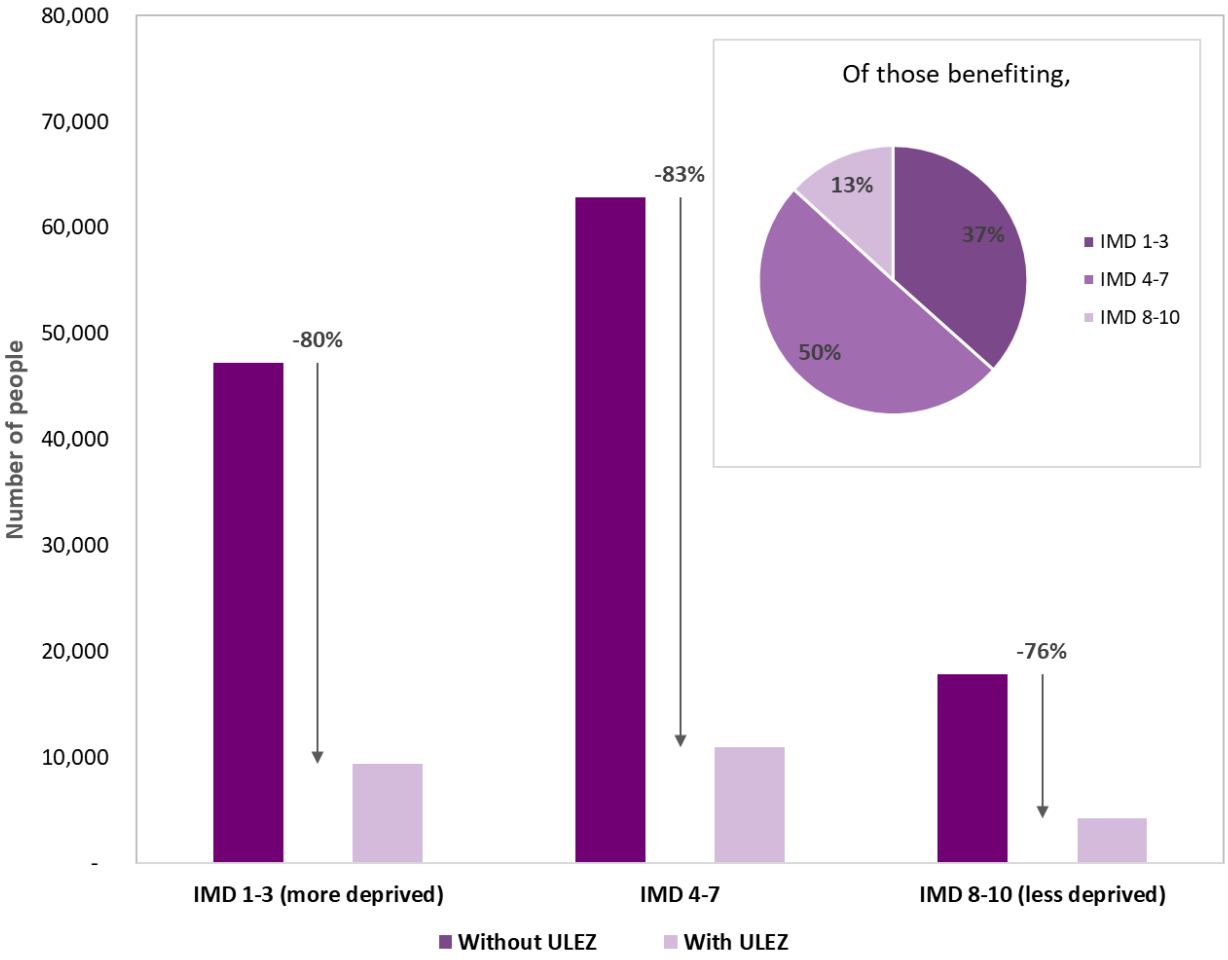

Figure 15: Change in population living by the TLRN in London, in areas where roadside NO_2 concentrations were predicted to exceed UK legal NO_2 limit (2023) with and without the impact of the ULEZ and its expansions, by IMD

Focusing on the outer London population living by the TLRN and benefiting from the implementation of the ULEZ:

- 45 per cent live in areas where IMD is 3 or below. The proportion of the population exposed to illegal levels of NO_2 reduced by 82 per cent, compared to a scenario without the ULEZ and its expansions.
- 45 per cent live in areas where IMD is 4-7. The proportion of the population exposed to illegal levels of NO_2 reduced by 84 per cent compared to a scenario without the ULEZ and its expansions.
- 10 per cent live in areas where IMD is 8 or above. The proportion of the population exposed to illegal levels of NO_2 reduced by 76 per cent, compared to a scenario without the ULEZ and its expansions.

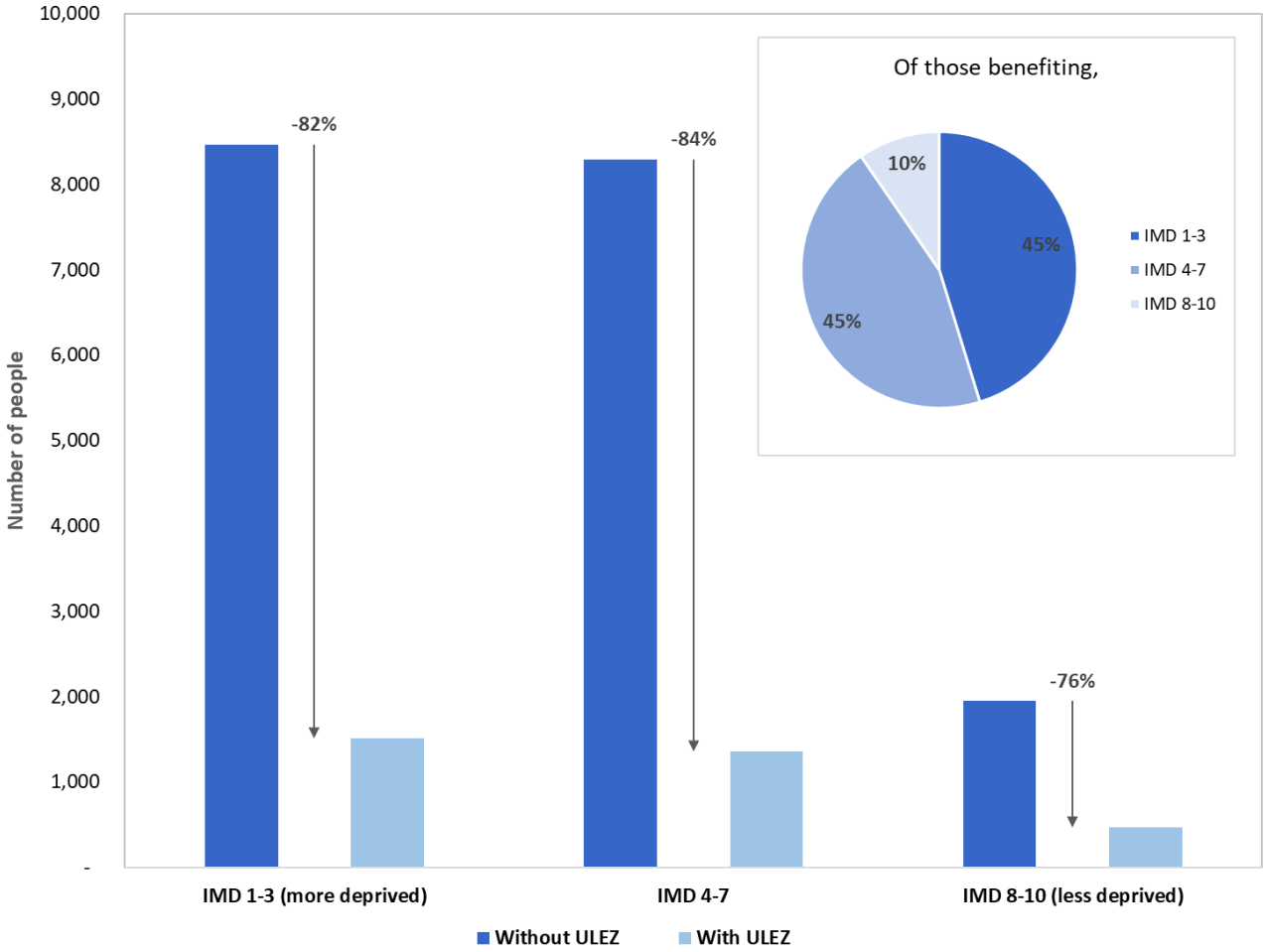

Figure 16: Change in population living by the TLRN in outer London, in areas where roadside NO_2 concentrations were predicted to exceed UK legal NO_2 limit (2023) with and without the impact of the ULEZ and its expansions, by IMD

Overall, this analysis shows that, as a result of the ULEZ and its expansions, communities living in areas with higher levels of deprivation have experienced greater improvements in terms of reduction in exposure to illegal levels of NO_2 pollution compared with those living in areas with the lower levels of deprivation. This suggests that the ULEZ has benefited communities in areas with higher levels of deprivation more than those communities where deprivation levels are lower.

Traffic

The ULEZ was not designed as a traffic congestion management tool, but the way it operates means it could influence travel behaviour and traffic, as has been shown in previous ULEZ monitoring reports. TfL uses Automatic Traffic Count (ATC) data that provides traffic volumes at representative sites, often on key roads across London, to monitor changes in traffic flows. These sites provide total traffic flows for all vehicles for each hour of the day.

People who own non-compliant vehicles may choose to pay the daily charge, change their vehicle, drive it less, avoid driving in the zone, or choose an alternative mode of transport for some or all of their journeys. These individual choices may influence overall traffic volumes and patterns over time.

ATC data provides monthly traffic flows which enables comparison to months in previous years and assessment of short-term changes in traffic since ULEZ was expanded, it does not provide traffic flows by vehicle type. It is important to note that overall changes in traffic flows do not necessarily reflect the changes to individual vehicle types.

Method

Data from ATC sites within London have been analysed. This includes data from over 200 sites that have been assigned to three areas across London: central London (the original ULEZ area), an inner ring representing the expanded inner London ULEZ area (excluding both central London and the North and South Circular Roads), and the expanded outer London area that is now part of the London-wide ULEZ (excluding the central and inner London ULEZ areas).

The data have been used to index the average daily flow per month for the ATCs in each zone. This has been done twice. Firstly, comparing the daily average per month against a January 2019 index. Secondly, comparing the daily average for the period of January to September of each year against January to September of 2019. This period is selected to allow direct comparison with the data available in 2024 for this report. An index of 101% equates to average flows that are one per cent higher than the respective index. The monthly index for each area and period is shown in Appendix 5.

Indexed traffic flows can be affected by non-scheme factors such as seasonality or variability in the road network, including diversions, roadworks and lane closures. Areas with fewer sites or lower average traffic are susceptible to greater variability in indexed traffic flow.

Traffic flow data represents circulating vehicles travelling on roads across London and is not the same as unique vehicles detected by the camera network, which only need to be seen once by any camera during the day. This means that changes in the average number of unique vehicles detected do not necessarily equate to the same changes in traffic flows.

Findings

Analysis of the monthly average, indexed against January 2019, shows that since the ULEZ was expanded London-wide, each month has maintained a similar flow, with some minor fluctuations both above and below months in the previous year. It demonstrates that across the zones and on the ULEZ boundary, traffic flow quantity and seasonal trends have stayed broadly the same.

When the average indexed traffic flows for the periods of January to September each year are indexed against the same period from 2019 there has been marginal growth in traffic year to year since 2022 as a reflection of post-pandemic recovery since 2021.

> In 2024, most zones and along the ULEZ boundary either show no notable change in average traffic flow, or a slight increase of around one percent over the previous period in 2023, which follows the same trend as from 2022 to 2023.

There are normal fluctuations in the traffic data and average daily traffic flows vary year on year, as demonstrated in Table 78 whereby indexed traffic flows across all zones show no clear trend between 2022 and 2024.

General seasonal trends year to year have remained the same as reflected in the monthly indexed flows, with traffic flows higher in September 2024 than August 2024 because of the school holidays ending. As expected, traffic is lower in December 2023 and January 2024 as a reflection of the Christmas holidays. Both seasonal trends are demonstrated in previous years of indexed traffic flows.

Overall, trends in traffic flows over the 2024 mirror those shown in previous years, with the same or a marginal growth in traffic in most zones consistent with a post-pandemic recovery in traffic since 2021.

Traffic around the London-wide ULEZ boundary

Analysis of detected vehicles shows that there is a higher proportion of newer, cleaner vehicles in the zone, particularly after the scheme launched. Examination of traffic count data is required to understand any impacts of this on traffic flows at the boundary. For this report, analysis of data from 48 ATCs around the boundary of the GLA are examined up to

the end of September 2024. The monthly index and the January to September index for the ULEZ boundary is shown in Appendix 5.

> The analysis indicates that there are no notable changes in traffic flows near the ULEZ boundary due to expansion of the London-wide ULEZ.

The monthly flows, indexed against January 2019, show expected seasonal patterns in both 2023 and 2024, with lower flows in August during the summer holidays as well as December and January for the Christmas period. There are minor monthly fluctuations in flow, both up and down, when comparing 2023 with 2024 however there is no notable change overall.

Highways England data has also been analysed outside the zone between the ULEZ boundary and M25. There is minor growth observed in the January to September period when indexed against the same period from 2019, which is in line with traffic trends observed across London. This demonstrates that flows in the vicinity of London have not been affected by the scheme and that trends remain consistent. When examining monthly data indexed against January 2019, there is slightly lower indexed flow in September 2024 than September 2023, which may be a function of road closures on some of the Highways England boundary roads being examined that month. A summary table of the Highways England data can be found in Appendix 5.

Summary

Analysis of the traffic data over the period of a year shows that traffic trends have remained consistent over the course of the first year of operation of the London-wide ULEZ. A small level of growth has been observed which is in line with post-pandemic recovery trends, although in many zones and months most of the fluctuations are marginal and not considered to be related to the scheme. This has remained consistent across all London zones and the ULEZ boundary.

Footfall and economic activity

The London-wide ULEZ expansion may have had indirect economic effects on high street business activities and office working. This section assesses the impact of the London-wide ULEZ expansion on visitor and worker footfall and in-store spending, to ascertain if there had been any wider positive or negative impacts on high streets, local retailers and businesses due to the expansion.

Footfall and in-store spend data shown in the figures below was anonymised and aggregated by BT Active Intelligence and Mastercard[87]. The entire Greater London area is divided into 350 metre hexagon areas, and footfall counts are based on the number of people who spend at least 10 minutes in a hexagon in a three-hour period using mobile device data. Economic activity is determined by analysing in-store Mastercard transactions, aggregated to a 100 metre resolution grid across daily three-hour time periods.

People are classified in each hexagon as either residents, workers, or visitors. A home location is assigned as the hexagon in which a person spends the majority of their time and would, therefore, be considered as a 'resident' when in that location. A workplace location is also assigned for each mobile device based on the second most dwelt at location where people would be classified as a 'worker.' A person is classified as a 'visitor' when they dwell for at least 10 minutes in any other location, not classed as their home or workplace location.

More information about the methodology for this analysis is in Appendix 7.

Figure 17 and Figure 18 show visitor and worker footfall trends from 29 August 2022 to 28 August 2024 for four areas which broadly align with the ULEZ boundaries: London-wide, central London, inner London and outer London. Footfall counts are normalised to the year prior to the London-wide ULEZ expansion, where a value of one is the average daily footfall between 29 August 2022 to 28 August 2023. The data has been smoothed with a seven-day rolling average to reduce the impact of weekly seasonality.

The long-term trend over this period is relatively stable, with the year following the ULEZ expansion (29 August 2023 to 28 August 2024) showing little deviation from footfall in the year preceding the expansion in each of the zones. Both visitor and worker footfall show variability, reflecting seasonal activity and other short-term factors such as major events, weather or industrial action, which happen independent of the London-wide ULEZ. Central

[87] via the GLA's High Streets Data Service

London had slightly more pronounced seasonal fluctuations, compared to inner and outer London.

Overall, outer London saw visitor footfall growth of 1.87 per cent in the year after the London-wide ULEZ expansion, compared to an increase of 0.08 per cent across all of London. Worker footfall in outer London increased by 8.89 per cent compared to 8.54 per cent across all of London.

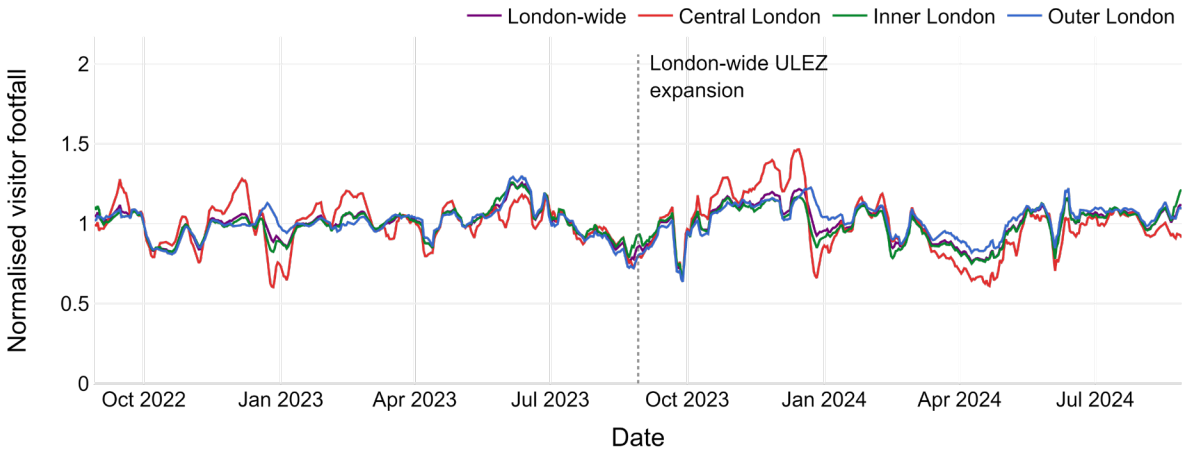

Figure 17: Normalised daily visitor footfall trends by zone, from 29 August 2022 to 28 August 2024. Data has been smoothed with a seven-day rolling average.

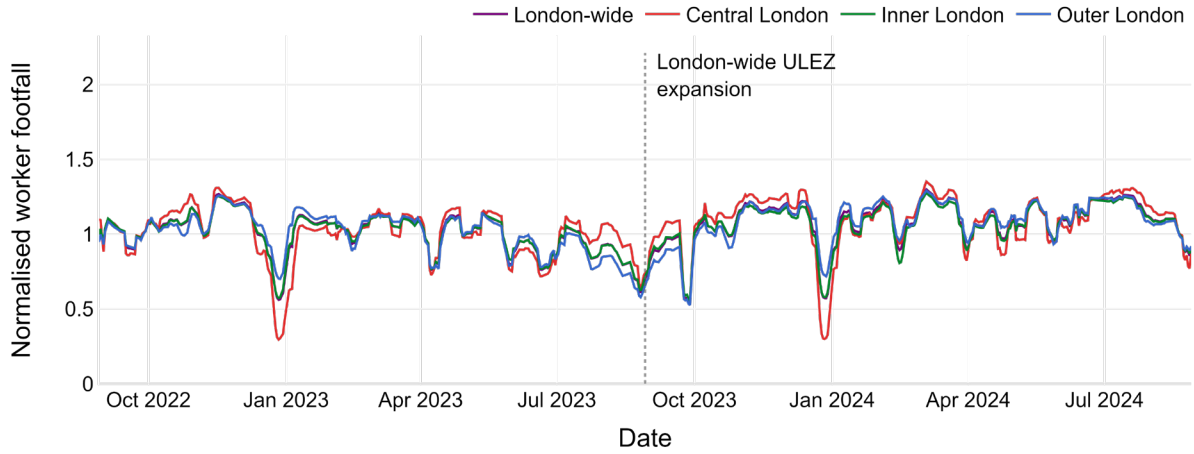

Figure 18: Normalised daily worker footfall trends by zone, from 29 August 2022 to 28 August 2024. Data has been smoothed with a seven-day rolling average.

Figure 19 shows in-store spend trends from 29 August 2022 to 28 August 2024 for four areas: London-wide, central London, inner London and outer London. Spend is normalised with respect to the daily average from 29 August 2022 to 28 August 2023 and has been

adjusted for inflation using monthly national consumer price inflation rates from the Office for National Statistics (ONS).The data has been smoothed with a seven-day rolling average to reduce the impact of weekly seasonality.

Similar to footfall, there are short-term and seasonal fluctuations in in-store spend. Seasonal fluctuations are shown prominently in Figure 19 as increases leading up to Christmas followed by sharp drops. Overall, in-store spend from 29 August 2023 to 28 August 2024 shows little deviation from spend in the year preceding the London-wide ULEZ expansion, in every zone. Each area shows a similar trend for the two-year period.

Spend in outer London dropped by 3.17 per cent, compared to a 3.42 per cent drop across all of London, the year following the London-wide ULEZ expansion. Whilst a reduction has been observed, this was not statistically significant, and is in-line with in-store retail performance seen across the rest of England during this time, as shown in Figure 20 below.

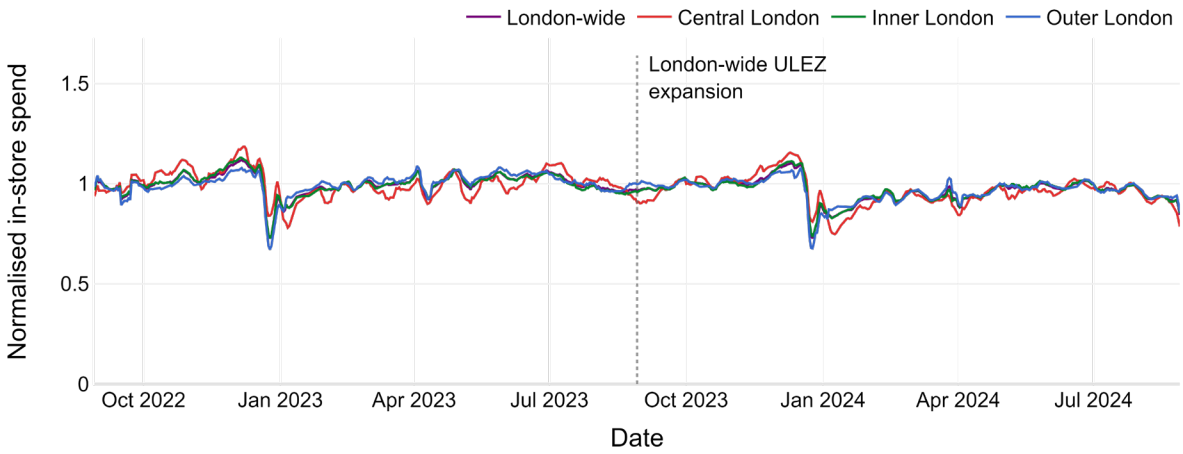

Figure 19: Normalised daily in-store spend trend split by zone, from 29 August 2022 to 28 August 2024. Data has been smoothed with a seven-day rolling average.

Figure 20 shows in-store spend trends from September 2022 to August 2024 for London and for the rest of England (excluding London). Spend is normalised with respect to the monthly average from September 2022 to August 2023 and has been adjusted for inflation using from ONS.

Figure 20 shows that monthly spend in England (excluding London) closely follows the London-wide trend, before and after the London-wide ULEZ expansion. Comparing the 12 months before and after the expansion, there was a 3.26 per cent[88] and a 3.36 per cent reduction in total in-store spend, in London and England, respectively. This suggests the reduction in in-store spend is part of a wider national trend and is not specific to London or the London-wide ULEZ expansion.

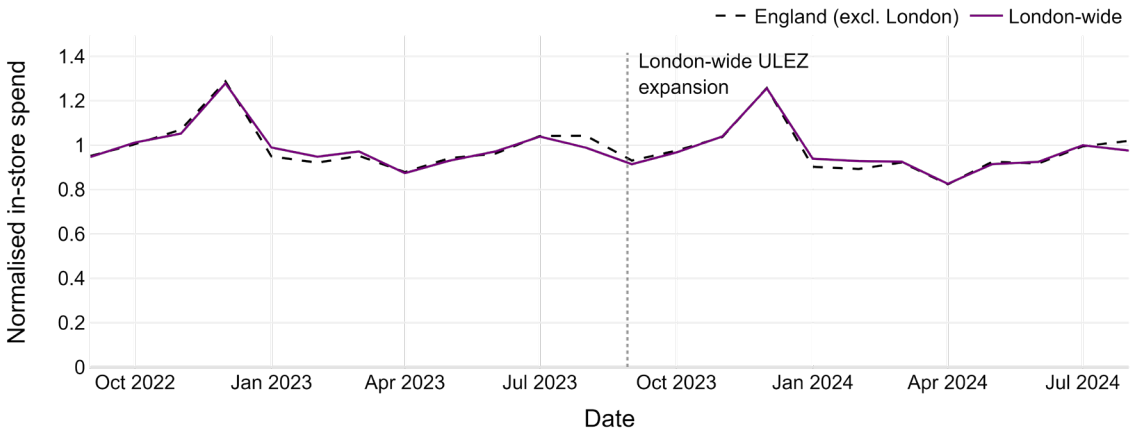

Figure 20: Normalised monthly in-store spend for London and the rest of England, from September 2022 to August 2024

Table 31: Percentage change in footfall and spend split by zone, comparing the year before and after the ULEZ expansion

London Zone	Change in visitor footfall	Change in worker footfall	Change in in-store spend
London-wide	+0.08%	+8.54%	-3.42%

[88] This per cent change (-3.26%) in London-wide in-store spending is slightly different from the per cent change reported in Table 34 above (-3.42%). This is because it is calculated using a different data source (Mastercard Spending Pulse vs Mastercard Retail Location Index – see Appendix 7) to allow for comparison with the rest of England.

London Zone	Change in visitor footfall	Change in worker footfall	Change in in-store spend
Central London	-1.12%	+9.90%	-4.07%
Inner London	-1.08%	+7.51%	-3.41%
Outer London	+1.87%	+8.89%	-3.17%

Statistical analysis shows that the London-wide ULEZ expansion has had no significant impact on footfall and spend in the outer London area, or at a London-wide level.

Conclusions

There is a strong body of research evidencing the negative health impacts associated with exposure to air pollution, and road transport is currently estimated to be the largest single source of NO_2 and $PM_{2.5}$ in London, the main pollutants of concern. The expansion of the ULEZ London-wide in August 2023 is the latest world-leading policy delivered in London under this Mayoralty aimed at tackling harmful air pollution emissions from road transport, specifically NO_2 and PM. The ULEZ disincentivises the use of older, more polluting vehicles within the city through applying a daily charge to vehicles that do not meet certain emissions criteria.

This report shows that, as a result of the ULEZ, a larger proportion of vehicles in London are cleaner, and compliance with the ULEZ emissions standards has increased for all vehicles subject to the standards. Now, 96.7 per cent of vehicles seen driving in the London-wide ULEZ meet the standards.

A cleaner fleet has translated to lower emissions from vehicles driving in London. Cumulatively over a six-year period (2019 – 2024) CO_2 emissions are estimated to be 813,000 tonnes lower; NO_X emissions are estimated to be 17,770 tonnes lower and $PM_{2.5}$ emissions are estimated to be 210 tonnes lower due to all phases of the ULEZ.

This means that people in London are breathing cleaner air. In the first year since the expansion to outer London, roadside NO_2 concentrations in outer London are on average up to 4.8 per cent lower (1.1 $\mu g/m^3$) than what would have been expected without the London-wide expansion of the ULEZ.

The combined impact of all phases of the ULEZ has contributed to greater overall air quality improvements in London. Harmful NO_2 concentrations alongside roads across all of London are estimated to be 27 per cent lower (9 $\mu g/m^3$) on average than they would have been without the ULEZ and its expansions.

Importantly, the ULEZ is making an impact in the communities that are living in areas with higher levels of deprivation. For some of the most deprived communities living near London's busiest roads, there's been an estimated 80 per cent reduction in people exposed to illegal levels of pollution[5].

Areas outside London are also seeing the benefits of the ULEZ, as roadside NO_2 concentrations within five kilometres of the Greater London boundary were on average 14 per cent lower in 2024 than an estimated "No ULEZ" scenario. Visitor footfall and economic spend has not been impacted by the expansion of the ULEZ.

This detailed analysis shows that both the London-wide ULEZ expansion, and the combined impact of all phases of the ULEZ has had a considerable positive impact on air quality in London. These demonstrated improvements in air quality due to all phases of the

ULEZ has brought cleaner air to nine million Londoners and shows the positive impacts that schemes such as the ULEZ can have in cleaning up the air for people who live, work and travel in London.

Appendix 1 – Monthly average compliance rates

This section provides the monthly average compliance rates and vehicles detected in the central London ULEZ area (the same area as the Congestion Charge zone), inner London ULEZ area (the entire area bounded by the North and South Circular Roads, excluding central London), and the expanded outer London ULEZ area (excluding the central and inner London area, including the North and South Circular roads). Dates chosen for this section represent the launch of the consultation on expanding the ULEZ London-wide in May 2022, the announcement of the Mayor's decision to expand the ULEZ London-wide in November 2022, and then monthly from May 2023, as this is the month where the extended camera network was established in outer London.

Central London ULEZ area

Table 32: **Daily average number and proportion of ULEZ compliant vehicles detected in the central ULEZ area per month (rounded to the nearest 1,000 vehicles)**

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	141,000	11,000	130,000	8.0%	92.0%
Nov-22	143,000	9,000	134,000	6.5%	93.5%
May-23	143,000	8,000	136,000	5.3%	94.7%
Jun-23	153,000	8,000	145,000	5.1%	94.9%

[89] November 2022 and May 2022 are based on the camera network in place before additional new cameras were installed for the London-wide ULEZ. Detected volumes for these months cannot be compared to London-wide ULEZ volumes for the new camera network. Data for May 2023 included the first data available from some cameras installed as part of the network changes, as well as bank holidays (including the coronation).

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jul-23	152,000	8,000	145,000	5.1%	94.9%
Aug-23	144,000	7,000	137,000	5.0%	95.0%
Sep-23	158,000	7,000	151,000	4.5%	95.5%
Oct-23	158,000	7,000	152,000	4.3%	95.7%
Nov-23	158,000	6,000	152,000	4.0%	96.0%
Dec-23	151,000	6,000	146,000	3.9%	96.1%
Jan-24	141,000	5,000	136,000	3.6%	96.4%
Feb-24	145,000	5,000	140,000	3.6%	96.4%
Mar-24	139,000	5,000	135,000	3.4%	96.6%
April-24	142,000	5,000	137,000	3.5%	96.5%
May-24	145,000	5,000	140,000	3.3%	96.7%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
June-24	148,000	5,000	143,000	3.4%	96.6%
July-24	149,000	5,000	144,000	3.4%	96.6%
Aug-24	142,000	5,000	137,000	3.4%	96.6%
Sep-24	152,000	5,000	147,000	3.3%	96.7%
Change between September 2023 and September 2024	-6,000	-2,000	-4,000	-1.2 ppt	+1.2 ppt
% Change in vehicles between September 2023 and September 2024	-4.1%	-30%	-2.8	N/A	N/A

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between June 2023 and September 2024	-1,000	-3,000	-2,000	-1.9 ppt	+ 1.9 ppt
% Change in vehicles between June 2023 and September 2024	-0.8%	-37%	-1.1%	N/A	N/A

Table 33: **Daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. taxis) detected in the central ULEZ area per month (rounded to nearest 1,000 vehicles)**

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	105,000	7,000	99,000	6.4%	93.6%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Nov-22	105,000	6,000	100,000	5.2%	94.8%
May-23	106,000	4,000	102,000	4.2%	95.8%
Jun-23	112,000	5,000	108,000	4.1%	95.9%
Jul-23	114,000	5,000	109,000	4.2%	95.8%
Aug-23	107,000	4,000	102,000	4.1%	95.9%
Sep-23	117,000	4,000	113,000	3.5%	96.5%
Oct-23	117,000	4,000	113,000	3.4%	96.6%
Nov-23	117,000	4,000	113,000	3.2%	96.8%
Dec-23	120,000	4,000	116,000	3.3%	96.7%
Jan-24	105,000	3,000	102,000	2.9%	97.1%
Feb-24	107,000	3,000	104,000	2.9%	97.1%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Mar-24	104,000	3,000	101,000	2.7%	97.3%
Apr-24	104,000	3,000	101,000	2.8%	97.2%
May-24	107,000	3,000	104,000	2.7%	97.3%
June-24	110,000	3,000	107,000	2.7%	97.3%
July-24	109,000	3,000	106,000	2.8%	97.4%
Aug-24	105,000	3,000	102,000	2.8%	97.4%
Sep-24	112,000	3,000	109,000	2.7%	97.3%
Change between September 2023 and September 2024	-5,000	-1,000	-4,000	-0.9 ppt	+0.9 ppt

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	-4.2%	-27%	-3.3%	N/A	N/A
Change between June 2023 and September 2024	0	-2,000	2,000	-1.5 ppt	+1.5 ppt
% Change in vehicles between June 2023 and September 2024	0.1%	-35%	1.6%	N/A	N/A

Table 34: Daily average number and proportion of ULEZ compliant vans (N1) detected in the central ULEZ area per month (rounded to nearest 100 vehicles)

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	28,700	4,200	24,500	14.7%	85.3%
Nov-22	31,600	3,700	28,000	11.6%	88.4%
May-23	29,100	2,800	26,300	9.7%	90.3%
Jun-23	32,000	3,000	29,000	9.3%	90.7%
Jul-23	30,600	2,800	27,800	9.3%	90.7%
Aug-23	29,900	2,600	27,200	8.9%	91.1%
Sep-23	32,200	2,700	29,500	8.4%	91.6%
Oct-23	32,100	2,600	29,500	8.1%	91.9%
Nov-23	32,800	2,500	30,300	7.6%	92.4%
Dec-23	25,100	1,800	23,200	7.4%	92.6%
Jan-24	28,900	1,900	27,000	6.5%	93.5%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Feb-24	29,900	1,900	28,000	6.5%	93.5%
Mar-24	27,400	1,700	25,600	6.4%	93.6%
April-24	28,600	1,800	26,800	6.3%	93.7%
May-24	28,500	1,800	26,800	6.2%	93.8%
June-24	28,800	1,800	27,000	6.1%	93.9%
July-24	30,400	1,800	28,600	5.9%	94.1%
Aug-24	28,000	1,600	26,300	5.8%	94.2%
Sep-24	30,400	1,700	28,600	5.7%	94.3%
Change between September 2023 and September 2024	-1,800	-1,000	-900	-2.7 ppt	+2.7 ppt

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	5.7%	36%	-2.9%	N/A	N/A
Change between June 2023 and September 2024	-1,600	-1,200	-400	-3.6 ppt	+ 3.6 ppt
% Change in vehicles between June 2023 and September 2024	-5.1%	-42%	-1.4%	N/A	N/A

Table 35: Daily average number and proportion of ULEZ compliant minibuses detected in the central London ULEZ area per month (rounded to nearest 10 vehicles)

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	310	70	250	20.9%	79.1%
Nov-22	320	60	250	20.2%	79.8%
May-23	320	60	260	19.4%	80.6%
Jun-23	360	70	290	19.3%	80.7%
Jul-23	320	70	250	22.7%	77.3%
Aug-23	240	50	180	22.8%	77.2%
Sep-23	310	60	250	19.1%	80.9%
Oct-23	300	60	240	20.0%	80.0%
Nov-23	320	60	260	17.8%	82.2%
Dec-23	260	50	210	19.7%	80.3%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jan-24	250	40	210	16.7%	83.3%
Feb-24	270	40	220	16.9%	83.1%
Mar-24	280	50	230	17.6%	82.4%
April-24	270	50	220	18.6%	81.4%
May-24	320	50	260	16.6%	83.4%
June-24	350	60	290	17.4%	82.6%
July-24	340	60	270	18.9%	81.1%
Aug-24	250	50	210	18.3%	81.7%
Sep-24	310	50	270	15.7%	84.3%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between September 2023 and September 2024	10	-10	20	-3.5 ppt	+3.5 ppt
% Change in vehicles between September 2023 and September 2024	2.6%	-16%	7.0%	N/A	N/A
Change between June 2023 and September 2024	-40	-20	-20	-3.7 ppt	+3.7 ppt
% Change in vehicles between June 2023 and September 2024	-11.9%	-29%	-7.9%	N/A	N/A

Table 36: **Daily average number and proportion of ULEZ compliant motorcycles (L) detected in the central London ULEZ area per month (rounded to nearest 10 vehicles)**

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	6,490	180	6,320	2.8%	97.2%
Nov-22	6,130	110	6,020	1.8%	98.2%
May-23	7,530	140	7,390	1.9%	98.1%
Jun-23	8,320	160	8,150	1.9%	98.1%
Jul-23	7,680	150	7,540	1.9%	98.1%
Aug-23	7,250	140	7,120	1.9%	98.1%
Sep-23	8,330	170	8,170	2.0%	98.0%
Oct-23	8,720	160	8,560	1.8%	98.2%
Nov-23	8,560	150	8,410	1.8%	98.2%
Dec-23	6,400	110	6,300	1.7%	98.3%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jan-24	7,010	110	6,900	1.5%	98.5%
Feb-24	8,030	130	7,900	1.6%	98.4%
Mar-24	8,180	130	8,050	1.6%	98.4%
April-24	8,640	150	8,490	1.8%	98.2%
May-24	9,080	160	8,920	1.7%	98.3%
June-24	9,210	180	9,030	1.9%	98.1%
July-24	9,040	170	8,870	1.9%	98.1%
August-24	8,230	160	8,070	1.9%	98.1%
Sep-24	8,650	170	8,490	1.9%	98.1%

Date	Unique vehicles detected in central ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between September 2023 and September 2024	320	0	320	-0.1 ppt	+0.1 ppt
% Change in vehicles between September 2023 and September 2024	3.9%	0%	3.9%	N/A	N/A
Change between June 2023 and September 2024	340	0	330	-0 ppt	+ 0 ppt
% Change in vehicles between June 2023 and September 2024	4.1%	-3%	4.1%	N/A	N/A

Inner London ULEZ area

Table 37: **Daily average number and proportion of ULEZ compliant vehicles detected in the inner London ULEZ area per month (rounded to the nearest 1,000 vehicles)**

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	929,000	57,000	871,000	6.2%	93.8%
Nov-22	912,000	49,000	863,000	5.4%	94.6%
May-23	911,000	41,000	870,000	4.5%	95.5%
Jun-23	935,000	42,000	893,000	4.5%	95.5%
Jul-23	903,000	40,000	863,000	4.4%	95.6%
Aug-23	840,000	36,000	803,000	4.3%	95.7%
Sep-23	911,000	37,000	874,000	4.1%	95.9%
Oct-23	903,000	36,000	867,000	4.0%	96.0%
Nov-23	926,000	36,000	890,000	3.9%	96.1%
Dec-23	888,000	33,000	855,000	3.8%	96.2%

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jan-24	881,000	30,000	851,000	3.4%	96.6%
Feb-24	905,000	32,000	873,000	3.5%	96.5%
Mar-24	906,000	30,000	876,000	3.4%	96.6%
April-24	897,000	30,000	867,000	3.4%	96.6%
May-24	920,000	31,000	889,000	3.3%	96.7%
June-24	926,000	30,000	896,000	3.3%	96.7%
July-24	907,000	30,000	878,000	3.3%	96.7%
Aug-24	850,000	27,000	823,000	3.2%	96.8%
Sep-24	910,000	28,000	882,000	3.1%	96.9%
Change between September 2023 and September 2024	-1,000	-9,000	8,000	-1 ppt	+1 ppt

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	-0.1%	-24%	0.9%	N/A	N/A
Change between June 2023 and September 2024	-26,000	-14,000	-12,000	-1.4 ppt	+1.4 ppt
% Change in vehicles between June 2023 and September 2024	-2.7%	-33%	-1.3%	N/A	N/A

Table 38: Daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. taxis) detected in the inner ULEZ area per month (rounded to nearest 1,000 vehicles)

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	778,000	35,000	742,000	4.6%	95.4%
Nov-22	757,000	30,000	727,000	4.0%	96.0%
May-23	764,000	26,000	738,000	3.4%	96.6%
Jun-23	779,000	26,000	753,000	3.3%	96.7%
Jul-23	755,000	25,000	730,000	3.3%	96.7%
Aug-23	698,000	23,000	675,000	3.3%	96.7%
Sep-23	758,000	23,000	735,000	3.1%	96.9%
Oct-23	750,000	23,000	727,000	3.0%	97.0%
Nov-23	768,000	22,000	746,000	2.9%	97.1%
Dec-23	760,000	23,000	737,000	3.0%	97.0%
Jan-24	738,000	19,000	718,000	2.6%	97.4%

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Feb-24	754,000	20,000	733,000	2.7%	97.3%
Mar-24	760,000	20,000	740,000	2.6%	97.4%
April-24	748,000	19,000	728,000	2.6%	97.4%
May-24	768,000	20,000	748,000	2.5%	97.5%
June-24	774,000	20,000	755,000	2.5%	97.5%
July-24	752,000	19,000	733,000	2.5%	97.5%
Aug-24	707,000	18,000	789,000	2.5%	97.5%
Sep-24	758,000	18,000	740,000	2.4%	97.6%
Change between September 2023 and September 2024	0	-5,000	5,000	-0.7 ppt	+0.7 ppt

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	0%	-22%	0.7%	N/A	N/A
Change between June 2023 and September 2024	-21,000	-8,000	-13,000	-0.9 ppt	+0.9 ppt
% Change in vehicles between June 2023 and September 2024	-2.7%	-30%	-1.7%	N/A	N/A

Table 39: Daily average number and proportion of ULEZ compliant vans (N1) detected in the inner ULEZ area per month (rounded to nearest 100 vehicles)

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	118,600	20,600	98,000	17.4%	82.6%
Nov-22	125,100	18,000	107,100	14.4%	85.6%
May-23	115,500	14,300	101,100	12.4%	87.6%
Jun-23	122,900	14,600	108,300	11.9%	88.1%
Jul-23	116,600	13,500	103,100	11.6%	88.4%
Aug-23	112,200	12,500	99,700	11.1%	88.9%
Sep-23	120,300	12,800	107,500	10.6%	89.4%
Oct-23	120,900	12,400	108,400	10.3%	89.7%
Nov-23	126,400	12,500	113,900	9.9%	90.1%
Dec-23	102,300	9,900	92,400	9.6%	90.4%
Jan-24	114,900	10,000	104,900	8.7%	91.3%

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Feb-24	120,900	10,600	110,300	8.7%	91.3%
Mar-24	114,700	10,000	104,700	8.7%	91.3%
April-24	117,400	10,000	107,300	8.6%	91.4%
May-24	117,900	9,900	108,000	8.4%	91.6%
June-24	117,200	9,700	107,600	8.3%	91.7%
July-24	121,600	9,600	112,100	7.9%	92.1%
Aug-24	110,800	8,500	102,200	7.7%	92.3%
Sep-24	118,400	8,800	109,600	7.4%	92.6%
Change between September 2023 and September 2024	-1,900	-4,000	-2,100	-3.2 ppt	+3.2 ppt

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	-1.6%	-31%	1.9%	N/A	N/A
Change between June 2023 and September 2024	-4,400	-5,800	-1,400	-4.5 ppt	+4.5 ppt
% Change in vehicles between June 2023 and September 2024	-3.6%	-40%	1.3%	N/A	N/A

Table 40: **Daily average number and proportion of ULEZ compliant minibuses detected in the inner London ULEZ area per month (rounded to nearest 10 vehicles)**

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	1,660	350	1,310	21.1%	78.9%
Nov-22	1,740	340	1,400	19.4%	80.6%
May-23	1,590	310	1,280	19.4%	80.6%
Jun-23	1,750	340	1,410	19.5%	80.5%
Jul-23	1,440	310	1,130	21.5%	78.5%
Aug-23	990	220	770	22.1%	77.9%
Sep-23	1,540	280	1,260	18.3%	81.7%
Oct-23	1,470	280	1,200	18.7%	81.3%
Nov-23	1,740	300	1,430	17.6%	82.4%
Dec-23	1,300	240	1,060	18.5%	81.5%
Jan-24	1,460	240	1,220	16.5%	83.5%
Feb-24	1,500	250	1,250	16.7%	83.3%

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Mar-24	1,580	270	1,310	16.8%	83.3%
April-24	1,330	220	1,100	16.9%	83.3%
May-24	1,590	260	1,320	16.5%	83.3%
June-24	1,690	290	1,410	16.9%	83.3%
July-24	1,560	280	1,280	17.9%	83.3%
Aug-24	1,000	190	820	18.7%	83.3%
Sep-24	1,560	240	1,330	15.1%	83.3%
Change between September 2023 and September 2024	20	-50	70	-3.2 ppt	+3.2 ppt

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	1.2%	-16%	5.2%	N/A	N/A
Change between June 2023 and September 2024	-180	-100	-80	-4.4 ppt	+4.4 ppt
% Change in vehicles between June 2023 and September 2024	-10.6%	-31%	5.7%	N/A	N/A

Table 41: Daily average number and proportion of ULEZ compliant motorcycles (L) detected in the inner London ULEZ area per month (rounded to near 10 vehicles)

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	30,540	1,010	29,530	3.3%	96.7%
Nov-22	28,640	770	27,870	2.7%	97.3%
May-23	29,880	820	29,060	2.7%	97.3%
Jun-23	31,610	890	30,720	2.8%	97.2%
Jul-23	29,500	810	28,690	2.7%	97.3%
Aug-23	28,480	770	27,710	2.7%	97.3%
Sep-23	30,890	850	30,040	2.8%	97.2%
Oct-23	30,720	790	29,930	2.6%	97.4%
Nov-23	30,130	740	29,390	2.5%	97.5%
Dec-23	25,190	590	24,600	2.3%	97.7%
Jan-24	26,520	600	25,920	2.3%	97.7%

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Feb-24	29,080	670	28,410	2.3%	97.7%
Mar-24	29,870	660	29,200	2.2%	97.7%
April-24	30,780	740	30,040	2.4%	97.7%
May-24	32,370	800	31,570	2.5%	97.7%
June-24	33,130	870	32,260	2.6%	97.7%
July-24	32,510	840	31,670	2.6%	97.7%
Aug-24	30,810	790	30,020	2.6%	97.7%
Sep-24	31,430	800	30,630	2.5%	97.7%
Change between September 2023 and September 2024	540	-50	590	-0.2 ppt	+0.2 ppt

Date	Unique vehicles detected in 2021 ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	1.8%	-6%	2.0%	N/A	N/A
Change between June 2023 and September 2024	-180	-90	-90	-0.3 ppt	+0.3 ppt
% Change in vehicles between June 2023 and September 2024	-0.6%	-10%	-0.3%	N/A	N/A

Expanded outer London ULEZ area

Table 42: Daily average number and proportion of ULEZ compliant vehicles detected in the expanded outer London area per month (rounded to the nearest 1,000 vehicles)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	862,000	129,000	733,000	14.9%	85.1%
Nov-22	926,000	110,000	816,000	11.9%	88.1%
May-23	1,580,000	150,000	1,430,000	9.5%	90.5%
Jun-23	1,714,000	156,000	1,558,000	9.1%	90.9%
Jul-23	1,697,000	147,000	1,550,000	8.6%	91.4%
Aug-23	1,636,000	128,000	1,508,000	7.8%	92.2%
Sep-23	1,679,000	80,000	1,599,000	4.8%	95.2%
Oct-23	1,683,000	76,000	1,606,000	4.5%	95.5%
Nov-23	1,761,000	75,000	1,685,000	4.3%	95.7%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Dec-23	1,717,000	71,000	1,647,000	4.1%	95.9%
Jan-24	1,735,000	65,000	1,669,000	3.8%	96.2%
Feb-24	1,819,000	69,000	1,750,000	3.8%	96.2%
Mar-24	1,830,000	67,000	1,763,000	3.7%	96.3%
April-24	1,814,000	67,000	1,747,000	3.7%	96.3%
May-24	1,864,000	66,000	1,798,000	3.6%	96.4%
June-24	1,875,000	66,000	1,809,000	3.5%	96.5%
July-24	1,833,000	63,000	1,770,000	3.5%	96.5%
Aug-24	1,743,000	60,000	1,683,000	3.4%	96.6%
Sep-24	1,873,000	61,000	1,812,000	3.3%	96.7%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between September 2023 and September 2024	194,000	-19,000	213,000	-1.5 ppt	+1.5 ppt
% Change in vehicles between September 2023 and September 2024	11.6%	-24%	13.3%	N/A	N/A
Change between June 2023 and September 2024	159,000	-95,000	254,000	-5.8 ppt	+5.8 ppt

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between June 2023 and September 2024	9.3%	-61%	16.3%	N/A	N/A

Table 43: Daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. Taxis) detected in the expanded outer London area per month (rounded to nearest 1,000)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	745,000	93,000	652,000	12.5%	87.5%
Nov-22	780,000	78,000	702,000	10.0%	90.0%
May-23	1,371,000	110,000	1,261,000	8.0%	92.0%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jun-23	1,483,000	113,000	1,369,000	7.6%	92.4%
Jul-23	1,473,000	107,000	1,367,000	7.2%	92.8%
Aug-23	1,416,000	91,000	1,325,000	6.4%	93.6%
Sep-23	1,457,000	52,000	1,405,000	3.6%	96.4%
Oct-23	1,459,000	49,000	1,409,000	3.4%	96.6%
Nov-23	1,526,000	48,000	1,478,000	3.2%	96.8%
Dec-23	1,521,000	49,000	1,472,000	3.2%	96.8%
Jan-24	1,516,000	43,000	1,473,000	2.8%	97.2%
Feb-24	1,584,000	45,000	1,539,000	2.9%	97.1%
Mar-24	1,603,000	45,000	1,558,000	2.8%	97.2%
April-24	1,581,000	44,000	1,537,000	2.8%	97.2%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-24	1,628,000	44,000	1,584,000	2.7%	97.3%
June-24	1,639,000	44,000	1,595,000	2.7%	97.3%
July-24	1,592,000	42,000	1,550,000	2.6%	97.4%
Aug-24	1,519,000	40,000	1,479,000	2.6%	97.4%
Sep-24	1,635,000	41,000	1,594,000	2.5%	97.5%
Change between September 2023 and September 2024	178,000	-11,000	189,000	-1.1 ppt	+ 1.1 ppt
% Change in vehicles between September 2023 and September 2024	12.2%	-21%	13.5%	N/A	N/A

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between June 2023 and September 2024	152,000	-72,000	224,000	-5.1 ppt	+ 5.1 ppt
% Change in vehicles between June 2023 and September 2024	10.3%	-64%	16.4%	N/A	N/A

Table 44: Daily average number and proportion of ULEZ compliant diesel cars (M1 excl. PHVs and taxis) detected in the expanded outer London area per month (rounded to nearest 100)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	214,000	85,800	128,200	40.1%	59.9%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Nov-22	206,700	72,500	134,200	35.1%	64.9%
May-23	312,900	100,300	212,600	32.1%	67.9%
Jun-23	332,200	103,100	229,100	31.0%	69.0%
Jul-23	324,400	97,000	227,400	29.9%	70.1%
Aug-23	298,800	82,400	216,400	27.6%	72.4%
Sep-23	282,800	47,600	235,200	16.8%	83.2%
Oct-23	280,400	45,100	235,200	16.1%	83.9%
Nov-23	286,700	44,000	242,700	15.4%	84.6%
Dec-23	285,400	44,900	240,600	15.7%	84.3%
Jan-24	277,900	39,200	238,700	14.1%	85.9%
Feb-24	290,200	41,200	249,100	14.2%	85.8%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Mar-24	292,000	40,600	251,300	13.9%	86.1%
April-24	286,900	39,900	247,000	13.9%	86.1%
May-24	292,400	39,800	252,600	13.6%	86.4%
June-24	293,000	39,500	253,400	13.5%	86.5%
July-24	281,700	37,800	243,900	13.4%	86.6%
Aug-24	262,600	36,100	226,400	13.8%	86.2%
Sep-24	288,400	37,200	251,200	12.9%	87.1%
Change between September 2023 and September 2024	5,600	-10,400	16,000	-3.9 ppt	+3.9 ppt

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between September 2023 and September 2024	2.0%	-22%	6.8%	N/A	N/A
Change between June 2023 and September 2024	-43,800	-65,900	22,200	-18.2 ppt	+18.2 ppt
% Change in vehicles between June 2023 and September 2024	-13.2%	-64%	9.7%	N/A	N/A

Table 45: Daily average number and proportion of ULEZ compliant vans (N1) detected in the expanded outer London area per month (rounded to nearest 100)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	113,300	35,000	78,300	30.9%	69.1%
Nov-22	141,400	31,400	110,000	22.2%	77.8%
May-23	183,800	39,000	144,700	21.2%	78.8%
Jun-23	201,100	41,200	160,000	20.5%	79.5%
Jul-23	194,000	38,300	155,600	19.8%	80.2%
Aug-23	190,600	35,200	155,500	18.5%	81.5%
Sep-23	191,300	26,400	164,900	13.8%	86.2%
Oct-23	193,500	25,400	168,100	13.1%	86.9%
Nov-23	203,800	25,500	178,300	12.5%	87.5%
Dec-23	169,500	20,500	149,100	12.1%	87.9%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jan-24	189,900	20,800	169,100	11.0%	89.0%
Feb-24	204,000	22,400	181,600	11.0%	89.0%
Mar-24	195,000	22,400	181,600	11.0%	89.0%
April-24	199,500	22,400	181,600	11.0%	89.0%
May-24	200,200	22,400	181,600	11.0%	89.0%
June-24	198,900	22,400	181,600	11.0%	89.0%
July-24	204,300	22,400	181,600	11.0%	89.0%
Aug-24	188,700	22,400	181,600	11.0%	89.0%
Sep-24	201,700	22,400	181,600	11.0%	89.0%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between September 2023 and September 2024	10,400	-8,000	18,400	-4.7 ppt	+ 4.7 ppt
% Change in vehicles between September 2023 and September 2024	5.4%	-30%	11.2%	N/A	N/A
Change between June 2023 and February 2024	600	-22,700	23,300	-11.3 ppt	+ 11.3 ppt

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between June 2023 and February 2024	0.3%	-55%	14.6%	N/A	N/A

Table 46: Daily average number and proportion of ULEZ compliant minibuses detected in the expanded outer London area per month (rounded to nearest 10)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-22	1,350	420	940	30.8%	69.2%
Nov-22	1,540	400	1,140	26.0%	74.0%
May-23	2,190	540	1,660	24.5%	75.5%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jun-23	2,530	620	1,910	24.6%	75.4%
Jul-23	2,100	550	1,550	26.2%	73.8%
Aug-23	1,450	400	1,060	27.2%	72.8%
Sep-23	2,230	480	1,750	21.3%	78.7%
Oct-23	2,140	460	1,680	21.5%	78.5%
Nov-23	2,560	520	2,040	20.2%	79.8%
Dec-23	1,840	390	1,450	21.3%	78.7%
Jan-24	2,190	430	1,760	19.7%	80.3%
Feb-24	2,260	440	1,810	19.6%	80.4%
Mar-24	2,410	460	1,940	19.2%	80.8%
April-24	2,950	380	1,570	19.3%	80.7%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-24	2,340	450	1,890	19.2%	80.8%
June-24	2,590	510	2,070	19.8%	80.2%
July-24	2,290	470	1,820	20.4%	79.6%
Aug-24	2,410	300	1,120	20.9%	79.1%
Sep-24	2,340	400	1,940	17.1%	82.9%
Change between September 2023 and September 2024	110	-80	190	-4.3 ppt	+ 4.3 ppt
% Change in vehicles between September 2023 and September 2024	4.9%	-16%	10.6%	N/A	N/A

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between June 2023 and September 2024	-190	-220	30	-7.5 ppt	+ 7.5 ppt
% Change in vehicles between June 2023 and September 2024	-7.7%	-36%	1.5%	N/A	N/A

Table 47: Daily average number and proportion of ULEZ compliant motorcycles (L) detected in the expanded outer London area per month (rounded to nearest 10)

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
May-23[90]	23,590	1,000	22,580	4.2%	95.8%
Jun-23	28,060	1,220	26,840	4.4%	95.6%
Jul-23	27,420	1,150	26,270	4.2%	95.8%
Aug-23	27,650	1,110	26,540	4.0%	96.0%
Sep-23	28,330	960	27,370	3.4%	96.6%
Oct-23	28,020	890	27,130	3.2%	96.8%
Nov-23	28,110	880	27,240	3.1%	96.9%
Dec-23	24,760	760	24,000	3.1%	96.9%

[90] Data on motorcycles available from May 2023 following enhancements to the camera network in preparation for London-wide ULEZ scheme. Data for May 2023 included the first data available from some cameras installed as part of the network changes, as well as bank holidays (including the coronation).

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Jan-24	25,970	770	25,190	3.0%	97.0%
Feb-24	28,870	860	28,010	3.0%	97.0%
Mar-24	29,860	890	28,970	3.0%	97.0%
April-24	31,250	1,000	30,240	3.2%	96.8%
May-24	33,480	1,100	32,380	3.3%	96.7%
June-24	34,800	1,190	33,610	3.4%	96.6%
July-24	34,160	1,120	33,040	3.3%	96.7%
Aug-24	33,580	1,110	32,470	3.3%	96.7%
Sep-24	33,950	1,100	32,850	3.2%	96.8%

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
Change between September 2023 and September 2024	5,620	140	5,480	-0.2 ppt	+ 0.2 ppt
% Change in vehicles between September 2023 and September 2024	19.8%	15%	20%	N/A	N/A
Change between June 2023 and September 2024	5,890	-120	6,010	-1.1 ppt	+ 1.1 ppt

Date	Unique vehicles detected in 2023 expanded ULEZ zone[89]	Number of non-compliant vehicles	Number of compliant vehicles	Proportion of non-compliant vehicles	Proportion of compliant vehicles
% Change in vehicles between June 2023 and September 2024	21%	-10%	22.4%	N/A	N/A

Appendix 2 – Air quality emissions

Methodology for estimating emissions between 2019 and 2024

Emissions for each year between 2019 and 2024 have been estimated using calculated emission rates for observed vehicle fleet composition and vehicle kilometre data for traffic on the road network in the ULEZ area (excluding M25 and roads outside London) as represented in the London Atmospheric Emissions Inventory 2019[16]. Observations of fleet compositions outside the London area and on the M25 are not available to the same level of detail.

The annual vehicle fleet compositions are based on analysis of daily captures from the available TfL camera network by vehicle type for each of central, inner and outer London ULEZ areas, aggregated to each year. The annual fleet composition is based on circulating traffic and represents the proportion of vehicle kilometres driven, reflecting that some vehicles travel much further and/or more frequently than others (e.g. delivery drivers, PHV's). The proportions by fuel type (e.g. petrol, diesel, hybrid, electric), age and Euro standard of vehicles are based on analysis of observations from TfL's camera network. London's vehicle fleet becomes cleaner over time and policies like ULEZ, LEZ, and taxi and PHV licensing requirements continue to influence the fleet composition by incentivising the uptake of cleaner vehicles above and beyond natural turnover. Fleet composition changes would also include the impacts of the Mayor's scrappage scheme and reflect consumer awareness of issues such as the Dieselgate scandal and the trend of increasing uptake of electric vehicles, which work alongside schemes such as ULEZ to encourage cleaner vehicles.

Vehicle kilometre estimates for the ULEZ area in 2019 are based on the London Atmospheric Emissions Inventory 2019[16]. Data from available Automatic Traffic Count (ATC) sites across London, as well as Department for Transport (DfT) manual traffic counts[84] providing annual average traffic flows by vehicle type, have been used to calculate the growth in traffic on roads in London, which was then used to calculate the annual vehicle kilometres travelled, up to and including 2023. As DfT data (by vehicle type) is not available for 2024, the change in total traffic between 2023 and 2024 has been based on TfL ATC data, and the proportion of kilometres of each vehicle type have been assumed the same as in 2023. Table 48 provides the overall vehicle kilometres for the ULEZ zone between 2019 and 2024. Supplementary Data Sheet 1 - Emissions provides further breakdown of the vehicle kilometres for central, inner and outer London ULEZ areas.

Table 48: Annual vehicle kilometres by vehicle type between 2019 and 2024 in the ULEZ area in billion vehicle kilometres (Bvkm)

Year	Total	Cars	PHV	Taxis	Motor-cycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	27.62	19.65	1.12	0.58	0.60	3.77	0.84	0.24	0.31	0.49
2020	22.44	15.52	0.88	0.46	0.47	3.45	0.78	0.22	0.25	0.42
2021	24.17	16.76	0.94	0.49	0.57	3.65	0.85	0.22	0.27	0.43
2022	25.45	17.59	0.98	0.50	0.68	3.82	0.90	0.22	0.28	0.48
2023	25.38	17.53	0.98	0.50	0.68	3.81	0.90	0.22	0.28	0.48
2024	25.63	17.71	0.99	0.51	0.69	3.85	0.91	0.22	0.28	0.48

COPERT[68] speed related vehicle emissions factors require vehicle speeds for traffic. Annual average speeds from the LAEI 2019 have been used, providing wider coverage of speeds across the network than individual traffic count point information. Average speeds are lowest in central London and highest in outer London[13]. No further assumptions on changes to traffic speeds across years have been applied.

Combining speed-related emission factors with fleet composition information, vehicle kilometres and speeds allows an annual emission rate by vehicle type to be calculated. For this report, annual emission rates have been used to calculate the annual NO_X, $PM_{2.5}$ and CO_2 exhaust emissions from road traffic. Table 49 provides an example of the emission rates for NO_X for 2019 to 2024 split by vehicle type for central London. Further tables showing the annual emission rates for inner and outer London, and for $PM_{2.5}$ and CO_2 by vehicle type are provided in Supplementary Data Sheet 1 – Emissions.

Table 49: Average NO_X emission rate (g/km) by vehicle type in central ULEZ area for 2019 to 2024

Year	Cars	PHV	Taxi	Motor-cycle	Van	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	0.370	0.255	1.202	0.110	1.074	1.938	2.707	6.048	0.794
2020	0.283	0.220	0.858	0.100	0.943	1.386	1.840	4.457	0.731
2021	0.250	0.196	0.794	0.100	0.894	1.287	1.608	4.863	0.674
2022	0.207	0.159	0.703	0.089	0.752	1.181	1.426	5.854	0.659
2023	0.176	0.128	0.528	0.082	0.615	1.105	1.190	5.526	0.661
2024	0.160	0.112	0.402	0.078	0.537	1.020	1.071	5.774	0.653

Table 49 shows how the average emission rate of each vehicle type continues to reduce over time in central London. The ULEZ was in place in central London in April 2019 (and included both heavy and light vehicles) but it can be seen that emission rates continue to reduce in the central London area as the fleet continues to improve as well as being compounded with on-going impacts of the wider roll out of the LEZ to whole of London in March 2021, inner ULEZ expansion in October 2021 and then the London-wide ULEZ expansion to outer London in August 2023.

Whilst annual emission rates have been used for the estimation of emissions, the data analysis is based on monthly data, and these emission rates provide useful insight to the ongoing changes in average vehicle emissions over time, based on vehicles observed each month. Figure 21 shows the average monthly emission rate for cars (excluding PHVs) and vans in central, inner and outer London. Reductions in emission rates in central London in April 2019 coincided with the introduction of the central London ULEZ, and the impact of inner London ULEZ expansion in October 2021 can be clearly seen for both cars and vans, whilst outer London emission rates reduced further throughout 2023 and following the ULEZ expansion to outer London in August 2023. The trend in monthly emission rates fluctuates, reflecting differing levels of activity over time, including during the Covid pandemic and post-pandemic recovery, seasonality (e.g. school holidays and Christmas), and the general mix of vehicles being driven in different areas. Complex patterns of emission rates across the zones occur, especially in central London, where speeds tend to be much lower on average and simultaneously the Congestion Charge also operates.

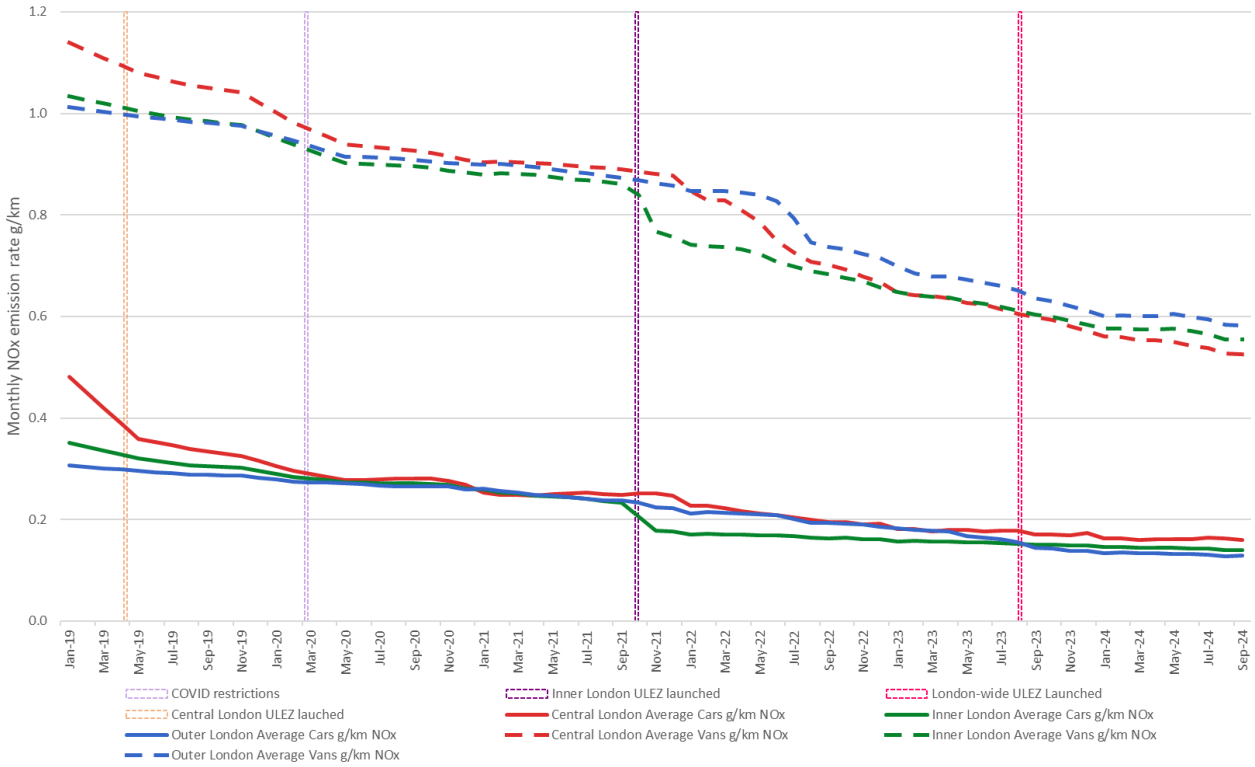

Figure 21: Average monthly NO_X emission rate (g/km) for cars (excluding PHVs) and vans in London ULEZ areas

Annual emissions are calculated for each year by multiplying the annual vehicle kilometres by the average emission rate for each vehicle type. For 2019 through to 2024 the annual emissions reflect the observed situation i.e. with ULEZ in place. The following section provides a summary of how emissions changed between 2023 and 2024, and whilst these do not represent the impact of ULEZ, they provide useful information on current road transport exhaust emissions trends in London.

Emission trends between 2023 and 2024

This section provides annual trends in exhaust emissions from road transport in 2023 and 2024. This comparison is based on observed traffic flows and vehicle fleet compositions that includes both natural vehicle fleet turnover and any additional effects of ULEZ phases and other policies (such as changes to taxi licensing requirements) on the fleet in both years. Emissions rates in 2023 reflect the observed data which includes the operation of the previous expansion of the ULEZ to inner London and the subsequent expansion of the ULEZ to London-wide from 29th August 2023. These overall changes in emissions between

2023 and 2024 do not represent the impact of the London-wide ULEZ expansion – the impacts of ULEZ on emissions are presented in the Emissions section of the report.

Emissions estimates do not include areas outside London or the M25.

Table 50 provides the emissions for NO_X from light vehicles (cars including PHVs, vans and motorcycles) and heavy vehicle (HGVs, buses and coaches) in 2023 and 2024, and Table 51 provides the change in NO_X emissions. Table 52 and Table 53 provides $PM_{2.5}$ exhaust emissions, and Table 54 and Table 55 provide CO_2 exhaust emissions.

Table 50: NO_X emissions (tonnes) from light vehicles (cars, vans, motorcycles and taxis) and heavy vehicles (HGVs and buses and coaches) in 2023 and 2024

London Zone	2023 – Light Vehicles	2023 – Heavy Vehicles	2023 -All Vehicles	2024 – Light Vehicles	2024 – Heavy Vehicles	2024 -All Vehicles
Central	130	100	230	110	100	210
Inner	1,560	560	2,120	1,420	500	1,920
Outer	3,970	800	4,770	3,410	670	4,080
London-wide	5,660	1,460	7,120	4,950	1,270	6,220

Table 51: Change in NO_X emissions (tonnes and percentage) between 2023 and 2024

London zone	Change in Emissions (Tonnes) - Light Vehicles	Change in Emissions (Tonnes) - Heavy Vehicles	Change in Emissions (Tonnes) - All Vehicles	Change in Emissions (%) - Light Vehicles	Change in Emissions (%) - Heavy Vehicles	Change in Emissions (%) - All Vehicles
Central	-20	-	-20	-14%	1%	-8%
Inner	-140	-60	-200	-9%	-11%	-9%
Outer	-560	-130	-690	-14%	-16%	-15%
London-wide	-720	-190	-910	-13%	-13%	-13%

Table 52: $PM_{2.5}$ exhaust emissions (tonnes) from light vehicles (cars, vans, motorcycles and taxis) and heavy vehicles (HGVs and buses and coaches) in 2023 and 2024

London zone	2023 Light Vehicles	2023 Heavy Vehicles	2023 All Vehicles	2024 Light Vehicles	2024 Heavy Vehicles	2024 All Vehicles
Central	1	1	2	1	1	1
Inner	10	5	15	9	4	13

London zone	2023 Light Vehicles	2023 Heavy Vehicles	2023 All Vehicles	2024 Light Vehicles	2024 Heavy Vehicles	2024 All Vehicles
Outer	28	8	36	20	7	27
London-wide	39	13	52	30	12	42

Table 53: Change in $PM_{2.5}$ exhaust emissions (tonnes and percentage) between 2023 and 2024

London zone	Change in Emissions (Tonnes) - Light Vehicles	Change in Emissions (Tonnes) - Heavy Vehicles	Change in Emissions (Tonnes) - All Vehicles	Change in Emissions (%) - Light Vehicles	Change in Emissions (%) - Heavy Vehicles	Change in Emissions (%) - All Vehicles
Central	-0	-	-0	-11%	-1%	-6%
Inner	-1	-1	-1	-9%	-10%	-9%
Outer	-7	-1	-9	-27%	-15%	-24%
London-wide	-8	-2	-10	-22%	-13%	-20%

Table 54: CO_2 exhaust emissions (tonnes) from light vehicles (cars, vans, motorcycles and taxis) and heavy vehicles (HGVs and buses and coaches) in 2023 and 2024

London zone	2023 Light Vehicles	2023 Heavy Vehicles	2023 All Vehicles	2024 Light Vehicles	2024 Heavy Vehicles	2024 All Vehicles
Central	78,000	55,000	132,000	75,000	54,000	129,000
Inner	1,061,000	511,000	1,572,000	1,037,000	490,000	1,527,000
Outer	2,571,000	892,000	3,463,000	2,521,000	847,000	3,368,000
London-wide	3,710,000	1,458,000	5,168,000	3,633,000	1,391,000	5,023,000

Table 55: Change in CO_2 exhaust emissions (tonnes and percentage) between 2023 and 2024

London zone	Change in Emissions (Tonnes) - Light Vehicles	Change in Emissions (Tonnes) - Heavy Vehicles	Change in Emissions (Tonnes) - All Vehicles	Change in Emissions (%) - Light Vehicles	Change in Emissions (%) - Heavy Vehicles	Change in Emissions (%) - All Vehicles
Central	-3,000	-1,000	-4,000	-4%	-2%	-3%
Inner	-24,000	-21,000	-45,000	-2%	-4%	-3%
Outer	-50,000	-45,000	-95,000	-2%	-5%	-3%

London zone	Change in Emissions (Tonnes) - Light Vehicles	Change in Emissions (Tonnes) - Heavy Vehicles	Change in Emissions (Tonnes) - All Vehicles	Change in Emissions (%) - Light Vehicles	Change in Emissions (%) - Heavy Vehicles	Change in Emissions (%) - All Vehicles
London-wide	-77,000	-67,000	-144,000	-2%	-5%	-3%

Across London, emissions of NO_X from all vehicles are estimated to be 13 per cent lower in 2024 compared to 2023. Reductions have occurred in all London zones, with central London reduced by 8 per cent, inner London reduced by 9 percent, and the largest reduction of 15 per cent in outer London. The greater reduction in outer London reflects that the ULEZ is now fully operational in this area.

Exhaust emissions of $PM_{2.5}$ have reduced by 20 per cent London-wide between 2023 and 2024. Reductions in central, inner and outer London were 6 per cent, 9 per cent and 24 per cent respectively.

Exhaust emissions of CO_2 have reduced by 3 per cent London-wide between 2023 and 2024, with similar percentage reductions in all zones.

Supplementary Data Sheet 1 – Emissions provides the emissions for 2023 and 2024 for all vehicle types.

Methodology for No ULEZ and No London-wide ULEZ emissions

Emissions for 2019 to 2024 represent observed traffic and fleet compositions.

In order to estimate the impact of the ULEZ, a “No ULEZ” scenario for fleet compositions with only natural churn in the vehicle fleet, and vehicle kilometres without ULEZ impacts have been used. The resulting emissions represent what they would have been without the ULEZ in place.

Fleet compositions for the “No ULEZ” scenario in 2019 to 2022 are based on fleet compositions used in previous reports for the inner London ULEZ. These were derived

from projections in the LAEI 2016[91] prior to expanding the ULEZ to inner and outer London, and prior to tightened LEZ standards. The fleet compositions for taxi licensing represent those without additional age limits and licensing requirements for zero-emission capable taxis as these were part of the complementary packages of measures to reduce emissions alongside ULEZ. The TfL bus fleet assumes previous forecasts of the fleet prior to policy changes related to LEZ standards and electric bus uptake is more limited. The trend from the 2019-2022 has been used to forecast the emissions for 2023 and 2024 without the ULEZ.

For this report an additional set of emissions has been estimated representing 2023 and 2024 without the London-wide ULEZ expansion in outer London, but with previous phases of the ULEZ in place, and assuming some natural churn would occur between 2023 and 2024. The resulting emissions represent what they would have been without the London-wide ULEZ expansion in place.

Fleet compositions for the 2023 “No London-wide ULEZ” scenario are derived from the observed fleet in 2023 and adjusted using the response modelling previously undertaken for the consultation and planning of the London-wide ULEZ expansion. Based on monitoring, the performance of the London-wide ULEZ is in-line with the consultation modelling and it was, therefore, considered to be suitable to use the response modelling to roll back the observed fleet in order to represent the scenario without it.

The observed changes in vehicle fleet for inner London between 2023 and 2024 have been used as a proxy for natural turnover that would be expected in outer London without the London-wide ULEZ. These changes have been applied to the “No London-wide ULEZ” scenario fleet for 2023 to obtain 2024 estimates. This method has been used because the ULEZ was already operating in inner London meaning changes between 2023 and 2024 mainly represent vehicle churn. Assuming some natural churn in outer London is important to reflect that improvements in the fleet would be expected to occur in this area even without the expansion of the ULEZ and that estimated impact on emissions excludes the natural churn.

Figure 22 shows the average emission rate for cars for observed data (ULEZ), and for the “No ULEZ”, and “No London-wide ULEZ” scenarios for 2019 to 2024. It can be seen that

[91] London Atmospheric Emissions Inventory (LAEI) 2016. Available at London Atmospheric Emissions Inventory (LAEI) 2016 - London Datastore

the emission rates for the scenarios without the scheme are predicted to reduce each year as the vehicles becomes cleaner due to natural vehicle churn. The ULEZ scheme-related emission rates improve much more rapidly as a result of the scheme, incentivising the faster uptake and use of cleaner vehicles and faster removal of the older, more polluting vehicles than would otherwise occur due to natural churn. It can be seen that especially in outer London, the emission rates for the observed ULEZ are lower than the “No London-wide ULEZ” scenario reflecting the additional contribution of this phase of the scheme to improving emissions.

Average emission rates for each vehicle type for each scenario are provided in Supplementary Data Sheet 1 - Emissions.

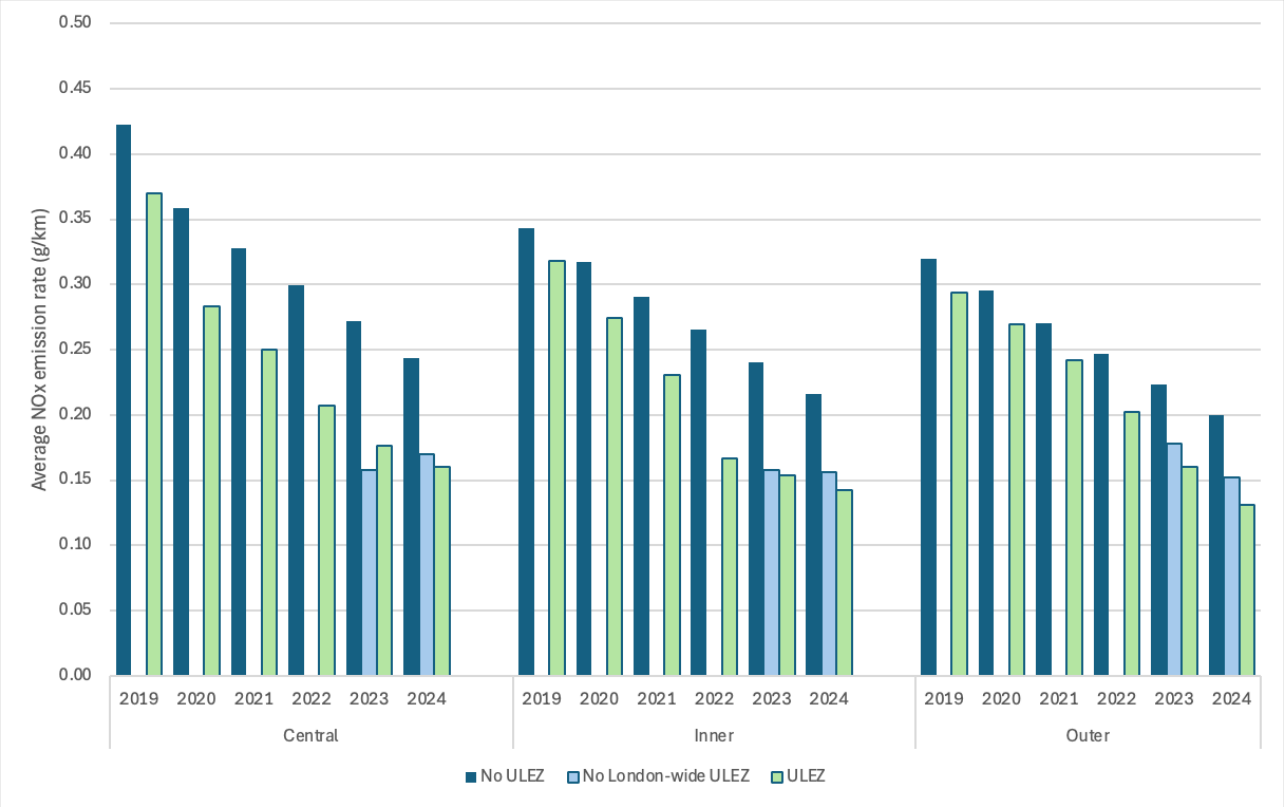

Figure 22: Average NO_x emission rate (g/km) for cars (excluding PHVs) in London ULEZ areas for ULEZ (observed), No ULEZ and No London-wide ULEZ

Vehicle kilometre adjustments for the No ULEZ and No London-wide ULEZ scenarios are based on previous ULEZ impact and consultation reports. Table 56 to Table 58 show the percentage impacts on kilometres by vehicle type for central, inner and outer London respectively. A negative percentage means the scheme would have reduced vehicle kilometres; therefore observed vehicle kilometres have been increased to take account of the impact of the “No ULEZ” and “No London-wide ULEZ” scenarios.

Table 56: Percentage impacts on kilometres by vehicle type in central London.

Year	Cars	PHV	Taxis	Motor cycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	-6.2	-6.2	-	-6.2	-6.2	-6.2	-6.2	-6.2	-
2020	-	-	-	-	-	-	-	-	-
2021	-0.7	-0.7	-	-0.7	-0.7	-	-	-	-
2022	-2.7	-2.7	-	-2.7	-2.7	-	-	-	-
2023	-0.9	-0.9	-	-	0.0	-	-	-	-
2024	-0.9	-0.9	-	-	0.0	-	-	-	-

Table 57: Percentage impacts on kilometres by vehicle type in inner London.

Year	Cars	PHV	Taxis	Motorcycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	-1.1	-1.1	-	-1.1	-1.1	-1.1	-1.1	-1.1	-
2020	-	-	-	-	-	-	-	-	-
2021	-0.7	-0.7	-	-0.7	-0.7	-	-	-	-
2022	-2.7	-2.7	-	-2.7	-2.7	-	-	-	-
2023	1.0	1.0	-	-	-0.2	-	-	-	-
2024	1.0	1.0	-	-	-0.2	-	-	-	-

Table 58: Percentage impacts on kilometres by vehicle type in outer London.

Year	Cars	PHV	Taxis	Motorcycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	0.5	0.5	-	0.5	0.5	0.5	0.5	0.5	-
2020	-	-	-	-	-	-	-	-	-
2021	-1.0	-1.0	-	-1.0	-1.0	-	-	-	-
2022	-2.2	-2.2	-	-2.2	-2.2	-	-	-	-
2023	-1.0	-1.0	-	-	0.0	-	-	-	-
2024	1.0	1.0	-	-	-0.2	-	-	-	-

Table 59 provides the “No ULEZ” vehicle kilometres. And Table 60 provided the vehicle kilometres for the “No London-wide ULEZ”. Further tables with the vehicle kilometres for these scenarios in each ULEZ area are provided in Supplementary Data Sheet 1 - Emissions.

Table 59: Annual vehicle kilometres by vehicle type between 2019 and 2024 in ULEZ area in billion vehicle kilometres (Bvkm) for No ULEZ scenario

Year	Total	Cars	PHV	Taxis	Motorcycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2019	27.63	19.64	1.13	0.58	0.61	3.78	0.84	0.24	0.31	0.49
2020	22.43	15.52	0.88	0.46	0.47	3.44	0.78	0.22	0.25	0.42
2021	24.36	16.90	0.95	0.49	0.57	3.68	0.85	0.22	0.27	0.43
2022	25.98	17.99	1.01	0.50	0.70	3.91	0.90	0.22	0.28	0.48
2023	25.46	17.61	0.98	0.50	0.68	3.81	0.90	0.22	0.28	0.48
2024	25.44	17.53	0.98	0.51	0.69	3.85	0.91	0.22	0.28	0.48

Table 60: Annual vehicle kilometres by vehicle type between 2019 and 2024 in ULEZ area in billion vehicle kilometres (Bvkm) for No London-wide ULEZ scenario

Year	Total	Cars	PHV	Taxis	Motorcycles	Vans	Rigid HGVs	Artic HGVs	Non TfL Buses and Coaches	TfL Buses
2023	25.46	17.61	0.98	0.50	0.68	3.81	0.90	0.22	0.28	0.48
2024	25.44	17.53	0.98	0.51	0.69	3.85	0.91	0.22	0.28	0.48

Results

Table 16 shows the estimated cumulative NO_X emissions in London, split by vehicle type between 2019 and 2024, with and without ULEZ. The data for each year between 2019 and 2024 is shown in Table 61.

Table 61: Estimated annual NO_X emissions (tonnes) across London split by vehicle type between 2019 and 2024 with and without all ULEZ phases

Scenario	Year	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
NO ULEZ	2019	16,600	6,880	3,700	640	3,670	1,710
NO ULEZ	2020	12,680	5,020	3,230	480	2,670	1,290
NO ULEZ	2021	12,360	5,020	3,290	480	2,340	1,220
NO ULEZ	2022	11,990	4,900	3,400	490	1,990	1,210
NO ULEZ	2023	10,700	4,350	3,200	470	1,590	1,090
NO ULEZ	2024	9,680	3,900	3,090	450	1,270	980
ULEZ	2019	14,460	6,260	3,750	640	2,890	910
ULEZ	2020	10,290	4,440	3,160	360	1,940	380
ULEZ	2021	9,460	4,250	3,190	360	1,450	220
ULEZ	2022	8,670	3,610	2,920	330	1,570	240
ULEZ	2023	7,120	2,950	2,460	260	1,230	230
ULEZ	2024	6,220	2,510	2,230	200	1,050	210
Change	2019	-2,140	-620	50	0	-780	-800
Change	2020	-2,390	-580	-70	-110	-730	-900
Change	2021	-2,890	-770	-100	-130	-890	-1,000
Change	2022	-3,310	-1,280	-480	-150	-420	-980
Change	2023	-3,570	-1,400	-740	-210	-360	-870
Change	2024	-3,460	-1,380	-850	-250	-210	-760
% Change	2019	-13%	-9%	1%	0%	-21%	-47%
% Change	2020	-19%	-12%	-2%	-24%	-27%	-70%
% Change	2021	-23%	-15%	-3%	-26%	-38%	-82%
% Change	2022	-28%	-26%	-14%	-32%	-21%	-80%
% Change	2023	-33%	-32%	-23%	-45%	-22%	-79%
% Change	2024	-36%	-35%	-28%	-56%	-17%	-78%

Table 19 shows the estimated cumulative $PM_{2.5}$ exhaust emissions in London, split by vehicle type between 2019 and 2024, with and without ULEZ. The data for each year between 2019 and 2024 is shown in Table 62.

Table 62: Estimated annual $PM_{2.5}$ exhaust emissions (tonnes) across London split by vehicle type between 2019 and 2024 with and without all phases of the ULEZ

Scenario	Year	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
NO ULEZ	2019	201.7	114.1	32.6	10.1	32.3	12.5
NO ULEZ	2020	139.3	75.1	23.0	8.2	23.5	9.4
NO ULEZ	2021	124.3	68.7	19.1	7.1	20.4	9.0
NO ULEZ	2022	108.9	61.2	15.7	5.6	17.5	9.0
NO ULEZ	2023	85.2	47.8	11.3	3.8	14.1	8.2
NO ULEZ	2024	64.6	35.7	8.1	2.1	11.3	7.4

Scenario	Year	All Vehicles	Cars[72]	Vans	Taxis	HGVs	TfL Buses
ULEZ	2019	156.9	81.7	32.0	6.8	28.7	7.7
ULEZ	2020	104.4	55.7	23.1	3.4	18.9	3.3
ULEZ	2021	89.6	50.6	20.3	2.1	14.4	2.1
ULEZ	2022	69.5	37.4	14.3	1.4	14.0	2.3
ULEZ	2023	51.7	27.8	10.0	0.7	11.0	2.2
ULEZ	2024	41.6	22.2	7.4	0.5	9.5	2.1
Change	2019	-44.8	-32.4	-0.6	-3.3	-3.6	-4.9
Change	2020	-34.9	-19.4	0.0	-4.8	-4.6	-6.1
Change	2021	-34.7	-18.1	1.2	-5.0	-6.0	-6.9
Change	2022	-39.5	-23.8	-1.4	-4.2	-3.4	-6.7
Change	2023	-33.5	-20.0	-1.3	-3.2	-3.1	-6.0
Change	2024	-23.0	-13.6	-0.6	-1.6	-1.9	-5.3
% Change	2019	-22%	-28%	-2%	-33%	-11%	-39%
% Change	2020	-25%	-26%	0%	-59%	-20%	-65%
% Change	2021	-28%	-26%	6%	-70%	-29%	-76%
% Change	2022	-36%	-39%	-9%	-74%	-20%	-75%
% Change	2023	-39%	-42%	-12%	-82%	-22%	-73%
% Change	2024	-36%	-38%	-8%	-78%	-17%	-72%

Table 24 shows the estimated cumulative CO_2 emissions in London, split by vehicle type between 2019 and 2024, with and without ULEZ. The data for each year between 2019 and 2024 is shown in Table 63.

Table 63: Estimated annual CO_2 emissions (thousand tonnes) across London split by vehicle type between 2019 and 2024 with and without all phases of the ULEZ

Scenario	Year	All Vehicles	Cars [72]	Vans	Taxis	HGVs	TfL Buses
NO ULEZ	2019	6,079	3,456	854	158	1,186	425
NO ULEZ	2020	4,961	2,661	775	121	1,050	354
NO ULEZ	2021	5,270	2,835	829	126	1,111	369
NO ULEZ	2022	5,538	2,959	891	124	1,157	406
NO ULEZ	2023	5,382	2,830	873	118	1,156	406
NO ULEZ	2024	5,356	2,793	882	113	1,163	406
ULEZ	2019	6,034	3,418	866	157	1,180	413
ULEZ	2020	4,963	2,675	795	98	1,048	347

Scenario	Year	All Vehicles	Cars [72]	Vans	Taxis	HGVs	TfL Buses
ULEZ	2021	5,226	2,830	844	98	1,108	345
ULEZ	2022	5,358	2,873	883	94	1,145	363
ULEZ	2023	5,168	2,753	877	80	1,109	349
ULEZ	2024	5,023	2,694	867	72	1,071	320
Change	2019	-45	-39	12	-1	-6	-12
Change	2020	2	14	20	-23	-2	-7
Change	2021	-44	-5	15	-27	-3	-24
Change	2022	-180	-86	-8	-30	-12	-44
Change	2023	-214	-77	4	-37	-47	-57
Change	2024	-332	-99	-15	-41	-92	-85
% Change	2019	-1%	-1%	1%	0%	0%	-3%
% Change	2020	0%	1%	3%	-19%	0%	-2%
% Change	2021	-1%	0%	2%	-22%	0%	-6%
% Change	2022	-3%	-3%	-1%	-24%	-1%	-11%
% Change	2023	-4%	-3%	0%	-32%	-4%	-14%
% Change	2024	-6%	-4%	-2%	-36%	-8%	-21%

Appendix 3 – Air quality concentrations methodology

Air pollution monitoring concentrations

All air quality data analysis was performed using the open-source statistical software R[92]. Air pollutant monitoring data from approximately 800 real time monitoring analysers across England were initially considered from national and local air quality monitoring networks[93]. The full list of monitoring sites considered is provided in Supplementary Data Sheet 2 - Concentrations published alongside this One Year Report.

Hourly concentrations from these sites were obtained using the R package openair[94], which provides convenient functions to query the key air quality monitoring networks in operation across the UK and download data in bulk, including historical data.

From this extensive dataset of hourly monitoring concentrations, average monthly concentrations have been calculated for each site over the period 2010 to 2024. This report focuses on the results between 2014 and 2024 representing a 10-year period. Monitoring sites have then been grouped by site type to calculate average "Roadside" and "Urban Background" concentrations. For this analysis "Suburban" or "Urban Centre" sites have been treated as "Urban Background". "Kerbside[95]", "Industrial", "Airport" or "Rural" sites have been excluded from the analysis, as they are fewer in number and not typical of population exposure.

Roadside sites are typically within one to five metres of a busy road and usually located close to adult breathing height. Roadside sites enable us to track and understand changes in air pollution concentrations from traffic. These sites give the best estimate of public exposure on busy roads. Roadside sites are useful for identifying air quality hotspots caused by traffic that may have potential health impacts, especially those areas frequented by large numbers of people travelling on the road or pavement or where homes are close to the kerb.

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[92] https://www.r-project.org/

[93] Air quality monitoring stations are run and managed by a variety of different organisations including national and locally-funded sites. There are many reasons why air quality monitoring stations open and close over time, including changing the location to prioritise local hotspots, changes to funding, or meeting legal compliance meaning monitoring is no longer formally required.

[94] https://cran.r-project.org/web/packages/openair/index.html

[95] Kerbside sites, are sites where sampling is within one metre of the kerb of a busy road (London Local Air Quality Management - Technical Guidance 2019 (LLAQM.TG(19))

Urban background sites are located further away from the main sources of emissions and are not influenced by one single nearby pollution source. In London, and most of the rest of England, traffic is the main source for background sites to avoid being influenced by and there are guidelines about how close background sites can be to roads[96]. The benefit of urban background sites is that they are usually representative of air pollution exposure for the wider population.

Additionally, monitoring sites have been grouped by geographical areas to calculate average concentrations for key locations, as follows:

- central, inner and outer London
- a 0–5 km zone around Greater London, recognising this area is close to the boundary of the London-wide ULEZ
- a 5–40 km zone around Greater London which provides a control comparison for outer London
- rest of England (sites beyond 40 km from Greater London) representing wider trends in England (excluding London and its surroundings), distant from the London ULEZ scheme

Air pollution concentrations are highly sensitive to changes in meteorological conditions, such as wind speed, wind direction, precipitation, and temperature, as well as the associated long-range transport of pollutants from outside London. Many pollutants also have a seasonal cycle. This seasonal cycle may be caused by seasonally varying emissions, such as heating in the winter or agricultural emissions during the spring. Seasonal cycles can also be caused by other factors, including sunlight, that can induce chemical reactions between air pollutants, and meteorological conditions hindering dispersal. These seasonal and day-to-day variations can make it difficult to assess short-term trends and the impact of interventions such as the ULEZ. One approach to minimise the impact of these variations is to consider a sufficiently long period. Another is to use statistical methods to smooth out short-term variability, which helps to reduce the impact of weather and seasonal factors.

In line with previous reports, statistical smoothing of the monthly means was carried out using the LOESS (Locally Estimated Scatterplot Smoothing) curve fitting methodology, a type of local polynomial regression, to reduce the impacts of weather and seasonal

[96] London Local Air Quality Management (LLAQM) Technical Guidance 2019. Available at: llaqm_technical_guidance_2019.pdf (london.gov.uk)

changes in the long-term trend data. The smoothing was applied to the average monthly concentrations, using a span parameter[97] of 0.375, in line with previous ULEZ reports.

Over the period covered by the analysis, several monitoring stations have opened, moved, or closed, whilst others may have experienced issues that led to missing data, such as power outages.

In order to remove potential outliers and reduce noise in the averaging and smoothing of the data, a number or rules have been applied to the dataset, as follows:

- A data capture threshold of 75 per cent was applied to the dataset when calculating monthly averages from hourly mean concentrations. This means that, for any given month, if there was less than 75 per cent valid hourly concentrations within that month at a site (i.e. more than 25 per cent data was missing or not reported for any reason), the monthly average was not calculated for that site.
- To avoid / reduce the effect of closed / new sites in operation on the zonal averages, any site with less than three years' worth of data in the period covered by the analysis (2010 – 2024) was not used in the analysis. An exception to this has been made to take account of new sites recently installed across London over the past three years (these sites therefore having less than three years of data), to compensate for the closure of a number of sites in 2024, notably in central London (this last point is the only change compared to the rules applied to filter sites used in the Six Month Report).

Figure 23 provides a map of the London zones and the location of both roadside and urban background monitoring sites that have been used in the analysis.

[97] The span parameter of the LOESS methodology controls the number of datapoints used to smooth the data, and therefore the degree of smoothing. If the span is too small, it can result in insufficient data to determine an accurate fit, resulting in a large variance. If the span is too large, the regression will be over-smoothed, resulting in a loss of information.

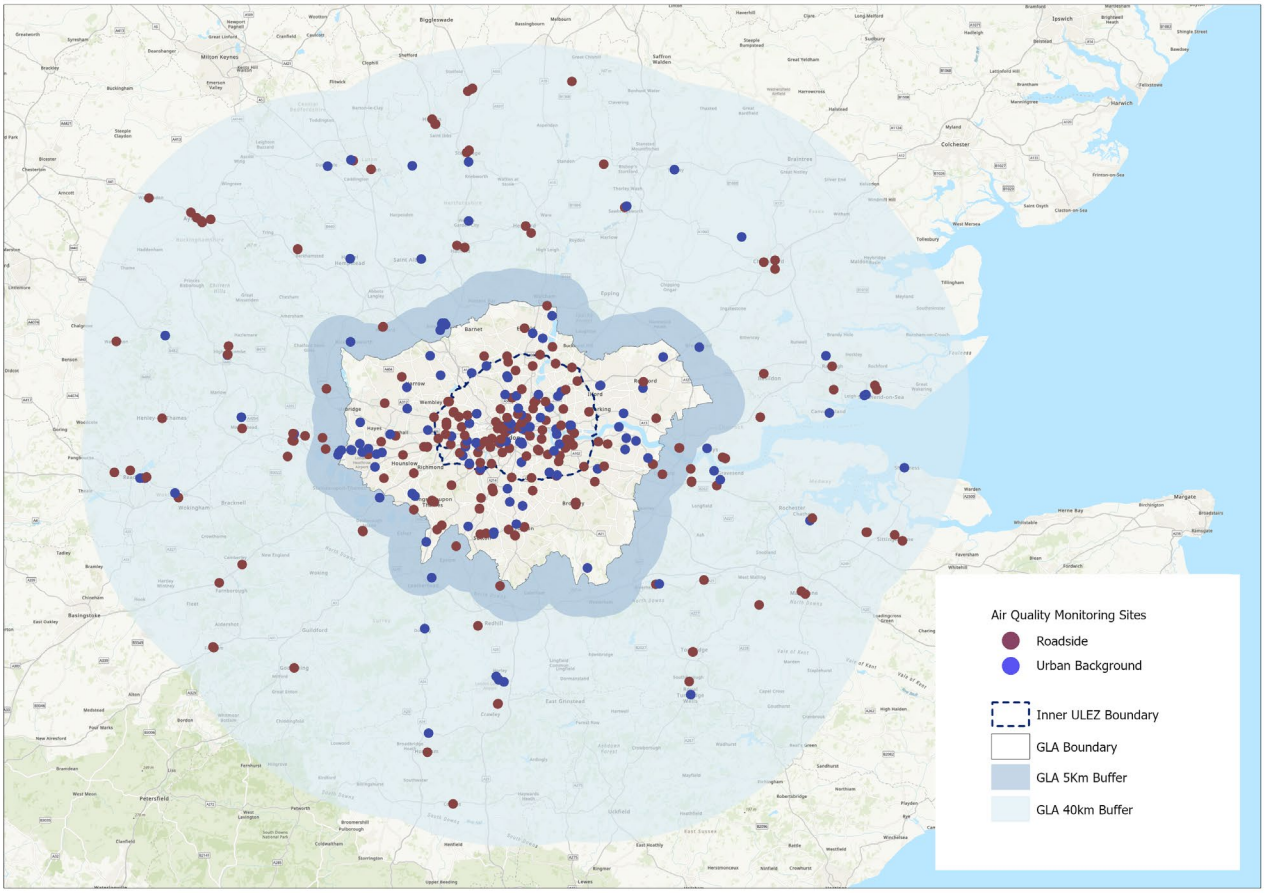

Figure 23: Map of London showing the location of roadside and urban background monitoring sites that were used in the analysis

Table 64 shows the final number of sites used in the analysis, by pollutant, site type, and area, based on the rules described above. The total number of sites used in the analysis (roadside and urban background) is 440 for NO_2 and 197 for $PM_{2.5}$.

Table 64: Summary of the roadside and urban background monitoring sites used in the analysis

Area	Roadside NO_2	Roadside $PM_{2.5}$	Urban Background NO_2	Urban Background $PM_{2.5}$
Central London	9	2	6	6
Inner London	55	31	14	10
Outer London	29	12	26	15
5km from GLA Boundary	8	1	7	8
5-40km from GLA Boundary	47	12	18	3
Rest of England	155	45	66	52
Total used in Analysis	**303**	**103**	**137**	**94**

Further to the above, the below maps show the location of the monitoring locations identified by Site ID and site type (i.e. roadside or urban background), corresponding to the heatmap of concentrations over time in Figure 8 and Figure 9.

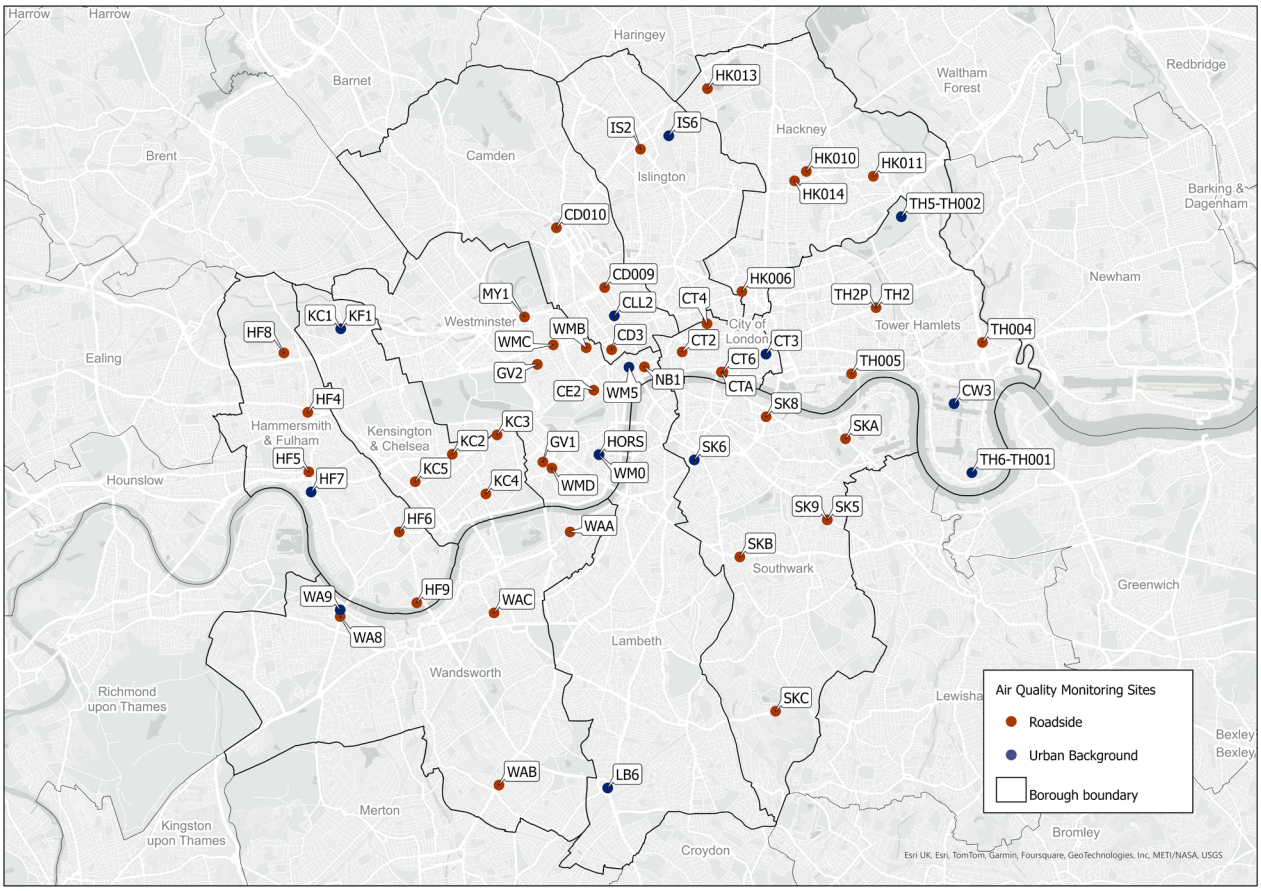

Figure 24: Map showing monitoring locations in central and inner London boroughs, labelled with Site ID and colour-coded by site type

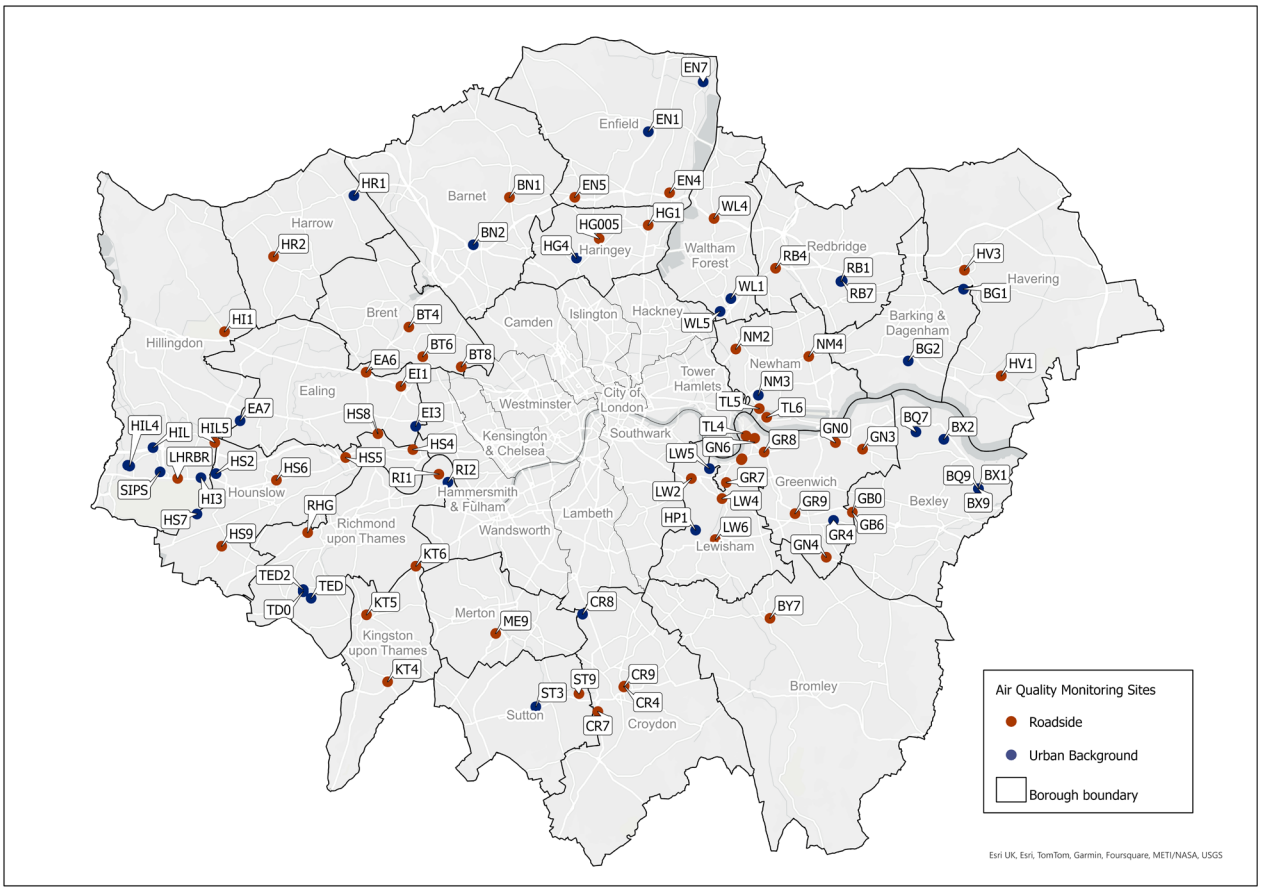

Figure 25: Map showing monitoring locations in outer London boroughs, labelled with Site ID and colour-coded by site type

Methodology to estimate the "No ULEZ" scenario

The method used in this report to estimate the trend in concentrations across London if the ULEZ had not been implemented is based on a similar approach used in the earlier central and inner London ULEZ monitoring reports. The use of control sites, and an estimated "No ULEZ" scenario, are fundamentally required, as observed data will always represent the situation with the ULEZ being in operation. This method also recognises that a general trend of improvement in concentrations would normally be expected even without the ULEZ because there is natural fleet churn, whereby older vehicles drop out of the fleet and newer cleaner vehicles come into it over time.

It notably uses the notion of "road increment[98]" concentration at roadside sites (described in more detail further below). The road increment is defined as the total concentration observed at roadside sites minus the background concentration. Removing the background component from roadside concentration allows for the isolation of the traffic related component, or signal, within observed concentrations.

The average changes in road increment in areas unlikely to be affected by the ULEZ have been applied to the London zones (central, inner, outer) to estimate the likely trend in concentration, assuming the ULEZ was not in place.

The previous ULEZ reports used the following principles:

- measured data from air quality monitoring stations have been used as the basis for all analysis
- outer London serves as a suitable control area against which to assess the impact of the central and inner London ULEZ
- the changes in road increment of NO_2 in outer London (subtracting outer urban background concentrations from total roadside concentrations in outer London) represented the trend that would be expected without the ULEZ package of measures
- concentrations for a "No ULEZ" scenario are estimated, in order to assess observed changes in concentration trends

In addition, in order to assess the impact of the third phase of the ULEZ (the expansion to include outer London), for this analysis, a further control zone between 5-40 km of London was added.

Monitoring trends from the area between 5-40 km from London have been considered suitable to enable an assessment of the impacts in outer London and in the immediate 0-5 km around the boundary. The 5-40 km control zone was chosen because:

- it does not include sites immediately around the boundary of the ULEZ
- it excludes sites in the south of England that are affected by different local meteorological conditions especially on the coast
- meteorological and regional background influences in this surrounding area are similar to those for London, which is unlikely to be the case for the rest of England

[98] Font, A. & Fuller, G. (2016) Did policies to abate atmospheric emissions from traffic have a positive effect in London? Environmental Pollution, Volume 218, November 2016, Pages 463-474

NO_2 road increment calculations

A technique often used to isolate the proportion of pollution related to traffic sources is to subtract the background concentration from the roadside concentration. The resulting concentration is referred to as the "road increment". This road increment isolates the changes in concentration at the roadside from changes in background concentrations, using the equation below:

$$R_{inc} = roadside\ concentration - urban\ background\ concentration$$

This removes the impact of changes over time due to processes at the regional scale (such as meteorological conditions, boundary layer dynamics, policies outside the city) as described in more detail by Lenschow et al[99] and Font and Fuller[98] in a London context.

The average NO_2 road increment was calculated separately for each area considered in the analysis, based on statistical smoothing of the roadside and urban background monthly means, as follows:

- **Central / inner London:** The average urban background concentration in outer London was subtracted from the average roadside concentrations in these zones.
- **Outer London / 0-5 km zone from London / 5-40 km zone from London:** The average urban background concentration in the 5-40 km zone from Greater London was subtracted from the average roadside concentrations in these zones.
- **Rest of England:** The average urban background concentration in the area beyond 40 km from Greater London (all monitoring sites in England except those within 40 km from London) was subtracted from the average roadside concentration in that zone.

[99] Lenschow et al (2001), Some ideas about the sources of PM_{10}, Atmospheric Environment,, Volume 35, Supplement 1, 2001, Pages S23-S33

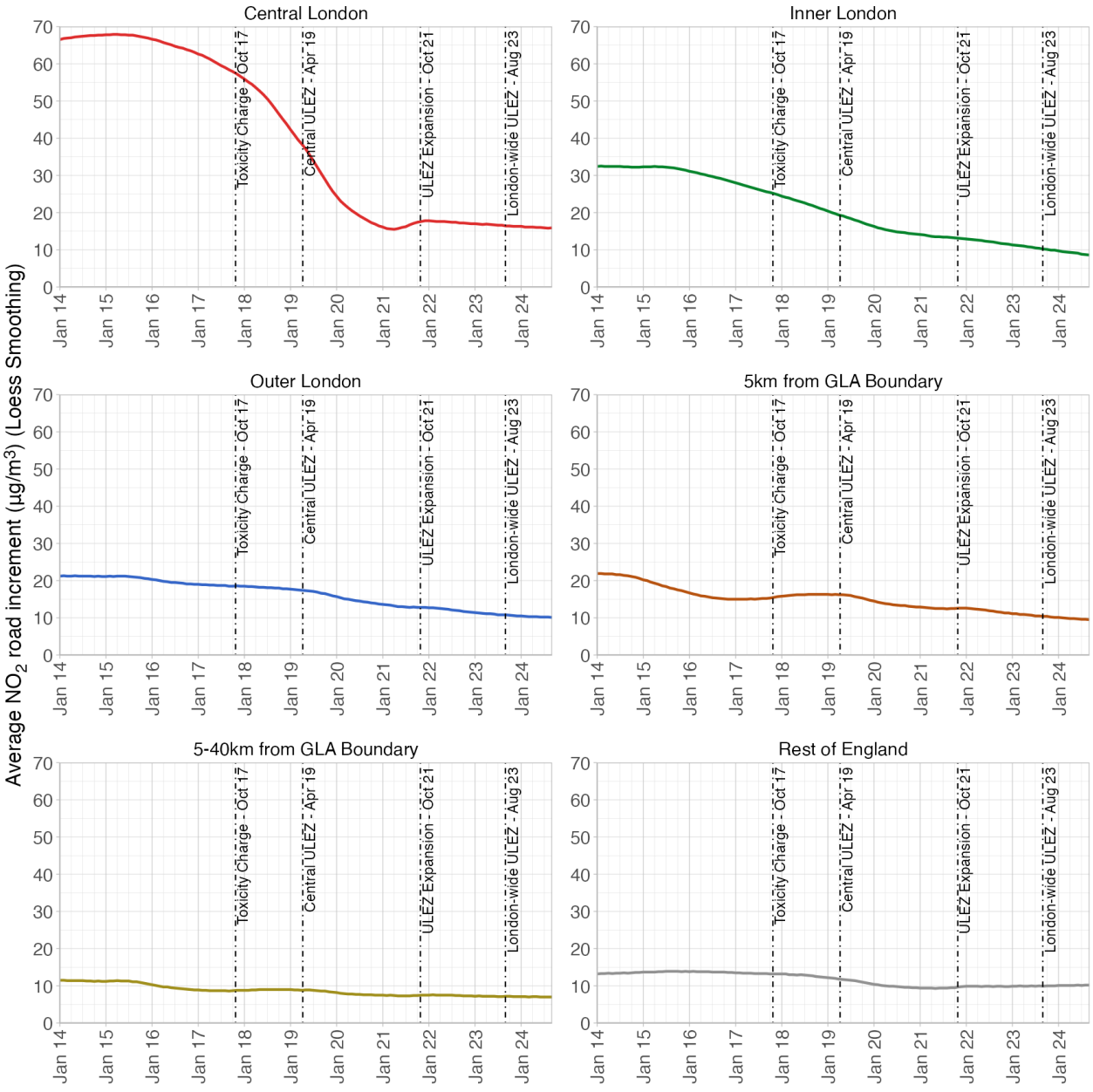

Figure 26: LOESS trend of average NO_2 road increment (traffic component) concentrations

Figure 26 shows that the NO_2 road increment has reduced across all areas over the past 10 years (which is to be expected due to the natural turnover of the vehicle fleet towards cleaner vehicles), but especially in London zones, which can be linked to the ULEZ scheme. Trends in the road increment around the boundary of Greater London (and the ULEZ area) are more variable, but overall show a gradual reduction with little difference between inner London, outer London and the zone 5 km beyond the GLA boundary over

the past couple of years (2023-2024). However, the 5 km boundary analysis is based on fewer sites, meaning conclusions must be treated with caution. The road increment in the rest of England (beyond 40 km from London) is generally slightly higher than areas within 40 km of London, which may be due to the higher number of monitoring sites from large urban areas in the rest of England. The average road increment for the rest of England zone has historically been lower than London, but the data suggests there has been little improvement with a very flat trend over the last 10 years, although a small reduction has occurred following the pandemic. Data also suggests that the average road increment in London is now very similar to the average for the rest of England as substantial reductions have occurred across all zones in London.

Estimated road increment for the "No ULEZ" and "No London-wide ULEZ" scenarios

Following the calculation of the road increment in each zone as described above, the road increment for the "No ULEZ" and "No London-wide ULEZ" scenarios were estimated for each zone as follows:

- **Central / inner London:** Remaining consistent with previous reporting, changes in the average road increment in outer London have been used to represent the changes that would have occurred to the road increment in a "No ULEZ" scenario for central and inner London. This is a limitation of this approach, as it means that additional impacts in the central and inner zones due to the London-wide expansion of the ULEZ may be missed, since any improvements would be included in the changes in roadside increment for outer London. Additionally, and as in previous reports, policies including the LEZ and other transport schemes have also been implemented in outer London. Therefore, changes in air quality in outer London are not solely due to natural turnover over the fleet. It is more likely that impacts are underestimated rather than overestimated and, therefore, the results represent a conservative approach to the assessment of the impacts of the ULEZ.

- **Outer London:** Changes in the average road increment concentrations in the 5-40 km zone from London have been used to represent the change that would have happened in a "No ULEZ" scenario for sites in outer London and for the zone within 5 km of London, which represents boundary sites outside the London-wide ULEZ. The 5-40 km zone is largely away from the influence of the earlier central and inner London ULEZ phases, although there may be some influence due to the recently expanded London-wide ULEZ. It also includes improvements that would have been expected as part of natural turnover. A potential limitation of using the 5-40 km zone is that the LEZ and London-wide ULEZ, as well as other transport schemes such as local interventions, may have had some impact on the road traffic component in these areas and this could be included in the analysis. However, compared to the

rest of England, this zone is generally affected by similar meteorological and regional background influences as outer London. Therefore, the 5-40 km zone, rather than the rest of England, is considered to be a suitable control group to assess the impacts of the ULEZ in outer London.

The above change in road increment is calculated from January 2017 onward for the "No ULEZ" scenario, and from December 2022 onward for the "No London-wide ULEZ" scenario. December 2022 chosen as this is after the London-wide ULEZ was confirmed and allows for pre-compliance where vehicle owners may start to prepare for the upcoming scheme.

For each London zone, the estimated road increment for any subsequent month *i* beyond the relevant started point was calculated as follows:

- For the "No ULEZ" scenario:

$$R_{inc}^{central/inner\ no\ ulez}{}_{i} = R_{inc}^{central/inner}{}_{Jan2017} - \left(R_{inc}^{outer}{}_{Jan2017} - R_{inc}^{outer}{}_{i} \right)$$

$$R_{inc}^{outer\ no\ ulez}{}_{i} = R_{inc}^{outer}{}_{Jan2017} - \left(R_{inc}^{5-40km\ from\ London}{}_{Jan2017} - R_{inc}^{5-40km\ from\ London}{}_{i} \right)$$

- For the "No-London-wide ULEZ" scenario:

$$R_{inc}^{outer\ no\ londonwide\ ulez}{}^{i}_{Dec2022} = R_{inc}^{outer}{}_{Dec2022} - \left(R_{inc}^{5-40km\ from\ London}{}_{Dec2022} - R_{inc}^{5-40km\ from\ London}{}_{i} \right)$$

Finally, the total roadside concentrations for the "No ULEZ" and "No London-wide ULEZ" scenarios are calculated by adding back the relevant average urban background concentration discussed above to the estimated road increment concentrations.

Now that the ULEZ operates London-wide, impacts have also been assessed for London as a whole. This has been undertaken by estimating the changes in road increment at each monitoring site and then taking an average of them all to obtain the London average.

Assessment of impacts

Comparison of the trends based on observed measurements to the estimated "No ULEZ" or "No London-wide ULEZ" trend in each zone reveals the additional impacts of all phases of the ULEZ and the London-wide ULEZ expansion specifically.

Limitations

The ULEZ is one of many schemes and policies to reduce air pollution from road transport and other sources in London. Other local schemes and policies include the London-wide LEZ (for heavy vehicles); investment in cleaner buses and taxis; the Low Emission Zone for non-road mobile machinery and planning policies; and supporting local traffic reduction and air quality projects, alongside wider policies such as the progressively tighter European exhaust controls for new vehicles. As a result, it is not straightforward to isolate the impact of the ULEZ and its expansion.

Air quality monitoring is affected by seasonality due to variation in activity from pollution sources and meteorological conditions which affects the dispersion of pollutants. Statistical smoothing of variations over short-term periods is used to reduce fluctuations and noise in the data in order to focus on long term trends.

Key amongst the strengths is the ease of analysis, allowing data to be analysed as it becomes available (once a suitable amount of time has passed), along with the large number of measurement sites involved, especially in London. Despite the rules applied to the monitoring data (75 per cent data capture minimum, dismiss sites with less than 3 years of data), the change in the number of roadside and urban background monitoring sites available for each month across each zone may have an influence on the trendlines but the overall number of sites reduces this impact. Monthly average concentrations were used to calculate trends in the period from 2010 to the end of September 2024. It should be noted that measurement data from late 2024 has not yet been ratified which may affect specific sites but due to the large number of sites used this impact should be minimised.

Grouping of monitoring sites is used to obtain average trendlines and impacts for each zone, but there will be variation at individual sites depending on local conditions. This could be if a site was affected by major roadworks which would not be reflected in the zonal average.

Using control zones as a means for detecting the difference in trends has both strengths and weaknesses. The key weakness stems from differences in the vehicle fleets in the ULEZ compared with outside London. Traffic in London has a greater proportion of certain vehicle types, such as taxis, PHVs and buses, and proportionally fewer private cars compared to outside London - although this tends to be more of the case for central and inner London than outer London. The method used here recognises these issues and, therefore, a control zone outside of London has been used for outer London. A further weakness of the method is that there are no major urban areas within the 5–40 km from London zone. However, the need to consider prevailing meteorological conditions has been the determining consideration and the use of data which is geographically close to

London also acts, to some extent, as a control for the weather and seasonal factors that can confound this type of analysis.

Additional analysis following consultation with the advisory group

For this report, TfL and the GLA were assisted by an advisory group of experts in air quality analysis, in order to provide further independent advice and review of the air quality analysis and associated methodology. We are very grateful to the support received from the advisory group, who have dedicated their time to assist TfL and the GLA with this analysis.

The advisory group provided a technical function and agreed that the fundamental methodology employed in previous reporting was robust and appropriate. However, a number of points were discussed during the meetings to further improve the confidence in the results. From these discussions, it was agreed to:

- Carry out sensitivity test in relation to the dates selected for the “No ULEZ” and “No London-wide ULEZ” scenarios, using a start point detection methodology (Pettitt Test).
- Further test the potential effect of seasonality on the long-term trend pollutant concentrations, based on the Seasonal-Trend decomposition using LOESS (STL) method, to compare against the main LOESS smoothing methodology.
- Check the likely impact of the influence of the changing number of monitoring sites used along the time series by using the median, instead of the mean, to calculate monthly average roadside and urban background concentrations.
- Investigate ways to estimate uncertainties in the calculations, using the bootstrapping methodology.

The above items were tested and refined following further discussions with the advisory group, and the methodology and outcomes are presented in more detail in the following sections.

Sensitivity Test – No ULEZ and No London-wide ULEZ scenarios starting points

As discussed further above (see p 173), both estimated “No ULEZ” and “No London-wide ULEZ" air quality monitoring trends were applied to the observed monitoring trends from a specific point in time, from when the effects of the scheme were deemed to start being visible in the data:

- For the “No ULEZ” scenario, the selected starting point was January 2017.

- For the “No London-wide ULEZ” scenario, the selected starting point was December 2022.

Both dates were originally chosen to represent the point in time around when the phases of the scheme were announced, and therefore potential changes in the vehicle fleet around London started, to ensure pre-compliance of vehicle owners ahead of the schemes being operational.

However, it was acknowledged that the reported impacts of the schemes, in terms of percentage reduction in NO_2 concentrations, were likely to be sensitive to these selected starting points.

To investigate the appropriateness of these dates, further analysis has been carried out, using change point detection techniques. Change point detection focuses on detecting a moment of abrupt change in time series, that may represent a transition in a data trend, that could be attributed to a significant change in underlying conditions, such as, in our case, the implementation of the different phases of the ULEZ.

A number of methods exist to detect change points in a time series. The method selected for this analysis is the Pettitt method[100], which is a rank-based non-parametric test for abrupt changes in a time series. It provides, as an output, the most probable change point based on the maximum of a test statistic, and a measure of the validity of that probable change point, based on the “p-value” output statistic. The smaller the p-value, the more likely the detected point can be considered as a significant point, with a p-value ≤ 0.05 typically used as a critical level below which one can be confident that the output is reliable.

The Pettitt Test was applied to monthly average roadside measured concentrations of NO_X across the following areas:

- For the “No ULEZ” scenario, central, inner, outer London, and London as a whole.
- For the “No London-wide ULEZ” scenario, Outer London area only.

The Pettitt Test was applied to NO_X rather than NO_2 concentration, as the former is considered a better proxy to understand changes in road traffic emissions, compared to NO_2, for which levels are not only affected by exhaust emissions (primary NO_2), but also

[100] Pettitt A. N. (1979), A Non-Parametric Approach to the Change-Point Problem. Royal Statistical Society, Volume 28, Issue 2, Pages 126-135

by atmospheric chemistry, notably the formation of secondary NO_2 due to the reaction of NO (nitric oxide) and O_3 (ozone).

Moreover, the Pettitt Test can only detect a single change point in the time series, and as such, it is unlikely to produce valid results if the data has been affected by multiple key events, such as the combination of ULEZ scheme and Covid pandemic lockdown. The Pettitt Test was, therefore, performed on the following dataset, to exclude the effect of the pandemic on average air pollution trends:

- January 2010 to February 2022 monthly concentrations for the ULEZ scenario.
- January 2022 to November 2024 monthly concentrations for the London-wide ULEZ scenario.

The same assumptions described in p 165 and used in the main analysis were applied to the dataset.

Figure 27 and Figure 28 illustrate the monthly average roadside NO_X concentrations by zone, and the change point detected by the Pettitt Test for the “No ULEZ” and “No London-wide ULEZ” scenarios respectively.

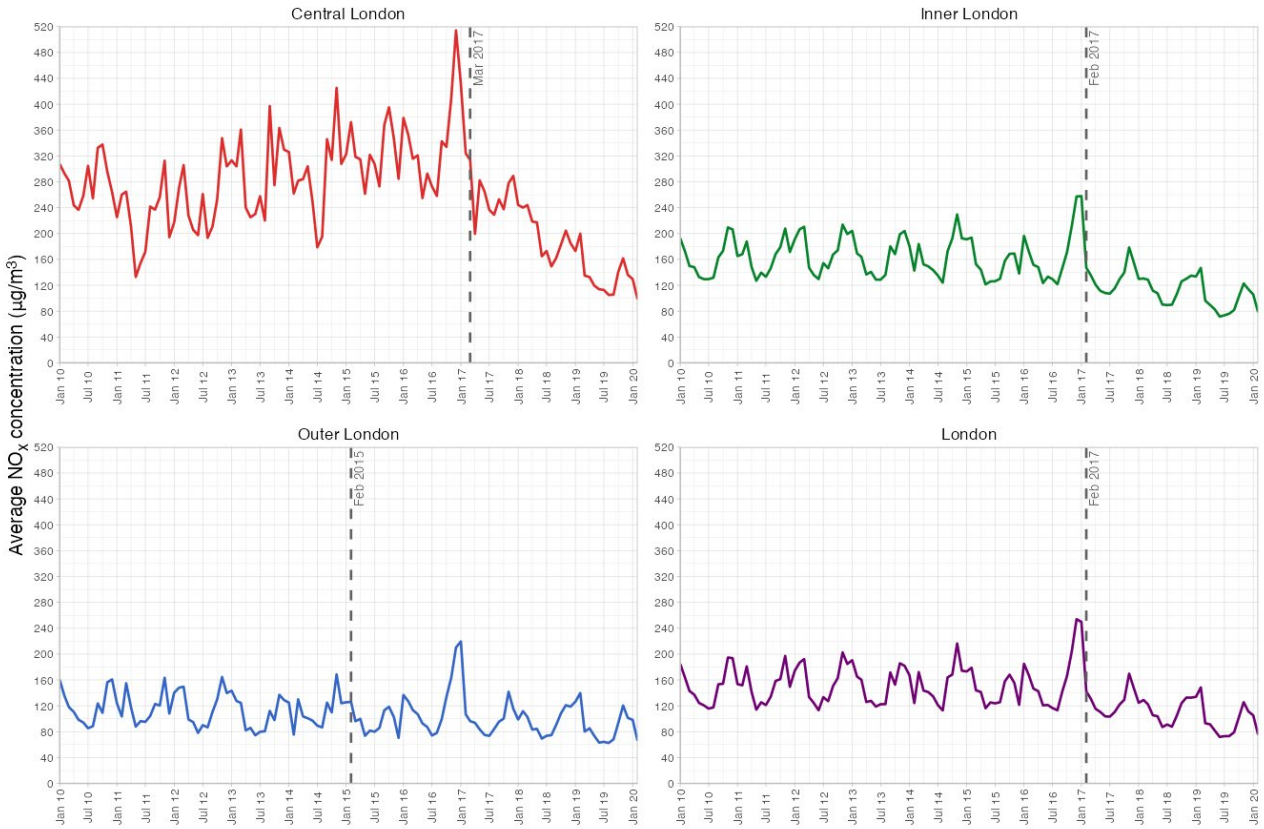

Figure 27: Average roadside NO_X (Jan 2010 to Feb 2020) and detected change point by area

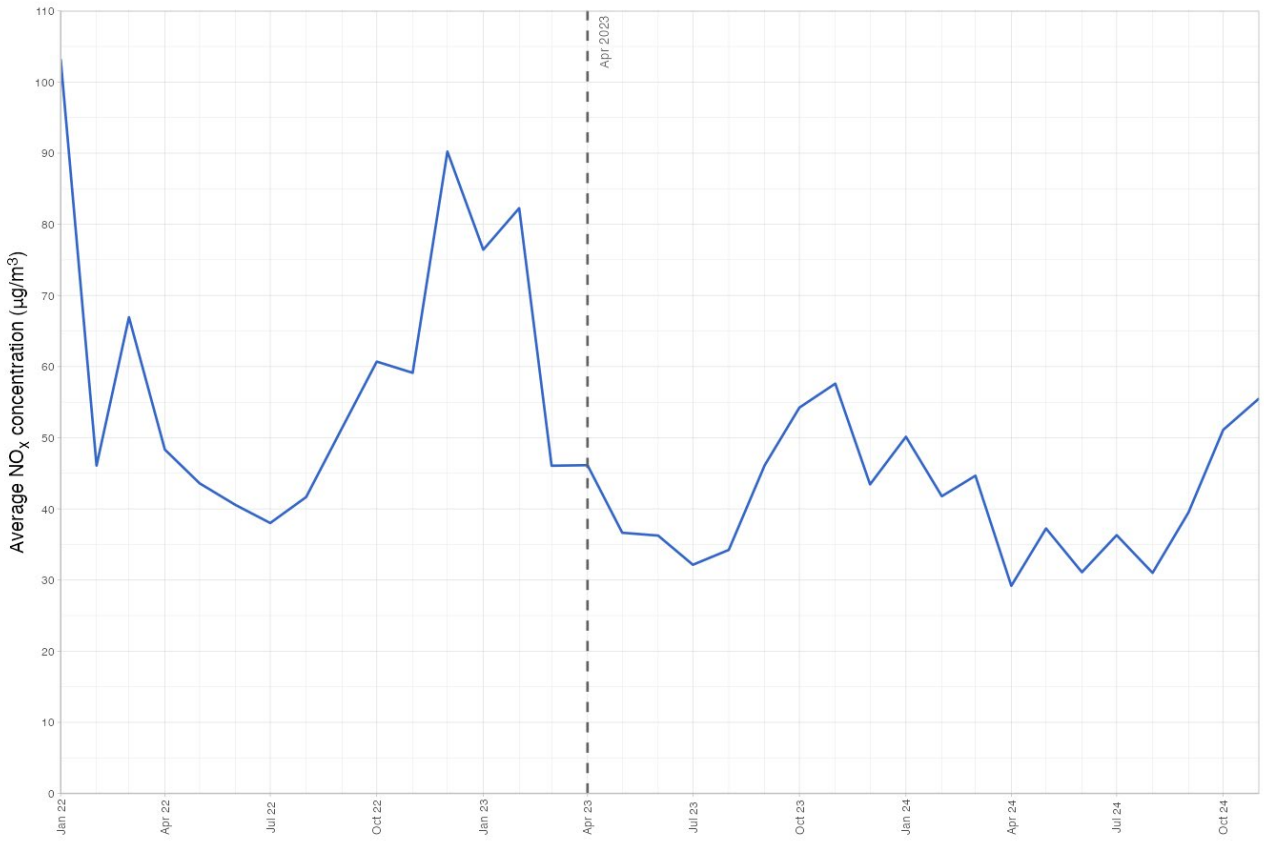

Figure 28: Average roadside NO_X (Jan 2022 to Nov 2024) and detected change point for outer London

Table 65 and Table 66 provide the summary of the Pettitt Test, including the detected change point (date) and associated p-value.

For both tests, the p-value is well below 0.05, which indicates that the detected change point is reliable.

For the test carried out over the January 2010 to February 2022 dataset, the detected change point date was March 2017 for central London, February 2017 for inner London and London as a whole, and February 2015 for outer London.

As the influence of the central London ULEZ on outer London was minimal, it is not surprising that the detected date for outer London is quite different to the other zones. This latter suggests that changes due to the fleet churn observed in outer London and with an impact on ambient air, were not enough to reduce air pollution levels in central and inner London. For central, inner London and London as a whole, the Pettitt Test results are in agreement with the date used as a starting point for the “No ULEZ” scenario (February - March 2017, vs. January 2017).

For the test carried out over the January 2022 to November 2024 dataset, the detected change point date was April 2023. This suggests a later date than the one used for the No London-wide ULEZ starting point (December 2022), although by only a few months. The p-value for this test is also much higher than those from the Pettitt Test performed over the January 2010-February 2022 period, which suggests that the detected date is less reliable for this dataset (although still below the 0.05 threshold).

These results confirm that the start point dates of January 2017 for the “No ULEZ” scenario and December 2022 for the “No London-wide ULEZ” scenario are valid, and therefore these have not been altered further, and the final impacts are based on those dates.

Table 65: Pettitt Test Results for NO_x Concentrations (Period Jan 2010 to Feb 2022)

Location	Number of Sites in Group	Number of Sites with Valid Data	Pettitt Test p-Value	Pettitt Test Change Point Date
Central London	8	3	6.18 e-08	March 2017
Inner London	46	27	1.23 e-09	February 2017
Outer London	28	14	3.56 e-03	February 2015
All	82	49	7.98 e-08	February 2017

Table 66: Pettitt Test Results for NO_X Concentrations (Period Jan 2022 to Nov 2024)

Location	Pettitt Test p-Value	Pettitt Test Change Point Date
Outer London	2.00 e-02	April 2023

Seasonal-Trend Decomposition using LOESS (STL)

As explained in p 165, the LOESS methodology was used to smooth average monthly concentrations, using a fixed span parameter[97], used across previous reports. It was suggested by the advisory group that further analysis could be useful to check whether this span parameter may need to be revised (since the smoothing level of a fixed span also depends on the length of the time series). One way to test this is to apply a seasonal decomposition technique to the dataset, to remove the seasonal component from the monthly concentrations. One such technique is called the Seasonal-Trend decomposition using LOESS (STL). As implied by the name, it also applies the LOESS method to a time series, but this smoothing is applied after attempting to split the dataset into a seasonal component and a longer-term trend (i.e. “de-seasonalised”) component. It also produces a “remainder” component (or noise), which, if the time series can clearly be decomposed into a seasonal and trend signals, should be minimal.

The STL procedure was applied to the average NO_2 roadside monthly concentrations aggregated for each area across London, and the smoothed trend component (i.e. without the influence of the seasonal trend) was extracted from the output. This trend has then been compared against the LOESS smoothing trend used in the main analysis of air quality monitoring data (also used in previous ULEZ reports).

Figure 29 shows the results of the STL methodology, once applied to all London NO_2 roadside sites used in the analysis. The top graph shows the average monthly roadside concentrations across all monitoring sites. The three other graphs provide the decomposition of that time series, using the STL methodology, into a remainder, seasonal, and trend component. The trend component is the one that has been extracted and

compared against the LOESS trend used in the main analysis of air quality monitoring data.

The STL methodology can only produce meaningful results if the time series includes a recurring temporal pattern. As can be seen on the seasonal chart in Figure 29 (third chart from the top), it is clearly the case, as proved by the cyclicity of the trend (a 12-month pattern which repeats over time). This provides confidence that the trend graph (bottom graph) is a good estimate of the long-term trend of NO_2 concentrations at roadside sites, stripped off that seasonal component.

Figure 30 shows an X-Y scatter plot of the NO_2 roadside concentrations from these smoothed trendlines, with the LOESS trend on the x-axis versus the STL trend on the y-axis, with the 1:1 line (identity line) plotted to help compare the output data from the two methods.

Figure 30 shows a good fit between the LOESS and STL trendlines, with results being close to the identity line, except for the highest and lowest concentrations, which represent the data near the start and end point of the time series. This is expected, as the LOESS smoothing typically produces more variable results near the start / end points of a dataset.

Based on the above, the span parameter used in LOESS smoothing applied to the monthly average concentrations in the main analysis was judged adequate, and it was not deemed necessary to amend it.

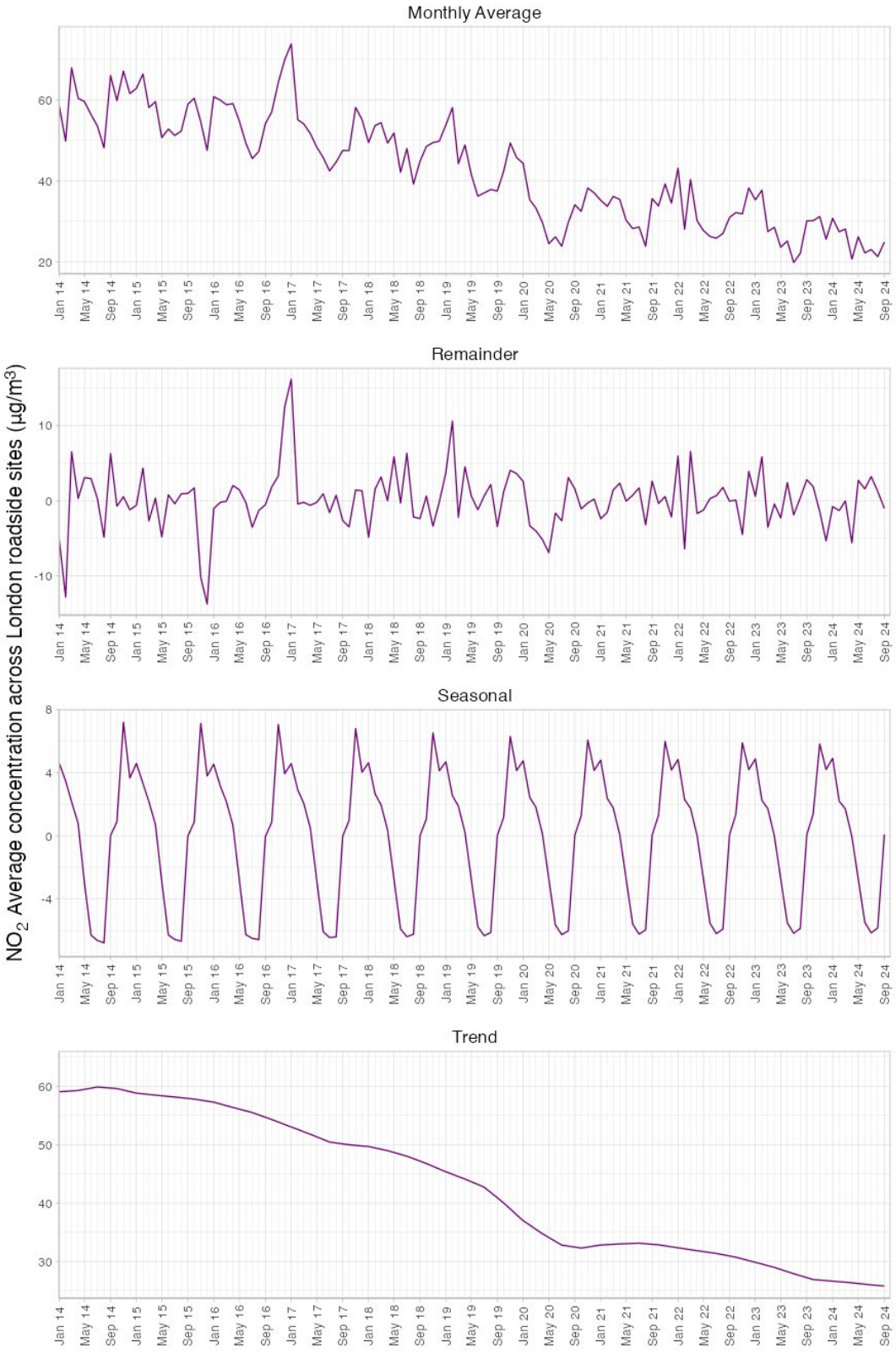

Figure 29: Seasonal Trend Decomposition using LOESS for London Roadside NO_2

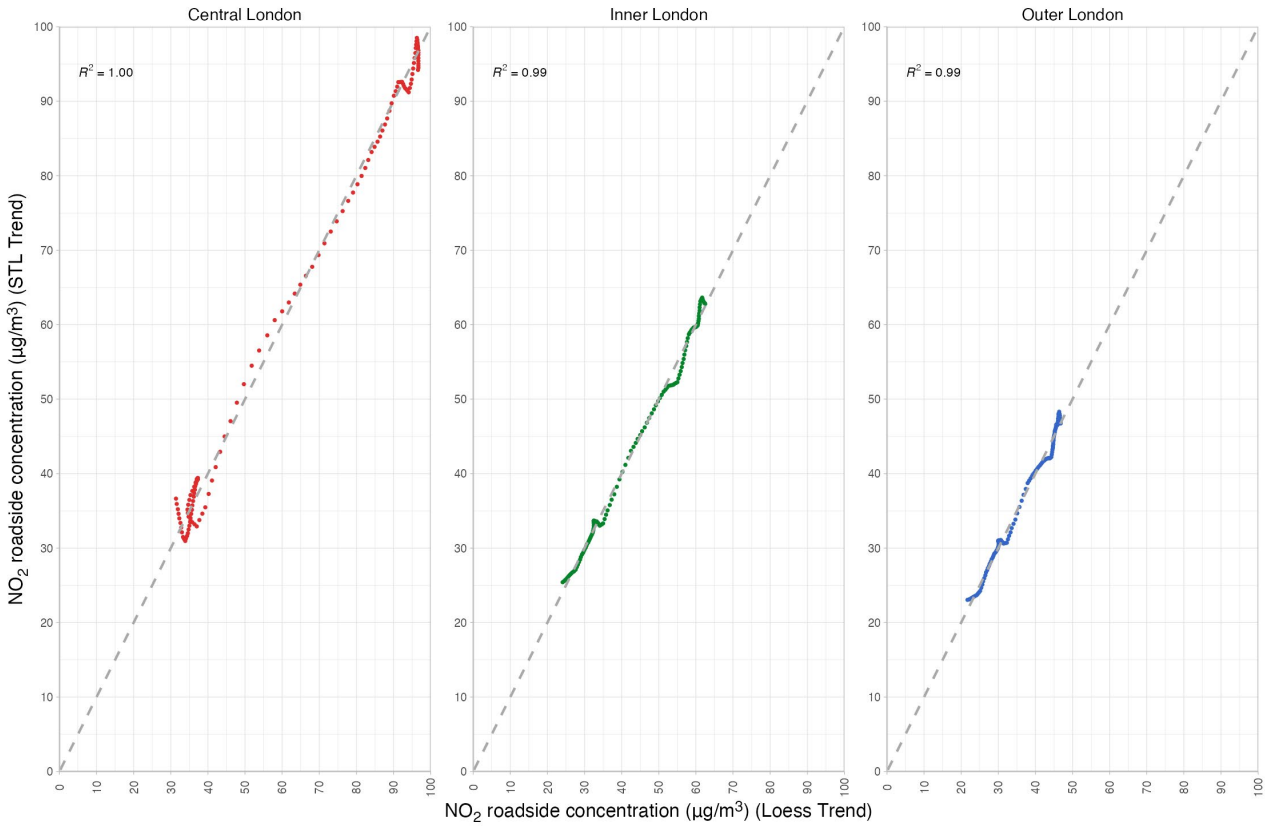

Figure 30: X-Y scatter plot of NO_2 LOESS vs STL trendline

Median vs mean monthly concentrations

The analysis of air quality monitoring data is based on the calculation of monthly mean concentrations. However, following discussions with the advisory group, it was agreed to test whether using the median could be used instead of the mean. The median (the middle number in a set of values when those values are arranged from smallest to largest) can be useful to remove the potential influence of outliers (unusually low or high values compared to the rest) in the dataset or when dealing with a wide range of data, which could skew the mean.

To determine whether this would be the case, the median of monthly concentrations for both roadside and urban background sites for each area was calculated before applying the LOESS smoothing methodology.

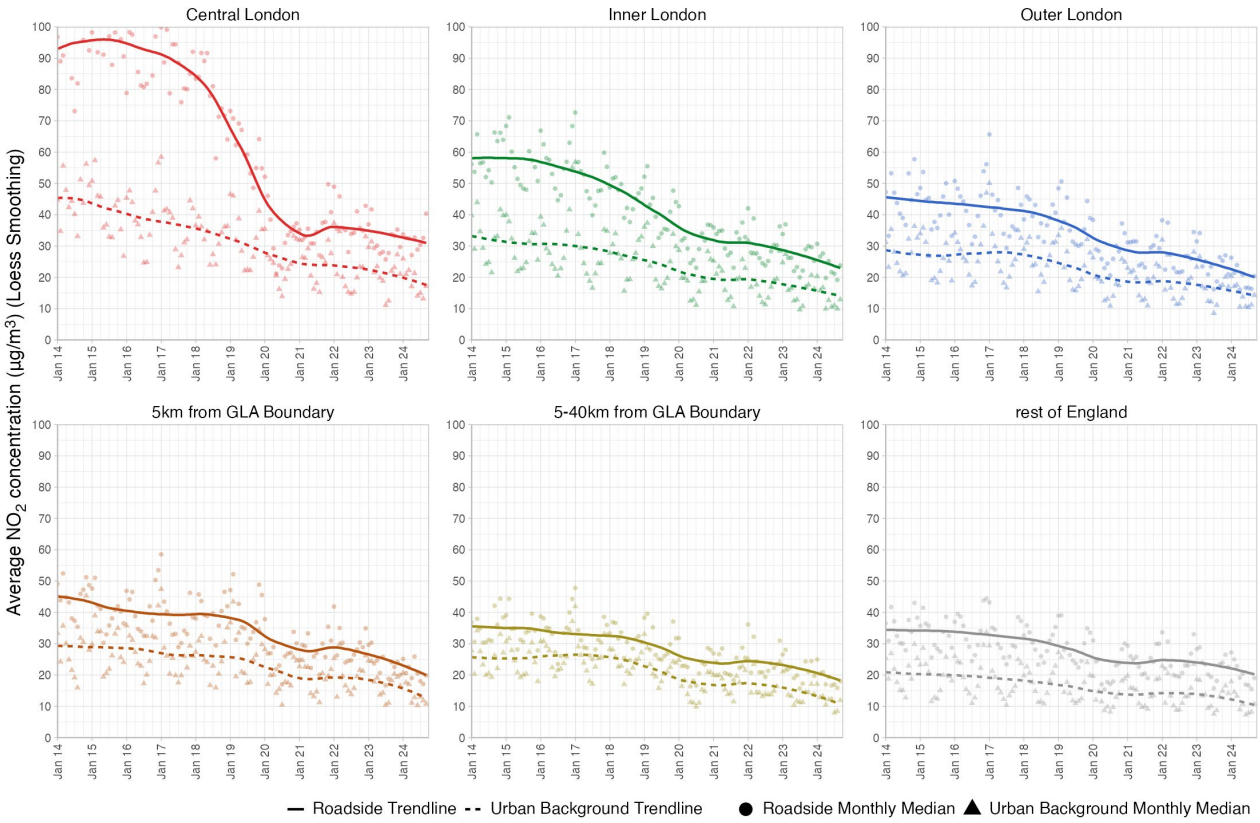

Figure 31: Trends in NO_2 roadside based on median monthly concentrations

Figure 31 shows the average roadside and urban background NO_2 trendline (LOESS smoothing applied) by zone, based on the monthly median concentrations, instead of the monthly mean concentrations (as shown in Figure 7). The results show that the impact of using the median rather than the mean on the LOESS trendlines is minimal, and unlikely to change the results presented in the main section of this report. This is likely to be due to the large number of sites used in the calculations, in combination with the smoothing of trendlines using the LOESS method. Consequently, this test shows that the monthly mean concentrations that underpin the air quality monitoring trendlines and the ULEZ / London-wide ULEZ impacts presented in this report, are unlikely to be significantly skewed by outliers, and applying the mean to air quality data is appropriate.

Estimating impact uncertainties using Bootstrap

As part of discussions with the advisory group, it was suggested to carry out further analysis to try and estimate the uncertainty in the ULEZ and London-wide ULEZ impacts calculated using the air quality monitoring data. One of the methods that can be used for such purpose is the bootstrap technique, which is widely used to find and plot the sampling

distribution of a statistic (e.g. the mean), which can then be used to calculate the standard error of that statistic and associated confidence intervals. The procedure consists in resampling, i.e. taking repeated random samples from the observed data (here, the monthly mean NO_2 concentrations for each monitoring site) and recalculating the statistic (the average monthly concentration for each area - central/inner/outer London etc) for each resample.

The bootstrap method, applied to the air quality monitoring data, included the following steps:

- For each area, draw a random sample of monitoring sites, the same size as the original dataset. This is achieved by sampling “with replacement”, which means that some of the sites are omitted from the sample, whilst others are duplicated.
- Calculate the average monthly concentrations by area from the random samples.
- Repeat this a large number of times (following discussions with the advisory group, 500 iterations were deemed sufficient to produce robust results).
- Apply the LOESS smoothing method to each resample.

This was also applied to the estimated No ULEZ / No London-wide ULEZ scenarios, which involved applying the bootstrap method to the calculation of monthly urban background concentrations by area, since this is a key parameter in the methodology used for these scenarios (urban background is removed from total concentrations to estimate the road increment component).

Based on this, it was possible to calculate the mean and confidence intervals (95% confidence interval as these are typically used in this type of analysis) of the distribution of monthly and yearly concentrations, both for the actual data, and the estimated “No ULEZ” / “London-wide ULEZ” scenarios.

As an example, Figure 32 shows the distribution of monthly average (LOESS) NO_2 roadside concentrations for September 2024 in each area considered in the analysis, once the bootstrap method was applied to the monthly concentrations at each monitoring site. The mean concentration (across all 500 concentrations from the bootstrap method) is shown by the dashed green line, whilst the two dotted green lines represent the 95% confidence interval. This shows that the uncertainty is greater for central London average concentrations compared to other areas. This is due to the fact that the number of monitoring sites used to calculate the average concentration across central London is much smaller than the sites available to calculate the average in the other areas, which

leads to greater uncertainties. The bootstrap method is a good way of demonstrating this fact.

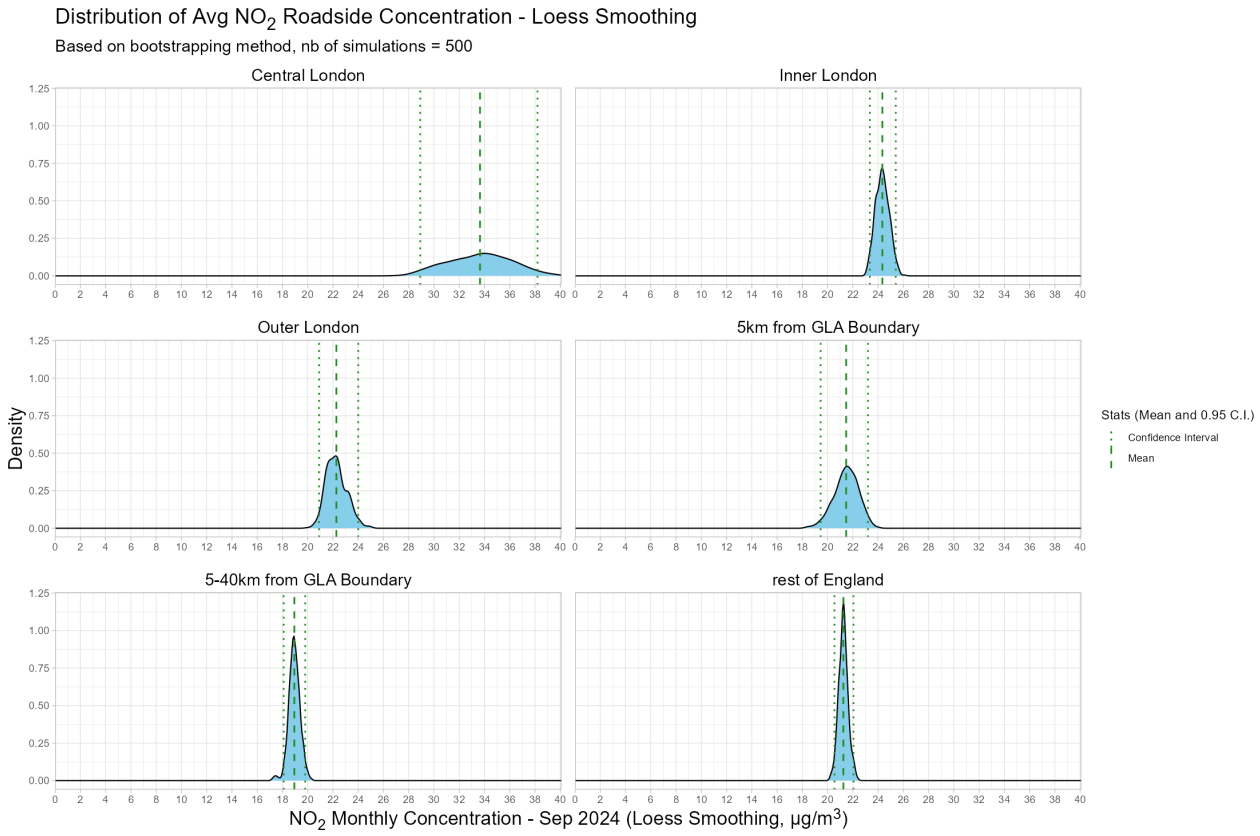

Figure 32: Example visualisation for September 2024 showing the distribution of the monthly means (LOESS) after bootstrapping

Table 67 below shows the results of the bootstrap method, which provides the NO_2 annual mean and associated uncertainty (based on the 95% confidence interval) for each area. This is to be compared with annual impacts shown in Table 25 to Table 28. Although the annual mean for each area, as shown below, can occasionally be slightly different from those reported in the above-mentioned tables (due to the resampling inherent to the bootstrap methodology), overall, they are very close. Note that the uncertainty (shown as "±" value, either in absolute concentration or percentage difference) is the sum of uncertainties from both actual and "no ULEZ" estimated scenario.

The 95% confidence interval is also reported in Table 67, which provides a measure of the uncertainty associated to the average annual NO_2 concentrations. For example, in outer London, in 2024, the reduction from the bootstrap method is 7 µg/m³ (from 30 µg/m³ for the "No ULEZ" scenario to 23 µg/m³ for the actual (observed) measured concentrations,

plus or minus 2 µg/m³. This translates in a reduction of 24% plus or minus 6% - which means the reduction could be between 18% and 30%.

The bootstrap results suggest that more caution should be used when interpreting the results for the zone 5 km beyond the GLA boundary because the uncertainty is greater than the average impact and this is likely a reflection of the fewer monitoring sites, as referenced in NO_2 road increment calculations.

Table 67: Bootstrap Results – Annual NO_2 Impacts for No ULEZ scenario

Year	Location	Actual (Measured) (µg/m³)	No ULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
2016	Central	93			
2017	Central	89	90	-1 ±3	-1% ±3%
2018	Central	78	88	-11 ±8	-12% ±9%
2019	Central	59	85	-25 ±9	-30% ±12%
2020	Central	38	77	-39 ±6	-51% ±8%
2021	Central	36	75	-39 ±5	-52% ±5%
2022	Central	38	75	-36 ±4	-49% ±4%
2023	Central	33	72	-38 ±3	-53% ±3%
2024	Central	33	70	-37 ±5	-53% ±6%
2016	Inner	58			
2017	Inner	55	56	-1 ±2	-2% ±3%
2018	Inner	50	54	-4 ±4	-7% ±6%
2019	Inner	43	50	-7 ±3	-15% ±6%
2020	Inner	35	43	-8 ±3	-19% ±5%
2021	Inner	33	41	-8 ±2	-20% ±5%
2022	Inner	32	40	-9 ±3	-22% ±5%
2023	Inner	28	38	-9 ±2	-24% ±5%
2024	Inner	25	35	-10 ±3	-28% ±7%
2016	Outer	45			
2017	Outer	44	45	-1 ±1	-2% ±3%
2018	Outer	42	44	-2 ±2	-4% ±4%
2019	Outer	38	40	-2 ±2	-5% ±5%
2020	Outer	32	36	-4 ±2	-11% ±5%
2021	Outer	31	35	-5 ±2	-14% ±5%
2022	Outer	29	35	-6 ±2	-17% ±5%
2023	Outer	26	33	-7 ±2	-21% ±5%
2024	Outer	23	30	-7 ±2	-24% ±6%
2016	5km from GLA boundary	41			
2017	5km from GLA boundary	41	41	0 ±1	0% ±3%

Year	Location	Actual (Measured) (µg/m³)	No ULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
2018	5km from GLA boundary	40	39	1 ±3	2% ±7%
2019	5km from GLA boundary	37	36	1 ±3	2% ±8%
2020	5km from GLA boundary	31	31	-1 ±3	-3% ±9%
2021	5km from GLA boundary	30	31	-1 ±3	-3% ±8%
2022	5km from GLA boundary	29	31	-2 ±3	-6% ±8%
2023	5km from GLA boundary	25	29	-3 ±2	-11% ±8%
2024	5km from GLA boundary	22	26	-4 ±3	-14% ±9%

Appendix 4 – Air quality concentrations results

Air quality trends

Table 68 summarises the change in annual average NO_2 concentrations between 2017 and 2024 at roadside and urban background sites, derived from monthly data provided in Figure 7 within the main body of the report.

Table 68: Annual average NO_2 concentrations at roadside and urban background sites by zone based on the statistically smoothed monthly trends analysis in Figure 7.

Location and site type	Average NO_2 in 2017 ($\mu g/m^3$)	Average NO_2 in 2024 (up to Sept, $\mu g/m^3$)	Change between 2017 and 2024 ($\mu g/m^3$)	Change between 2017 and 2024 (per cent)
Central Roadside	88	32	-56	-63%
Inner Roadside	53	25	-29	-54%
Outer Roadside	44	22	-21	-49%
All London Roadside	52	24	-27	-53%
5 km from GLA boundary Roadside	40	23	-17	-43%
5-40 km from GLA boundary Roadside	34	19	-14	-42%
Rest of England Roadside	32	21	-11	-33%
Central Background	36	17	-19	-52%
Inner Background	29	14	-15	-52%
Outer Background	29	16	-13	-46%
All London Background	30	15	-15	-49%
5 km from GLA boundary Background	27	13	-13	-50%
5-40 km from GLA boundary Background	27	13	-13	-50%
Rest of England Background	20	12	-8	-40%

Table 69 summarises the change in annual average $PM_{2.5}$ concentrations between 2017 and 2024 at roadside and urban background sites, derived from monthly data provided in Figure 9 within the main body of the report.

Table 69: Annual average $PM_{2.5}$ at roadside and urban background sites by zone based on statistically smoothed trends monthly analysis in Figure 9

Location and site type	Average $PM_{2.5}$ in 2017 ($\mu g/m^3$)	Average $PM_{2.5}$ in 2024 (up to Sept, $\mu g/m^3$)	Change between 2017 and 2024 ($\mu g/m^3$)	Change between 2017 and 2024 (per cent)
Central Roadside	17	8	-8	-50%
Inner Roadside	13	8	-5	-39%
Outer Roadside	12	9	-4	-29%
All London Roadside	13	8	-5	-37%
5 km from GLA boundary Roadside	10	NA	NA	NA
5-40 km from GLA boundary Roadside	11	8	-4	-33%
Rest of England Roadside	10	7	-2	-26%
Central Background	11	8	-3	-30%
Inner Background	12	8	-4	-33%
Outer Background	11	7	-4	-37%
All London Background	11	7	-3	-31%
5 km from GLA boundary Background	7	7	0	-4%
5-40 km from GLA boundary Background	11	7	-4	-38%
Rest of England Background	9	7	-3	-26%

Air quality impact analysis

Table 70 and Table 71 summarise the impacts on NO_2 roadside concentrations of the London-wide ULEZ expansion in outer London and in the zone 5 km beyond the GLA boundary respectively. This data is visualised in Figure 11 and Figure 12 respectively within the main body of the report. The monthly concentrations for the observed trends are compared against the “No London-wide ULEZ” scenario from December 2022 up to September 2024, providing the change in average concentration in $\mu g/m^3$ and as a percentage. It is worth noting that results for the zone 5 km beyond the GLA boundary are subject to more uncertainty, as they are based on fewer monitoring sites, compared to

outer London results. Results of the bootstrap method, presented in Table 67 (Appendix 3), confirmed that uncertainty in estimated impacts of the “No ULEZ” scenario is also more notable for that zone.

Table 70: Estimated impact of the expansion of London-wide ULEZ on roadside NO_2 concentrations in outer London based on trends analysis

Date	Actual (Measured) (µg/m³)	No LWULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
Dec-22	27.7	27.7	0.0	0.0%
Jan-23	27.5	27.5	0.0	0.0%
Feb-23	27.2	27.4	-0.2	-0.7%
Mar-23	27.0	27.2	-0.2	-0.7%
Apr-23	26.7	27.0	-0.3	-1.1%
May-23	26.5	26.8	-0.3	-1.1%
Jun-23	26.2	26.6	-0.4	-1.5%
Jul-23	25.9	26.4	-0.5	-1.9%
Aug-23	25.7	26.2	-0.5	-1.9%
Sep-23	25.4	26.0	-0.6	-2.3%
Oct-23	25.1	25.8	-0.7	-2.7%
Nov-23	24.8	25.5	-0.7	-2.7%
Dec-23	24.5	25.3	-0.8	-3.2%
Jan-24	24.2	25.0	-0.8	-3.2%
Feb-24	23.9	24.8	-0.9	-3.6%
Mar-24	23.6	24.5	-0.9	-3.7%
Apr-24	23.3	24.3	-1.0	-4.1%
May-24	23.0	24.0	-1.0	-4.2%
Jun-24	22.7	23.7	-1.0	-4.2%
Jul-24	22.4	23.4	-1.0	-4.3%
Aug-24	22.1	23.1	-1.0	-4.3%
Sep-24	21.7	22.8	-1.1	-4.8%

Table 71: Estimated impact of the expansion of London-wide ULEZ on roadside NO_2 concentrations in the zone 0-5 km from London based on trends analysis

Date	Actual (Measured) (µg/m³)	No LWULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
Dec-22	27.5	27.5	0.0	0.0%
Jan-23	27.2	27.3	-0.1	-0.4%
Feb-23	27.0	27.2	-0.2	-0.7%
Mar-23	26.7	27.0	-0.3	-1.1%
Apr-23	26.5	26.8	-0.3	-1.1%
May-23	26.2	26.6	-0.4	-1.5%
Jun-23	25.9	26.4	-0.5	-1.9%
Jul-23	25.6	26.2	-0.6	-2.3%
Aug-23	25.4	26.0	-0.6	-2.3%
Sep-23	25.0	25.8	-0.8	-3.1%
Oct-23	24.8	25.6	-0.8	-3.1%
Nov-23	24.4	25.3	-0.9	-3.6%
Dec-23	24.1	25.1	-1.0	-4.0%
Jan-24	23.8	24.8	-1.0	-4.0%
Feb-24	23.5	24.6	-1.1	-4.5%
Mar-24	23.2	24.3	-1.1	-4.5%
Apr-24	22.8	24.1	-1.3	-5.4%
May-24	22.5	23.8	-1.3	-5.5%
Jun-24	22.2	23.5	-1.3	-5.5%
Jul-24	21.8	23.2	-1.4	-6.0%
Aug-24	21.5	22.9	-1.4	-6.1%
Sep-24	21.1	22.6	-1.5	-6.6%

Table 72 summarises the monthly impacts on the average roadside NO_2 concentration in outer London estimated for all phases of the ULEZ, compared to those for the London-wide ULEZ on its own, from September 2023 to September 2024. Dividing the change attributed to just the London-wide ULEZ by the overall impact in each month gives the relative contribution of the London-wide ULEZ to reductions in NO_2 concentrations in outer London. This shows that the contribution of the London-wide ULEZ to the total reduction in

NO_2 concentrations gradually increased, from 9 per cent in September 2023, up to 16 per cent in September 2024.

Table 72: Proportion of impacts on NO_2 concentrations in outer London attributed to London-wide ULEZ

Date	Overall Impact due to ULEZ (µg/m³)	Impact due to LWULEZ (µg/m³)	Proportion of overall impact attributed to LWULEZ
Sep-23	-6.5	-0.6	9.2%
Oct-23	-6.6	-0.7	10.6%
Nov-23	-6.6	-0.7	10.6%
Dec-23	-6.7	-0.8	11.9%
Jan-24	-6.7	-0.8	11.9%
Feb-24	-6.8	-0.9	13.2%
Mar-24	-6.8	-0.9	13.2%
Apr-24	-6.9	-1.0	14.5%
May-24	-6.9	-1.0	14.5%
Jun-24	-6.9	-1.0	14.5%
Jul-24	-6.9	-1.0	14.5%
Aug-24	-6.9	-1.0	14.5%
Sep-24	-7.0	-1.1	15.7%

Figure 33 shows the impacts of the London-wide ULEZ for London as a whole.

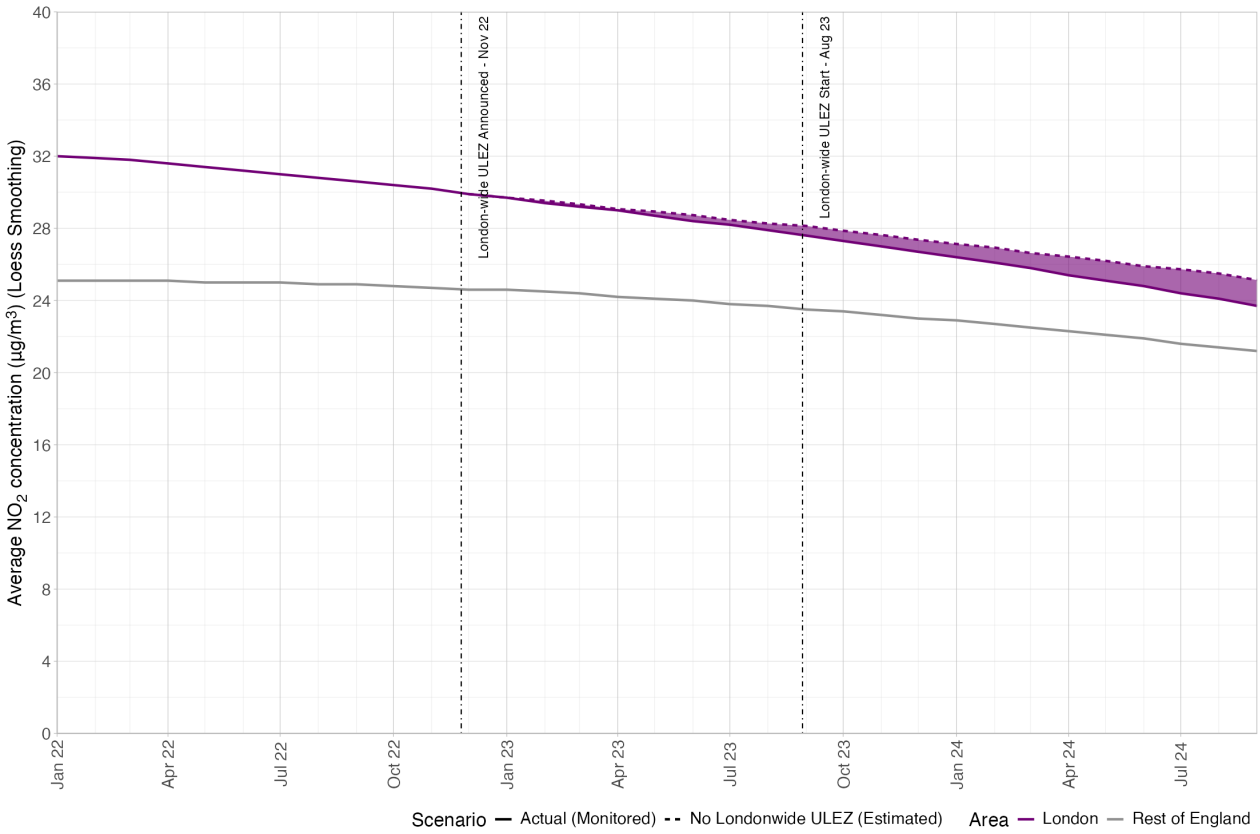

Figure 33: Trends in monthly average roadside NO_2 concentrations London-wide (with and without London-wide ULEZ) compared to outside London

The data that underpins Figure 33 is in Table 73. The reduction in average roadside NO_2 concentrations across London as a whole increased progressively every month since the start of operation of the London-wide ULEZ. Compared to the estimated "No London-wide ULEZ" scenario, measured roadside NO_2 average concentrations were 0.5 µg/m^3 lower in September 2023, representing a 1.9 per cent reduction. One year on, this reduction is now estimated to be 1.4 µg/m^3, representing a 5.7 per cent reduction (as of September 2024).

Table 73: Estimated impact of the expansion of London-wide ULEZ on roadside NO_2 concentrations in London as a whole based on trends analysis

Date	Actual (Measured) (µg/m³)	No LWULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
Sep-23	27.6	28.1	-0.5	-1.9%
Oct-23	27.3	27.9	-0.6	-2.0%
Nov-23	27.0	27.6	-0.6	-2.3%

Date	Actual (Measured) (µg/m³)	No LWULEZ (Estimated) (µg/m³)	Impact (µg/m³)	Impact (per cent)
Dec-23	26.7	27.4	-0.7	-2.4%
Jan-24	26.4	27.1	-0.7	-2.7%
Feb-24	26.1	26.9	-0.8	-3.1%
Mar-24	25.8	26.6	-0.8	-3.1%
Apr-24	25.4	26.4	-1.0	-3.9%
May-24	25.1	26.2	-1.1	-4.2%
Jun-24	24.8	25.9	-1.1	-4.2%
Jul-24	24.4	25.7	-1.3	-5.2%
Aug-24	24.1	25.5	-1.4	-5.5%
Sep-24	23.7	25.1	-1.4	-5.7%

Appendix 5 – Indexed traffic flows

Figure 34 shows the indexed traffic flows for central, inner, outer and London-wide ULEZ areas. This data is also summarised in Table 74 to Table 78.

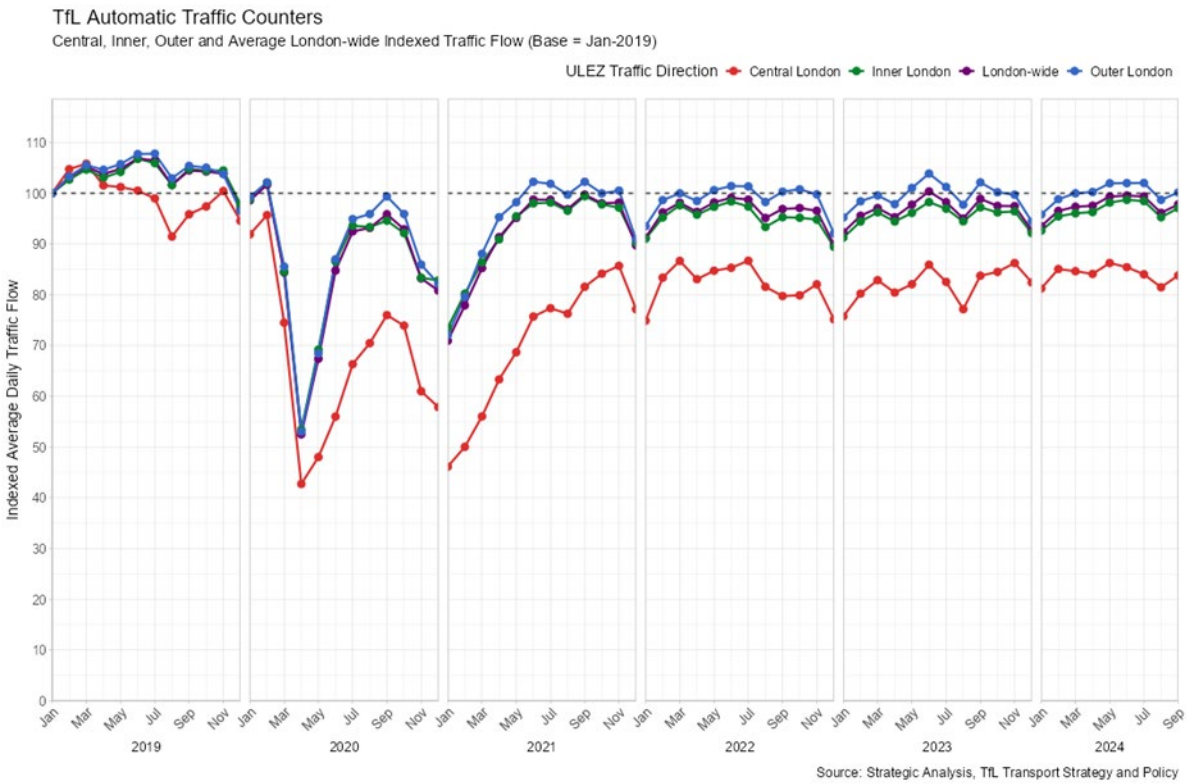

Figure 34: Indexed traffic flows for central, expanded inner, expanded outer and London-wide ULEZ areas

Table 74: Indexed monthly traffic in central ULEZ area (Indexed to January 2019)[101]

Central ULEZ	2019	2020	2021	2022	2023	2024
Jan	100%	92%	46%	75%	76%	81%
Feb	105%	96%	50%	83%	80%	85%
Mar	106%	74%	56%	87%	83%	85%
Apr	102%	43%	63%	83%	80%	84%
May	101%	48%	69%	85%	82%	86%
Jun	101%	56%	76%	85%	86%	85%

[101] ND means No Data

Central ULEZ	2019	2020	2021	2022	2023	2024
Jul	99%	66%	77%	87%	83%	84%
Aug	91%	70%	76%	82%	77%	81%
Sep	96%	76%	82%	80%	84%	84%
Oct	97%	74%	84%	80%	85%	ND
Nov	100%	61%	86%	82%	86%	ND
Dec	95%	58%	77%	75%	82%	ND

Table 75: Indexed monthly traffic in expanded inner ULEZ area (Indexed to January 2019)[101]

Expanded Inner	2019	2020	2021	2022	2023	2024
Jan	100%	99%	73%	91%	91%	93%
Feb	103%	102%	80%	95%	94%	95%
Mar	105%	85%	86%	98%	96%	96%
Apr	103%	53%	91%	96%	94%	96%
May	104%	69%	95%	97%	96%	98%
Jun	107%	87%	98%	98%	98%	99%
Jul	106%	94%	98%	97%	97%	98%
Aug	102%	93%	97%	93%	94%	95%
Sep	105%	95%	99%	95%	97%	97%
Oct	104%	92%	98%	95%	96%	ND
Nov	104%	83%	97%	95%	96%	ND
Dec	98%	83%	90%	89%	92%	ND

Table 76: Indexed monthly traffic in expanded outer ULEZ area (Indexed to January 2019)[101]

Expanded Outer	2019	2020	2021	2022	2023	2024
Jan	100%	99%	72%	93%	95%	96%
Feb	103%	102%	80%	99%	98%	99%
Mar	106%	86%	88%	100%	100%	100%
Apr	105%	53%	95%	98%	98%	100%
May	106%	68%	98%	101%	101%	102%
Jun	108%	87%	102%	101%	104%	102%
Jul	108%	95%	102%	101%	101%	102%

Expanded Outer	2019	2020	2021	2022	2023	2024
Aug	103%	96%	100%	98%	98%	99%
Sep	105%	99%	102%	100%	102%	100%
Oct	105%	96%	100%	101%	100%	ND
Nov	104%	86%	101%	100%	100%	ND
Dec	97%	82%	91%	92%	94%	ND

Table 77: Indexed monthly traffic in London-wide ULEZ area (Indexed to January 2019)[101]

London-wide	2019	2020	2021	2022	2023	2024
Jan	100%	99%	71%	91%	92%	94%
Feb	103%	102%	78%	96%	96%	97%
Mar	105%	84%	85%	98%	97%	97%
Apr	104%	53%	91%	96%	95%	98%
May	105%	67%	95%	98%	98%	99%
Jun	107%	85%	99%	99%	100%	100%
Jul	106%	92%	99%	99%	98%	99%
Aug	102%	93%	97%	95%	95%	96%
Sep	104%	96%	100%	97%	99%	98%
Oct	104%	93%	98%	97%	98%	ND
Nov	104%	83%	98%	97%	97%	ND
Dec	97%	81%	90%	90%	93%	ND

Table 78: Indexed traffic across different zones averaged for the January to September period of each year (indexed against January to September average for 2019)

Zone	2019	2020	2021	2022	2023	2024
Central ULEZ	100%	69%	66%	83%	81%	84%
Expanded Inner	100%	83%	88%	92%	92%	93%
Expanded Outer	100%	83%	89%	95%	95%	95%
London-wide	100%	82%	87%	93%	93%	94%

Traffic around the North and South Circular Roads and ULEZ boundary

Traffic data collected at 24 sites on the North and South Circular Roads (the boundary for the inner London ULEZ) has been analysed and indexed to January 2019 as well as indexed as the average for January to September for each year against the same period in 2019. Separate analysis of both the North and South Circular roads indicates that no notable change in indexed flows can be observed. The monthly index for each area is shown in Table 79 to Table 82.

Indexed flows on the North Circular remain broadly the same from September 2023 to September 2024 when compared against 2022 to 2023. Seasonal trends remain the same, with lower flows in August 2023 and 2024 as well as December 2023 and January 2024, representative of school holidays. The indexed flow for September 2024 is lower than August of the same year and thus is not in line with previous trends. The North and South Circular has fewer ATC sites than other London Zones and thus averages are sensitive to fluctuations in traffic due to non-scheme effects such as road closures and diversions. Road closures on the North Circular during this period likely account for this dip and it should be expected that traffic levels will stabilise once these end and data for future months is available.

When looking at the January to September indexed average for the North Circular in 2024, (see Table 79), it can be observed that traffic has slightly increased by around one percent, in line with post-pandemic recovery trends seen across most other London zones.

Indexed flows for 2023 are similar on the South Circular Road apart from a large spike in indexed flows in the summer prior to the schemes launch. This particularly effects May and June 2023. A reduced number of available sites on this road makes the data in these areas more susceptible to the effects of network related permutations such as diversions or road closures, especially when utilising indexed flows. However, following the London-wide ULEZ expansion, the pattern of an increasing flow from September 2023 to September 2024 is demonstrated much like with 2022, even though overall indexed traffic flow is marginally higher than 2022. Similarly, across 2024, the seasonal trends and flow activity is the same or nominally higher than 2022 showing a recovery to typical levels. Thus, this spike in the summer of 2023 was likely driven by local network permutations temporarily driving more traffic on to the South Circular.

When looking at the January to September indexed average for the South Circular in 2024 (see Table 80), the indexed flow in 2023 is greatly influenced by the spike observed in the summer of 2023. This leads to a temporary increase of 3 per cent but the same period in 2024 demonstrates a return to typical levels, remaining similar to the flow level in 2022.

Compliance rates on the North and South Circular roads have continued to increase since the London-wide ULEZ was launched, from 95.6 per cent in September 2023 to 96.9 per

cent in September 2024. Despite traffic levels remaining the same or growing marginally on these roads, the vehicles using them are cleaner.

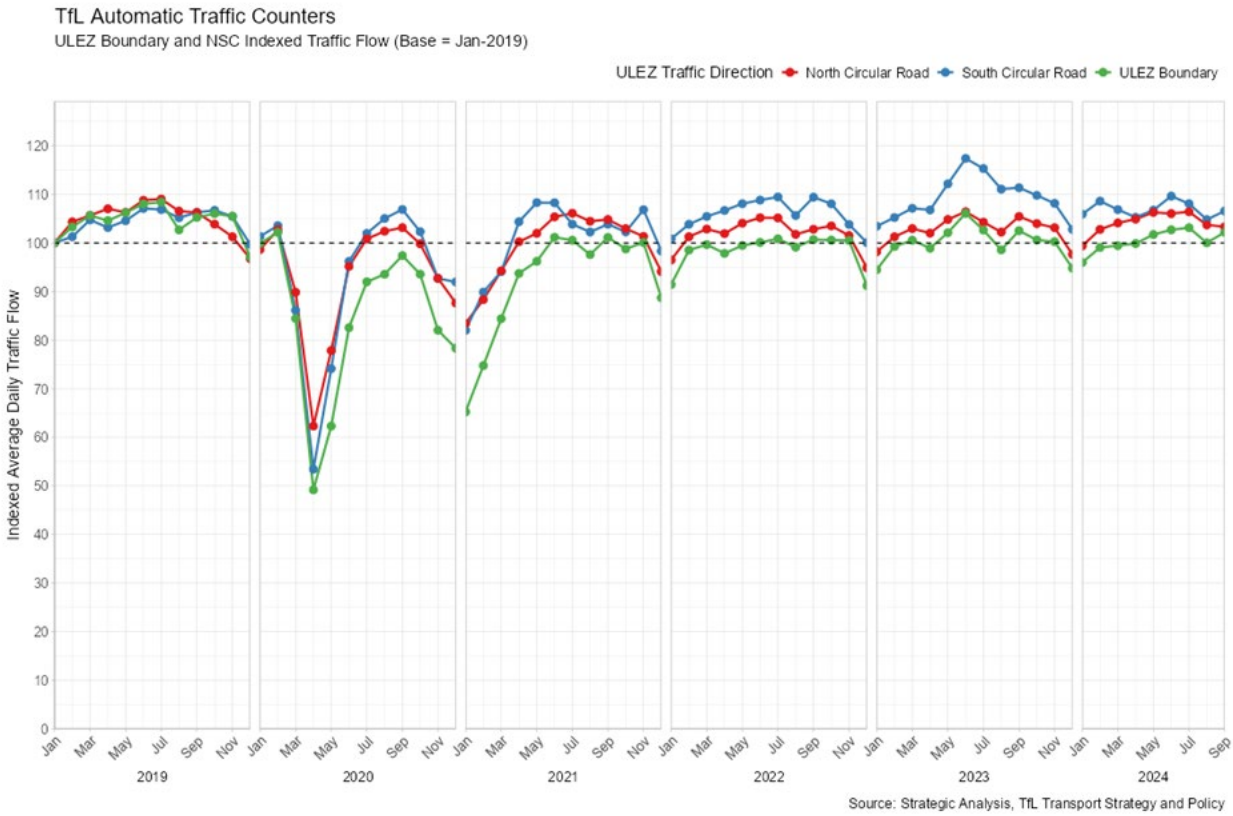

Figure 35: Indexed traffic flows for North Circular Road, South Circular Road and London-wide ULEZ boundary

Table 79: Indexed monthly traffic for North Circular Road (Indexed to January 2019)[101]

North Circular Road	2019	2020	2021	2022	2023	2024
Jan	100%	99%	83%	96%	98%	99%
Feb	104%	103%	88%	101%	101%	103%
Mar	106%	90%	94%	103%	103%	104%
Apr	107%	62%	100%	102%	102%	105%
May	106%	78%	102%	104%	105%	106%
Jun	109%	95%	105%	105%	106%	106%
Jul	109%	101%	106%	105%	104%	106%

North Circular Road	2019	2020	2021	2022	2023	2024
Aug	107%	102%	104%	102%	102%	104%
Sep	106%	103%	105%	103%	105%	103%
Oct	104%	100%	103%	104%	104%	ND
Nov	101%	93%	101%	102%	103%	ND
Dec	97%	88%	94%	95%	98%	ND

Table 80: Indexed monthly traffic for South Circular Road (Indexed to January 2019)[101]

South Circular Road	2019	2020	2021	2022	2023	2024
Jan	100%	101%	82%	101%	103%	106%
Feb	101%	104%	90%	104%	105%	109%
Mar	105%	86%	94%	105%	107%	107%
Apr	103%	53%	104%	107%	107%	105%
May	105%	74%	108%	108%	112%	107%
Jun	107%	96%	108%	109%	117%	110%
Jul	107%	102%	104%	109%	115%	108%
Aug	105%	105%	102%	106%	111%	105%
Sep	106%	107%	104%	109%	111%	107%
Oct	107%	102%	102%	108%	110%	ND
Nov	105%	93%	107%	104%	108%	ND
Dec	100%	92%	98%	100%	103%	ND

Table 81: Indexed monthly traffic for GLA boundary (Indexed to January 2019)[101]

GLA boundary	2019	2020	2021	2022	2023	2024
Jan	100%	100%	65%	91%	94%	96%
Feb	103%	102%	75%	99%	99%	99%
Mar	106%	84%	84%	100%	101%	99%
Apr	105%	49%	94%	98%	99%	100%
May	106%	62%	96%	99%	102%	102%
Jun	108%	83%	101%	100%	106%	103%
Jul	108%	92%	101%	101%	103%	103%

GLA boundary	2019	2020	2021	2022	2023	2024
Aug	103%	94%	98%	99%	99%	100%
Sep	105%	97%	101%	101%	103%	102%
Oct	106%	94%	99%	101%	101%	ND
Nov	105%	82%	100%	101%	100%	ND
Dec	97%	78%	89%	91%	95%	ND

Table 82: Indexed monthly traffic for Highways England boundary (indexed to January 2019)

Highways England boundary	2019	2020	2021	2022	2023	2024
Jan	100%	102%	55%	82%	82%	86%
Feb	104%	103%	68%	90%	89%	91%
Mar	107%	81%	78%	94%	91%	92%
Apr	105%	38%	90%	92%	92%	94%
May	109%	56%	93%	95%	97%	96%
Jun	113%	79%	99%	96%	102%	100%
Jul	116%	94%	97%	92%	99%	100%
Aug	108%	98%	100%	91%	96%	96%
Sep	112%	102%	100%	88%	97%	91%
Oct	111%	97%	97%	89%	97%	ND
Nov	110%	78%	96%	87%	95%	ND
Dec	102%	75%	89%	81%	85%	ND

Table 83: Indexed traffic across different zones averaged for the January to September period of each year (indexed against January to September average for 2019)

Zone	2019	2020	2021	2022	2023	2024
North Circular	100%	87%	93%	97%	97%	98%
South Circular	100%	88%	95%	102%	105%	102%
ULEZ boundary	100%	81%	86%	94%	96%	96%
Highways England boundary	100%	77%	80%	84%	87%	87%

Appendix 6 – LEZ compliance

Compliance for the LEZ is reported separately to the ULEZ as the scheme applies to different vehicles. More detailed information on the progression of emissions standards under the LEZ is available in the previous London Low Emission Zone Six Month Report and the Inner London Ultra Low Emission Zone – One Year Report.

The emissions standards for the LEZ were tightened to match the ULEZ standards on 1 March 2021. Data up to February 2021 is prior to the change in emissions standards, but all the data shown is the compliance with the tighter standards to show changes over time. Data from September 2023 includes information based on the newly installed cameras in outer London.

Table 84 shows the average monthly compliance rates for large and heavy vehicles travelling in the LEZ. It shows that the LEZ compliance rate is nearly 98 per cent, with an increase of 7.3 per cent since February 2021 (before the tighter standards). This highlights the success of the scheme in reducing the number of older, more polluting heavy vehicles on London's roads. This is based on the number of unique vehicles detected in the zone each day.

Table 84: London-wide LEZ compliance rate per month for large and heavy vehicles

Month	LEZ Compliance Rate (new emissions standards)
Feb – 2017 baseline§	48.0%
May-19*	71.0%
Sep-19*	73.7%
Jan-20*	78.5%
May-20†	83.2%
Jun-20†	83.4%

Month	LEZ Compliance Rate (new emissions standards)
Jul-20†	83.8%
Aug-20†	85.0%
Sep-20†	85.0%
Oct-20†	85.8%
Nov-20†	87.9%
Dec-20†	88.7%
Jan-21†	89.9%
Feb-21†	90.4%
Mar-21	93.5%
Apr-21	94.3%
May-21	94.5%
Jun-21	94.9%
Jul-21	95.3%

Month	LEZ Compliance Rate (new emissions standards)
Aug-21	95.5%
Sep-21	95.4%
Oct-21	95.7%
Dec-21	95.9%
Jan-22	96.1%
Feb-22	96.2%
Mar-22	96.1%
Apr-22	96.2%
May-22	96.2%
Jun-22	96.3%
Jul-22	96.7%
Aug-22	97.0%
Sep-22	97.0%

Month	LEZ Compliance Rate (new emissions standards)
Oct-22	97.1%
Nov-22	97.1%
Dec-22	97.1%
Jan-23	97.2%
Feb-23	97.4%
Mar-23	97.4%
Apr-23	97.4%
May-23	97.4%
Jun-23	97.4%
Jul-23	97.5%
Aug-23	97.7%
Sep-23	97.3%
Oct-23	97.3%

Month	LEZ Compliance Rate (new emissions standards)
Nov-23	97.3%
Dec-23	97.2%
Jan-24	97.4%
Feb-24	97.5%
Mar-24	97.4%
Apr-24	97.6%
May-24	97.5%
Jun-24	97.4%
Jul-24	97.5%
Aug-24	97.7%
Sep-24	97.7%
Overall change in compliance February 2017 to present	Increase of 49.7 percentage points

Month	LEZ Compliance Rate (new emissions standards)
Change in compliance since February 2021 (before the tighter standards)	Increase of 7.3 percentage points

§ February 2017 based on data from the London Atmospheric Emissions Inventory

** Analysis based on sampled days with these months, using historical data*

† Compliance rates estimated using information from ANPR camera data and associated vehicle information such as age and type of vehicle

Appendix 7 − Footfall and economic activity method

About the data

Footfall data from the High Streets Data Service is anonymised and aggregated mobile device location data from BT Active Intelligence, for 350 metre hexagon areas that cover the entire Greater London area. BT footfall counts are based on the number of people who spend at least 10 minutes in that hexagon in a three-hour period. For this analysis, each hexagon was assigned to one of the three zones (central London, inner London and outer London). Daily footfall for each zone was calculated by summing all hexagon counts within that zone and summing across all time periods within a day.

Spend data from the GLA High Streets Data Service comes from two different Mastercard sources:

1. The Mastercard Retail Location Index (MRLI), uses anonymised and aggregated transaction data from billions of Mastercard cards to measure sales, transactions and accounts. The geocoded location of all Mastercard transactions is aggregated to a 100-metre resolution grid and then aggregated to daily three-hour time periods to create a timeseries. The data only includes physical sales (i.e., not online purchases). The data is available as index values, not pound-pence values—it is thus useful for analysing relative changes in spend, not absolute spend. The method applied adjusts this index to account for inflation, the ongoing shift from cash to card payments, and Mastercard's growing share of the UK credit/debit card market, to better reflect 'on-the-ground' economic growth across London.
2. Spending Pulse is a macroeconomic indicator of retail sales across all payment types. Spending Pulse derives total and sector-level retail sales by aggregating sales activity in the Mastercard payments network and survey-based estimates for other payment types (including cash). These aggregates are then adjusted to account for macroeconomic factors. It is available as a pound-pence amount for inner London boroughs (including central London boroughs) and outer London Boroughs and England, monthly. This data is useful to track large-scale consumer retail trends over time. This analysis focused on total retail for physical sales, to best match MRLI.

For this analysis, the MRLI dataset was used to compare spend over time in each of the three zones, which broadly align with the ULEZ boundaries: central London, inner London and outer London. Each 100 metre squared area was assigned to one of these three zones and daily spend was calculated by summing all spend within that zone and summing across all time periods within a day.

The monthly Spending Pulse data was then used to compare spend trends for London with the rest of England.

To validate whether any changes in footfall or spend were due to the ULEZ expansion, or due to drifts in the timeseries caused by other factors (e.g. increasing cost of living), a statistical test was performed. A “linear shift” test was applied, which disrupts the true time relationship between the metric measured over time and the ULEZ expansion date, to determine whether the change is specific to the ULEZ expansion[102]. The test was administered individually to the changes observed in each of the three zones: central London, inner London and outer London for visitor and worker footfall and in-store spend. This analysis shows that the London-wide ULEZ expansion has had no significant impact on footfall and spend in the outer London area, or at a London-wide level.

High Street and borough-level data

In addition to examining changes to visitor footfall, worker footfall and in-store spend in each zonal area, impact on all London boroughs was assessed and across London’s 600+ high streets[103].

For each high street and borough, percentage change was calculated using summed footfall and spend from the year before (29 Aug 2022 to 28 Aug 2023) and the year after (29 Aug 2023 to 28 Aug 2024). Borough results are shown in Table 85 and high street results in Figure 36, Figure 37 and Figure 38. Each point on the maps in these figures represent the centre location of a London high street. The points are colour coded based on the footfall or spend percentage change amount. Dark red signifies a decrease of more than 15 per cent; light red – a decrease of between 5-15 per cent; grey – a change between -5 per cent to +5 per cent; light blue – an increase of between 5-15 per cent; dark blue – an increase of more than 15 per cent.

[102] Harris (2020). Nonsense correlations in neuroscience. Available at: Nonsense correlations in neuroscience | bioRxiv

[103] London's high streets were originally defined in Carmona (2015) as contiguous retail-dominated blocks at least 350 metre in length, identified using retail property data with buffers to include peripheral uses like offices and light industry. High streets in the Central Activity Zone (CAZ) are excluded due to their distinct global economic role, differing from the local and community-focused retail this analysis targets. Over the years, the GLA Regeneration team’s on-the-ground knowledge has further refined and validated these definitions.

While there is variation among individual high streets, variation is consistent across each of the London zones. I.e. the observed variations are distributed equally around the average change levels, and the variation appears to be randomly distributed, suggesting that the observed changes are due to normal variation rather than the London-wide ULEZ expansion.

Table 85: Change in visitor footfall, worker footfall and in-store spend split by London borough comparing the year before and after the London-wide ULEZ expansion

London Borough	Change in visitor footfall	Change in worker footfall	Change in in-store spend
Barking and Dagenham	4.39%	10.30%	-13.25%
Barnet	0.55%	7.13%	-5.17%
Bexley	2.66%	7.92%	0.64%
Brent	1.43%	10.14%	-4.39%
Bromley	2.59%	6.85%	-0.66%
Camden	-0.68%	4.26%	-2.00%
City of London	0.08%	15.06%	-4.73%
Croydon	0.05%	7.10%	0.82%
Ealing	2.78%	10.58%	-4.13%

London Borough	Change in visitor footfall	Change in worker footfall	Change in in-store spend
Enfield	1.52%	8.77%	-8.64%
Greenwich	0.99%	10.72%	-3.55%
Hackney	0.41%	9.70%	-1.26%
Hammersmith and Fulham	-5.22%	5.87%	-7.36%
Haringey	1.43%	8.86%	-3.91%
Harrow	-0.77%	6.54%	-3.28%
Havering	3.23%	9.39%	-9.86%
Hillingdon	3.39%	17.11%	1.48%
Hounslow	1.75%	10.51%	2.97%
Islington	-1.85%	6.73%	1.27%
Kensington and Chelsea	-1.14%	10.11%	-6.86%
Kingston upon Thames	-1.34%	1.26%	-6.49%

London Borough	Change in visitor footfall	Change in worker footfall	Change in in-store spend
Lambeth	-2.23%	6.92%	-0.32%
Lewisham	2.23%	9.05%	2.75%
Merton	2.04%	9.88%	-2.87%
Newham	0.43%	9.84%	-3.06%
Redbridge	2.42%	9.05%	0.41%
Richmond upon Thames	-0.19%	5.20%	-6.82%
Southwark	-3.24%	9.81%	0.84%
Sutton	-0.89%	2.39%	-4.78%
Tower Hamlets	-0.03%	8.88%	-6.46%
Waltham Forest	2.71%	8.53%	3.54%
Wandsworth	2.02%	6.88%	-1.11%
Westminster	-2.46%	6.28%	-6.93%

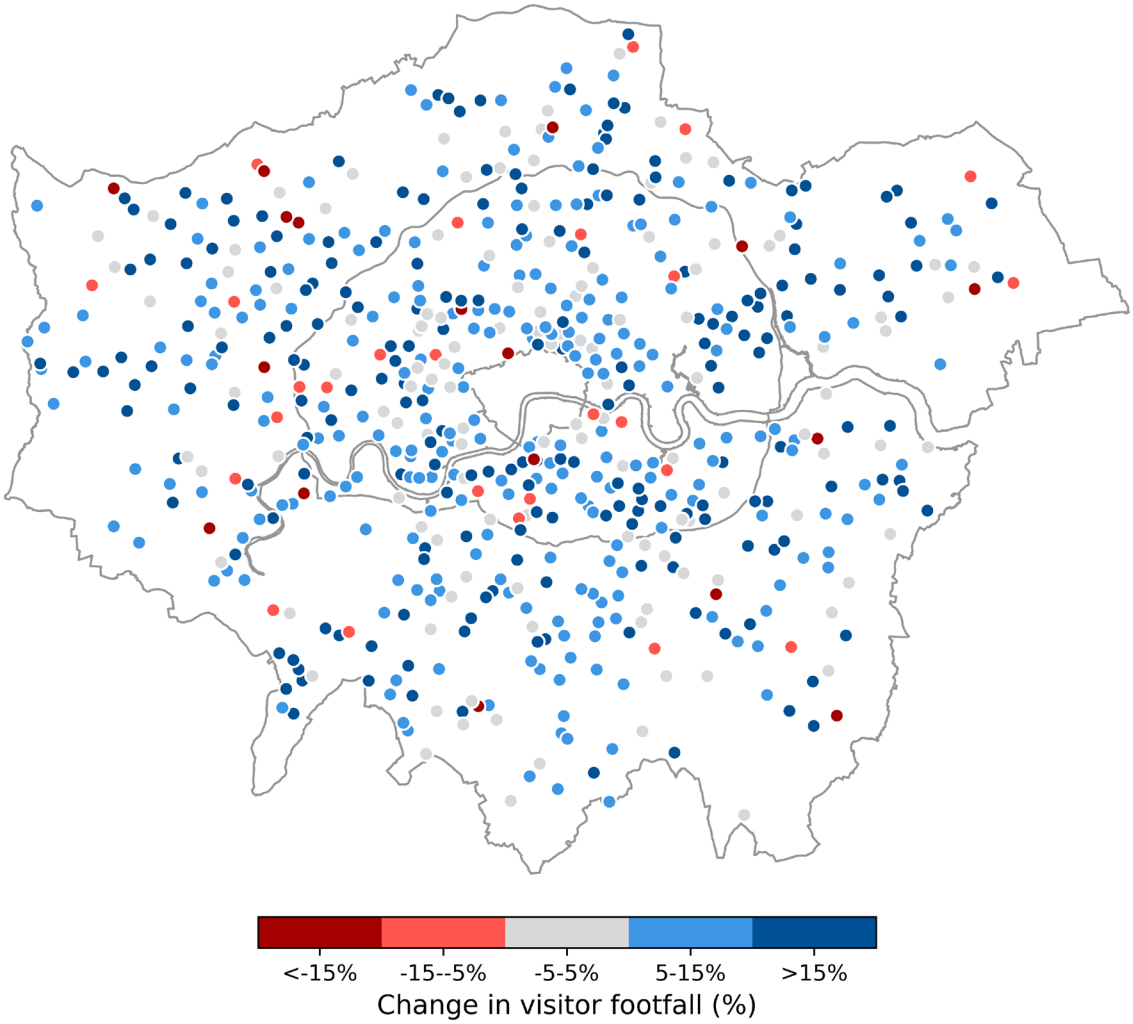

Figure 36: Percentage change in visitor footfall for each London high street, comparing the year before and after the ULEZ expansion

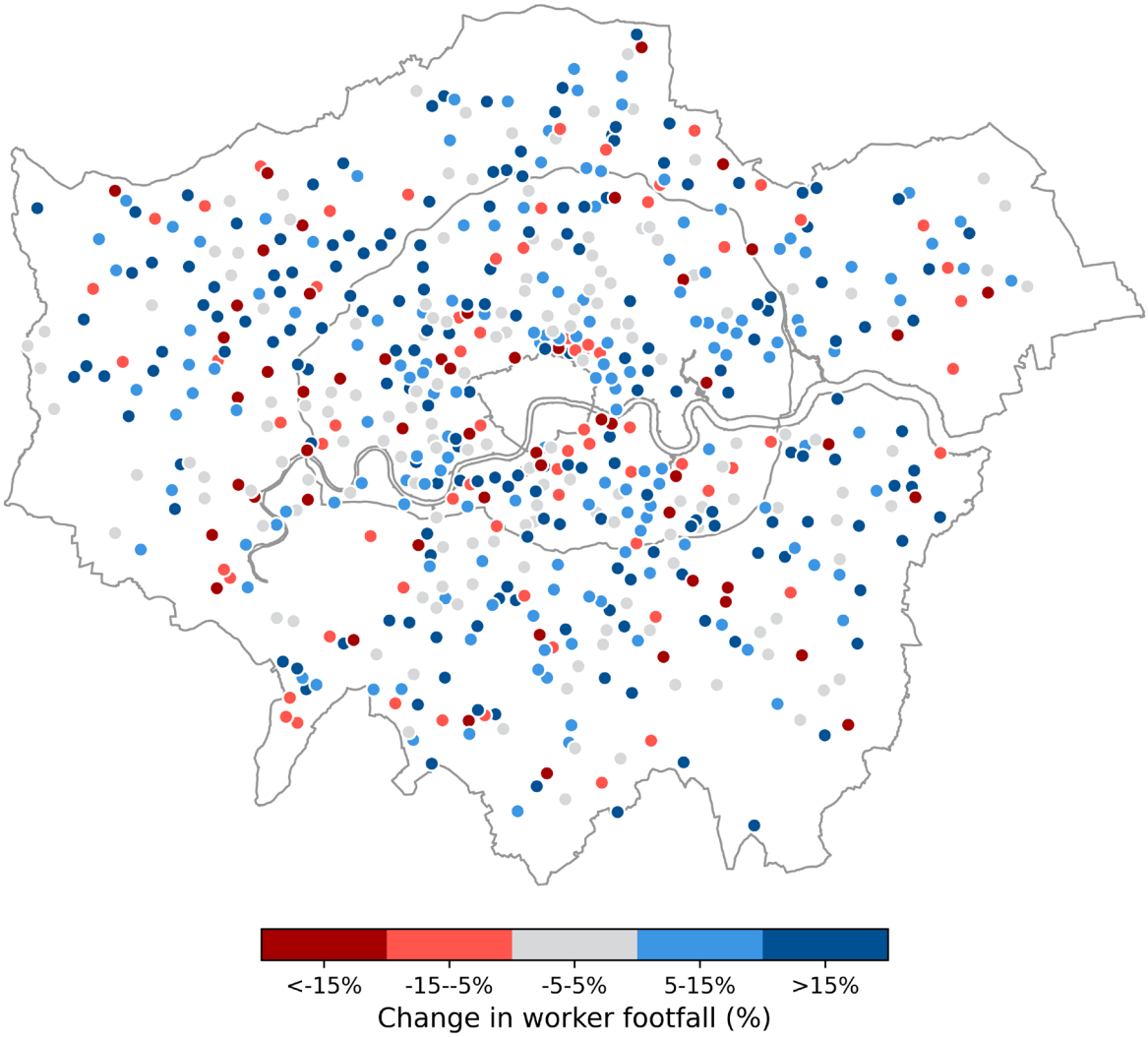

Figure 37: Percentage change in worker footfall for each London high street, comparing the year before and after the ULEZ expansion

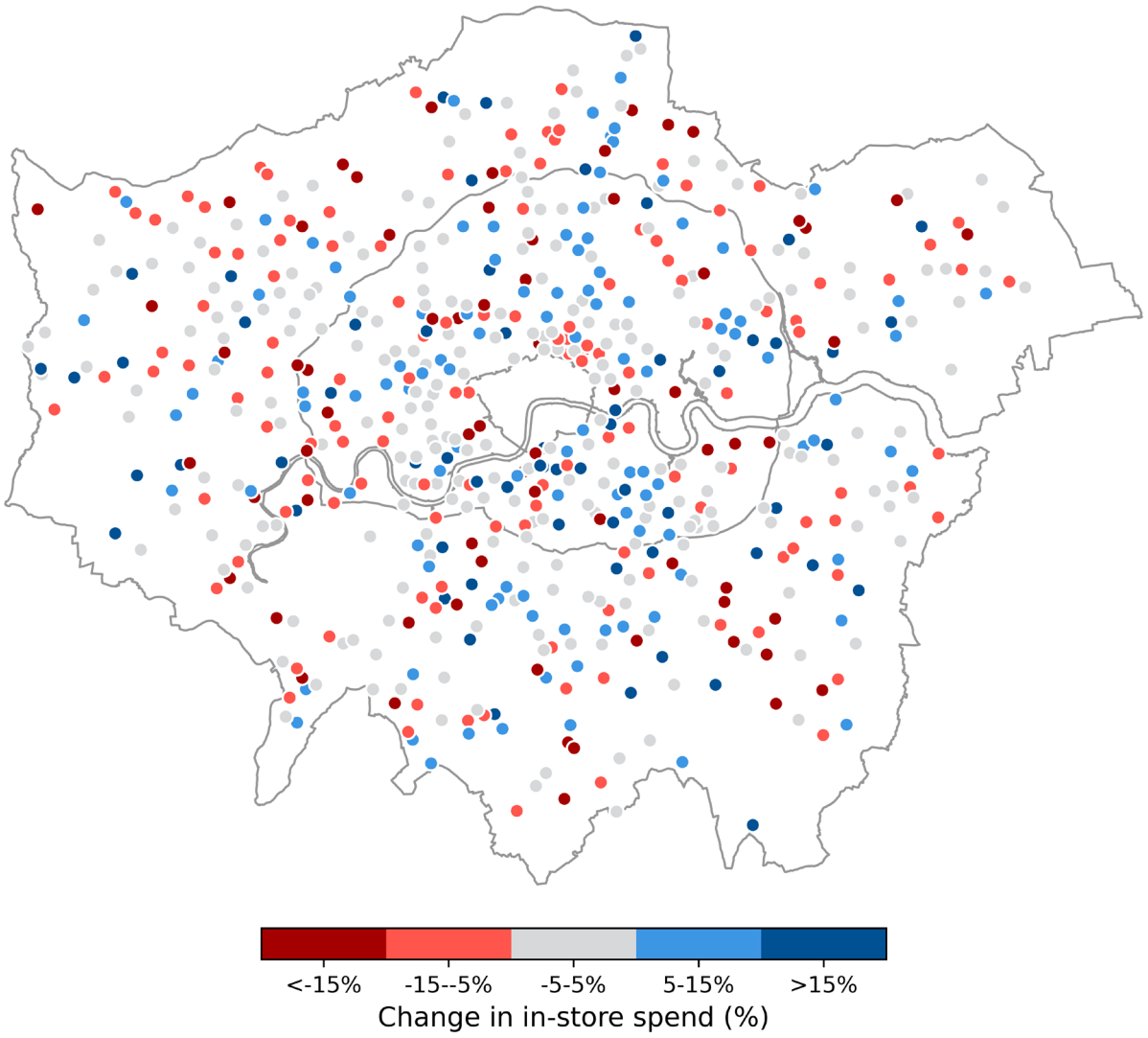

Figure 38: Percentage change in in-store spend for each London high street, comparing the year before and after the ULEZ expansion

Appendix 8 − Privacy and data minimisation

The ULEZ uses a network of ANPR cameras to identify non-compliant vehicles and enforce the scheme. The cameras along the boundary and within the zone operate as a single network for the whole expanded zone. This means that when a non-compliant vehicle is identified, even if it is observed on multiple cameras, only a single evidential record is retained for enforcement purposes to minimise the data collected. An evidential record will include a number of colour and black and white images to identify the vehicle and place it in the context of its surroundings.

When traffic is diverted into the zone because of road closures on or near the boundary, TfL does not use data from cameras along the diversion route to avoid unfairly penalising drivers of non-compliant vehicles who would not have otherwise entered the zone. Vehicles travelling off the diversion route and further into the zone will be picked up by the in-zone cameras.

A full Data Protection Impact Assessment for the scheme has been published on TfL's website.

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