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Local NO_2 Plans: baseline research findings

2020 Annual Report for the Evaluation of Local NO_2 Plans

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Executive summary

Local authorities with persistently high levels of air pollution, specifically NO_2 (nitrogen dioxide) concentrations, have been required by Government to develop and implement Local Plans to reduce these concentrations in the shortest possible time. This report provides an overview of the situation in Local Plan areas before these measures are implemented. It presents this baseline in terms of air quality trends as well as factors affecting the emissions of pollutants, such as traffic and the travel behaviour and attitudes of residents and businesses. Future reports will assess how these factors change post-implementation, and thereby evaluate the impact of NO_2 plans.

These baseline findings are part of the multi-year Evaluation of Local NO_2 Plans, which is being conducted by Ipsos MORI and the Institute for Transport Studies on behalf of the Government's Joint Air Quality Unit (JAQU). It is separate from, and complementary to, the monitoring and evaluation carried out by local authorities implementing Local Plans.

The evaluation uses two main methods of analysis. Analysis of air quality and traffic data assesses the extent to which changes in the concentration of NO_2 and other pollutants can be attributable to road-side emissions. At the same time, an evaluation approach known as contribution analysis assesses potential reasons for any changes in emissions and the influence of Local Plans on factors affecting air quality. The contribution analysis draws on case studies of selected Local Plan areas (deep dives) and topics of interest (rapid assessments).

Across the Local Plan areas, there is a consistent picture that levels of NO_2 have been falling in UK cities since 2015. With traffic levels broadly stable or slightly increasing, these modest improvements are likely to be due to upgrades in vehicle standards. The evaluation team tracked the impact of the COVID-19 lockdown on air quality across the UK. Concentrations of the pollutants NO, NO_2 and NO_x (nitrogen oxides) all decreased abruptly during the first UK lockdown in March 2020. However, following the return of vehicles to the roads, gradual increases in these pollutants were observed, offsetting much of the air quality improvement.

The evaluation surveyed residents in three Local Plan areas (Basildon & Essex, Birmingham, and Leeds) as part of deep-dive case studies. Most of those surveyed reported travelling in or around areas where measures would be implemented at least once a week. Awareness of the Local Plan measures was widespread in all three areas: at least four in five residents had heard of the measures, with higher levels of awareness in areas where the potential impact on residents was highest. Attitudes towards the measures were more positive than negative, with support varying from 42% to 57% and opposition varying from 12% to 34% across the residents surveyed in each area.

A large proportion of residents believed they would not change their behaviour as a result of the Local Plan measures. This is perhaps understandable considering that Clean Air Zone (CAZ) implementation will only affect around half of the Birmingham residents surveyed (based on their vehicle ownership) and would have affected few in Leeds. Furthermore, in Basildon & Essex a change in travel patterns is not required for the speed limit reduction to be effective, since reduced emissions are achieved through steadier driving. Among those who did intend to change how they travel following proposed CAZ implementation, most intended to use a different form of transport (20% in Birmingham and 17% in Leeds), or avoid the CAZ by choosing an alternative route (15% in Leeds and 10% in Birmingham). Surveys of businesses in Local Plan areas will identify the changes in businesses' behaviour predicted to occur as a result of the CAZ, which may have a larger impact than changes in residents' behaviour.

1 Introduction

1.1 Introduction to the report

Scope and purpose of this report

This report presents findings from the first year of a three-year evaluation of Local NO_2 Plans (henceforth the "Central Evaluation" or the "Evaluation"). This evaluation is being conducted on behalf of the Government's Joint Air Quality Unit (JAQU)[1]; it is separate from, and complementary to, the local monitoring and evaluation activity taking place in Local Plan areas.

Specifically, this report provides:

- a summary of data describing traffic levels and air quality from 2015 to mid-2020 in selected Local Plan areas, namely: Bath & North East Somerset, Basildon & Essex, Birmingham, Derby, Leeds, Nottingham and Southampton;
- early findings on the impacts of the first COVID-19 lockdown on air quality and traffic levels in selected Local Plan areas;
- a summary of baseline research findings around behaviours and attitudes to travel and the Local Plans, covering three Local Plans areas: Leeds, Birmingham and Basildon & Essex. Subsequent Evaluation reports will compare how behaviours and attitudes change from this baseline position in the period after the introduction of Local Plans measures; and,
- an overview of the Evaluation methodology and next steps for the Evaluation.

Further details on the evaluation methodology and findings are presented in annexes which accompany the report.

Future reports will evaluate the impact of NO_2 plans (post-implementation), assess the extent to which the NO_2 Plans programme outcomes are being achieved, and offer insight into what is/is not working well, in what context, where and for whom.

Overview of the Local NO_2 Plans

With the aim of promoting a cleaner natural environment and protecting the interests of public health, in July 2017, the government published its Air Quality Plan to tackle high levels of roadside nitrogen dioxide (NO_2) concentrations. This required 28 areas[2] with the most persistent NO_2 problems to develop and implement Local Plans to achieve compliance with statutory limits in the shortest possible time. Further areas were added in subsequent supplements to the Air Quality Plan. Some areas have proposed introducing charging Clean Air Zones (CAZs) as part of these plans. CAZs are areas where targeted action is taken to improve air quality. Charging CAZs involve charging certain types of polluting vehicles to drive within the zone, and are classified according to which vehicle types are potentially eligible for a

[1] The Joint Air Quality Unit is a joint unit of the Department for Transport (DfT) and the Department for Environment, Food and Rural Affairs (Defra)

[2] These are typically local authority areas, and local authorities are the bodies responsible for developing and implementing Local Plans. However, some Local Plan areas include more than one local authority, and/or do not cover the entire local authority area. For example, the Blackwater Valley Local Plan is the joint responsibility of Rushmoor Borough Council, Surrey Heath Borough Council, Hampshire County Council and Surrey County Council. Therefore, we often refer to "Local Plan areas" throughout this report rather than local authorities.

charge: class A CAZs cover the fewest vehicle types and class D CAZs cover the most, including private cars[3].

One Local Plan area, Leeds City Council, were due to be implementing a class B CAZ in 2021, but following air quality improvements and a joint review with JAQU, Leeds will no longer be introducing a CAZ[4].

The implementation of some of these measures has been delayed as a result of the COVID-19 pandemic in several areas and JAQU continue to work with local authorities to understand the impact of the pandemic on Local Plans.

1.2 Evaluation scope and objectives

JAQU commissioned Ipsos MORI, working in partnership with the Institute for Transport Studies (ITS) at the University of Leeds, to deliver the Central Evaluation of the impact of Local NO_2 Plans.[5] The aim of the Central Evaluation is to provide insights to support adaptive and future policymaking and inform the implementation of Local Plans. It will provide both formative evidence, including updates on whether and to what extent NO_2 concentrations have changed, and summative evidence to retrospectively report on the effectiveness of Local Plans in meeting their objectives on air quality and traffic. The Evaluation also seeks to identify the external factors that have influenced the performance of Local Plans, and present lessons learnt on what measures work best to reduce NO_2 concentrations. In particular, this Evaluation aims to respond to the five key questions below:

1. What impact have Local Plans had on air quality (particularly NO_2 concentrations, nitrogen oxide (NOx) emissions and health) and greenhouse gas (GHG) emissions?

2. How have Local Plans affected behaviours of businesses, private vehicle owners, transport users, public transport providers and public bodies? Have behaviours changed in expected or unexpected ways?

3. How has the impact of Local Plans varied for different local groups, including more vulnerable residents or transport users and SMEs?

4. How have external factors influenced the effectiveness of the Local Plans?

5. How does the approach to implementing Local Plans affect the scale and pace of impacts?

1.3 Evaluation method summary

The Central Evaluation aims to assess the contribution of Local Plans to any observed changes in traffic, concentrations of NO_2, other pollutants, greenhouse gas emissions and health in Local Plan areas. It is inherently challenging to attribute changes to these parameters to Local Plans, because there are multiple and complex factors affecting the outcomes of interest (e.g. air quality might be influenced by non-roadside emissions and weather aspects). Assessing the impact of Local Plans on health is particularly challenging, due to the wide range of other factors that affect health and the timescale over which we might expect to see improvements in health arising from Local Plans. Disruption arising from

[3] https://www.gov.uk/guidance/driving-in-a-clean-air-zone (accessed 31st January 2021)

[4] https://news.leeds.gov.uk/news/leeds-clean-air-zone-has-achieved-its-aims-early-and-is-no-longer-required-joint-review-finds (accessed 31st January 2021)

[5] In addition to the Central Evaluation, local authorities produce and implement local monitoring and evaluation plans for their own areas. The Central Evaluation aims to build on these local evaluations by providing an assessment of the impact of the policy as a whole, and comparing the relative impact of the different Local Plans measures adopted across areas.

the coronavirus pandemic in 2020, for example, changes to travel patterns, has added further complexity (see box on pages 18-19).

The approach adopted by this Central Evaluation (a 'contribution analysis')[6] aims to mitigate these risks by: (i) monitoring the factors that are expected to lead to the intended outcomes, in this case through a before-and-after analysis; (ii) monitoring the external factors that also affect travel and air quality, and by; (iii) assessing a range of alternative explanations for any trends observed during and after the period of the Local Plans' implementation. This approach enables an assessment of the likely impact of the Local Plans on the changes detected (e.g. in travel patterns, health, air quality). While in some cases it may not be possible for the evaluation to reliably *attribute* impacts to the Local Plans,[7] this approach is designed to enable the evaluation team to assess their *likely contribution* to the air quality and traffic outcomes observed.

An advanced before-and-after analysis approach is being applied to assess the extent to which observed changes in air quality can be attributable to a change in road-side emissions, while the contribution analysis[8] will be used to assess the key drivers of change in road-side emissions, analysing Local Plans' impacts on stakeholders' attitudes and behaviours towards the CAZ.

The contribution analysis approach involves devising a narrative which describes the ways in which the NO_2 Local Plans are expected to affect the key outcomes of interest, and identifying any other factors that might lead to changes (or lack of change) in the outcomes of interest. Data is then collected and analysed to track the implementation and the anticipated results of Local Plans, and those external factors that might also influence these results. In this way, we can assess the relative contribution made by the Local Plan measures to the observed outcomes, within their wider context of underlying changes such as the natural evolution of the vehicle fleet, traffic demand and trends in background air quality concentrations.

The explanation of how Local Plans are intended to achieve their desired outcomes is set out in the form of a theory of change, a narrative accompanied by a visual representation.[9] This is a common evaluation technique used to explain and understand how and why a desired change is expected to happen as a result of a particular intervention and in a particular context. The theory of change for the NO_2 Local Plans sets out step-by-step:

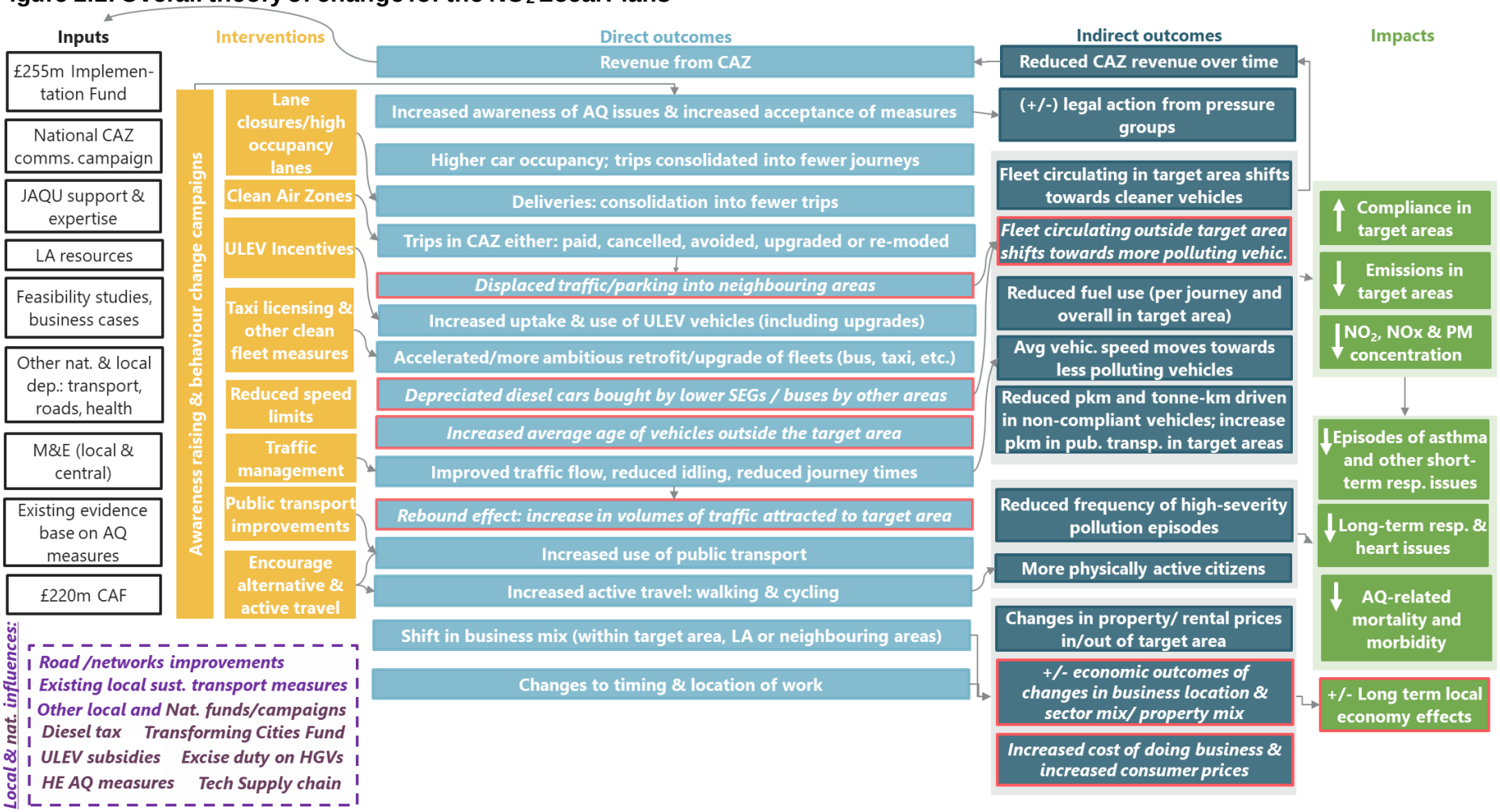
- The resources invested (inputs) with the aim to implement the Local Plans and further achieve its goals;
- The Local Plan measures (interventions) to be implemented;
- The direct and indirect changes that these activities are intended to lead to (direct and indirect outcomes) including changes in traffic levels, travel behaviour or business operations;
- How these changes are contributing to improvements in air quality and health (impacts).

[6] See Better Evaluation, the Magenta Book (HM Treasury, 2020) and Mayne, J, 2008 (Contribution analysis: An approach to exploring cause and effect) for descriptions of using contribution analysis to establish the contribution of interventions in real-world contexts (both pages accessed 1st February 2021).
[7] This is particularly the case of health outcomes which are longer-term and which depend on a complex range of factors other than air quality.
[8] See Better Evaluation, the Magenta Book (HM Treasury, 2020) and Mayne, J, 2008 (Contribution analysis: An approach to exploring cause and effect) for descriptions of using contribution analysis to establish the contribution of interventions in real-world contexts (both pages accessed 1st February 2021)
[9] See Better Evaluation for more information on developing a Theory of Change (accessed 31st January 2021).

The overall representation of the theory of change for the NO_2 Local Plans can be found in Figure 1.1 below. It represents an array of measures – charging CAZ, but also non-charging measures – which local areas are devising in their plans to reduce NO_2 emissions from road transport, and the measures intended direct and indirect outcomes. These include a shift towards cleaner vehicles driving in the target area, increased vehicle occupancy and consolidation of deliveries into fewer trips, increased active travel, etc. Beyond the intended consequences of NO_2 measures, these are also expected to drive unintended consequences, such as: increase/decrease in property prices; changes to business mix within the plan area; uptake of more polluting lower-cost vehicles in areas outside the CAZ (with uptake of these lower-cost vehicles potentially higher among lower social economic groups); effect on composition of traffic on roads just outside the plan area; increased parking just outside the plan area; and other unforeseen unintended consequences. The possible detrimental effects from NO_2 mitigation plans should be mapped in the NO_2 Local Plans and local areas can propose measures to counter some of these effects through funds from the Clean Air Fund (CAF). This Evaluation aims to monitor both the intended and unintended effects from NO_2 mitigation measures.

Chapter 2 details the latest developments of the method summarised here. A further description of the overall theory of change and a specific theory of change for a charging CAZ are provided in Annex 6.

Figure 1.1: Overall theory of change for the NO_2 Local Plans



Source: Ipsos MORI & ITS, based on inputs gathered during the Theory of Change Workshop, 25 March 2019.
Notes: (1) This Theory of Change does not depict all existing links between the its various elements, but only the links between the interventions and their key direct outcomes. (2) Implementation Fund and CAF values are correct as of March 2019.

1.4 Evaluation strands

To answer the key Evaluation questions, the Evaluation encompasses three main strands of data collection. The key aims of each of these strands are outlined below.

Before-and-after analysis of air quality and traffic data

The Central Evaluation uses ongoing analysis of air quality and traffic data, which captures data from before and after the implementation of the Local Plan measures, to identify whether the outcomes of interest are progressing in the right direction. The analysis tracks the trends in NO_2 and other key pollutants and compares them against the three baselines: (i) the expected change within the local area's business case; (ii) the observed change in control areas, and; (iii) a projected trend under business-as-usual conditions (i.e., a scenario without Local Plans). This analysis also tracks trends in traffic volumes and compositions.

Further information on the approach to the analysis of air quality and traffic data, as well as the initial findings, is provided in section 2.1 and Chapter 3.

Deep-dive case studies

Deep-dive case studies are mini-evaluations of a specific Local Plan. They employ a range of quantitative and qualitative research activities to collect evidence around how and why specific measures are affecting NO_2 concentrations, for example observing trends in residents' and businesses' travel behaviour. These case studies also include a light-touch assessment of the health impacts of the Local Plans. The deep-dive case studies last between two and three years, and measure relevant outcomes at three points: before, shortly after, and longer after the implementation of the Local Plans.

The case study approach adds important evidence to the Evaluation by allowing us to: understand how changes in air quality and traffic have been achieved; explore the impact of Local Plan measures across different groups and businesses; explore any unintended outcomes of Local Plans, and how these may have come about; and develop knowledge about contexts that can either help or hinder measures.

There will be eight deep-dive case studies based on different geographies, measures and demographics. Five have been selected to date, of which two are at baseline reporting stage: Birmingham and Basildon & Essex. Deep-dive research had also commenced in Leeds, and the Evaluation produced an initial report of baseline findings, but further research is now on hold following the decision that a CAZ is no longer required. Further information on the selected deep-dive case studies, methodology and initial findings is presented in sections 2.2 and 4.

Rapid assessment case studies

The Central Evaluation is expected to include approximately 10 rapid assessment case studies, which are short-term studies conducted over a period of 2 to 4 months, and focused on a specific issue, measure or target group. Rapid assessments also complement the statistical trend analysis by collecting evidence around causal factors leading to the observed trends in NO_2 concentrations in a given local area.

Their key aims are to enable action to be undertaken where NO_2 trends are not responding to measures as expected; inform early response to imminent external or internal threats to Local Plan effectiveness; and generate learning from good practice, and from what has worked less well, that can be shared across Local Plan areas.

1.5 Structure of the report

This introductory chapter provides an overview of the Local Plans, the Evaluation scope and framework, and the Evaluation progress to date, including the impacts of COVID-19 on our Evaluation. Chapter 2 provides an outline of the Evaluation approach, including further detail on the methodologies applied. Chapter 3 presents a summary of the trends in traffic and air quality, setting the baseline position of traffic and air quality, which will help answer the first evaluation question, namely, 'What impact have NO_2 Local Plans had on air quality GHG emissions', while Chapter 4 presents selected findings from baseline research in three Local Plan areas, which will form the basis for answering the remaining evaluation questions. These touch upon: Local Plans' impacts on behaviours and on distribution of impacts across stakeholder groups; the extent to which other factors could have influenced these changes; and the extent to which different approaches to implementing the plans have impacted its effectiveness. Finally, Chapter 5 outlines the next steps for the evaluation, and how this will provide formative and summative evidence for policy making.

1.6 Acknowledgements

The evaluation team would like to thank the local authority staff, residents and businesses in case study areas for their participation in the evaluation, and the team at JAQU for their support. We are also grateful to Dr David Carslaw, University of York, for conducting a peer review of this report.

2 Evaluation methodology: developments over last 12 months

This section summarises the progress of the Central Evaluation over the last 12 months and outlines methodological developments related to the three main strands of Evaluation activity, which are summarised in section 1.4.

2.1 Before-and-after analysis

Continuous Analyser and traffic data analysis approach

Air quality data for Central Evaluation monitoring is obtained from the Automatic Urban Rural Network (AURN)[10] and Local Air Quality Management (LAQM)[11] databases, and from local authorities submitted data (namely, data from continuous analysers that are not part of the AURN and NO_2 diffusion tubes). Local authorities submit data to a mailbox, and the data is then semi-automatically extracted and stored in an 'OpenSQL' database. The Evaluation will also rely on data from three additional continuous analysers to be installed in selected locations (further detail is provided on Annex 1).

Traffic data for the Central Evaluation is currently obtained from local authority submitted data from automatic traffic counts and, in the future, it will also rely on the automatic number-place recognition (ANPR) database held by the Department for Transport (DfT).[12]

The air quality data collected from continuous analysers will be analysed alongside the traffic data and other weather data to detect changes in pollutant concentrations attributable to road-side emissions. Robustly detecting trends and changes in air quality concentrations is widely acknowledged to be challenging because of underlying variations in levels due to the weather, fluctuations in "background" concentrations (i.e. pollutant concentrations in areas less affected by roadside emissions) and emissions from non-transport sources.

ITS has furthered the methods that attempt to remove the effects of variable weather and background concentrations from hour-by-hour measurements (continuous analysers), then identify the underlying trends and detect step-changes and more gradual deviations over weeks and months. The techniques are coded into a pre-release open-source (www.r-project.org) software package 'AQEval', so it can be efficiently run on data from the Local Plan areas. The package is currently undergoing 'user testing' by an external, independent air quality science team. The intention is that this package will be released under a general public license[13] so that researchers and practitioners across the UK and internationally can evaluate the impact of their own air quality policies and interventions. The methods, software and their application are described in recent peer reviewed scientific journal papers.[14] This approach will be applied under the Central Evaluation to track NO_2 concentrations across all local areas within the Evaluation's scope, applying continuous analyser data supplied to the Evaluation team. Where available, concentrations of NO_X will also be analysed, as this is a more direct indicator of traffic-related air pollution and vehicle emissions. The Evaluation team will also collect data from three additional

[10] https://uk-air.defra.gov.uk/networks/network-info?view=aurn (accessed 31st January 2021)
[11] https://laqm.defra.gov.uk/ (accessed 31st January 2021)
[12] All ANPR data used by the Central Evaluation is GDPR compliant.
[13] https://opensource.org/licenses/gpl-license (accessed 31st January 2021).
[14] The methods and their application are described in the peer reviewed journal publication Ropkins, K., Tate, J., Walker, A., Clark, T. 2021. Measuring the Impact of Air Quality Related Interventions. In Submission 27th January 2021.

continuous analysers that will be installed in priority areas as part of this Evaluation – Derby, Basildon & Essex and Liverpool.[15] All data collected is intended to be compared with control sites not subject to Local Plans measures, to help unpick the impact of the Local Plans. The approach for selecting the control sites is provided in Annex 1.

Diffusion Tube data analysis approach & next steps

In addition to using data from instruments that local authorities have already established, the Evaluation team will install a network of diffusion tubes to improve our ability to detect improvements in air quality. While it is recognised that diffusion tubes are inherently less precise than continuous analysers[16,17] and can only provide averaged monthly measurements (hence limiting the ability to remove "noise" from the data), their lower costs[18] enable a higher coverage of study areas than would be otherwise possible with continuous analyser data only. Furthermore, uncertainties of diffusion tubes can be reduced by following best-practice running triplicate tubes and verifying against a real-time station. The project team has explored diffusion tube measurement uncertainties, to inform how many samples are required to detect the expected improvement in air quality due to Local Plans,[19,20] and concluded that about six modified diffusion tubes or about 16 standard diffusion tubes would be needed to detect a 10% change in NO_2 concentrations. As it is unclear how viable deploying more than 50 DTs is, this suggests that the detection of changes smaller than 5% should be regarded as extremely challenging with diffusion tubes.[21] The approach for selecting areas to install the diffusion tubes is under development and is outlined in Annex 1.

PHEM method (Passenger car and Heavy-duty Emission Model)

As part of Local Plan packages, a number of local authorities are implementing traffic management measures, including reducing speed limits. There are concerns that the impact of such measures may be smaller than the techniques applied in 'AQEval' are able to detect, e.g. in situations where associated impacts are expected to be of the order of a few percent. In these situations it is therefore desirable to adopt an alternative approach of directly measuring and assessing the impact of traffic management interventions, by measuring changes in traffic flow / driver behaviour and emissions, and thereby modelling the effects. Basildon & Essex are the first Local Plan area to implement a speed limit reduction as part of their Local Plan and therefore the Evaluation team and JAQU agreed that it was most appropriate to use an approach tracking vehicle speed trajectories to inform (validated) Instantaneous

[15] Annex 1 describes the rationale for prioritising these three areas.

[16] Diffusion tubes (DTs) are widely used for low-cost air quality monitoring but have high measurement uncertainty, reportedly more than 20% for the 'conventional' DT design commonly used by local authorities in their LAQM, and less than 12% for newer 'modified' DTs. This means they are more suited to measuring high concentrations in polluted environments than being deployed to assess background (lower) levels.

[17] The project team is closely tracking the development of the UK Nitrogen Dioxide Diffusion Tube Network (the NO_2 Network), alongside AEA and their NETCEN division who are also undertaking a number of studies of DT tube performance.

[18] Diffusion tubes can be approximately 10,000 times less expensive than a real-time NO_2 station and deployable on any lamp-stand, also reducing installation costs.

[19] Any additional DT monitoring will meet the LAQM TG16 standards by using the accredited, well-established laboratories following UKAS methods GLM 7 and GLM 9, whilst also fulfilling the specifications of the 'UK Urban NO_2 Diffusion Tube Network' being established. This will include having triplicate samples from all sites, anonymising sampling locations and IDs, and co-locating a site with a real-time station where available. All new monitoring sites will meet the local authority diffusion tube siting guidelines.

[20] As reported in the literature, this is as an expanded 95% Confidence Interval (95% CI, k=2) for total Uncertainty, where this is defined as: $U_{total} = (U1^2 + U2^2 + U3^2 + U4^2)^{1/2}$
Where U_{total} is the Total Uncertainty; *U1* is the NO_2 in air measurement (chemiluminescence analyser) uncertainty; *U2* is the sampler uncertainty; *U3* is the lab uncertainty; and, *U4* is the sampling time uncertainty.
Pfeffer et al[20] reported these to be about 20% for conventional DTs and 12.6% for DTs fitted with mesh caps (hereafter referred to as modified samplers) based on measurements made at about 40 ug/m^3.

[21] Analysis of archived data from existing DT studies indicates that real-world uncertainties might be larger (about 1.5 times) but this analysis was limited to conventional DTs and the data used was not collected for the purposes of uncertainty testing. So, results should be treated as tentative.

Emission Modelling (IEM)[22] in this area. The detail around how this method was applied in Basildon & Essex is provided in Annex 1. In other areas, 'AQEval' has been the preferred method to track impacts on air quality, given it is understood to have higher accuracy.

2.2 Deep-dive case studies

Selection of deep-dive case studies

The Central Evaluation will deliver eight deep-dive case studies. Three have submitted baseline reports (although business baseline data collection is yet to be completed in two of these areas) and a further two are being planned, with the remaining three still to be selected.

The Local Plans selected to date are summarised below. These areas were chosen since they will be among the earliest areas to implement their Local Plan measures, and because these measures are similar to those being adopted elsewhere, meaning that evidence generated by these case studies will be relevant to a number of other Local Plan areas. Annex 3 provides more detail on the measures being proposed and implemented in each area, and the information that each deep-dive can contribute to the wider Evaluation.

Birmingham is implementing a CAZ class D[23] on the central A4540 Middleway Ring Road, with non-compliant vehicles charged for driving in the CAZ. This will affect all vehicle types, (except motorcycles), with vehicles being required to meet emissions standards in order to be compliant: Euro 6 for diesel vehicles and Euro 4 for petrol vehicles.[24] In addition to implementing the CAZ, a further set of measures have been proposed, including parking restrictions and restricting traffic flows at selected junctions, making two roads into through routes.

Basildon & Essex are implementing a speed limit reduction on the A127. The speed limit has been reduced from 70 miles per hour to 50 in both directions on a five mile stretch of the road, from Fortune of War roundabout in the West, to Pound Lane in the East. This reduction is expected to reduce NO_2 concentrations, as the reduced speed limit is expected to lead to a steadier driving cycle, which evidence shows is linked to lower emissions.

Bath & North East Somerset is implementing a CAZ Class C[25] in the centre of Bath. This will affect HGVs, buses, coaches, vans, taxis and private hire vehicles (PHVs) that are not compliant with emissions standards.

Sheffield & Rotherham is implementing a CAZ Class C+ in Sheffield, which will affect non-compliant taxis and private hire vehicles (PHVs), vans, HGVs, buses and coaches, which would be required to pay a charge to drive in the zone within the city's inner ring road. There are additional requirements (the "+") for taxi and PHVs that will require them to go beyond Euro 6 standard[26] and upgrade to either a petrol hybrid or ULEV. Non-charging measures will be implemented in Rotherham.

[22] Compared with other tools often used to impact the impact of similar interventions, IEM is able to simulate the difference in emissions based on different driving patterns

[23] Charging CAZ vary in terms of the categories of vehicles that they cover: depending on the coverage, a charging CAZ can be class A (buses, coaches, taxis, and private hire vehicles), B (Class A + HGVs), C (Class B + LGVs) or D (Class C + cars).

[24] Euro emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and European Economic Area (EEA) member states. Increasingly stringent standards have been progressively introduced.

[25] Charging CAZ vary in terms of the categories of vehicles that they cover: depending on the coverage, a charging CAZ can be class A (buses, coaches, taxis, and private hire vehicles), B (Class A + HGVs), C (Class B + LGVs) or D (Class C + cars)

[26] Euro emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. Increasingly stringent standards have been progressively introduced.

Leeds was selected as it was due to implement a CAZ class B+[27] in the central and northern part of the city. This would have affected HGVs, buses, coaches, taxis and private hire vehicles (PHVs) that are not compliant with emissions standards. There were additional requirements (the "+") for taxi and PHVs that would require them to go beyond Euro 6 standard[28] and upgrade to either a petrol hybrid or ULEV. Even though this area is no longer implementing a CAZ, it is still the focus of a deep-dive case study, since there may be learning to be shared with other local areas.

Approach to deep-dive case studies

As with the overall Evaluation, the deep-dive case studies have been structured around a theory of change (also referred to as a pathway to impact at local authority-level) for each case study. This sets out the anticipated effects of Local Plan measures on behaviours and attitudes. The pathway to impact diagrams were developed by Ipsos MORI and JAQU in collaboration with the local area staff involved in the delivery and Evaluation of the Local Plan.

At each deep-dive case study, a set of Evaluation questions was drawn up following an inception meeting, setting out the scope of the Evaluation. As well as meeting the needs of the Central Evaluation, these questions were developed in collaboration with the relevant local authorities, so to reflect their research priorities for their Local Plan.

Data collection for the deep-dive case studies

The Evaluation team proposed a set of data collection activities that would capture the information required to answer this set of Evaluation questions. This varied for each deep-dive case study, and typically comprised both quantitative and qualitative primary research with different groups likely to be affected by Local Plans, as well as a review of secondary data and insights from the before-and-after analysis. The data collection process for each deep-dive case study depends on the type and scale of intervention being implemented in the area, the groups likely to be affected, the data already available and the feasibility of data collection methods.

The current picture of the baseline position, as presented in Chapter 4, is based on a review of secondary data sources and the results of surveys with residents in each of the three areas, discussed below in further detail. Qualitative research for the first three deep-dive case studies is not scheduled to take place until the mid-line research. Due to the COVID-19 pandemic, the Evaluation team had also been unable to undertake the surveys of local businesses as planned for the Birmingham and Leeds case studies. The Birmingham business survey launched in September, with the Bath & North East Somerset business and resident surveys having been run in November. These will contribute to our baselining of indicators for direct and indirect outcomes within this stakeholder group.[29]

Telephone surveys with residents

The resident surveys were undertaken by telephone between February and April 2020. The surveys covered topics such as awareness and understanding of the Local Plan measures; attitudes towards these measures; travelling behaviour for commuting and personal journeys (route, mode and frequency of travel), and perceived impact of the Local Plan measures on this; vehicle ownership and purchasing decisions; perceptions of air quality and traffic in their local area; and perceptions around state of own

[27] Charging CAZ vary in terms of the categories of vehicles that they cover: depending on the coverage, a charging CAZ can be class A (buses, coaches, taxis, and private hire vehicles), B (Class A + HGVs), C (Class B + LGVs) or D (Class C + cars).

[28] Euro emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. Increasingly stringent standards have been progressively introduced.

[29] See the box at the end of this chapter for a summary of how the Evaluation is handling the impacts of COVID-19 on the outcomes of interest.

health, with follow-up questions for respondents who reported respiratory conditions about the frequency of episodes and extent of treatment required.

The surveys were not identical in the three areas, reflecting differences in the measures to be implemented, and JAQU and local authorities' priorities for data collection. This means that on some questions and measures, the results cover one or two of the areas rather than all three.

Quotas for age, gender and working status were set for the surveys, based on the population in each of the areas surveyed. However, there were some differences between the profile of those completing the survey and the population in the area; for example, young people were somewhat under-represented, and the level of vehicle ownership reported in the survey was higher than that reported in other sources (see annex 4, p.33). This may create biases if those under- or over-represented in the survey have systematically different views, perceptions or behaviour.

As with all surveys of this kind, data is self-reported. There may therefore be some inaccuracy in the answers respondents provide, for example due to recall bias (when respondents do not remember past events or experiences accurately), or social desirability bias (when respondents seek to provide responses which they think are more acceptable than their true behaviour or views). Similar limitations will apply to the other surveys to be carried out with residents and businesses as part of this evaluation.

2.3 Rapid assessment case studies

Rapid assessment case studies (RAs) are shorter-term case studies which focus on a particular area, measure or relevant theme. The Evaluation team and JAQU have drawn up a process for determining when to undertake a rapid assessment, set out in detail in Annex 5. This process foresees three main triggers for a Rapid Assessment:

- **Quarterly reports of air quality and traffic monitoring data** collected by ITS which will highlight the extent to which the air quality and traffic levels in Local Plans areas are in line with, or deviating from, the levels expected. The Central Evaluation team has not yet determined the level of divergence that would trigger further review, as it will first be necessary to better understand the precision of our air quality tracking methods.

- **JAQU regular oversight of local areas** to keep track of Plans' implementation and of research questions relevant for decision making and implementation. These RAs could identify problems or barriers to the implementation of the Plan, or positive developments such as a local area taking an innovative approach not used by others.

- **Local authority or other external interests in a particular measure or topic** that can be used to support adaptive policy-making. So far, this has been the main route for triggering RAs.

The Evaluation team is currently planning to undertake its first Rapid Assessments. One of these will investigate the impact of COVID-19 on businesses, both in terms of their operations in general (such as travel behaviour and fleet management), and in the way businesses are able to respond to CAZ launch. More detail is given in section 5.3 below.

Approach to handling the impact of COVID-19 on outcomes of interest

As detailed above, the evaluation uses a theory-based approach to assess the impact of Local Plans measures. A theory describing how Local Plans will change behaviours and how these changes will ultimately lead to improvements in air quality and public health is developed. During the evaluation the data collected will be applied to the theory to assess whether these assumptions hold true in practice. The pandemic adds a confounding factor, as some of its impacts will be similar to those expected as a result of the Local Plans measures, and because it has disrupted normal travel behaviour in ways that may be long-lasting and which remain unpredictable.

To help disentangle the impacts of COVID-19 from the Local Plans measures, the evaluation will gather evidence to build a picture of what impact Local Plans measures have had, above and beyond the changes that occur due to COVID-19. This will broaden the scope of data collection to look at the impacts of COVID-19 on the behaviours and outcomes being measured in the Evaluation. Specifically, this will include public and business travel, air quality and public health, and looking at data both nationally and for Local Plans areas. The data that will be used is outlined below.

- The baseline surveys undertaken during the pandemic period will include at least one question to help assess the extent to which the pandemic might have affected respondent's frequency of travel to the CAZ area.

- Data collected by ITS will enable the Evaluation to capture changes in traffic patterns in Local Plans areas before, during, and after the pandemic – enabling the Evaluation team to judge whether there are additional changes in Local Plans areas, or different patterns of changes in travel behaviours, compared with areas with no Local Plans measures being introduced. Likewise, ITS is collecting data on air quality from Local Plans areas and from control sites, which will allow the Evaluation team to judge whether the changes in Local Plans areas go above and beyond any improvements that happen anyway, as a result of changes in travel behaviour over the same period (due to COVID/other reasons).

- The Evaluation will draw on research data from national studies to explain trends in the secondary data (traffic patterns, air quality) at the national level – for example, the proportion of businesses allowing working from home, the extent of working from home in these businesses (% of staff/ working week).

- As outlined in section 5.3, the Evaluation is conducting a COVID-19 impacts survey which will gather data on the type and scale of changes businesses in Local Plans areas are making to their practices as a result of COVID, to provide context around what changes are already happening as a result of COVID-19 before Local Plans are introduced. The Evaluation team will also monitor COVID/lockdown restrictions in each of the Local Plans areas over the life of the evaluation, so that we can assess the findings in the light of the severity of the outbreak in each area and the extent/duration of lockdown measures.

- The follow-up surveys run as part of the evaluation will include questions about changes in residents'/business' behaviour and the reasons behind those changes. For instance, surveys might ask about changes in the frequency of travelling into the city centre by different modes of transport, and ask respondents the reasons for these changes to help unpick changes driven by Local Plans measures in comparison to COVID-19. In the mid-line and end-line waves of research will include qualitative interviews with affected businesses which will explore the reasons behind their decisions and behaviour, and with individuals at the local authority, who can discuss the impact of COVID-19 in the local area.

- Health outcomes are a key outcome of interest for this evaluation, which are obviously deeply affected by the pandemic. Within the residents' survey, we will ask residents to report health conditions that pre-dated COVID-19 as part of surveys and in-depth interviews at interim and end-

line stages. Secondary data on hospital admissions related to respiratory and heart disease will also focus on non-COVID-related conditions, and focus on the trends from before the pandemic and from the point when it is eventually controlled. However, it may still be expected that the outcomes from the plans will remain difficult to disentangle from the effects of COVID-19 on the general population, even more so considering that the long-term effects of COVID-19 are still to be better understood.

3 Baseline findings: before and after analysis

The aim of this strand of the Evaluation is to gather monitoring data to help assess the impact of the NO_2 Local Plans on air quality and traffic, over and above underlying trends in air quality, traffic demand, transport use and the evolution of the vehicle fleet. To do this, the Evaluation team are using both data which is already available and being collected regularly, such as from publicly available or government-owned databases and from local authorities' own air quality monitoring; and additional data from air quality monitoring technology that will be set up as part of this Central Evaluation. More details about the methods and technology used are provided in section 2.1 above and in Annex 1. This section provides a summary of statistical before/after analysis conducted to date, namely: an assessment of trends in NO_2 concentrations across the Local Plan areas, an analysis of the impacts of lockdown on selected areas for which sufficient traffic data was available (namely, Leeds and Southampton), and the baseline results of the PHEM survey in Basildon & Essex.

3.1 Baseline NO_2 concentration trends

The Central Evaluation team has estimated the observed air quality and traffic trends from 2015 to the end of 2019 (as data permitted), i.e. before the implementation of the Local NO_2 Plans, providing a baseline against which the plan effectiveness will be monitored. These trends have been estimated for the local areas which had accessible air quality and traffic data, and/or had submitted such data up to the end of 2019, namely: Bath & North East Somerset, Birmingham, Derby, Leeds, Nottingham and Southampton.

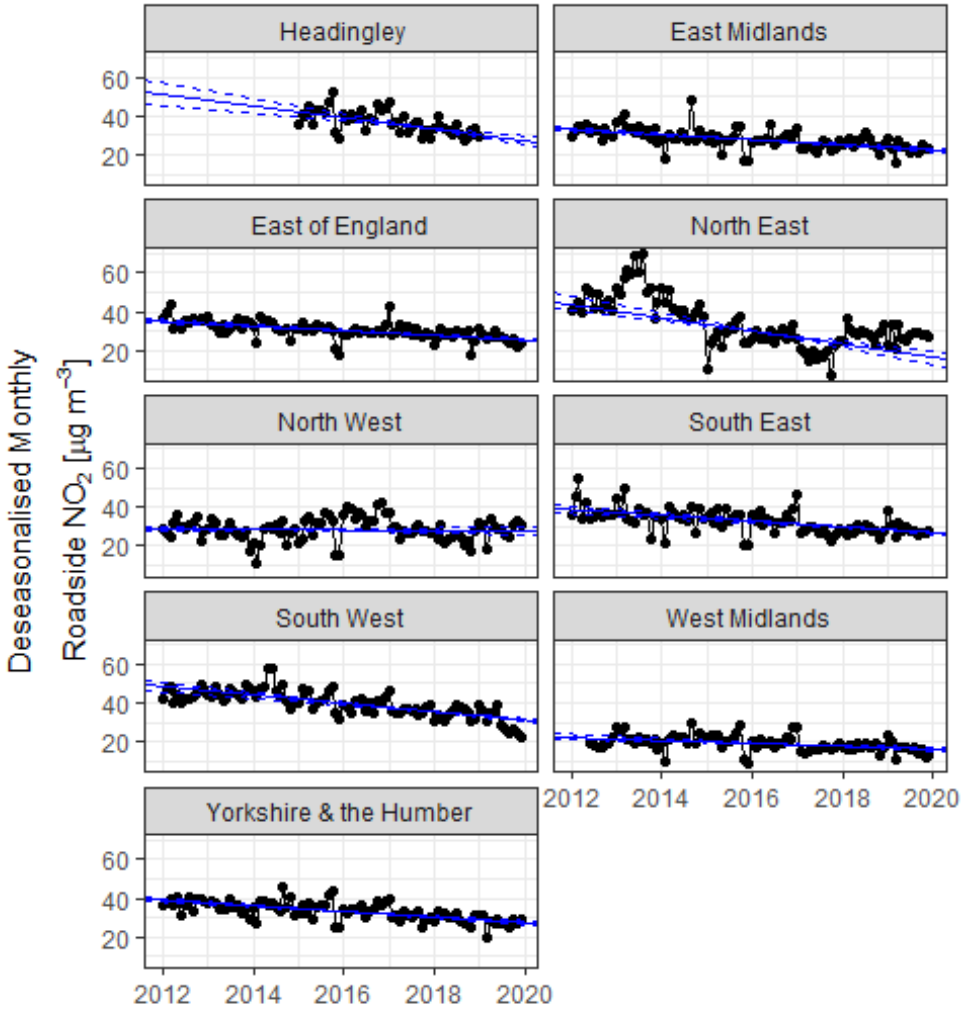
The trends observed at each of the local areas' continuous analyser monitoring locations were also contrasted with the average trends in each of the geographic regions of England. This regional analysis relied on data from the AURN as local authorities not involved in the Local Plans project are not required to publish and share their hourly continuous analyser data. The analysis is shown in Figure 3.1. The black dots are the monthly average of all the roadside sites in that region and the solid and dotted blue lines are the calculated trend of the monthly average and the confidence limits, respectively. For example, the data and trend at the Headingley kerbside AURN site in Leeds is set against the trends at the average of other roadside sites in the region. Whilst not a direct 'control', this regional analysis using publicly available data from AURN sites is considered to be a valuable comparison to identify whether changes are in line (or not) with the underlying shift towards cleaner air in the UK.

Taking a view across the local areas and considering the regional trends, there is a consistent picture that levels of NO_2 are now falling in UK cities, whether at urban background sites, or to a greater degree at roadside locations. With traffic levels broadly stable or demand increasing slightly, this suggests Euro 6a/b/c/D-temp/D and heavy-duty vehicle Euro VI standards[30] have been delivering the expected incremental, modest improvements to the state of UK air quality.

The Central Evaluation team are analysing and reporting the traffic and air quality trends for all the monitoring sites in Local Plan areas and sharing this with the local authorities on a regular basis.

[30] Euro emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. Increasingly stringent standards have been progressively introduced.

Figure 3.1: Comparison of long-term roadside deweathered and deseasonalised monthly average NO_2 data 2015 to 2019 (black) in Leeds (Headingley as the example) with other UK geographic regions and trend analysis (blue)



Source: ITS, based on data from continuous analysers in each region. Note: the West Midland chart is substantially lower than the remaining because roadside sites for this region are predominantly at 'open' roadside (i.e. not street canyons) and generally more set-back from the kerb edge. Resultingly, on average these report lower concentrations than other regions.

3.2 Summary of lockdown impacts on NO_2 concentrations

The UK government implemented a national lockdown in response to COVID-19 on the 23-26 March 2020. As elsewhere in Europe and internationally, associated restrictions initially limited individual mobility and workplace activity to essential services and travel, and significant air quality benefits were widely anticipated. While recognising the scale of the unforeseen challenges posed by the COVID-19 outbreak, many in the air quality research community have highlighted the impact of these restrictions on vehicle use, manufacturing work, emissions and air quality as an experience which we should actively seek to learn from in our on-going efforts to reduce pollution.[31] Modelling, satellite observation and monitoring data studies from countries that were earlier affected and/or earlier to implement lockdown

[31] Monks, P., 2020, Coronavirus: lockdown's effect on air pollution provides rare glimpse of low-carbon future April 15, The Conversation (2020), online at https://theconversation.com/coronavirus-lockdowns-effect-on-air-pollution-provides-rare-glimpse-of-low-carbon-future-134685 [last assessed 31st January 2021]

procedures all reported substantial associated reductions in pollutant levels, many of the order of 25-55% and 15-30% for NO_2 and particulate matter (PM_{10}), respectively.[32]

The Central Evaluation team has developed and applied the 'AQEval' package[33] to analyse continuous data from the Leeds and Southampton automatic traffic counters and continuous air quality analysers.[34] Acknowledging the complexities of air quality data, the package also applies deseasonalisation and deweathering procedures to the pollutant time-series prior to analysis, to reduce the influence of other sources of air quality variance, and methods based on Theil-sen regression[35] to characterise pre-existing air pollutant trends going into lockdown, because the lockdown should not be considered an event that occurred in isolation.

Lockdown impact in Leeds's NO_2 concentrations

The change-segment detection methods developed in 'AQEval' have also been adapted to run on automatic traffic count (ATC) data. The detected trend in traffic flow measured at an automatic traffic count site on the A660, upon which the Headingley kerbside AURN site is located, is illustrated below (Figure 3.2). This figure presents trends in NO_2 concentrations (top chart) and in traffic flow (lower chart) in the same area and over the same period of time, as well as the points in time where breakpoints have occurred (i.e. the points in time when a change in the trend is observed). The dotted blue lines represent the confidence intervals of the breakpoints. The methods identified the modest rise in traffic demand after the Christmas holiday period (first breakpoint in the bottom chart), then substantial reductions in the third and fourth weeks of March when the UK went into COVID-19 lockdown. The return of demand as mobility restrictions are lifted is also observed, with flow returning to nearly 50% of pre-COVID-19 levels by the end of May 2020.

The detected trend in the *deweathered*[36] daily average air quality measurements for the Headingley kerbside site also clearly illustrates the step-change reduction in NO_2 concentrations around mid-March (first breakpoint in top chart), then a further reduction before levels stabilise through the latter part of April and the months of May and June. It is important to appreciate that the estimated trends of the most recent (and 'provisional') air quality data are more uncertain, with confidence improving as more data becomes available.

The trend in NO_2 through the lockdown period is what may have been intuitively expected, with concentrations falling broadly in line with traffic flow, once the residual background contribution is taken into account, followed by an incremental rise through April and May.

[32] Tobías, A., Carnerero, C., Reche, C., Massagué, J., Via, M., Minguillón, M.C., Alastuey, A. and Querol, X., 2020, Changes in air quality during the lockdown in Barcelona (Spain) one month into the SARS-CoV-2 epidemic, Science of the Total Environment, p.138540. https://doi.org/10.1016/j.scitotenv.2020.138540 (accessed 31st January 2021)

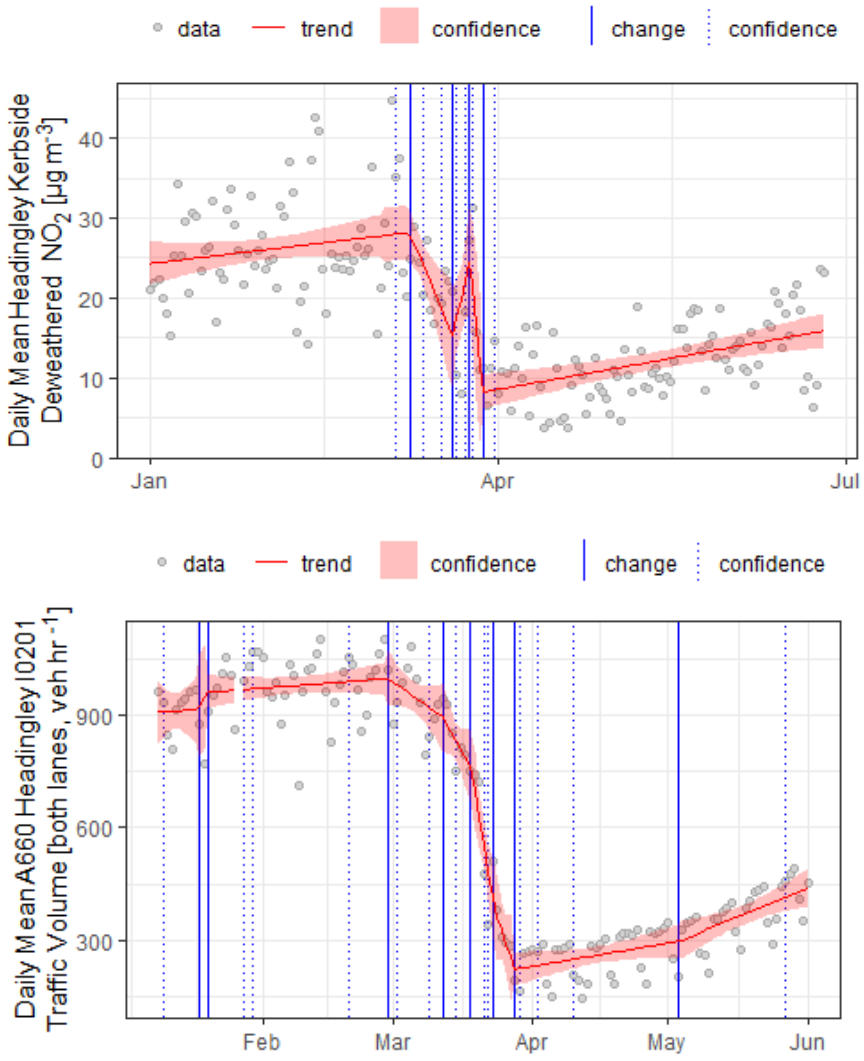
[33] Early findings from this work were submitted to Defra's Call for Evidence on 'Estimation of changes in air pollution emissions, concentrations and exposure during the COVID-19 outbreak in the UK' (UK Defra, 2020) but here we extend the analysis to comment on air quality trends as lockdown restrictions on movement lessened through to the end of June 2020.

[34] The package applies breakpoint/segment analyses. One of the unique features of this approach is that the breakpoint step does not assume event dates, but instead uses changes in linear regression properties in a data-series over time to identify likely points-of-changes, so provides a more independent measure of events and their timescales than a classical 'before and after' analysis.

[35] A statistical technique used for estimating a linear trend.

[36] A statistical technique to 'remove' the influence of meteorology from air quality time series data.

Figure 3.2: Detected trends in daily average traffic flow and deweathered NO_2 concentrations in Headlingley (Kerbside AURN), January-June 2020

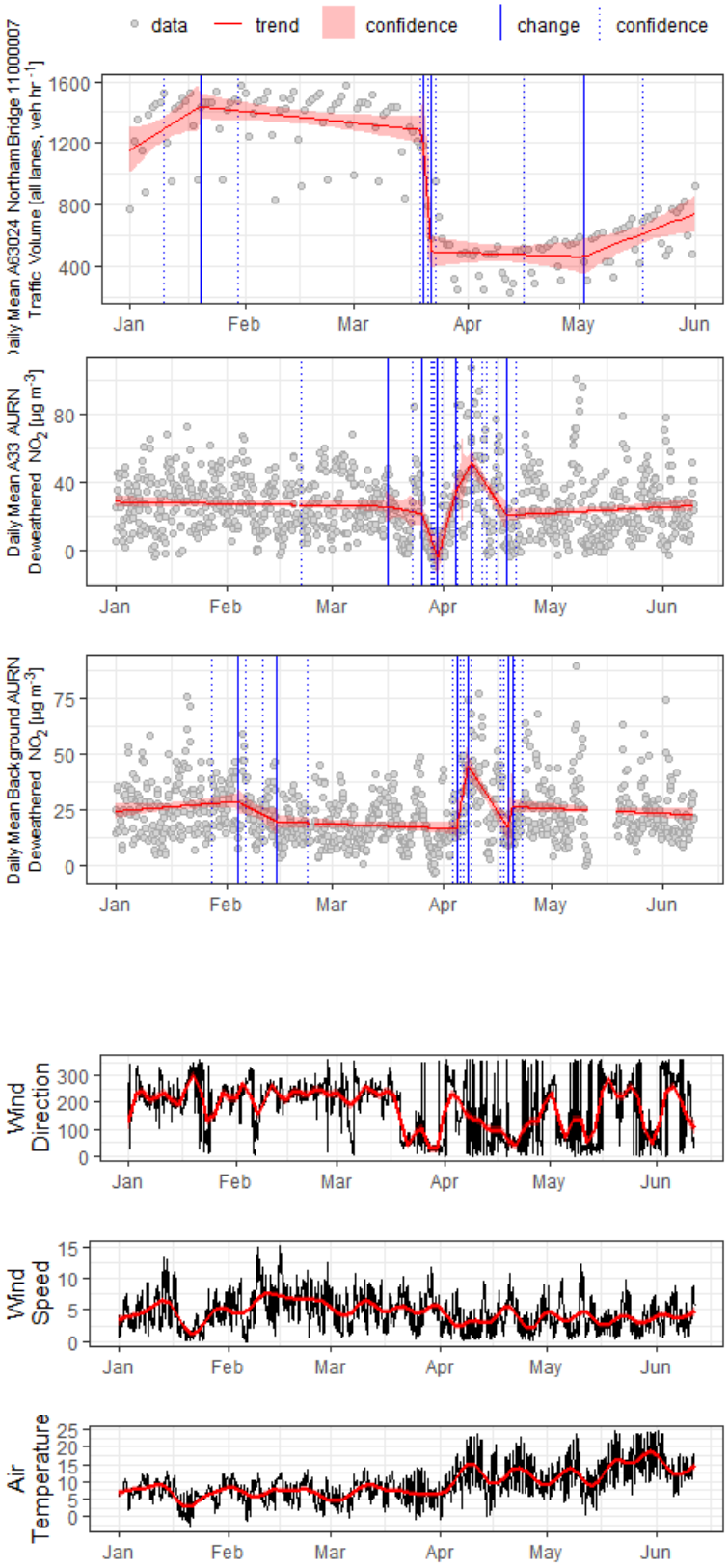


Source: ITS, based on AURN data from Headingley Kerbside site and data from an automatic traffic count site on the A660 in He adingley.

Lockdown impacts in Southampton NO_2 concentrations

Figure 3.3 below shows the comparable data and change in traffic flow levels from a key bridge road link to the east of Southampton city centre reflects the changes seen in Leeds, with a step-change reduction at the onset of lockdown, then slow return of demand. The changes in NO_2 levels at the Southampton A33 roadside and urban background site, however, are more unexpected. The fall in concentrations at the start of lockdown are more modest than in Leeds, but then are observed to sharply increase to levels greater than the norm. They then return to a stable level around the level of the pre-COVID-19 trend, despite there being significantly less traffic. An explanation for these unexpected fluctuations and trends is being explored, including considering whether the shift in the observed weather patterns from stronger winds from the north, to lighter winds from the south that would draw shipping emissions from the port into the city. The possibility of a minor pollution episode, with elevated background levels across the south coast in this period, is also being considered.

Figure 3.3: Analysis of pollution levels and wind speed/direction in Southampton, January-June 2020



Summary of COVID-19 impacts across the UK

The 'AQEval' package has facilitated the Central Evaluation team tracking the impact of COVID-19 on air quality concentrations across the UK for multiple pollutants (NO_2, ozone (O_3) and particulate matter ($PM_{2.5}$ and PM_{10})).

Whilst this research is not considered to be a core component of Central Evaluation,[37] as it is applying the techniques to publicly available continuous analyser AURN data across the UK, it can provide policymakers with valuable insights as to the impact of COVID-19 on other pollutants in non-Local Plan areas.

Here, breakpoint/segment methods are applied to air pollutant time-series from the first half of 2020 to provide an independent estimate of the likely timings of discrete changes in nitrogen oxides (NO, NO_2, NO_x), O_3, PM_{10} and $PM_{2.5}$ from AURN monitoring stations across the UK.

As shown in Figure 3.4, NO, NO_2 and NO_x all exhibit abrupt decreases at the time the UK was locking down of (on average) 7.6 µg m^{-3} to 17 µg m^{-3} (or 32% to 50%) at urban traffic stations and 4 µg m^{-3} to 5.7 µg m^{-3} (or 26% to 46%) at urban background stations. However, after the initial abrupt reduction, gradual increases were then observed through the lockdown, then periods where mobility restrictions were eased from the 13th of May 2020 to allow return to work, unlimited exercise and travel to beauty spots. This suggests that the return of vehicles to the road during lockdown and period of easing restrictions has already offset much of the air quality improvement seen at locking down. At the same time O_3 increased (7 µg m^{-3} to 7.4 µg m^{-3} or 14% to 17% at urban stations) broadly in line with NO_2 reductions. However, the limited amount of O_3 monitoring at urban traffic stations, where the largest COVID-related changes would be expected, may limit representativeness, and later changes suggest significant non-lockdown contributions to O_3.

Observed trends for both PM_{10} and $PM_{2.5}$ were highly inconsistent with an air quality response to the lockdown. Across the UK, irrespectively of AURN site type, increases were observed for both pollutants while locking down (PM_{10} 5.9 µg m^{-3} to 6.3 µg m^{-3} and $PM_{2.5}$ 3.9 µg m^{-3} to 5.0 µg m^{-3}) and trends both before and after were distinctly different to those expected for a lockdown response, indicating that the lockdown was not the major source (or not a direct source) of the most pronounced changes in levels of either of these species during this period. This suggests other sources and/or more complex contributions, e.g. from resuspension of deposited particulate matter from the road surface leading to higher pollutant concentrations in the air, are more likely the major driving factors for these changes rather than the lockdown.

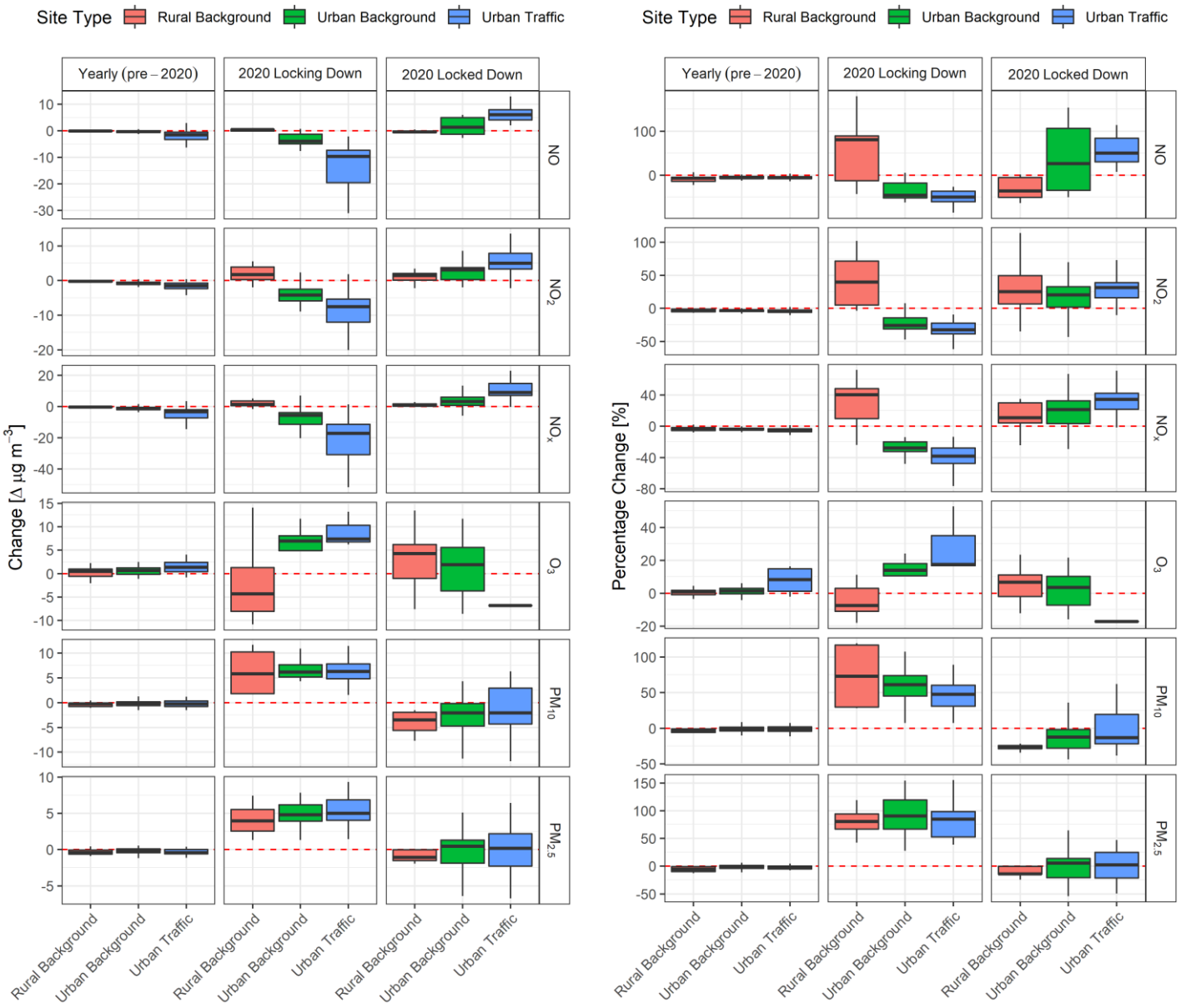
However, perhaps the most important observation is that even for pollutants like NO_2 that appear, in the UK at least, to exhibit a well-isolated response to lockdown, the lockdown period was not a stable baseline. Numbers of vehicles on the roads were changing during this time. As a result, even in the most ideal cases, studies that apply a conventional 'before-and-after' model to selected periods before and during lockdown should be considered only as provisional estimates of the impact of the lockdown. More accurate estimates will be possible once the Evaluation can robustly characterise both pre- and post-lockdown baselines and look critically at all the potential sources of air quality change about lockdown.

[37] ITS has published this analysis in a scientific journal as a short communication paper: Ropkins, K. and Tate, J.E., 2020. Early Observations on the impact of the COVID-19 Lockdown on Air Quality Trends across the UK. Science of The Total Environment, 754, p.142374. https://doi.org/10.1016/j.scitotenv.2020.142374 (accessed 31st January 2021)

Reading these plots

Each of the plots depict the variation in the concentration of key pollutants. The horizontal line in the centre of each bar represents the estimated median concentration, while the filled bars bound the range where 50% of the measurements fall, the lines of "whiskers" is an estimate of the 95% confidence intervals. The green-filled bars (urban background) and blue-filled bars (urban traffic) are the ones expected to vary with changes in traffic (flow and/or fleet mix), while the pink bars (rural background) are not usually expected to be affected by such changes. Note that the 'yearly (pre-2020)' trends are shown in Figure 3.1.

Figure 3.4: NO_2 Trends observed at individual AURN stations

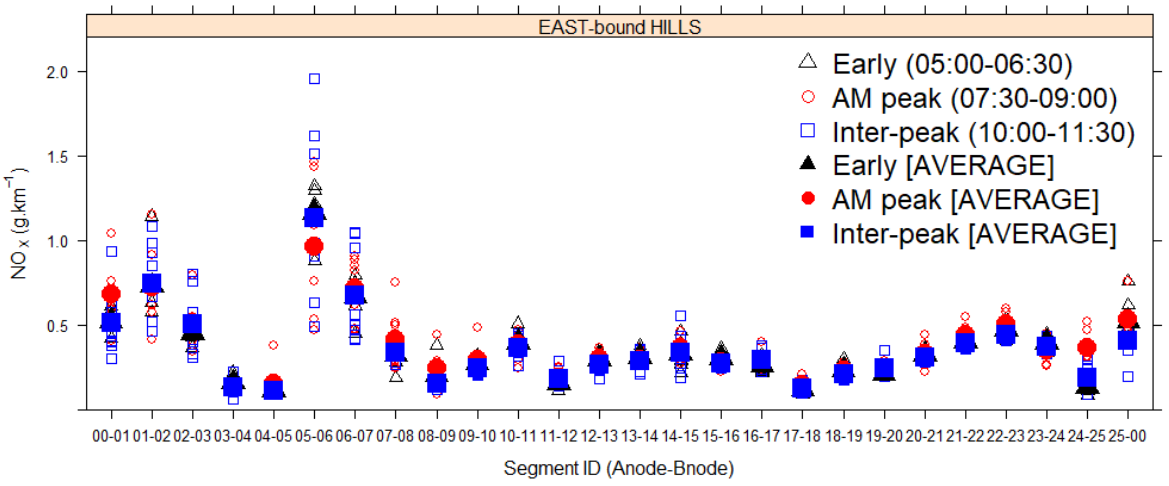


3.3 Baseline PHEM analysis

The baseline PHEM survey in Basildon & Essex has assessed the emission levels of a vehicle travelling through the A127, prior to the implementation of the speed limit reduction from 70 mph to 50 mph. Figure 3.5 below shows the variability in NO_X emission rates for an illustrative Euro 6a/b diesel passenger car visualised for each eastbound road segment, with the influence of road gradient considered. Each speed

trajectory in the 3 time periods are illustrated as different coloured symbols, with solid symbols presenting the average result. There is a significant variation in NO_X emission rates (grams.km^{-1}) along the route. Segments '00-01', '01-02' and '02-03' are at the national speed limit. The higher speeds and drag forces result in elevated emission rates. The test vehicle is predominantly decelerating in segment '03-04' as it approaches a 40 mph speed limit in the approach to the 'Fortune of War Roundabout', so emissions are low. Similarly segment '04-05' is the approach to negotiate the roundabout, so the vehicle is predominantly decelerating and fuel consumption and associated NO_X emissions are low. Conversely the segment exiting the roundabout vehicles are accelerating to attain their desired cruising speed. Emission rates are therefore significantly higher. The average emission rate in the morning peak is lower, as the higher flow rate limits the road space available and opportunity to accelerate freely.

Figure 3.5: Emissions rates for a Euro 6a/b diesel passenger car for east-bound road segments, by time of day (see paragraph above for guidance on interpreting this figure)



The next steps are to compare the PHEM estimates of NO_X emission rates with those predicted by the Emissions Factors Toolkit (EFT).[38] The emission rates for each vehicle sub-category will then be scaled by the UK fleet composition average in January 2020, along with a local fleet mix if this data is available (e.g. ANPR data cross-referenced with the UK vehicle registration database) to establish the total emission rates along the route in each time period.

Once the 'after' survey data is available the observed change in emissions and vehicle dynamics on road segments will be assessed considering speed levels:

- Outside the speed limit reduction area.
- Inside the speed limit reduction area.
- On the boundary of speed limit reduction area.

Further information on the steps taken to undertake the PHEM analysis is presented in Annex 2.

[38] Defra (2020) Emissions Factors Toolkit (accessed 31st January 2021)

4 Baseline findings: case studies

4.1 Introduction

This chapter presents findings from the first three deep-dive case studies in Basildon & Essex, Birmingham and Leeds. [39] Research has been carried out with local residents to understand the baseline position in each area (the situation before the Local Plan measures are implemented).

The Central Evaluation team have collected information to help answer evaluation questions #2 to #4 (see section 1.3). This has covered topics related to the anticipated outcomes of the Local Plan including residents' travelling behaviour (such as frequency and mode of travel), their vehicle ownership, their perceptions of traffic and air quality, and their health. This data will be compared with data gathered at two points after implementation[40] to help understand the impacts of Local Plans.

This chapter presents the findings that are likely to be most useful for adaptive policymaking at this stage: those related to residents' awareness and understanding of their Local Plan, their attitude towards the Local Plan and how residents think it may affect them. Full details of the baseline position in these areas for all topics included in the surveys, and a more detailed analysis of demographic differences in the findings presented below, are provided in Annex 4.

Overview of Local Plan measures in Basildon & Essex, Birmingham and Leeds

Basildon & Essex's full business case approved in 2019 is focused on a speed limit reduction on the A127.[41] The speed limit has been reduced from 70 miles per hour to 50 in both directions on a five mile stretch of the road, from Fortune of War roundabout in the West, to Pound Lane in the east.

Birmingham is implementing a Clean Air Zone (CAZ) class D on the central A4540 Middleway Ring Road. The measure of compliance will be Euro 6 for diesel vehicles and Euro 4 for petrol vehicles. Additional measures such as parking restrictions are also being introduced.

Leeds was due to implement a CAZ class B+ in the central and northern part of the city, up to the Outer Ring Road boundary. This would have affected HGVs, buses, coaches, taxis and private hire vehicles (PHVs) that were not compliant with emissions standards. Following a joint review by the city council and government a CAZ is no longer required.

4.2 Baseline position: residents' awareness and understanding

Awareness of Local Plan measures

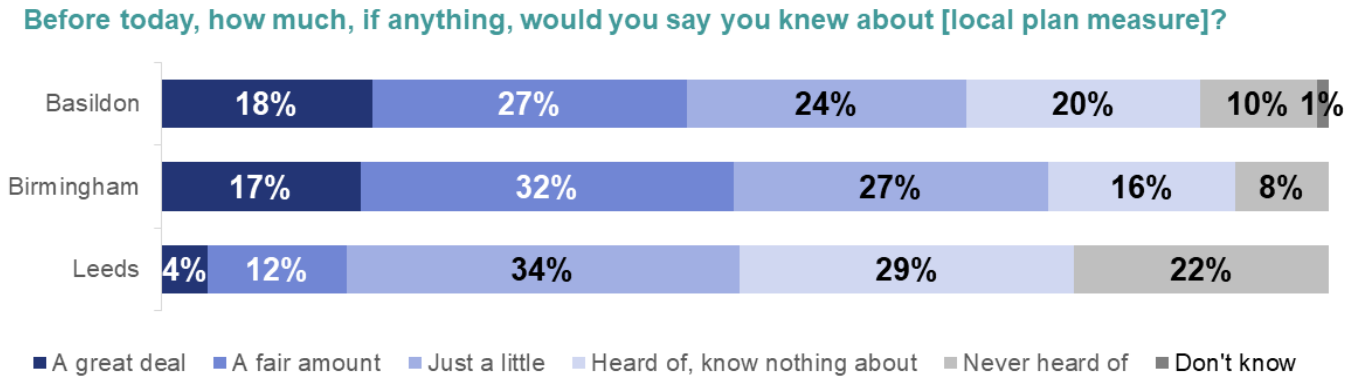
Awareness of the Local Plan measures was widespread in all three areas: at least four in five residents in each area had heard of the measures. However, levels of awareness were varied, with Basildon & Essex and Birmingham having higher proportions of residents who knew anything about the proposed measures beyond having heard of them (Figure 4.1). About half of those interviewed in Birmingham

[39] The rationale for selecting these areas is covered in section 2.2 and in Annex 3.
[40] These two points are referred to as the mid-line (around three months after implementation) and end-line (around nine months after implementation) research stages.
[41] Basildon & Essex is producing a second business case with a further measure beyond the speed limit change; this was not confirmed at the time this report was prepared.

(49%) said they knew at least a fair amount about the CAZ there, and 45% of Basildon & Essex's residents interviewed reported knowing at least a fair amount about the speed limit reduction.

This is likely to reflect the potential impact of the measures on residents. Birmingham's CAZ affects private cars as well as business vehicles, while the speed limit reduction in Basildon & Essex applies to a heavily-used road (80% of those interviewed used this road at least once per week, and awareness was highest among these users). In contrast, a lower proportion of Leeds residents were likely to be directly affected by Local Plan measures there, since the class B CAZ affects only business vehicles. Only 16% of respondents in Leeds reported knowing at least a fair amount about the proposed CAZ.

Figure 4.1: Local Plan awareness across areas



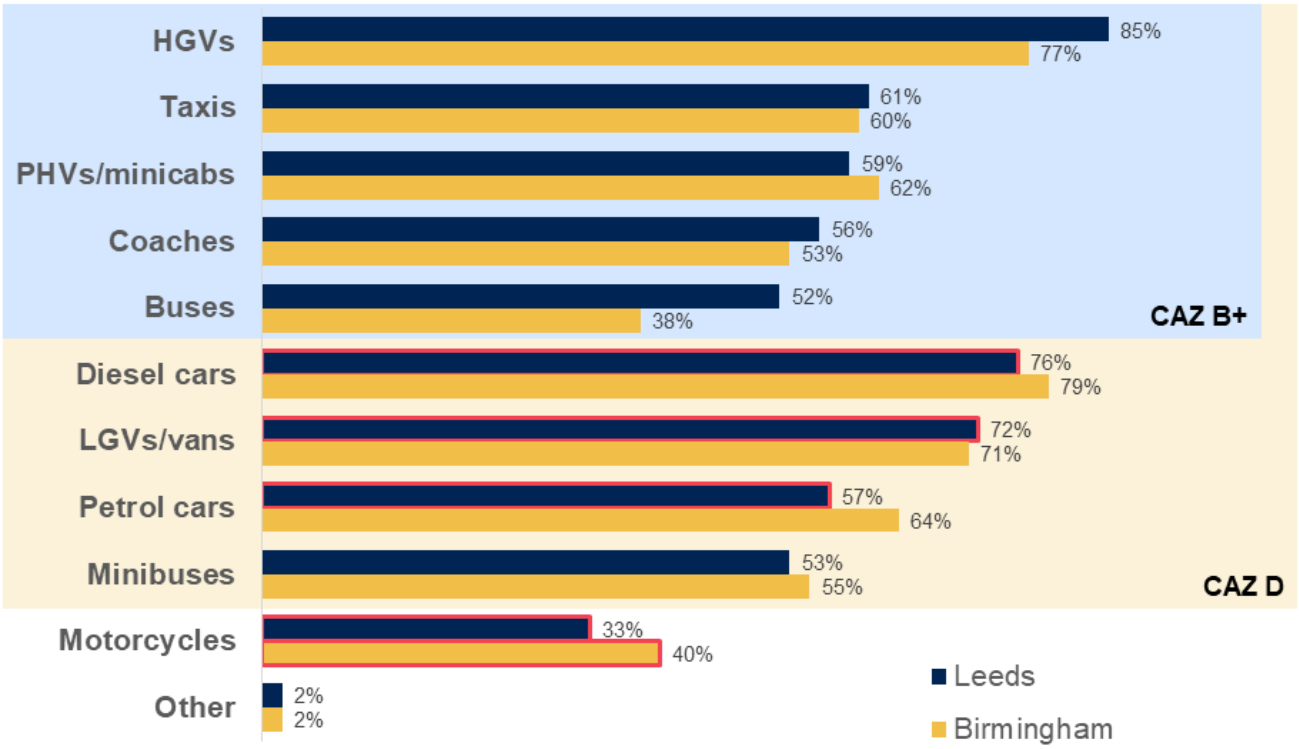
Base: All respondents (300 in Basildon & Essex, 500 in Birmingham, 500 in Leeds).

Knowledge of Local Plan measures: Clean Air Zones

Different classes of CAZ affect different types of vehicles. Figure 4.2 captures the respondents' understanding of which vehicles are affected and helps understand the need for further communications targeted to affected groups. While the range of vehicles affected in Birmingham's CAZ is wider than those that would have been affected in Leeds, in both areas, residents broadly thought that the same vehicles were affected. This suggests some misunderstanding among respondents in Leeds, where fewer vehicle types would have been affected. In particular, in Leeds there was a widespread misunderstanding that private cars and vans would have been affected.

In Birmingham, nearly all (97%) of the respondents with any knowledge of the CAZ could correctly identify at least one group of vehicles that would be affected, although two in five respondents incorrectly thought that motorcycles would be affected by the CAZ. In Leeds, 91% of this group of respondents gave at least one correct answer to this question, with the most common being HGVs (identified by 85% of those interviewed). However, 76% of Leeds respondents (77% of car owners) incorrectly believed that diesel cars would be affected, 72% incorrectly thought LGVs would be affected, and 57% (58% of car owners) thought that petrol cars would be affected. People living further from the proposed CAZ or who stated they had limited knowledge of the CAZ were more likely to think that diesel cars would be affected.

Figure 4.2: Which, if any, of the following vehicles do you think will be affected by the Clean Air Zone in [area]?



Base: All respondents reporting some knowledge of the CAZ (259 in Leeds, 370 in Birmingham). Red border indicates incorrect answers.

Although most Birmingham respondents were aware that there will be some exemptions to the CAZ, residents had relatively low awareness of the measures available to support affected businesses and individuals. Of those respondents who reported having some knowledge of the CAZ, one in four (25%) were aware of measures being implemented by Birmingham City Council to help those affected by the CAZ. A small number of respondents (6% of the overall sample) were aware of the details of one or more of these measures, most often about the mitigation measures for low earners working within the CAZ.

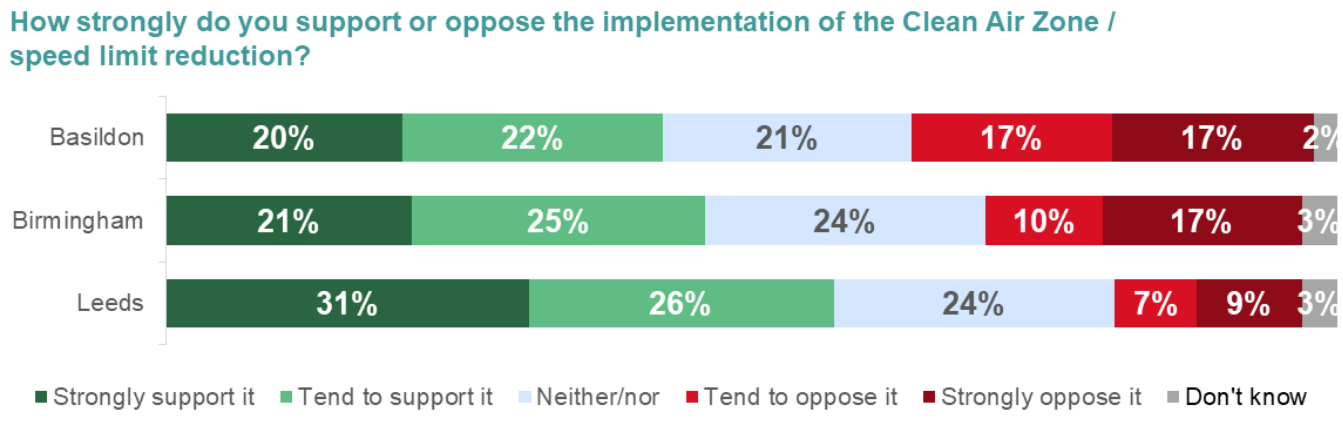
Knowledge of Local Plan measures: speed limit reduction

Awareness of the value of the speed limit reduction in Basildon & Essex was relatively high: six in ten (62%) of all participants correctly stated that the speed limit will be reduced from 70 mph to 50 mph. Among those who knew at least a little about the measure, 90% correctly stated what the speed limit was changing from and to.

4.3 Baseline position: residents' attitudes towards Local Plan measures

Attitudes towards the measures were more positive than negative in all three areas (see Figure 4.3 below), but levels of support varied across areas, again perhaps reflecting the proportion of respondents likely to be negatively affected by the introduction of the measures. In Basildon & Essex, where a high proportion of respondents used the road in question, 42% supported the speed limit reduction but 34% opposed it. Support for CAZs was higher; 46% of Birmingham respondents and 57% of Leeds residents supported the proposed CAZ in their area.

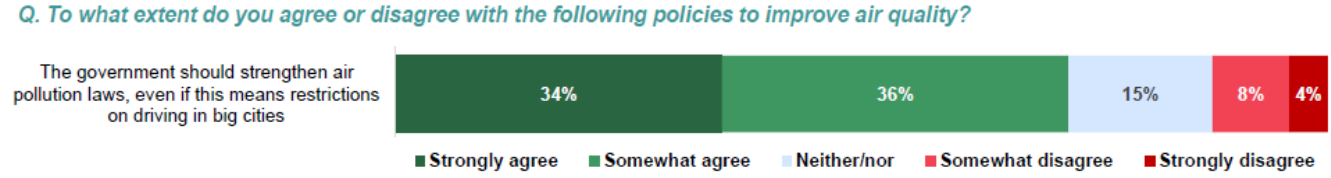
Figure 4.3: Attitudes to implementation of Local Plan measures



Base: All respondents (300 in Basildon & Essex, 500 in Birmingham, 500 in Leeds).

Ipsos MORI has recently conducted national polling for the Conservative Environment Network[42] on support for environmental policies, including restrictions on driving in big cities to improve air quality, which have also shown higher approval than otherwise to driving restrictions in big cities. Support was, however, higher than in the local surveys conducted (70% of the public in the national polling, against e.g. 57% in the Leeds deep-dive), potentially reflecting the speculative nature of this question (see Figure 4.4: 4.4 below).

Figure 4.4: British attitudes to driving restrictions in big cities to improve air quality



Base: 2,178 adults aged 16-75 in Great Britain : Fieldwork dates : 24th to 26th June 2020 : data weighted by age, gender, region and working status. Proportions do not add to 100% because 'don't know' answers are not shown.

Data on public attitudes to the CAZs is also available from public consultations, although these are self-selecting and likely to over-represent people who will be negatively affected by the CAZ. In Birmingham, responses to the public consultation held in summer 2018 appear to be more negative about the CAZ than the levels of support shown here: around half (52%) of those responding to the consultation felt the CAZ would have an overall negative impact on Birmingham, with one-third (32%) believing the impact would be positive[43]. In contrast, responses to the Leeds CAZ consultation appeared fairly positive, although respondents were not asked directly whether they supported or opposed the CAZ: 61% of residents said that a CAZ in Leeds would have a significant impact on reducing air pollution in Leeds and 76% agreed that improving air quality in Leeds should be a priority for the Council.[44]

In Basildon & Essex, the survey asked residents for their reasons for supporting or opposing the scheme. Those who supported the scheme were much more likely to spontaneously mention reduced accidents (77%) than reduced air pollution (19%), whereas those opposing most commonly cited more traffic (54%) and longer journeys (44%). Road safety was also thought by many respondents to be the

[42] Conservative Environment Network (June 2020). 'Support for a Green Recovery' (viewed on 31st January 2021)
[43] Tonic Consultants Ltd (2018). Independent Consultation Analysis Report: Clean Air Zone for Birmingham (viewed on 31st January 2021)
[44] CAZ informal consultation (Phase 1) Jan-Mar 2018, 8,744 responses to an online survey (m.e.l Research)

reason behind the speed limit reduction: when asked to suggest (in their own words) why Basildon & Essex Councils are implementing the speed limit reduction, many more survey participants spontaneously cited[45] reducing accidents (54%) than improving air quality and/or public health (33%), suggesting the reasons for the policy may not be well understood.

In Birmingham and Leeds, at least three in every five respondents could correctly cite at least one of the main reasons for implementing the CAZ (respondents were allowed to give more than one reason). Seven in ten respondents in Leeds (70%) and nearly as many in Birmingham (63%) correctly thought the CAZ was being implemented to improve air quality, reduce air pollution and/or improve public health[46]. Unsurprisingly, in both cities people who supported the CAZ were more likely to give one of these answers.

In Birmingham, one in five respondents (20%) believed the purpose of the CAZ was related to climate change or reducing carbon emissions; 18% believed its purpose was to raise funds for the council; and 9% did not know. Other reasons supplied included reducing traffic and noise pollution. A smaller proportion of residents in Leeds (9%) saw the CAZ as a money-making initiative: residents who travel into the CAZ as commuters were more likely to see it as a means of raising money (13% vs. 5% for leisure travellers).

4.4 Anticipated changes to travel behaviour

All three surveys asked respondents how they might change their travel behaviour as a result of the Local Plan measures (once these measures had been briefly explained). Respondents were asked to comment in their own words, rather than being provided with a list of options to agree or disagree with.

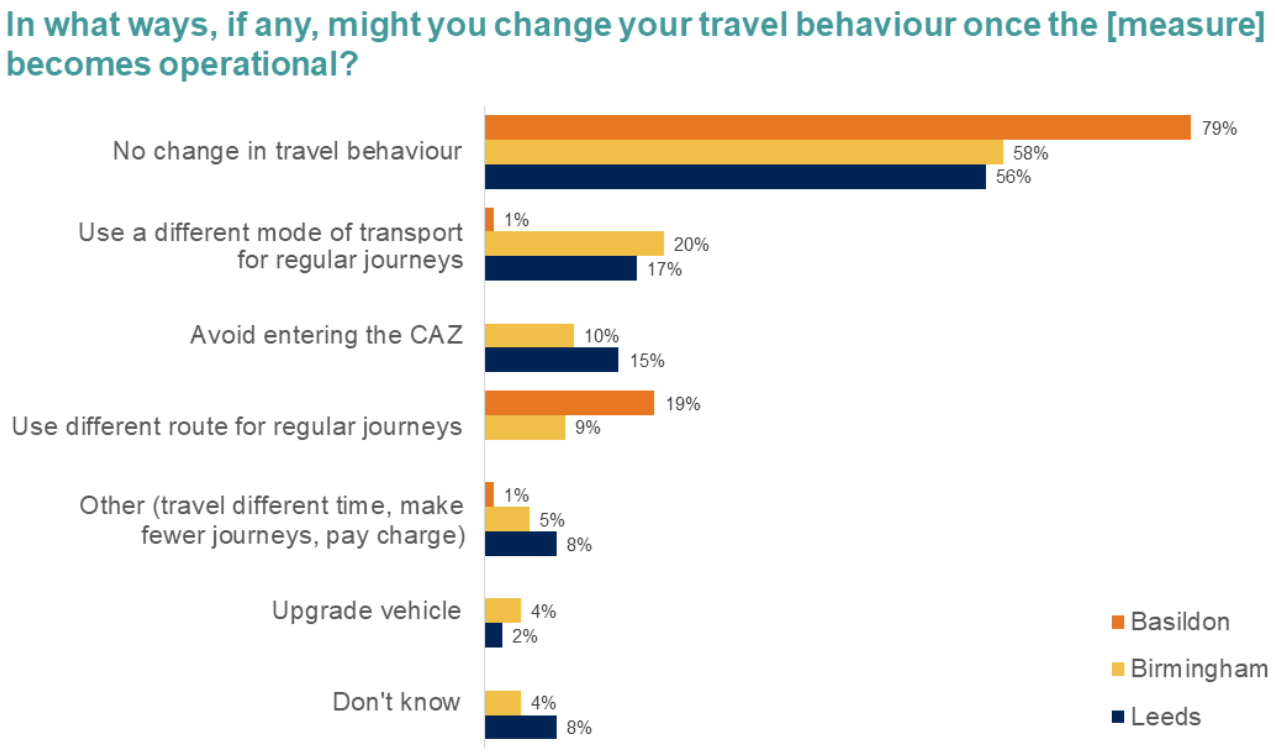
As Figure 4.5: 4.5 shows, in each area, a large proportion believed they would not change their behaviour as a result of the Local Plan measures. This is perhaps understandable considering that in Leeds, very few respondents would have been directly affected by the measures, and in Birmingham, only around half are likely to be affected (based on the figures on vehicle ownership obtained by the survey – see Annex 4).[47] In Basildon & Essex, while the speed limit reduction is likely to affect the majority of respondents, many may judge that the change in speed limit does not warrant a noteworthy change in their travel patterns, and indeed this is not required for the measure to be effective (since reduced emissions are achieved through steadier driving). The business surveys will identify the changes in businesses' behaviour predicted to occur as a result of the CAZ, which may have a larger impact than changes in residents' behaviour.

[45] Survey participants could suggest more than one reason for the council introducing the speed limit reduction if they wished

[46] 7% of Birmingham respondents referred to public health without specifically mentioning air quality.

[47] 11% of respondents did not own a vehicle, and 31% of respondents (36% of vehicle owners) had only compliant vehicles. This means that up to 58% of respondents may have owned a non-compliant vehicle, but it was only possible to determine that this was the case for 38% of respondents (44% of vehicle owners).

Figure 4.5: Anticipated changes in travel behaviour



Base: Basildon: all respondents who travel on the A127 (297); Birmingham and Leeds: all respondents (500 in each city).

In Basildon & Essex, four in five (79%) of those who travel on the A127 believed they would not change their travel behaviour in response to the speed limit reduction. Of those who did anticipate changing their behaviour, the most common response was using different routes for their regular journeys (19%).

Most Leeds residents surveyed said they did not anticipate changing their behaviours (56%). Among those who did intend to change how they travel following the proposed CAZ implementation, most intended to use a different form of transport (17% of all surveyed), or to re-route their trips by avoiding the CAZ or choosing an alternative route (15% of all surveyed). In Birmingham, around one in five (18%) of respondents anticipated that they would avoid the CAZ area and/or take a different route for their journey.

Focusing on those who typically *drive* into the CAZ area, a larger proportion of people anticipate that they may change their behaviours following the CAZ implementation: 52% in Birmingham and 40% in Leeds. In Birmingham, respondents who owned a non-compliant vehicle were more likely to say they would change their behaviour (49% said they may change their behaviour, compared to 35% of owners of compliant vehicles and 17% of non-vehicle owners). Those respondents were more likely to say that they would use a different mode of transport for their journeys (27%) or upgrade their vehicle (8%). In Leeds, respondents who knew a great deal or a fair amount about the proposed CAZ, or view the levels of traffic to be a problem, were more likely to say that they would change their behaviour. These differences were not apparent in Birmingham.

Birmingham City Council asked a similar question of the 10,392 individuals who responded to its public consultation about the CAZ in summer 2018. Two-thirds of these individuals (68%) said they would change their behaviour in some way as a result of the CAZ[48]. This is a noticeably higher figure than in

[48] Steer Group (October 2018), Birmingham CAZ behavioural research, accessed online 31st January 2021

our survey, which is likely to be because a self-selecting consultation is more likely to attract responses from people who will be affected. Compared to consultation respondents, respondents to our survey were more likely to say that they would use a different mode of transport, and less likely to say that they would make fewer journeys, pay the charge[49], or upgrade their vehicles.

4.5 Other highlights from the baseline findings

The baseline surveys assessed other relevant parameters which will be tracked in the mid-line and end-line case study research to assess the impact of the Plans. The other highlights of the survey are summarised below.

- In Leeds and Birmingham, at least three in five (69% and 61%, respectively) of those surveyed reported travelling in or around the proposed CAZ at least once a week. Overall, only 5% of respondents said they never travelled within the CAZ. Likewise, in Basildon & Essex, the section of the A127 between Fortune of War and Pound Lane is used extensively: eight in ten respondents (80%) travel on this stretch of road at least once per week.

- In Birmingham, respondents were also asked about the fuel type and age of their vehicle/s to determine whether or not they were likely to be eligible for a charge. One-third (36%) of vehicle owners owned only compliant vehicles, and 44% of vehicle owners owned at least one non-compliant vehicle. For the remaining vehicle owners (20%) it was not possible to determine whether their vehicle/s were compliant because they were unable to provide information about the fuel type and approximate date of registration. People in work were more likely to have a non-compliant vehicle than people who were retired or otherwise not working. The survey found that the majority of those who owned a non-compliant vehicle (56%) drove it in or around the CAZ at least once a week, and around a third (32%) did so five or more days a week.

- Traffic appears to be a problem for a significant proportion of residents in all three areas. In Basildon & Essex, four in ten (39%) report traffic is always or often a problem for them when getting around the area; in Birmingham, this figure was 47% and in Leeds it was 50%. In Basildon & Essex, residents were asked for their views on the likely impact of the speed limit reduction on traffic: many more residents think that the speed limit reduction will increase traffic (44%) than decrease it (9%) and more traffic was the most commonly cited reason for opposing the scheme.

- In Basildon & Essex, clean air quality is a key issue to those surveyed, half of whom (52%) perceive local air quality to be good (although this includes just 5% that would describe it as very good). This is compared with 12% that believe air quality is poor. More than half (57%) reported clean air to be very important while another third (36%) felt it was important.

- Survey respondents were evenly split in their views of air quality in Birmingham, with equal proportions describing it as good and poor (27%), and a larger proportion of respondents describing it as neither (37%). The proportion of respondents describing air quality as poor increased with age, with 49% of over-65s reporting this compared to 19% of 18-34 year-olds.

- Four in ten (42%) of the surveyed residents in Leeds rate the air quality as either very or fairly good, with a quarter describing it as poor.

[49] Note that at the time of the consultation, the charge levels had not been published. By the time the survey took place the charges had been published on the Birmingham City Council website, although the levels of charges were not mentioned in the survey script.

5 Next steps

This section sets out the tasks planned to be implemented across the Evaluation strands. It also considers how the impacts of the COVID-19 pandemic might affect the delivery of the Evaluation.

5.1 Before-and-after analysis

The next steps for the before-and-after analysis are:

- Continue to analyse air quality and traffic data on a quarterly basis for each Local Plan area;
- Explore the sensitivity of analysis methods, including learning from the results from implemented Local Plans, COVID-19 restrictions and lockdowns, and other events such as road works and closures;
- For local areas whose plans are implemented in the coming months, introduce comparisons with air quality and traffic trends in control sites and with the expected changes as modelled in the Local Plans' full business cases (FBCs);
- Expand analysis to include other local authority areas, as FBCs are approved;
- Expand analysis to cover data from diffusion tubes as well as the data from continuous analysers;
- Include ANPR data in the analysis to understand the changes in the vehicle mix on the roads and estimates of the associated impact on vehicle emissions. This will inform an analysis of the causal link between changes in traffic flow, vehicle emissions and ambient air quality concentrations.

5.2 Data monitoring

As outlined on section 2.1, the monitoring of air quality data will be complemented by the installation of three additional continuous analysers funded by the Central Evaluation. The continuous analysers for Derby, Basildon & Essex and Liverpool have been commissioned and will be installed once power connection arrangements are progressed.

For diffusion tubes, the next step is to determine where the Central Evaluation modified diffusion tubes should be installed. The team will make use of the latest information in FBCs provided by Wave 2 and 3 local authorities, but more importantly, with knowledge of the distribution and specific siting locations of the UK Nitrogen Dioxide Diffusion Tube Network (the NO_2 Network).

5.3 Rapid assessments

To date, one rapid assessment has been approved and one has been repurposed to boost sampling for the deep-dive baseline research. The approved rapid assessment is summarised below.

Impact of COVID-19: This rapid assessment will examine the impacts of COVID-19 on business behaviour that is relevant to the Local Plan theory of change (e.g. business travel and the need for staff to commute), as well as how the pandemic may have affected businesses' capacity to respond to the CAZ.

This will be done by means of a survey of businesses in two waves with a baseline in autumn 2020. It will cover Wave 1 and Wave 2 Local Plan areas that are currently planning to introduce a CAZ.[50]

Future rapid assessments will be chosen based on the selection process outlined in Annex 5.

5.4 Deep-dive case studies

The next steps for the deep-dive case studies are:

- Complete baseline research with businesses for Birmingham;
- Carry out baseline research with residents and businesses for Bath & North East Somerset, and Sheffield and Rotherham;
- Redesign the Leeds deep-dive case study as a result of a CAZ no longer being required;
- Select the three remaining deep-dive areas;
- Conduct mid-line and end-line research in areas that have implemented their plans (the mid-line phase of research will take place around three months after implementation of the Local Plan measures, and the end-line phase will take place around nine months after implementation).

5.5 COVID-19 impact on Evaluation

The ongoing COVID-19 pandemic is likely to continue to affect both the implementation of Local Plan measures and the Central Evaluation. Some of the key challenges are:

- Further COVID-19 lockdowns could have implications for whether the Central Evaluation team could contact businesses for research within the same time/budget assumed in the current research proposals. While the telephone interviewing can continue (Ipsos MORI interviewers are set up to work from home), businesses' ability to respond may be affected if they close or reduce staffing levels temporarily. This may affect specific areas in the case of local outbreaks, or have a wider effect during subsequent national lockdowns.
- The impact of the pandemic and associated developments on Local Plans will be considered by local authorities with JAQU. This may require the research plans to be amended accordingly, in particular the case study research, and/or require that further rapid assessments are undertaken to investigate these changes.
- The pandemic is already affecting many of the outcomes and impacts measured by the Evaluation, including travel behaviour and health as well as air quality itself. This introduces an added factor into the contribution analysis and will make it more challenging to attribute changes to Local Plans. The Evaluation team will monitor the situation closely and consider the timing of research waves with respect to this.

5.6 Future annual reports

Future reports will be produced in subsequent years of the evaluation. These reports will evaluate the impact of Local Plans following implementation, assess the extent to which the NO_2 Plans programme

[50] Birmingham (Wave 1), Bath & North East Somerset, Bristol, Greater Manchester, Sheffield and Rotherham, and Tyneside (Wave 2).

outcomes are being achieved, and offer insight into what is/is not working well, in what context, where and for whom.

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