Greater Manchester's Clean Air Plan to tackle Nitrogen Dioxide Exceedances at the Roadside

Evidence Submission for a new GM Clean Air Plan

Sensitivity Testing Report

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Version Status:	APPROVED	**Prepared by:**	Transport for Greater Manchester on behalf of the 10 Local Authorities of Greater Manchester
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Contents

1 Purpose of this Document

1.1.1 This document addresses the sensitivity testing carried out for the Greater Manchester Clean Air Plan (GM CAP). It summarises the results of the sensitivity testing and draws conclusions on the implications for the GM CAP.

1.1.2 This document is part of a suite of documents that have been produced to describe the transport and air quality modelling deliverables for the study. The documents in the series include:

- Local Plan Transport Modelling Tracking Table (T1), which demonstrates that the transport modelling requirements for the study are being met;
- Local Plan Transport Model Validation Report (T2), which explains in detail how the road traffic model was validated against real-world data;
- Local Plan Transport Modelling Methodology Report (T3), this document details the development of the future year without scheme model (Do Minimum);
- Local Plan Transport Model Forecasting Report (T4), which presents baseline and scenario forecasts for GM CAP;
- Local Plan Air Quality Modelling Tracking Table (AQ1), which demonstrates that the air quality modelling requirements for the study are being met;
- Local Plan Air Quality Modelling Methodology Report (AQ2), which provides an overview of the air quality modelling process;
- Local Plan Air Quality Modelling Report (AQ3), which provides details of modelled NOx and NO_2 concentrations for the base and forecast years, including comparisons with measured concentrations for the base year;
- Sensitivity Testing Report (this document), which provides a summary of the sensitivity tests carried out on the core scenarios to test areas of uncertainty, understand whether the tests result in a positive or negative benefit and the scale of benefit; and
- Analytical Assurance Statement, consider the limitations, uncertainties and risks in the evidence base, and the implications of these for decision makers.

2 Greater Manchester Clean Air Plan Overview

2.1 Background to the Clean Air Plan

2.1.1 In 2017 the Secretary of State (SoS) for Environment, Food and Rural Affairs issued directions under the Environment Act 1995 requiring many local authorities, to produce feasibility studies to identify the option which will deliver compliance with the requirement to meet legal limits for nitrogen dioxide (NO_2) in the shortest possible time. The legal limit being defined as the long-term annual mean legal limit of 40 µg/m^3.

2.1.2 In Greater Manchester (GM), the ten local authorities, the Greater Manchester Combined Authority (GMCA) and Transport for Greater Manchester (TfGM) are working together to develop a Clean Air Plan to tackle NO_2 exceedances at the roadside, herein known as Greater Manchester Clean Air Plan (GM CAP).

2.1.3 The development of the GM CAP is funded by government and is overseen by the Joint Air Quality Unit (JAQU), the joint Department for Environment, Food and Rural Affairs (DEFRA) and Department for Transport (DfT) unit established to deliver national plans to improve air quality and meet legal limits. The costs related to the business case, implementation and operation of the GM CAP are either directly funded or underwritten by government acting through JAQU and any net deficit over the life of the GM CAP will be covered by the New Burdens Doctrine, subject to a reasonableness test[1].

2.1.4 In March 2019, the ten GM Local Authorities collectively submitted an Outline Business Case (OBC)[2] for the GM CAP to JAQU outlining a package of measures to deliver regional compliance with legal limits for NO_2 emissions in the shortest possible time.

2.1.5 In July 2019, the Environment Act 1995 (Greater Manchester) Air Quality Direction 2019 was made, which required all ten of the GM local authorities to implement a charging Clean Air Zone Class C[3] with additional measures. There was also an obligation to provide further scenarios appraisal information to demonstrate the applicable Class of Charging CAZ and other matters to provide assurance that the local plan would deliver compliance in the shortest possible time and by 2024 at the latest.

[1] The new burdens doctrine is part of a suite of measures to ensure Council Tax payers do not face excessive increases. New burdens doctrine: guidance for government departments - GOV.UK (www.gov.uk)

[2] https://cleanairgm.com/technical-documents/#outline-business-case

[3] https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england/annex-a-clean-air-zone-minimum-classes-and-standards

2.1.6 In March 2020, the Environment Act 1995 (Greater Manchester) Air Quality Direction 2020 was made, which required the submission of an Interim FBC (along with confirmation that all public consultation activity has completed) as soon as possible and by no later than 30 October 2020. The 2020 direction confirmed that legal duty remains to ensure the GM CAP (Charging Clean Air Zone Class C with additional measures) is implemented so that NO_2 compliance is achieved in the shortest possible time and by 2024 at the latest and that human exposure is reduced as quickly as possible. The Ministerial letter accompanying the March 2020 direction confirmed that the minister was satisfied that the main evidence queries from the July 2019 direction had been addressed.

2.1.7 A statutory consultation on the proposals took place in Autumn 2020.

2.1.8 The GMCA - Clean Air Final Plan report[4] on 25th June 2021[5] endorsed GM's Final CAP and policy in compliance with this direction, following a review of all of the information gathered through the GM CAP consultation and wider data, evidence and modelling work. Throughout the development of the previous Plan, the JAQU reviewed and approved all technical and delivery submissions. Within this document, this is referred to as the Previous GM CAP.

2.2 The Previous GM CAP and the impacts of Covid-19

2.2.1 Under the Previous GM CAP, GM was awarded £123 million by government for funds aimed at encouraging vehicle upgrades to secure compliance and mitigating the impacts of the GM-wide CAZ. The funds included £15.4 million for bus retrofit, £3.2 million for bus replacement, £10.2 million for Private Hire Vehicles (PHVs), £10.1 million for Hackney Carriages, £7.6 million for Heavy Goods Vehicles (HGVs), £4.4 million for coaches, £2.0 million for minibuses and £70.0 million for Light Goods Vehicles (LGVs).

2.2.2 The June 2021 Clean Air Final Plan report set out that the Air Quality Administration Committee (AQAC) had the authority to establish and distribute the funds set out in the agreed GM Clean Air Plan policy. On 21 September 2021 the AQAC approved the establishment and distribution of the agreed bus replacement funds.

2.2.3 On 13 October 2021 the AQAC agreed the distribution of Clean Air funds set out in the agreed GM Clean Air Plan policy as follows:

- From 30 November 2021 applications for funding would open for HGVs.
- From the end of January 2022 applications for funding would open for PHVs, Hackney Carriages, coaches, minibuses and LGVs.

[4] https://democracy.greatermanchester-ca.gov.uk/documents/s15281/GMCA%20210621%20Report%20Clean%20Air%20Plan%20-%20FINAL%20FINAL.pdf
[5] Also considered by the GM authorities through their own constitutional decision-making arrangements.

2.2.4 On 20th January 2022, the AQAC considered the findings of an initial review of conditions within the supply chain of LGVs in particular following Covid-19 related impacts, which were impacting the availability of compliant vehicles and supply-side constraints resulting in price increases, particularly in the second-hand market[6]. The AQAC agreed that a request should be made to the SoS to pause the opening of the next phase of Clean Air Funds. This was to allow an urgent and fundamental joint policy review with government, to identify how a revised policy could be agreed to deal with the supply issues and local businesses' ability to comply with the GM CAP.

2.2.5 On 8th February 2022, the AQAC noted the submission of a report "Issues Leading to Delayed Compliance Based on the Approved GM CAP Assumptions". The report concluded that on balance, the latest emerging evidence suggested that with the approved plan in place, it was no longer likely that compliance would be achieved in 2024. Members also requested that arrangements were put in place for those vehicles owners who had already placed orders pending funding opening at the end of January to ensure they are not detrimentally impacted by the decision to pause the opening of the funds. Government subsequently issued The Environment Act 1995 (Greater Manchester) Air Quality Direction 2022[7] which confirmed that the March 2020 Direction had been revoked and required that by 1st July 2022 the GM authorities should:

- Review the measures specified in the local plan for NO_2 compliance and associated mitigation measures; and
- Determine whether to propose any changes to the detailed design of those measures, or any additional measures.

2.2.6 This Direction ('the Direction') also stated that the local plan for NO_2 compliance, with any proposed changes, must ensure the achievement of NO_2 compliance in the shortest possible time and by 2026 at the latest. It should also ensure that human exposure to concentrations of NO_2 above the legal limit is reduced as quickly as possible.

2.3 The Case for a new GM CAP

2.3.1 On 1st July 2022, the AQAC noted that the 'Case for a new Greater Manchester Clean Air Plan[8] document and associated appendices would be submitted to the SoS as a draft document subject to any comments of GM Authorities.

2.3.2 On 17th August 2022, the AQAC agreed to submit the 'Case for a new Greater Manchester Clean Air Plan' to the SoS as a final version and approved the Case for a New Plan - Air Quality Modelling Report for submission to JAQU.

[6] https://democracy.greatermanchester-ca.gov.uk/documents/s18685/ARUP%20Technical%20Note.pdf
[7] The Environment Act 1995 (Greater Manchester) Air Quality Direction 2022 (publishing.service.gov.uk)
[8] https://assets.ctfassets.net/tlpgbvy1k6h2/7jtkDc5AODypDQIw0cYwsl/67091a85f26e7c503a19ec7aeb2e8137/Appendix_1_-_Case_for_a_new_Greater_Manchester_Clean_Air_Plan.pdf

2.3.3 The 'Case for a new Greater Manchester Clean Air Plan' set out that challenging economic conditions, rising vehicle prices and ongoing pandemic impacts meant that the original plan of a GM-wide charging CAZ was no longer the right solution to achieve compliance, instead proposing an investment-led, non-charging GM CAP.

2.3.4 The primary focus of the 'Case for a new Greater Manchester Clean Air Plan' was to identify a plan to achieve compliance with the legal limit value for NO_2 in a way that considered the cost-of-living crisis and associated economic challenges faced by businesses and residents. This would be achieved through an investment-led approach combined with wider measures that the GM Authorities are implementing and aimed to reduce NO_2 emissions to within legal limits, in the shortest possible time and at the latest by 2026.

2.3.5 The 'Case for a new Greater Manchester Clean Air Plan' proposed using the remaining funding that the government has awarded to GM for the Previous GM CAP to deliver an investment-led approach to invest in vehicle upgrades, rather than imposing daily charges, and deliver new Zero Emission Buses (ZEBs) as part of the Bee Network[9] (a London-style integrated transport network for GM). The new plan would ensure that the reduction of harmful emissions would be at the centre of GM's wider objectives. Within this document, this plan is referred to as the 'Investment-led Plan'.

2.3.6 The GM Authorities committed to a participatory approach to the development of the new plan to ensure that the GM Authorities' proposals would be well-grounded in evidence in terms of the circumstances of affected groups and possible impacts of the new plan on them, and therefore the deliverability and effectiveness of that plan.

2.3.7 Between August and November 2022, the GM Authorities carried out engagement and research with key stakeholders - vehicle-owning groups and representatives of other impacted individuals, such as community, business, environment and equality-based groups. This activity included targeted engagement sessions with all groups, and an online survey and supporting qualitative research activity with vehicle-owning groups.

2.3.8 Input from those engaged informed the ongoing policy development process as the GM Authorities developed the package of measures forming the Investment-led Plan.

[9] The Bee Network is Greater Manchester integrated transport system joining together bus, Metrolink, rail and active travel https://tfgm.com/corporate/business-plan/case-studies/bee-network

2.4 The Investment-led Plan and the impact of bus retrofit issues

2.4.1 Having submitted the 'Case for a new Greater Manchester Clean Air Plan'[10] in July 2022, the GM Authorities were asked by government in January[11] 2023 to:

- *Provide modelling results for a benchmark CAZ to address the persistent exceedances identified in central Manchester and Salford, in order for these to be compared against your proposals.*
- *Identify a suitable approach to address persistent exceedances identified in your data on the A58 Bolton Road in Bury in 2025, and to propose a suitable benchmark.*
- *Set out how the measures you have proposed will be modelled and evidenced overall, and to ensure that they are modelled without any unnecessary delay.*

2.4.2 The GM Authorities undertook the work required to supply this further evidence and on 8th March 2023 submitted the report 'Approach to Address Persistent Exceedances Identified on the A58 Bolton Road, Bury'[12]. GM Authorities also worked to address the remaining two requests from government by June 2023 on the basis of providing further information to support its Investment-led Plan and testing the proposal against a suitable benchmark CAZ, herein referred to as the 'CAZ Benchmark'.

2.4.3 In April 2023, government advised TfGM that it was to pause any new spending on bus retrofit as it had evidence that retrofitted buses have poor and highly variable performance in real-world conditions[13]. This new evidence followed a JAQU-funded study to quantify nitrogen oxide (NO_X) and NO_2 emissions from buses under real-world driving conditions in three cities across the UK, including Manchester (monitoring took place in Manchester City Centre between 21st November and 12th December 2022). The monitoring indicated that retrofitted buses were not reducing emissions as expected, with significant variation in performance between bus models with retrofit technologies. Furthermore, emissions of primary-NO_2 (as opposed to NO_X) were highly variable, potentially worsening roadside NO_2 concentrations despite an overall reduction in NO_X emissions.

2.4.4 Government therefore commenced a six-month focused research programme to quickly investigate the causes of this poor performance and scope how it could be improved, which was anticipated to be reported in Autumn 2023.

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[10] https://assets.ctfassets.net/tlpgbvy1k6h2/7jtkDc5AODypDQIw0cYwsl/67091a85f26e7c503a19ec7aeb2e8137/Appendix_1_-_Case_for_a_new_Greater_Manchester_Clean_Air_Plan.pdf

[11] https://democracy.greatermanchester-ca.gov.uk/documents/s24937/Appendix%201.%20Ministerial%20Letter%20to%20GM%20with%20attachment.pdf

[12] https://democracy.greatermanchester-ca.gov.uk/documents/s24939/Appendix%203.%20GM%20CAP%20A58%20Bury%20Measure%20Report%20DRAFT%20for%20AQAC%20Approval%20Feb%2023.pdf

[13] https://democracy.greatermanchester-ca.gov.uk/documents/s27699/Appendix%201.%20Letter%20from%20DfT%20to%20Greater%20Manchester%20regarding%20Bus%20Retrofit%20Update.pdf

2.4.5 In the light of government's new evidence, JAQU issued revised general guidance[14] to authorities producing CAPs nationwide. In summary, this required that air quality modelling should no longer assume any air quality benefits from a retrofitted bus.

2.4.6 GM incorporated the revised guidance, as agreed with JAQU, into the modelling which underpins the development of its CAP to produce a report that appraises the ability of the Investment-led Plan and the CAZ Benchmark to deliver compliance with the legal limit value in the shortest possible time and by no later than 2026. The key findings from government's six-month focused research programme were not available at the time this work was undertaken.

2.4.7 The first version of the *Appraisal Report* and supporting documentation was submitted to government in December 2023. The *Appraisal Report* concluded that GM's Investment-led Plan can deliver compliance in 2025 and performs better than a CAZ Benchmark.

2.5 Key developments since December 2023 submission

2.5.1 Since the submission of evidence to JAQU in December 2023 there have been a number of key developments, resulting in a need to update the modelling, the *Appraisal Report* and supporting documentation.

2.5.2 Further modelling was undertaken in Summer 2024 to consider and address the following key developments:

- Delay to Stockport all-electric bus depot;
- Changes to bus fleets (operational and planned); and
- Correction to Euro V retrofit bus modelling emission values.

2.5.3 Drafts of the *Appraisal Report* and supporting documentation were updated to take account of the key developments and the Summer 2024 modelling, in preparation for submission to government. These updates did not change GM's conclusion that the Investment-led, non-charging plan can deliver compliance in 2025 and performs better than a CAZ Benchmark.

2.6 Developments following Summer 2024 modelling

2.6.1 Following the substantial drafting to update the *Appraisal Report* and supporting material (to address the key developments since the December 2023 submission), two additional issues have arisen.

2.6.2 Firstly, a risk identified in the December 2023 submission "Delays to bus depot electrification" has materialised and there is now a delivery delay to the electrification of Queens Road depot. This was due to take place by January 2025, which was the assumed delivery date in the modelling of the Investment-led Plan.

[14] Bus Retrofit Update - Technical Guidance for Local Authorities, JAQU Guidance, May 2023

2.6.3 This poses a significant challenge to achieving compliance in 2025, as 73 ZEBs are to be operated out of Queens Road depot. The issue affects 12 bus services, which run through 17 forecast ‘Do Minimum’ exceedance sites in 2025.

2.6.4 Secondly, in July 2024 National Highways also advised TfGM that the temporary speed limit on the M602 is to be removed, and the 70mph speed limit reinstated. The M602 temporary speed limit is assumed to be in place in the Investment-led Plan modelling assumptions.

2.6.5 The implications of these two issues are addressed in the *Supplementary Appraisal Report*, included as part of this evidence submission documentation. Therefore, the *Appraisal Report* and associated documentation, including this report, should be read in conjunction with the *Supplementary Appraisal Report*.

2.6.6 In addition, since the drafting of the *Appraisal Report* and supporting material, government published the ‘Bus Retrofit Performance Report’[15] on the 12th September 2024. The key findings of this report include that the retrofit technology fitted onto retrofitted buses is not reducing NO_X emissions to the levels expected and retrofit performance is highly variable. These findings are consistent with the guidance issued in May 2023. Therefore, the publication of the study findings has no impact on the Investment-led Plan, the *Appraisal Report* and supporting material.

[15] https://assets.publishing.service.gov.uk/media/66e1ab11951c1776394a003c/bus-retrofit-performance-24.pdf

3 Context of this Document

3.1.1 In order to inform the AAS and its assessment of the limitations, uncertainties and risks in the evidence base, GM has carried out a programme of sensitivity testing.

3.1.2 The purpose of the sensitivity testing is to understand the possible impact of uncertainty in the appraisal of the GM CAP. In particular, to understand whether variations in the assumptions underpinning the modelling, or the modelling methodology, would lead to a different decision or outcome or alter confidence in the conclusions.

3.1.3 For the GM CAP, the key questions are:

- Are there any plausible circumstances under which the GM CAP would no longer be required, or would not be required in its current form? How confident can GM be in the results of its analysis?
- Are there any plausible circumstances under which the GM CAP would not achieve compliance in the shortest possible time, compared to a benchmark CAZ? How confident can GM be in the results of its analysis?

3.1.4 This report sets out the results of the latest round of sensitivity testing, undertaken in Spring/Summer 2024, which was carried out to support the assessment of uncertainty for the GM CAP.

4 The Modelling Process

4.1.1 An overview of the modelling tools used to assess the impacts of GM CAP are discussed in the section below.

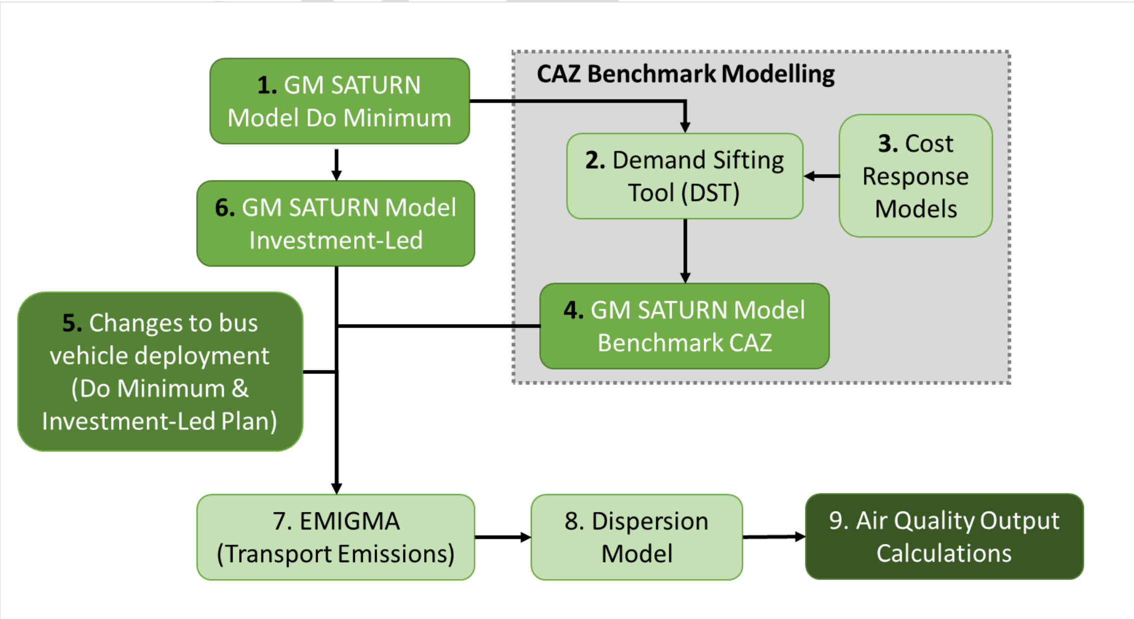
4.1.2 The GM CAP is underpinned by an evidence base derived from data collection, research, analysis and modelling. Throughout the technical development process from 2017 to date, GM has used best practice methodology and assumptions and worked closely with government in accordance with national guidance.

4.1.3 The overall modelling process has remained consistent throughout the development of the GM CAP, whilst updates have been made at relevant stages to take account of a number of factors including reflecting changes to revised vehicle fleet age assumptions (due to Covid-19) or as a response to policy refinements as a result of public consultations.

4.1.4 The modelling approach has been developed in line with JAQU guidance and the GM CAP Policy. The purpose of the modelling process is to quantify the impact of traffic by vehicle type on emissions and consequently on concentrations of NO_2 at the roadside in GM.

4.1.5 The modelling for the study is being undertaken using the CAP modelling suite as illustrated in **Figure 4-1**.

Figure 4-1 Overview of Modelling Suite



4.1.6 The modelling system consists of the following components:

- **The Greater Manchester highway SATURN model (GMSM)**, which uses information about the road network and travel demands for different years and growth scenarios to estimate traffic flows and speeds for input to the emissions model and forecasts of travel times, distances and flows for input to the economic appraisal.

- **Cost Response models**, currently only being used to model the CAZ Benchmark, these are models developed to better understand commercial vehicle, taxi, and coach/minibus behavioural changes to the GM CAP. These have been developed by assembling available data on the known fleets and movements within GM.
- **The Demand Sifting Tool (DST)**, Currently only being used to model the CAZ Benchmark, the DST has been developed to allow measures to be tested in a quick and efficient way prior to detailed assessments being undertaken using the highway and air quality models. The sifting tool uses fleet specific Cost Response models to determine behavioural responses to the CAP proposals (pay charge, upgrade vehicle, change mode, cancel trip etc.). The outputs comprise demand change factors which are applied to the Do Minimum SATURN matrices to create Do Something demands for assignment.
- **The emissions model**, which uses TfGM's EMIGMA (Emissions Inventory for GM) software to combine information about traffic speeds and flows from the SATURN model with road traffic emission factors and fleet composition data from the Emission Factor Toolkit (EFT) to provide estimates of annual mass emissions for a range of pollutants including oxides of nitrogen (NOx), primary-NO_2, particulate matter (PM_{10} and $PM_{2.5}$) and CO_2.
- **The dispersion model**, which uses ADMS-Urban software to combine information about mass emissions of pollution (from EMIGMA) with dispersion parameters such as meteorological data and topography to produce pollutant concentrations. The outputs of the dispersion model are processed to convert them to the verified air quality concentrations, using Defra tools and national background maps.

5 Analytical Assurance

5.1.1 The reporting is supported by an Analytical Assurance Statement (AAS). The purpose of the AAS is to consider the limitations, uncertainties and risks in the evidence base, and the implications of these for decision makers. It considers whether an appropriate procedure has been followed, in terms of the modelling process and the source data, and whether appropriate checks have been carried out. It considers whether appropriate expertise has been utilised, and whether sufficient time and resources have been allocated to the analysis.

5.1.2 The analysis was needed to support the following decisions:

- The agreement of forecast exceedances that must be tackled by the GM CAP through the **revised Do Minimum forecasting** exercise, which updated the results set out as part of the Target Determination process;
- The **specification of policies and scheme design for each of the identified measures** identified in Option 8, to form the Option for Consultation designed to meet the requirements of the Ministerial Direction; and
- The **decision to proceed** with the consultation with the public and stakeholders, on the basis of the Package for Consultation.

5.1.3 An updated AAS has been prepared to support the GM CAP. That analysis is needed to support the following decisions by GM:

- The agreement of forecast exceedances that must be tackled by the GM CAP through the **revised Do Minimum forecasting** exercise, taking into account the impacts of Covid-19 on vehicle fleets;
- The **specification of policies and scheme design for each of the identified measures**, to form the GM CAP Policy following consultation designed to meet the requirements of the Ministerial Direction; and
- The **decision to proceed** with submission of the GM CAP in order to inform government decision making and secure funding.

6 Description of the Sensitivity Tests

6.1 Overview

6.1.1 GM has developed a programme of sensitivity testing based on the following inputs:

- **JAQU guidance** – JAQU supplied local authorities with guidance on sensitivity testing as a “Supplementary Note on Sensitivity Testing” in October 2017. Where relevant, GM has also drawn on the DfT’s Transport Analysis Guidance (TAG) in terms of the approach that should be taken to sensitivity testing in transport modelling and appraisal.[16]
- **Feedback from JAQU’s Technical Independent Review Panel (TIRP)** – GM have sought TIRP feedback at regular intervals throughout the project. At each stage, GM has provided a response to previous feedback, and that feedback has led to further data collection and analysis and methodological changes as appropriate, as well as informing the CAP programme of sensitivity tests.
- **Joint working between the GM CAP and JAQU Technical Teams** – GM’s technical team have worked closely with JAQU to develop the modelling methodology and evidence base and have collectively developed an approach to modelling and sensitivity testing. Some tests reflect questions asked by the JAQU Technical Team or suggestions they have made, whilst others have been developed by the GM CAP Technical Team to reflect questions arising from the evidence base, and their assessment of what aspects are potentially impactful and relevant.

6.1.2 **Table 6-1** presents a summary of the sensitivity tests undertaken, including a brief description, the type of test, and whether the test is being applied to the Do Minimum (DM) and/or Do Something (DS) scenarios.

6.1.3 For some of the tests, to properly reflect the impacts of the change applied would require revisiting the base year analysis and re-verifying the model. It was advised by JAQU that updating the baseline and verification should not be undertaken, as that would re-open the Target Determination process leading to a delay in scheme development.

6.1.4 The interaction of revised base year verification and the associated adjustment factors, with the future year scenario outputs is complex and has the potential to either uplift or depress the absolute modelled concentrations and also magnify or compress the scale impacts of any behavioural responses. Therefore, the outputs of these tests should be treated with additional caution.

[16] Transport analysis guidance - GOV.UK (www.gov.uk)

6.1.5 The majority of tests have been modelled explicitly pivoting off the Summer 2024 core DM and Investment-led Plan models. However, where agreed with JAQU, some of the tests are not explicitly modelled from the GM CAP core modelling, and hence narratives have been developed from previously available tests or evidence.

6.1.6 In order to consider the materiality of a test’s impacts. the forecast year of compliance is the most significant metric, particularly for the Investment-led Plan scenario as this could alter whether compliance is achieved in the shortest possible time. For the DM tests, the forecast year of natural compliance is not modelled explicitly and is assumed to be 2030, which is the latest point that electric buses will be operational from the Stockport depot. The DM sensitivity tests’ forecast year of compliance has been estimated using professional judgement based on the scale of change in concentration produced by the test. To help summarise the test results which are calculated for thousands of receptor points, the maximum concentrations and number of exceedances for the DM and Investment-led Plan scenarios have also been considered as reference points.

Table 6-1: List of Sensitivity Tests

Test No.	Test	Description	DM	DS	Type of Test
1	Emissions at low speeds*	Emissions rise steeply at low speeds in the Government's Emissions Factor Toolkit (EFT) model so the impact of low speeds in the AQ modelling can be high, this assesses how sensitive the modelling is to this effect.	Yes	Yes	Model test
2	Projections of f-NO_2	Primary NO_2 as a proportion of NOx emissions may be lower than forecast. f-NO_2 values are reduced by 40% in the future projected year.	Yes	Yes	Model test
3	High city centre taxi proportions of demand*	Taxi flows in the Regional Centre may be significantly greater than in other parts of the GM. Adjust taxi trips on roads inside the Inner Relief Road so that they represent 25% of the combined car plus taxi flow.	Yes	Yes	Model test
4	A57 Area LTM	A57 Local Traffic Management (LTM) measures run independently of A34 LTM measures, with incremental testing LTM package (i.e. speed limit, signal times).	No	Yes	Model test
5	A34 Area LTM	St John's area around A34 Quay St LTM independently of A57 LTM measures.	No	Yes	Model test
6	High Retrofit Bus emissions	Adjust modelled bus emissions to JAQU guidance for the High Emissions sensitivity test.	No	Yes	Model test
7	Low Retrofit Bus emissions	Adjust modelled bus emissions to JAQU guidance for the Low Emissions sensitivity test.	No	Yes	Model test
8	Older fleet/ Removal of EV car forecast	Fleet is older than modelled due, for example, to greater-than-expected impacts of Covid-19 pandemic or other factors slowing electric car penetration.	Yes	Yes	Narrative
9	Comparison of zonal and full model domain verification and canyon effects	GM applied a zonal approach to verifying the AQ model, splitting the Regional city centre into a zone with the canyon effects in the model, and a secondary zone for the rest of GM without the canyon. To check how this improved model performance alters forecast year concentrations.	Yes	Yes	Model test
10	f-NO_2 and verification	The fraction of primary NO_2 (f-NO_2) released direct from the tailpipe is a significant source of uncertainty in roadside air quality modelling. Use of continuous analyser measured f-NO2 instead of EFT.	Yes	Yes	Model test

Test No.	Test	Description	DM	DS	Type of Test
11	Meteorology	Meteorology can have a significant impact on NO_2 concentrations. The modelling has used a 2016 base year meteorological dataset, for all Base and Forecast years. Testing of meteorological data from the same station for 2015, 2017 and 2018 was undertaken at earlier phases of the CAP.	Yes	Yes	Narrative
12	Low ZEC taxi uptake	Zero Emission Capable (ZEC) taxi uptake may be lower than forecast, for example because of pandemic impacts on the trade. Assumes 0% taxi upgrade to ZEC. The electric taxi proportion in the 2025 forecast is set at the current propulsion mix from the 2023 taxi database and does not reflect the general trend of increasing electrification of the PHV and Hackney Carriage fleet.	Yes	Yes	Narrative
13	ZEB delivery programme risks	ZEBs mainly applied as a CAP measure, and not well represented in DM scenarios. Review depot electrification programme and risk to routes/exceedances, based on specific depots not being operational in 2025.	Yes	Yes	Narrative
14	Extra 40% Non-GM licensed PHV taxis	Increase taxi proportion of all car demand based on evidence of non-GM licensed PHVs from JAQU evidence at 40% greater than GM fleet.	Yes	Yes	Narrative
15	ANPR projection methodology	GM 2023 ANPR rolled forward to 2025 using the approved methodology, then applied into the EFT9.1 EMIGMA modelling tools.	Yes	Yes	Model test
16	Impact of EFTv12 / Future emissions standards*	GM's modelling applies version 9.1a of the Government's Emissions Factor Toolkit (EFT); EFTv12 is now available but is not compatible with GM's modelling process, because the base year of 2016 isn't available.	Yes	Yes	Model test
17	Regional Centre traffic demand	Compare Regional Centre model traffic growth assumptions to most recent available observed count data, which will be a reduction in van/car demand based on current knowledge.	Yes	Yes	Model test
18	Combined: ANPR Projection & Regional Centre Traffic	In-Combination: ANPR projection methodology & Regional Centre traffic demand trends - Combined Test 15 and Test 17.	Yes	Yes	Model test
19	Combined: ANPR Projection, Regional Centre Traffic & f-NO_2	In-Combination: ANPR projection methodology & Regional Centre traffic demand trends & Projection of f-NO_2 - Combined Test 15, Test 17 and Test 2.	Yes	Yes	Model test

Test No.	Test	Description	DM	DS	Type of Test
*Test that to properly reflect the impacts from change applied would require revisiting the base year analysis and re-verifying the model. The approach used has been agreed with JAQU.					

7 Sensitivity Testing Results

7.1 Introduction

7.1.1 This chapter reports the results for each of the isolated sensitivity tests (Test 1 to Test 17). Each test has a summary table of the metrics, where reduced risk is coloured green, increased risk is red whilst those marked in grey are procedural tests which are demonstrated to be sub-optimal, no impact or no conclusions are drawn. The air quality results from all of the modelled tests, at the locations that are predicted to be in exceedance in the DM 2025 scenario, are presented in **Appendix 1**.

7.2 Sensitivity Test 1: Emissions at low speeds

Introduction

7.2.1 Emissions rise steeply at low speeds for emissions factors calculated using the Government's Emissions Factor Toolkit (EFT), so that the impact of low speeds in the AQ modelling can be high, especially for buses and Heavy Goods Vehicles (HGVs).

7.2.2 JAQU's guidance on sensitivity testing notes that road traffic emission estimates on roads with low speeds are likely to be much more uncertain than roads with higher speeds. This is partly due to a lack of available drive cycle testing data around emissions at low speeds but is also due to greater variability in traffic behaviour, with more stop-start driving and uncertainty about emissions estimated using emission rates based on average speed models such as Copert and SATURN. There will also be greater uncertainty around average speeds from the traffic model for roads with stop-starting driving, as this is difficult to represent in conventional highway assignment models such as SATURN.

7.2.3 The low-speed emissions test restricts the influence of increasing emissions at very low speeds to assess the impacts of inaccuracies in the emission factors. The test will only impact on sites with modelled speeds less than 10kph, where congestion is severe, and the impacts of junction delays are most significant.

Methodology and Assumptions

7.2.4 Uncertainty surrounding emissions at low speeds has been investigated by running a 'low emissions' sensitivity test, which involved re-running the 2025 DM and DS EMIGMA modelling with a minimum speed cut-off of 10kph. The core model runs have assumed that the EFT emission factors can be applied for the full range of modelled speeds from its Copert speed functions, which assume that the NOx factors can be used for speeds as low as 5kph for some vehicle types, so that they effectively represent 'high emission' forecasts for sites with low speeds.

7.2.5 The test has not been applied into the base 2016 modelling methodology, or the AQ model verification process.

7.2.6 The test was applied as follows:

- Reset link speeds that were <10kph in the core modelling to 10kph, keeping vehicle flows from the SATURN model fixed;
- Run EMIGMA to calculate mass emissions for the test for input to the dispersion model; and
- Run the forecast year dispersion model to calculate air quality concentrations.

<u>EMIGMA Results</u>

7.2.7 **Figure 7-1** shows fleet-weighted NO_x emission rates (in grammes per km travelled) for compliant and non-compliant vehicle types travelling at speeds of 5 and 10 kph from the 2025 EMIGMA modelling. The figure shows that the impact of capping the minimum speed is most significant for HGVs and buses, which have much higher emissions factors and the greatest differences between emission rates at low speeds. The impacts of capping the speeds for other vehicle types are relatively modest.

7.2.8 The locations of links with modelled speeds of less than 10 kph (in any modelled time period) from the 2025 DM SATURN models are shown in **Figure 7-2.** These links represent approximately 5% of the total network mileage within the County and tend to be short links in areas with dense networks and a higher frequency of road junctions (such as town centres), on the approach to signalised junctions, (or minor arms at priority junctions where traffic must give way to opposing major road movements), where junction delays and queues are significant.

Figure 7-1: 2025 Fleet Weighted NOx Emissions Factors at Speeds of 5 and 10 kph

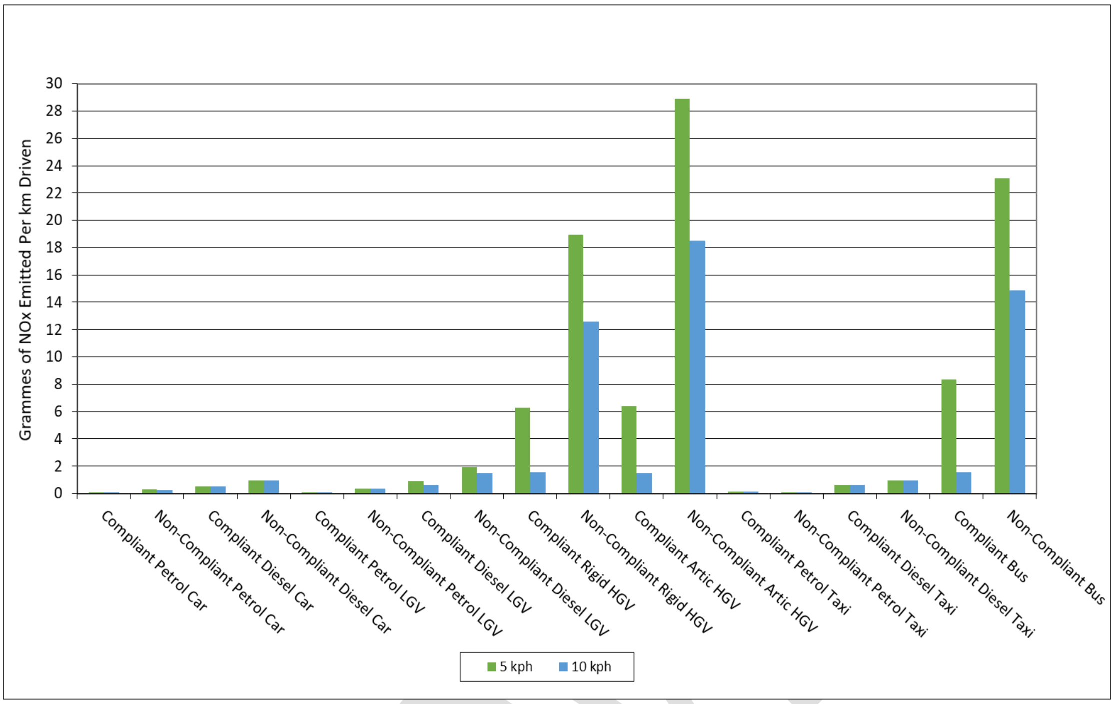
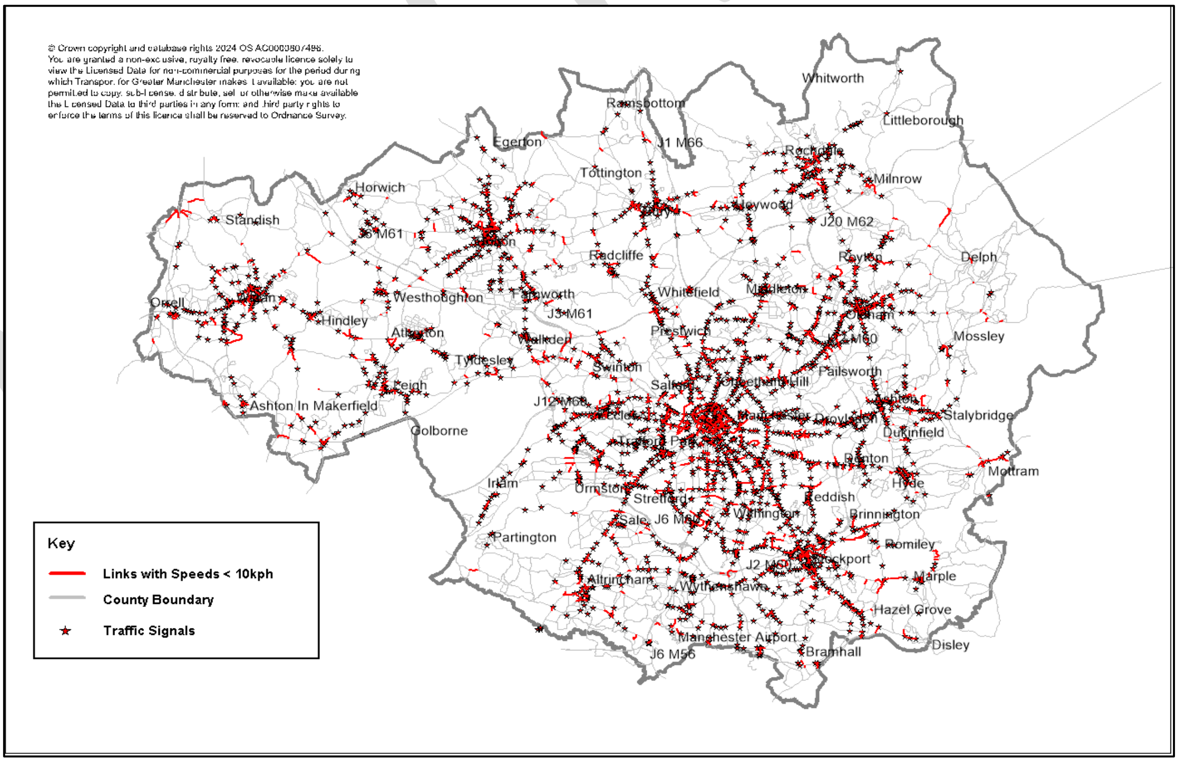
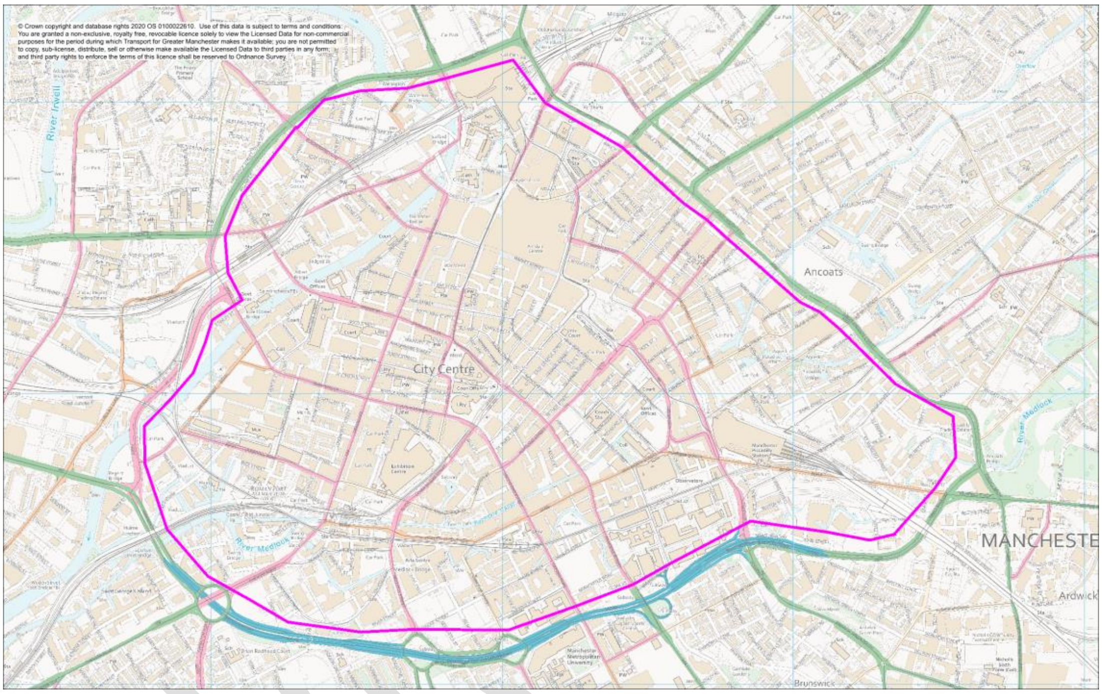


Figure 7-2: Links with Modelled Speeds <10 kph (2024 Do-Minimum)



7.2.9 Summary results from the EMIGMA modelling for the test are presented in **Table 7-1**, separately by vehicle type and for all vehicles combined. Results are presented separately for the DM and DS scenarios, for the Regional Centre and for the whole of Greater Manchester. The area representing the Regional Centre is shown in **Figure 7-3**, which also forms the area inside the Inner Relief Route (IRR).

Figure 7-3: Regional Centre Cordon (IRR)



7.2.10 The results for Greater Manchester as a whole show that NOx emissions from all vehicles combined are forecast to reduce by approximately 1% relative to the Core scenarios for both the DM and DS tests. These reductions are primarily driven by reductions in NO_x emissions from HGVs and buses, which have much higher emissions rates compared to light duty vehicles and the most significant differences between emission rates at low speeds, as illustrated earlier in **Figure 7-1**.

7.2.11 The emission impacts for the Regional Centre show that NO_x emissions from all vehicles combined are forecast to reduce by 17% relative to the Core DM scenario, and by 15% relative to the DS forecast. The impacts of the test in the Regional Centre are significantly greater than those for GM as a whole due to the increased prevalence of bus emissions in the central area, which is more congested and has higher bus flows, which exhibit steep rises in emission rates at low speeds.

Table 7-1: Emissions at Low Speeds Test Road Traffic NOx Emissions with percentage changes from the Core Model Runs (2025, Tonnes Per Year)

Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Regional Centre						
Car	11.6	11.6	-0.2%	11.7	11.7	-0.2%
LGV	6.5	6.1	-5.7%	6.5	6.1	-5.3%
HGV	2.5	1.6	-33.8%	2.4	1.7	-30.7%
Taxi	1.7	1.7	0.0%	1.5	1.5	0.0%
Bus	21.3	15.1	-29.1%	13.5	9.3	-31.1%
Total	43.6	36.2	-17.0%	35.6	30.3	-14.9%
Greater Manchester						
Car	2,468	2,468	0.0%	2,468	2,467	0.0%
LGV	1,601	1,594	-0.4%	1,601	1,594	-0.4%
HGV	529	498	-5.7%	529	499	-5.8%
Taxi	294	294	0.0%	259	259	0.0%
Bus	381	348	-8.6%	316	289	-8.7%
Total	5,273	5,202	-1.3%	5,173	5,107	-1.3%
Notes: Percentage changes may differ due to rounding.						

Air Quality Impacts

7.2.12 A summary of the air quality impacts of the test are provided in **Table 7-2**.

7.2.13 There is an improvement in NO_2 concentrations, as the maximum emission rate in the model is capped as a result of the test. Roads with very low speeds and high bus / HGV flows are the locations most impacted by this test.

7.2.14 The DM improves with reduced concentration exceedances, and the first year of natural compliance may be brought forward from 2030.

7.2.15 The Investment-led Plan also improves with reduced concentrations and increased headroom (i.e. the gap between the modelled concentration and the legal limit of 40.4 ug/m^3). However, there are no forecast exceedances in 2025 and the compliance year isn't altered. The test has minimal impact on the last points of compliance (A57 Regent Road, A34 Quay Street, Great Bridgewater Street) which have had Local Traffic Management (LTM) measures implemented to improve traffic flow conditions.

7.2.16 This is a test that, to properly reflect the impacts from the change applied, would require revisiting the base year analysis and re-verifying the model. Therefore, the results should be treated with caution.

Table 7-2: Air Quality Summary Impacts: Emissions at Low Speeds Test

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 46.0 DS: No change
Change in no. of exceedances in 2025	DM: 26 → 14 DS: No change
Forecast Compliance Year[17]	DM: 2030 → 2028? DS: No change
Impact	Reduced risk

7.3 Sensitivity Test 2: Projections of f-NO_2

7.3.1 JAQU guidance sets out that future fleet could have lower f-NO_2 proportions than specified in the EFT/NAEI, notably associated with older petrol car emissions.

Methodology and Assumptions

7.3.2 The proportion of NO_x emitted as NO_2 was reduced by 40% in the forecast modelling inputs to the NO_x to NO_2 calculator.

Air Quality Impacts

7.3.3 Roads with high diesel car/van or retrofit bus emissions contributions are the locations most impacted by this test. This is because these vehicle types have the greater f-NO_2 proportions than non-retrofit buses or petrol cars or HGVs.

7.3.4 The DM improves with reduced concentrations and fewer exceedances, and the first year of natural compliance would be brought forward from 2030.

[17] For the DM tests, the forecast year of natural compliance is not modelled explicitly and is assumed to be 2030, which is the latest point that electric buses will be operational from the Stockport depot. The DM sensitivity tests' forecast year of compliance has been estimated using professional judgement based on the scale of change in concentration produced by the test.

7.3.5 The Investment-led Plan also improves with reduced concentrations and increased headroom. It is noted that previous liaison with JAQU has confirmed that the approach taken by GM in its core modelling remains consistent with their guidance and best practice. In practice, plausible variations in f-NO_2 could increase certainty that compliance can be achieved in the shortest possible time.

Table 7-3: Air Quality Summary Impacts: Projections of f-NO2

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 44.2 DS: 40.3 → 37.5
Change in no. of exceedances in 2025	DM: 26 → 9 DS: No change
Forecast Compliance Year	DM: 2030 → 2027? DS: No change
Impact	Reduced risk

7.4 Sensitivity Test 3: High Regional City Centre Taxi Proportions of Demand

Introduction

7.4.1 The base year taxi matrices for input to the CAP modelling were formed by applying blanket factors to the car matrices (for trips with an origin or destination inside Greater Manchester) based on the number of taxi trips as a proportion of total car trips calculated from Automatic Number Plate Recognition (ANPR) data collected at sites within the county in 2016. The estimated taxi trips were then subtracted from the car matrices to avoid any ‘double counting’. The matrix factors were applied equally across the whole of the modelled area, with taxi and private hire vehicle trips combined representing approximately 7% of total car travel.

7.4.2 Whilst this approach has provided a reasonable estimate of taxi travel at an aggregate level, the fraction of taxi trips will vary by location, which could have an impact on overall NOx emissions in areas with significantly higher or lower taxi flows.

7.4.3 **Table 7-4** shows taxi as a proportion of total car plus taxi flows calculated from ANPR surveys undertaken within the County in 2023, disaggregated by location. The results indicate that whilst the GM-wide estimate of 7% based on the 2016 ANPR data is reasonable for the area inside the M60 and for GM as a whole, there is a significantly higher proportion of taxis inside the Regional Centre.

Table 7-4: 2023 ANPR Car & Taxi Counts

Vehicle Type	Inside IRR	Inside M60	Outside M60	All GM
Car	3,474,854	57,759,135	50,533,576	108,292,711
Taxi	869,443	5,491,915	2,336,031	7,827,946
Total Car + Taxi	4,344,297	63,251,050	52,869,607	116,120,657
Taxi as % of Total Car + Taxi	20.0%	8.7%	4.4%	6.7%

Methodology and Assumptions

7.4.4 In 2023, for the ANPR camera sites inside the IRR a range of taxi proportions were captured between 15-29%, with an average of 20%. The air quality impacts of the underestimation of taxi trips within the Regional Centre have been investigated by adjusting the traffic flows from the SATURN models (that feed into EMIGMA) to reflect a 25% taxi proportion as follows:

- For roads within the Regional Centre calculate a combined car + taxi flow;
- Calculate a revised taxi flow for the test equivalent to the combined flow from Step 1 x 0.25, for each of the modelled hours;
- Calculate a revised car flow for the test to be the combined flow from Step 1 x 0.75 (for each of the modelled hours);
- Split the adjusted taxi and car trips between compliant and non-compliant vehicle types pro rata to the forecast fleet mix from the Core modelling, for each link;
- Run EMIGMA to calculate mass emissions for input to the dispersion model; and
- Run the dispersion model to calculate air quality concentrations for the test.

7.4.5 Separate model runs have been undertaken for the DM and DS scenarios for 2025. No changes were made to traffic speeds of flows for other vehicle types for the test.

7.4.6 The test has not been applied into the base year 2016 modelling methodology or the AQ model verification process, which could impact on the adjustment factors and forecast changes in future years. The potential impacts of this effect are unknown.

EMIGMA Results

7.4.7 Summary results from the EMIGMA modelling for the test are presented in **Table 7-5**, which shows modelled annual NO_x emission totals separately by vehicle type and for all vehicles combined. Results are presented for the DM and DS scenarios for roads inside the Regional Centre, as shown in **Figure 7-3**.

7.4.8 As would be expected, the impacts of the test on predicted emissions from taxis are very significant, with NO_x emissions from taxis and Private Hire Vehicles in the central area being almost three times greater than in the Core modelling for each of the scenarios. The impacts of the test on total traffic emissions (from all vehicle types) are more modest, however, with an increase in total road traffic NO_x emissions of approximately 5% for the forecasts. Forecast NO_x emissions from cars are modelled to be approximately 20% lower in both scenarios.

7.4.9 Total NO_x emissions from cars and taxis combined are forecast to increase by approximately 16% for the DM test and by 12% for the DS test. This reflects the increased use of diesel-powered vehicles for taxi trips and differences between the projected fleet mix forecasts for the two vehicle types.

Table 7-5: Regional Centre Taxi Demand Test Road Traffic NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes Per Year)

Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Car	11.6	9.4	-19.3%	11.7	9.4	-19.3%
LGV	6.5	6.5	0.0%	6.5	6.5	0.0%
HGV	2.5	2.5	0.0%	2.4	2.4	0.0%
Taxi	1.7	6.1	254.5%	1.5	5.4	255.6%
Bus	21.3	21.3	0.0%	13.5	13.5	0.0%
Total	43.6	45.7	4.8%	35.6	37.2	4.5%
Notes: Percentage changes may differ due to rounding.						

Air Quality Impacts

7.4.10 The test is impacted by both the age of the car versus the taxi fleet, and also the relative fuel mix. The proportion of taxi fleet modelled as diesel is >90% (CAZ Compliant: 95% Private Hire Vehicles, 40% Hackney Carriage), whereas the private car fleet is 45% diesel. Also, within the modelling, all hybrids are assumed to be diesel but this is a pessimistic assumption as many hybrids are petrol with lower emissions.

7.4.11 Therefore, whilst the compliance rate is very similar, increasing the proportion of car demand that is taxi increases emission rates because a greater proportion in the test is diesel.

7.4.12 Modelled concentrations inside the IRR increase by up to 1.5 ug/m3, and this changes the location of maximum modelled concentration in the Investment-led Plan scenario from the A57 Regent Road in the core modelling to King Street in the sensitivity test.

7.4.13 The results of the modelled impacts, and the location of ANPR cameras and the 2023 taxi proportions are presented in **Figure 7-4.**

7.4.14 It should be noted that taxi flows vary spatially, and further indicative breakpoint analysis has been undertaken to investigate the proportion of taxi flows that might lead to an exceedance under the Investment-led Plan. This has applied a linear response to the NO_2 incremental impact of the 25% taxi proportion test result, scaling the change to calculate the proportion of taxi flow that would lead to exceedance at 40.5 ug/m3. This is a simplification because the NO_2 response is non-linear, but reasonable given the other uncertainties with the methodology and availability of ANPR data by road link.

7.4.15 This breakpoint analysis would indicate that there are only three roads where increased taxi proportions could forecast an exceedance under the Investment-led Plan in 2025 (i.e. the required taxi proportion breakpoint is <100% of total car flows). These are A34 Bridge Street (breakpoint: 44%), King Street (10%) and New York Street (25%). There is ANPR data for Bridge Street which shows measured taxi proportions of 24% in 2023, but there are no ANPR cameras available on King Street or New York Street. The maximum ANPR measured taxi proportion is 29% at John Dalton Street and Oxford Road, so the emissions performance of taxis is an area of uncertainty for compliance in 2025.

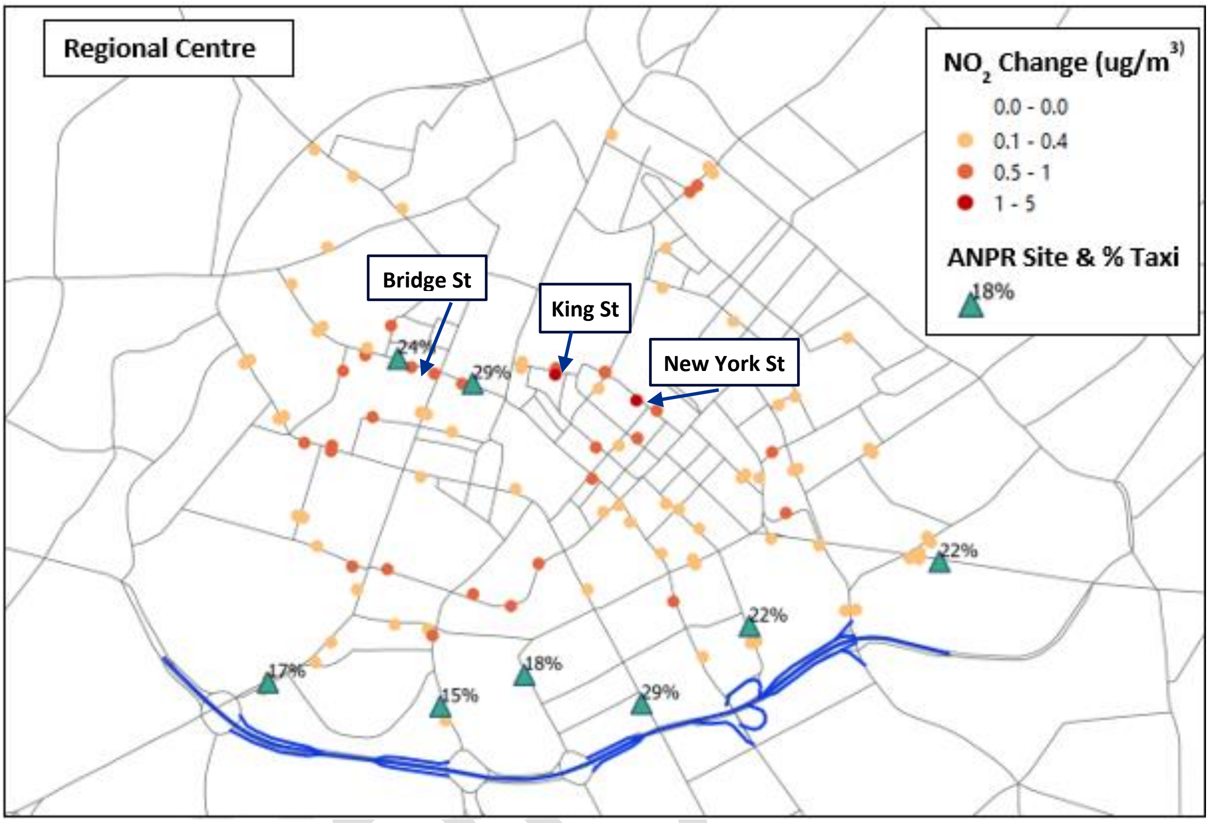
7.4.16 It should be noted that this test has not been applied to the Base Year verification process, which could depress some adjustment factors off-setting impacts forecast in future years. The overall net impact of this effect is not known but would likely worsen the DM forecast, but also magnify the scale of benefit delivered by the taxi measure potentially offsetting the DM worsening, and which would also provide greater CAP resilience for roads without bus measures. However, the reported results from this test should be treated with additional caution.

7.4.17 Based purely on the modelled results, compliance with the Investment-led Plan would be delayed until 2026. However, forecast compliance in 2026 would still be earlier than the CAZ Benchmark (which is also adversely impacted by this test result). However, uncertainty associated with taxi flows means that delivery of the CAP taxi measure would reduce risks associated with scheme and the complex nature of representing the diversity of taxi operation within the modelling process.

Table 7-6: Air Quality Summary Impacts: High Regional City Centre Taxi Proportions of Demand

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 50.1 DS: 40.3 → 41.3
Change in no. of exceedances in 2025	DM: 26 → 30 DS: 0 → 2
Forecast Compliance Year	DM: Not known DS: 2025 → 2026?
Impact	Increased ILP exposure benefits / Increased risk to compliance date

Figure 7-4: Air Quality Summary Impacts: High Regional City Centre Taxi Proportions of Demand and Measured ANPR Site Taxi Proportion for 2023



7.5 Sensitivity Test 4: A57 Area Local Traffic Measures

Introduction

7.5.1 The A57 Regent Road (between Ordsall Lane and A6042 Trinity Way) was forecast to be one of the final exceedance sites and local traffic management measures would be required to reduce through traffic and NO_2 concentrations.

7.5.2 Salford City Council and TfGM have worked together to identify a solution for this location. The scheme comprises of:

- Speed limit change and enforcement measures;
- Signal Optimisation; and
- Yellow box enforcement along the A57 Regent Road corridor.

7.5.3 This sensitivity test assesses this package of measures in isolation, and is not tested in the DM as it is part of the Investment-led Plan set of measures.

Methodology and Assumptions

Speed limit change and enforcement measures

7.5.4 The traffic model assessed the impacts of a speed reduction from 40mph to 30mph on the A57 Regent Road between Oldfield Road and the M602. The measure would reduce the number of vehicles travelling past the A57 Regent Road exceedance site with some displacement to nearby parallel routes, thus reducing the modelled NO_2 concentrations at this exceedance site. The displaced trips are being accommodated by the adjustments to signals at the junctions of Oldfield Road / Middlewood Street, Ordsall Lane / Middlewood Street / Hampson Street and Hampson Street / A6042 Trinity Way.

7.5.5 The implementation of the speed reduction would be delivered through a Traffic Regulation Order made by Salford City Council by 31st December 2024 which allows sufficient time to capture the full year air quality benefit of this scheme being in place in 2025.

7.5.6 GM is seeking to add robustness to this measure with Greater Manchester Police enforcing the speed limit change via average speed cameras along the A57 Regent Road corridor (between M602 and Inner Ring Road). It is proposed that average speed cameras are deployed to cover the route which will be operational seven days a week across a 24-hour period. This supporting measure will help to regulate the traffic flow travelling through the exceedance site, particularly out of the peak periods where higher average speeds are observed.

Signal Optimisation

7.5.7 There is also potential to provide a more regulated flow of traffic onto A57 Regent Road, by updating signals/signal control along the corridor.

7.5.8 The signals at the following junctions have been identified for improvement:

- A57 Regent Road /M602 Circulatory; and
- A57 Regent Road Ordsall Lane.

7.5.9 The A57 Regent Road /M602 Circulatory currently operates using fixed time signals. This could benefit from introduction of variable demand dependent signals, which would assist in control of stage timings by allowing stages to operate using a minimum/maximum time-period. This can be further enhanced by using SCOOT[18] to optimise flow throughout the corridor.

7.5.10 To make the corridor a less attractive route option, a delay can be induced on the A57 Regent Road eastbound approach of A57 Regent Road/Ordsall Lane junction, by allocating a proportion of green time from the eastbound movement to the westbound right turn movement (A57 Regent Road westbound to Ordsall Lane northbound).

[18] https://trlsoftware.com/products/traffic-control/scoot/

Yellow box enforcement along the A57 Regent Road corridor

7.5.11 The implementation of enforcement measures for incursions into existing yellow box junctions along the A57 Regent Road corridor are planned as a supporting measure to achieve compliance. There are currently yellow boxes present at the following junctions along the corridor:

- M602/A5063 Albion Way/A57 Regent Road/A6042 Trinity Way;
- A57 Regent Road/ A5066 Oldfield Road;
- A57 Regent Road/Ordsall Lane; and
- A57 Regent Road/A6042 Trinity Way.

7.5.12 The introduction of enforcement at junctions will provide added robustness to the local measures along the A57 Regent Road Corridor. The local highway authority, Salford City Council, will manage the implementation of yellow box enforcement along the corridor with the measure implemented to support compliance being achieved at the exceedance site in 2025.

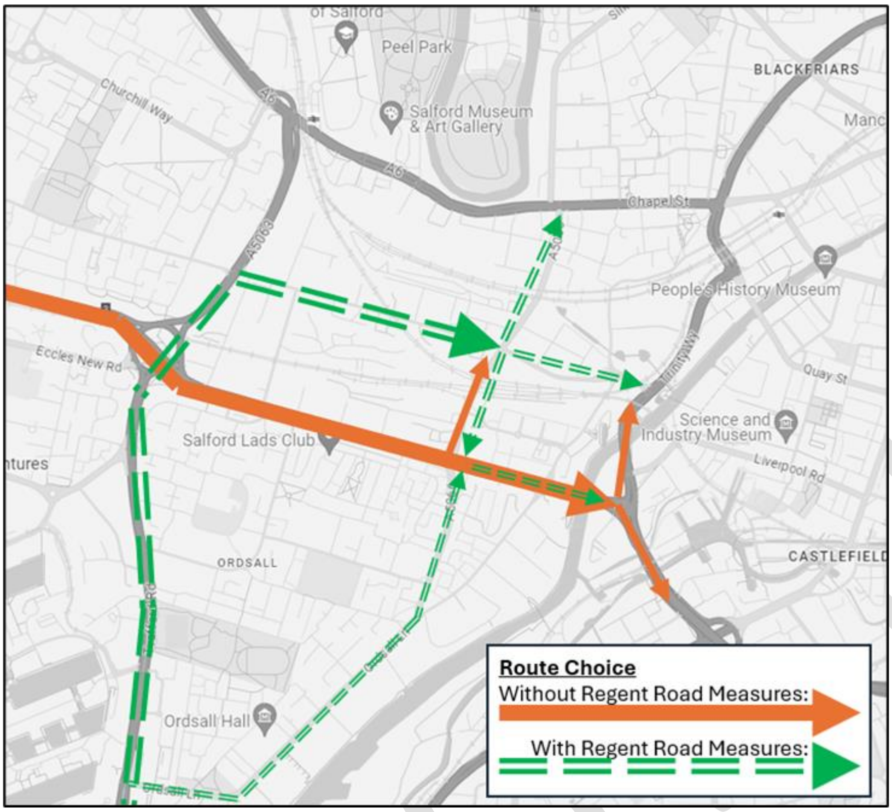
Modelling Approach

As the GM SATURN is a strategic traffic model, it has inherent assumptions about driver behaviour and a simplified approach to traffic signal control. Therefore, the aspects which have been included in the test are the speed reductions and amendments to the (fixed) signal times at junctions in the corridor as described above.

Traffic Impacts

7.5.13 Overall, the impacts of the A57 Regent Road measures are localised to the A57 Regent Road and the area within a mile of the road, with the largest impacts being a reduction of traffic along the route, with vehicles reassigning to parallel routes, mainly Liverpool Street as shown in the schematic presented in **Figure 7-5**. Impacts on the wider area are minimal, particularly in terms of speed and delays and for areas within the IRR. The site of exceedance on A57 Regent Road is not impacted as heavily as the rest of the road, but there is still a reduction of vehicles between 10-100 depending on the peak period and direction of traffic.

Figure 7-5: A57 Regent Road Measures - Route Choice Impact



7.5.14 The reassignment is mostly as expected, with the measures making A57 Regent Road less desirable as an option, resulting in vehicles using other routes. The main patterns visible are traffic heading to/from the city centre using Liverpool Street rather than A57 Regent Road and also traffic choosing to use alternative junctions on the M60 to reach the city centre without using A57 Regent Road. Other patterns of reassignment include vehicles near A57 Regent Road that have their routes become less or more desirable due to traffic which uses Liverpool Street and other roads rather than A57 Regent Road. This reassignment is not as large and does not impact sites of exceedance.

7.5.15 Traffic Impacts at the A57 Regent Road exceedance site:

- Traffic flows on A57 Regent Road reduce through the exceedance site, with a forecast reduction of up to 150 fewer vehicles per hour (two way) in the AM peak;
- Smaller reductions in other time periods, as eastbound A57 Regent Road is less congested during these hours; and

7.5.16 Minimal changes in vehicle speeds also noted in the AM peak.

7.5.17 **Table 7-7** shows the impact of the test on flow and speed at the exceedance site.

Table 7-7: Flow and speed difference at A57 Regent Road exceedance site

Parameter	Direction	AM		IP		PM	
		DM	Diff	DM	Diff	DM	Diff
Flow (PCU/hr)	Westbound	2,427	-34	2,339	-73	2,357	-5
	Eastbound	2,289	-142	1,629	-42	1,754	7
Net Speed (mph)	Westbound	16	0	16	0	26	0
	Eastbound	3	1	5	0	5	-1

7.5.18 A further sensitivity test was also undertaken just within the traffic model to understand the impacts of just the signal optimisation aspects of the Regent Road package (i.e. full Investment-led Plan minus the speed reduction to 30mph on Regent Rd). This test, which is focused on the Inter Peak as speeds are already typically below 30mph during peak hours, showed relatively small changes in flow relative to the overall Investment-led Plan. The flow and speed impacts for the Interpeak are presented below in **Table 7-8.**

Table 7-8: Flow and speed difference at A57 Regent Road exceedance site (30mph speed impacts) - Interpeak

Interpeak	Direction	DM	ILP (minus speed change)	ILP
Flow (PCU/hr)	Westbound	2,339	2,297	2,257
	Eastbound	1,629	1,587	1,570
Net Speed (mph)	Westbound	16	16	16
	Eastbound	5	5	5

EMIGMA Results

7.5.19 The test was applied in the EMIGMA modelling as follows:

- Feed the traffic flows from the updated SATURN assignments described above into EMIGMA to calculate mass emissions for input to the dispersion model; and
- Re-run the dispersion modelling to calculate air quality concentrations for the test.

7.5.20 The EMIGMA runs for the test include the impacts of GM's Investment Led Plan measures to deliver compliance, including updates to the bus fleet and taxi emission standards and the LTM measures in the St John's area around Quay St[19].

7.5.21 Summary results from the EMIGMA modelling for the test are presented in **Table 7-9**, which shows modelled annual NO_x emission totals at the exceedance site separately by vehicle type and for all vehicles combined. Results are presented incrementally for the DM, the Test and the DS Investment-led Plan scenarios, with percentage changes in emissions totals for the Test relative to the DM and the DS Investment-led Plan relative to the Test.

Table 7-9: LTM A57 Regent Road Exceedance Site NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario			% Change	
	Core DM	Test	ILP DS	Test vs DM	ILP vs Test
Car	0.552	0.536	0.533	-2.9%	-0.6%
LGV	0.386	0.372	0.372	-3.6%	-0.2%
HGV	0.220	0.225	0.225	2.1%	-0.2%
Taxi	0.077	0.067	0.066	-13.6%	-0.7%
Bus	0.007	0.000	0.000	-100.0%	0.0%
Total	1.242	1.200	1.195	-3.4%	-0.4%
Notes: Percentage changes may differ due to rounding.					

7.5.22 The results show that the A57 Regent Road measures deliver reductions in NOx emissions from cars of around 3% relative to the DM and reductions in LGV emissions of approximately 3.5%. NO_x emissions from HGVs are forecast to be approximately 2% greater than those in the DM. Taxi emissions at the site are forecast to fall by around 13%, partly associated with the traffic management measures, but also in response to the introduction of the taxi licensing measures for the Investment-led Plan. Bus emissions at the site are modest (as only one bus service passes through the exceedance site) but have reduced to zero for the Test as all buses operating this service are assumed to upgrade ZEBs for the Test and the Investment-led Plan. Total NO_x emissions for or the Test (from all vehicles combined) are forecast to fall by approximately 3% relative to the DM.

7.5.23 The modelling results for the A57 test (which includes all of the other Investment-led Plan measures, including the measures in the St John's area around Quay St LTM) at the exceedance site show small reductions in NOx emissions for all vehicle types relative to the Test, with a forecast reduction in total emissions (from all vehicles combined) of 0.5%.

[19] See Sensitivity Test 5 for details measures in the St Johns Area around Quay St

7.5.24 **Table 7-10** presents annual NO_x emission totals for the Test for roads inside the Regional Centre disaggregated by vehicle type. These show reductions in total road traffic emissions (for all vehicles combined) of approximately 19% for the Test relative to the DM, mainly associated with reductions in emissions from buses and upgrades to the bus fleet. The do-something results show a small increase in total emissions within the Regional Centre for the Investment-led Plan (which includes the A34 Quay Street measures) relative to the Test of around 0.3%. This is likely to represent re-routing effects associated with interactions between the measures but will also represent differences associated with the re-convergence of the traffic assignments for the Test, and a small amount of assignment ‘noise’ within the models associated with changes to the points at which the stopping criteria are achieved during the assignments. It needs to be borne in mind, however, that traffic flows will vary from day-to-day and that individual drivers will have different perceptions regarding the choice of minimum cost routes, so that small differences are virtually inevitable in any modelling exercise

Table 7-10: A57 LTM Test Regional Centre Road Traffic NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario			% Change	
	Core DM	Test	ILP DS	Test vs DM	DS vs Test
Car	11.6	11.6	11.7	-0.2%	0.5%
LGV	6.5	6.5	6.5	-0.5%	0.0%
HGV	2.5	2.4	2.4	-2.4%	-0.3%
Taxi	1.7	1.5	1.5	-12.0%	0.2%
Bus	21.3	13.4	13.5	-36.8%	0.4%
Total	43.6	35.5	35.6	-18.7%	0.3%
Notes: Percentage changes may differ due to rounding.					

Air Quality Impacts

7.5.25 The A57 LTM measures deliver compliance at Regent Road, as they do in the core Investment-led Plan scenario. The impacts of the A57 LTM measures are shown in **Figure 7-6.**

7.5.26 The localised re-routing associated with the A57 LTM measures leads to some increases in NO_2 as a result of the Investment-led Plan on Liverpool St, which offsets benefits from Taxi measures (bus measures aren’t impacting these roads). However, these locations of increase are not in exceedance (maximum concentration 35.4 ug/m3).

7.5.27 There is a minimal beneficial interaction with the A34 Quay Street, where LTM measures are included in this test, but this location remains in exceedance at 41.1 ug/m3 in 2025 as does Great Bridgewater Street which is not affected.

7.5.28 The incremental testing of the 30mph speed limit along the A57 separately from the signal timings measures shows that the speed limit measure contributes -0.2 ug/m3 of the total LTM package improvement of -0.5 ug/m3 at the exceedance site. Therefore, whilst the speed limit is not the dominant measure in the package, it does provide an important contribution to modelled delivery of compliance.

Figure 7-6: Air Quality Summary Impacts: A57 LTM Impacts in the Regional Centre

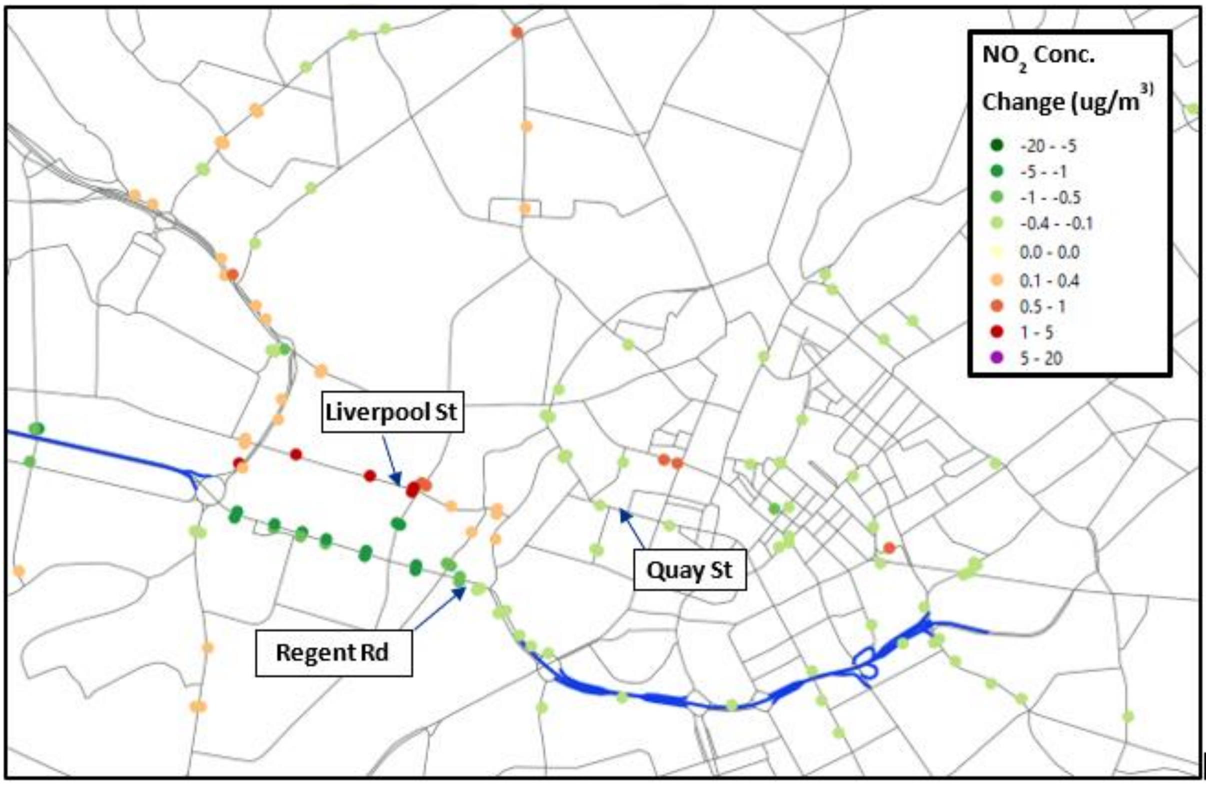


Table 7-11: Air Quality Summary Impacts: A57 LTM

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.4 → 41.1
Change in no. of exceedances in 2025	DM: na DS: 0 → 2
Forecast Compliance Year	DM: na DS: 2025 → 2026?
Impact	No risk as LTM measures not implemented separately

7.6 Sensitivity Test 5: A34 Area Local Traffic Measures

<u>Introduction</u>

7.6.1 The A34 Quay Street area was forecast to be one of the final exceedance sites and local measures would be required to reduce through traffic to reduce NO_2 concentrations. The site of exceedance is the section of A34 Quay Street between Lower Byrom Street and Gartside Street.

7.6.2 This test considers the incremental impact of the A34 Quay Street Local Traffic Management (LTM) measures deployed in the St Johns area of the Regional Centre in addition to the A57 Regent Road LTM measures described in Section 7.5.

<u>Methodology and Assumptions</u>

7.6.3 Manchester City Council and TfGM have identified a solution which complements the objectives of the wider City Centre Transport Strategy (CCTS) and local plans for the Regional Centre.

7.6.4 The measure consists of traffic management measures in the St John's area of Manchester City Centre. Specifically, this test has considered the impacts of measures on the adjacent network to reduce through traffic accessing Quay Street through the exceedance site.

10mph Speed Limit

7.6.5 As part of the earlier iteration of the Investment-led Plan, submitted to JAQU in December 2023, the local traffic measure modelled to achieve compliance at the A34 Quay Street and Great Bridgewater Street in 2025 comprised of the introduction of a 10mph speed limit on Lower Byrom Street and Gartside Street. Whilst this measure was modelled to achieve compliance at these two remaining exceedance sites in 2025, discussions with the Local Highway Authority (Manchester City Council) resulted in the need to identify a locally-deliverable scheme which would replicate the modelled test in emissions terms and achieve forecast compliance.

7.6.6 Since December 2023, GM has worked closely with Manchester City Council to develop a deliverable alternative local traffic measure scheme which also is modelled to achieve compliance at the A34 Quay Street and Great Bridgewater Street. The alternative, updated scheme includes traffic management measures in the St John's area of Manchester City Centre, reducing movements for general traffic whilst supporting movement for bus and local residents.

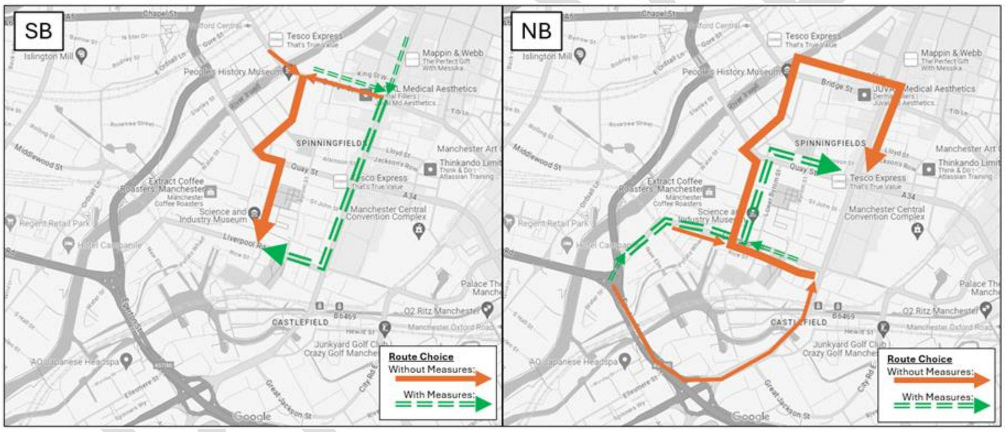
In preparation for the Summer 2024 submission, the detailed design for traffic management measures were insufficiently progressed to include in the core modelling for the Investment-led Plan, as reported in the *T4 report*. Therefore, the sensitivity testing for the Investment-led Plan LTM retains the 10mph speed limit on Lower Byrom Street and Gartside Street (see **Figure 7-7**) as used in in the core model run with the traffic management measures in the St John's Area of Manchester City Centre.

Figure 7-7: Overview of 10mph Speed Limit measure

Traffic Impacts

7.6.7 The most significant impact is seen in the vehicle flow difference. There is a reduction in flows in each peak through each of Lower Byrom Street, A34 Quay Street and Gartside Street. The highest difference is on Lower Byrom Street, followed by Gartside Street, which contains the site of exceedance. The reduction in flow at the exceedance site is between 10-100pcus per hour depending on peak and direction of traffic, with differences of over 100pcus visible on Lower Byrom Street. In general, A34 Quay Street is impacted to a lesser extent, with no pattern of reassignment emerging as a result of the measures. However, vehicles which are travelling southbound, using Deansgate to access Lower Byrom Street, rather than using Bridge Street, Gartside Street and then Lower Byrom Street. For vehicles heading northbound, vehicles choose to enter the city centre via Liverpool Street instead of Deansgate, using Lower Byrom Street to head eastbound on A34 Quay Street, rather than using the section of Quay Street and Gartside Street which contain the sites of exceedance. A schematic of these shifts is shown in **Figure 7-8**.

Figure 7-8: 10mph Speed Limit measure - Route Choice Impact



7.6.8 The re-routing impacts only lead to minor adverse impacts at other areas within the Regional Centre where air quality risks are forecast. Therefore, the modelling suggests that the air quality at sites of exceedance is likely to not be materially impacted. **Table 7-12** shows the impact of the test on actual flow and speed at the exceedance site.

Table 7-12: Flow and speed difference at the A34 Quay Street exceedance site

Parameter	Direction	AM		IP		PM	
		DM	Diff	DM	Diff	DM	Diff
Flow (PCU/hr)	Westbound	602	3	438	-69	436	17
	Eastbound	813	-46	521	-16	362	14
Net Speed (mph)	Westbound	3	0	4	2	1	0
	Eastbound	10	5	22	1	20	0

EMIGMA Results

7.6.9 The test was applied in the EMIGMA modelling as follows:

- Feed the traffic flows from the updated SATURN assignments described above into EMIGMA to calculate mass emissions for input to the dispersion model
- Re-run the dispersion modelling to calculate air quality concentrations for the test.

7.6.10 The EMIGMA runs for the test include the impacts of GM's Investment Led Plan measures to deliver compliance, including updates to the bus fleet, taxi emission standards and the LTM measures A57 Regent Road.

7.6.11 Summary results from the EMIGMA modelling for the test are presented below in **Table 7-13**, which shows modelled annual NO_x emission totals at the A34 Quay Street exceedance site separately by vehicle type and for all vehicles combined. Results are presented incrementally for the DM, the Test and the DS Investment-led Plan scenarios, with percentage changes in emissions totals for the Test relative to the DM and the DS Investment-led Plan relative to the Test.

Table 7-13: A34 LTM Quay Street exceedance site NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario			% Change	
	Core DM	Test	ILP DS	Test vs DM	ILP vs Test
Car	0.089	0.080	0.080	-10.2%	-0.1%
LGV	0.062	0.054	0.055	-12.6%	1.5%
HGV	0.050	0.020	0.018	-59.6%	-10.8%
Taxi	0.014	0.011	0.011	-22.3%	0.1%
Bus	0.084	0.000	0.000	-100.0%	0.0%
Total	**0.299**	**0.165**	**0.164**	**-44.7%**	**-0.8%**
Notes: Percentage changes may differ due to rounding.					

7.6.12 The results at the exceedance site for the Test show that the measures deliver reductions in NO_x emissions from cars of around 10% relative to the do-minimum and reductions in LGV emissions of approximately 13%. NO_x emissions from HGVs are forecast to reduce by almost 60%. Taxi emissions at the site are forecast to fall by around 13% relative to the do-minimum, partly associated with the traffic management measures, but also in response to the introduction of the Taxi licensing measures for the Investment-led Plan. Bus emissions have reduced to zero for the Test as all buses passing through the site are assumed to upgrade ZEBs for the Test and the Investment-led Plan. Total NO_x emissions for or the Test (from all vehicles combined) are forecast to fall by approximately 45% relative to the DM.

7.6.13 Modelled NO_x emissions at the exceedance site for the Investment-led Plan (which includes the A57 Regent Road measures) show modest increases in taxi and LGV emissions and a small reduction in emissions from cars relative to the Test. NO_x emissions from HGVs are forecast to reduce by 10%, although the absolute change is relatively small. Total NO_x emissions (from all vehicle types combined) are forecast to reduce by approximately 1% relative to the Test.

7.6.14 **Table 7-14** presents annual NO_x emission totals for the Test for roads inside the Regional Centre disaggregated by vehicle type. These show reductions in total road traffic emissions (for all vehicles combined) of approximately 18% for the Test relative to the DM, mainly associated with reductions in emissions from buses and upgrades to the bus fleet. The DS results show a small reduction in total emissions within the Regional Centre for the Investment-led Plan (which includes the A57 Regent Road measures) relative to the Test of 0.1%. This will represent re-routing effects associated with interactions between the measures but will also represent differences associated with the re-convergence of the traffic assignments for the Test, and a small amount of assignment 'noise' within the models associated with changes to the points at which the stopping criteria are achieved during the assignments.

Table 7-14: A34 Quay Street LTM Test Regional Centre Road Traffic NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario			% Change	
	Core DM	Test	ILP DS	Test vs DM	ILP DS vs Test
Car	11.6	11.7	11.7	0.6%	-0.3%
LGV	6.5	6.5	6.5	-0.1%	-0.4%
HGV	2.5	2.4	2.4	-1.6%	-1.2%
Taxi	1.7	1.5	1.5	-11.5%	-0.3%
Bus	21.3	13.4	13.5	-36.7%	0.3%
Total	**43.6**	**35.6**	**35.6**	**-18.3%**	**-0.1%**
Notes: Percentage changes may differ due to rounding.					

Air Quality Impacts

7.6.15 The St John's area LTM measures around A34 Quay Street deliver compliance at all the locations in the vicinity, as they do in the core Investment-led Plan scenario. The impacts of the St John's LTM measures are shown in **Figure 7-9**.

7.6.16 The localised re-routing associated with the St John's area LTM measures around A34 Quay Street leads to some increases in NO_2 as a result of the Investment-led Plan on Peter St and Hardman St, which offsets benefits from Taxi measures (bus measures aren't impacting these roads). However, these locations of increase are not in exceedance (maximum concentration: 29 ug/m^3). The increases on Bridge Street are not sufficient to lead to exceedance, with bus measures already delivering improvements.

7.6.17 There is a minimal beneficial interaction with the A57 Regent Road, where LTM measures are included in this test, but this location remains in exceedance at 40.9 ug/m^3 in 2025.

Figure 7-9: Air Quality Summary Impacts: A34 LTM Impacts in the Regional Centre

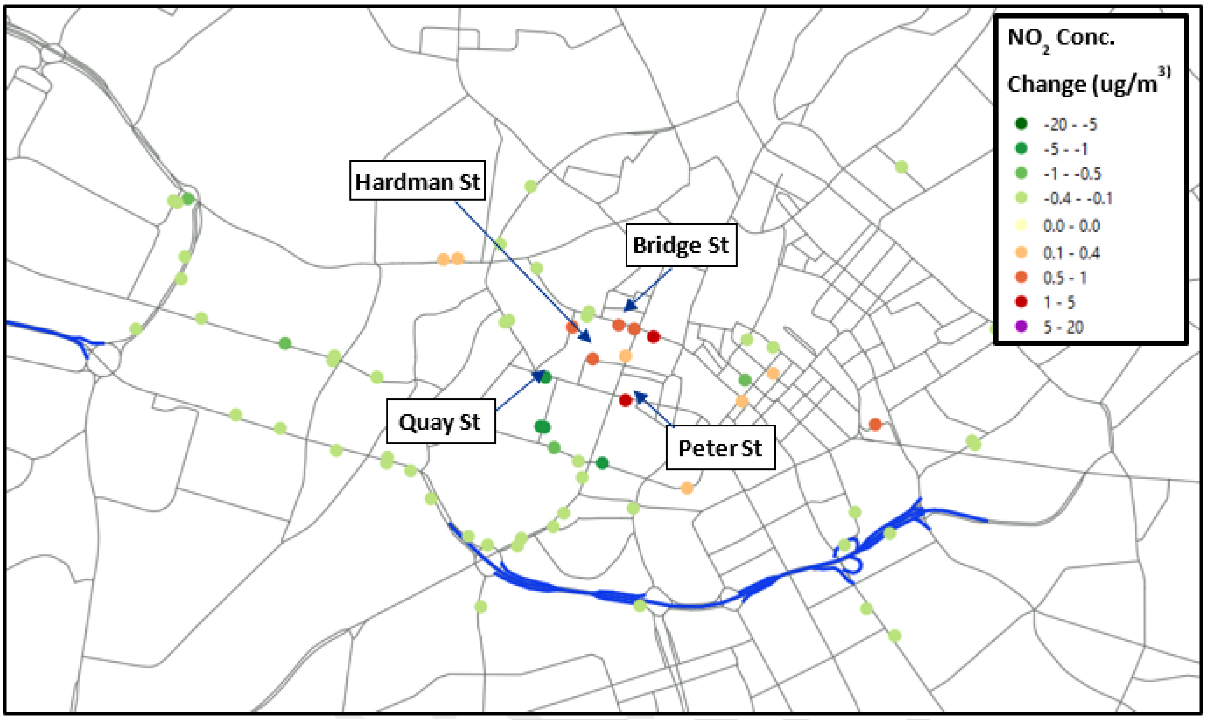


Table 7-15: Air Quality Summary Impacts: St John's Area LTM

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.4 → 40.9
Change in no. of exceedances in 2025	DM: na DS: 0 → 1
Forecast Compliance Year	DM: na DS: 2025 → 2026
Impact	No risk as LTM measures not implemented separately

7.7 Sensitivity Test 6: Higher Retrofit Bus Emissions

Introduction

7.7.1 Real-world emissions testing undertaken by JAQU has provided evidence of variable performance of retrofit bus technology, which had been designed to reduce NOx emissions from retrofitted vehicles to levels produced by OEM Euro VI buses.

7.7.2 This monitoring campaign has highlighted evidence to suggest that the Selective Catalytic Reduction (SCR) technology on retrofitted buses is not reducing NOx emissions to the levels expected. The monitoring also showed significant variation in primary NO_2 (also known as f-NO_2) emissions from different bus models with different retrofit technologies.

7.7.3 JAQU issued guidance in 2023 which advised that retrofitted bus emissions should be reset to the original vehicle Euro standard, and Primary NO_2 fractions (f-NO_2) increased from 5% (as currently used in the EFT for an OEM Euro VI bus) to 35.8% for core scenarios. The guidance also provided technical details of additional High and Low sensitivity tests (described below) to capture the observed variability in performance.

Methodology and Assumptions

7.7.4 The Higher Emission Scenario represents retrofit technology having a detrimental impact on emissions compared to Euro V OEM buses. The values provided below are based on the poorest performing retrofit technology captured in the monitoring campaign.

- For NOx emissions, use the existing pre-retrofit OEM euro standard for all retrofitted buses.
- f-NO_2 should be modelled at 56%.

7.7.5 The sensitivity test has been undertaken for the 2025 DS scenario by adjusting the emission factors for retrofitted buses that are input to EMIGMA as described above. The bus flow and fleet mix inputs for the modelling are unchanged and emissions for all other vehicle types remain the same.

EMIGMA Results

7.7.6 Summary results from the EMIGMA modelling for the test are presented below in **Table 7-16**, which shows modelled NO_2 emission totals disaggregated by vehicle type for roads within the Regional Centre (as shown in **Figure 7-3**) and for the whole of Greater Manchester.

7.7.7 The results for Greater Manchester as a whole show that NO_2 emissions from buses are forecast to increase by approximately 56% relative to the core Investment-led Plan, with an increase in total road traffic emissions (from all vehicle types combined) of approximately 4%.

7.7.8 The emission impacts for the Regional Centre show that NO_2 emissions from buses are forecast to increase by 54% relative to the core Investment-led Plan , with an increase in total road traffic emissions (from all vehicle types combined) of approximately 21%. The impacts of the test in the Regional Centre are significantly greater than those for GM as a whole due to the increased prevalence of bus emissions in the central area. The impacts will vary by location, however, being most significant at sites with high bus flows and services delivered using retrofitted vehicles.

Table 7-16: Higher Retrofit Bus Emission Test NO_2 Emissions with Percentage Changes from the Do-Something Investment-led Plan Totals (2025, Tonnes per Year)

Vehicle Type	ILP DS	Test	% Change
	Regional Centre		
Car	3.2	3.2	0.0%
LGV	2.0	2.0	0.0%
HGV	0.2	0.2	0.0%
Taxi	0.4	0.4	0.0%
Bus	3.8	5.8	53.9%
Total	**9.7**	**11.7**	**21.1%**
	Greater Manchester		
Car	685	685	0.0%
LGV	509	509	0.0%
HGV	38	38	0.0%
Taxi	77	77	0.0%
Bus	104	161	55.6%
Total	**1,412**	**1,470**	**4.1%**
Notes: Percentage changes may differ due to rounding.			

Air Quality Impacts

7.7.9 This test impacts where Euro V retrofit buses are expected to be operating under the Investment-led Plan in 2025. Note, the test wasn't run for the DM scenario.

7.7.10 The impacts occur in areas where Investment-led Plan bus measures had not been required (which remove any retrofit buses), and concentrations are increased by up to 3 ug/m3, predicting new exceedances in locations in Manchester, Stockport, Bolton, Oldham & Wigan.

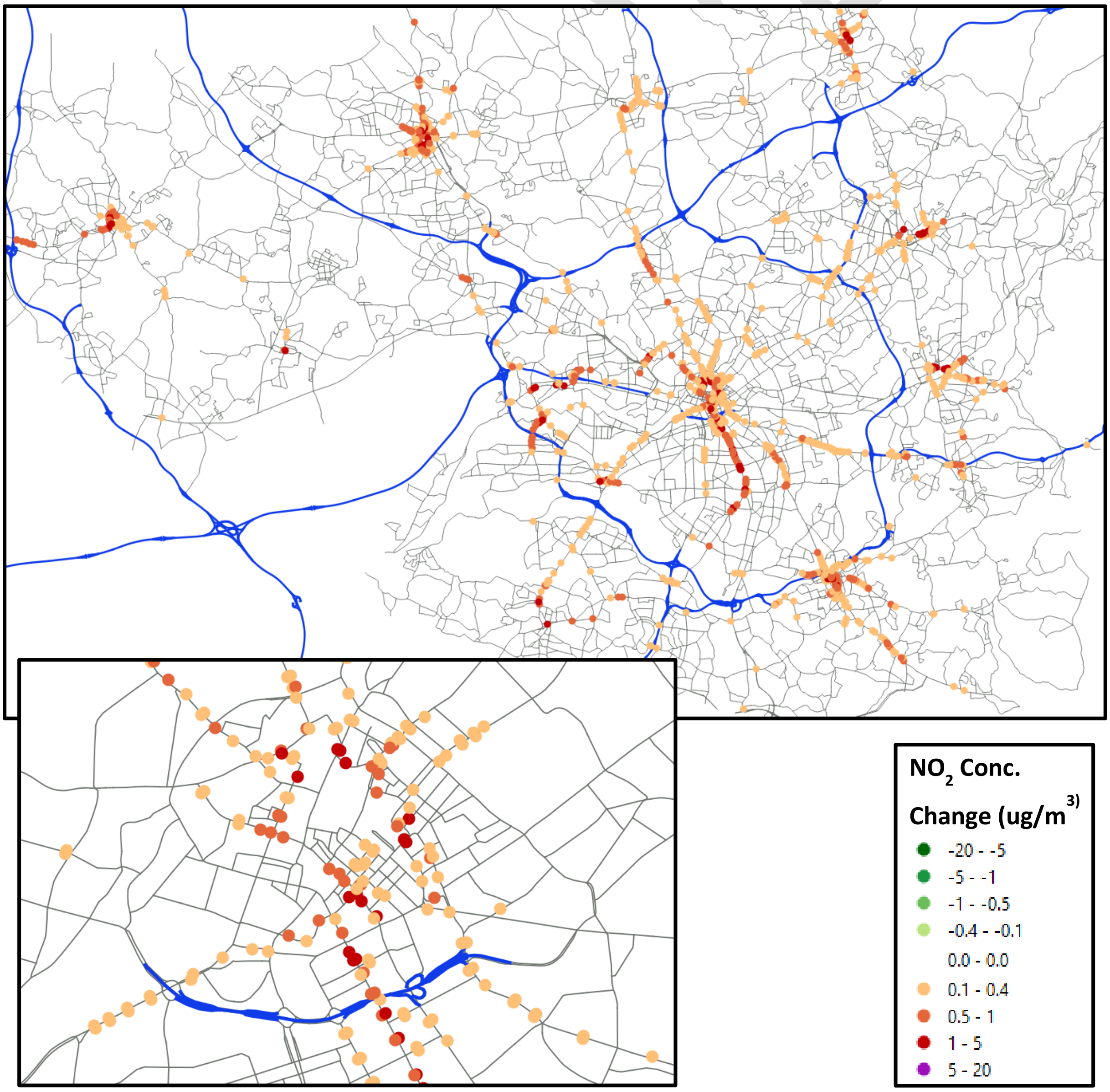
7.7.11 Compliance would be delayed, or GM would need to obtain additional cleaner buses to run on key services.

7.7.12 The results of the modelled impacts are presented in **Table 7-17**.This test has not been applied to the Base Year verification process, but there are not believed to have been any retrofitted buses operating in GM in 2016.

Table 7-17: Air Quality Summary Impacts: Bus Retrofit High Emissions

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.3 → 42.5
Change in no. of exceedances in 2025	DM: na DS: 0 → 6
Forecast Compliance Year	DM: na DS: 2025 → 2027?
Impact	Increased risk

Figure 7-10: Air Quality Summary Impacts: Bus Retrofit High Emissions



7.8 Sensitivity Test 7: Lower Retrofit Bus Emissions

Introduction

7.8.1 As described in Test 6, real-world emissions testing undertaken by JAQU has provided evidence of variable performance of retrofit bus technology.

Methodology and Assumptions

7.8.2 The Lower Emission Scenario represents retrofit technology having a beneficial impact on emissions, but not reducing emissions equivalent to those from Euro VI OEM buses. The values provided below are based on the best performing retrofit technology captured in the monitoring campaign. The values provided below are based on the best performing retrofit technology captured in the monitoring campaign.

- The NO_x emissions for retrofitted buses should be modelled as 0.3 times the Copert Euro V SCR emissions.
- f-NO_2 should be modelled at 20%.

7.8.3 The lower retrofit bus test has been undertaken for the 2025 DS scenario by adjusting the emission factors for retrofitted buses that are input to EMIGMA as described above. The bus flow and fleet mix inputs for the modelling are unchanged and emissions for all other vehicle types remain the same.

EMIGMA Results

7.8.4 Summary results from the EMIGMA modelling for the test are presented below in **Table 7-18**, which shows modelled NO_2 emission totals disaggregated by vehicle type for roads within the Regional Centre (as shown in **Figure 7-3**) and for the whole of Greater Manchester.

7.8.5 The results for Greater Manchester as a whole show that NO_2 emissions from buses are forecast to fall by approximately 80% relative to the Core DS with a reduction in total annual road traffic emissions (from all vehicle types combined) of approximately 6%.

7.8.6 The emission impacts for the Regional Centre show that NO_2 emissions from buses are forecast to fall by 78% relative to the Core DS, with a reduction in total road traffic emissions (from all vehicle types combined) of approximately 31%. As noted above, the impacts of the test in the Regional Centre are significantly greater than those for GM as a whole due to the increased prevalence of bus emissions in the central area. The impacts will vary by location, however, being most significant at sites with high bus flows and services delivered using retrofitted vehicles.

Table 7-18: Lower Retrofit Bus Emission Test NO_2 Emissions with Percentage Changes from the Do-Something Investment-led Plan Totals (2025, Tonnes per Year)

Vehicle Type	ILP DS	Test	% Change
	Regional Centre		
Car	3	3	0.0%
LGV	2	2	0.0%
HGV	0	0	0.0%
Taxi	0	0	0.0%
Bus	4	1	-78.1%
Total	**10**	**7**	**-30.6%**
	Greater Manchester		
Car	685	685	0.0%
LGV	509	509	0.0%
HGV	38	38	0.0%
Taxi	77	77	0.0%
Bus	104	20	-80.6%
Total	**1,412**	**1,328**	**-5.9%**
Notes: Percentage changes may differ due to rounding.			

Air Quality Impacts

7.8.7 This test impacts where Euro V retrofit buses are expected to be operating under the Investment-led Plan in 2025. Note, the test wasn't run for the DM scenario.

7.8.8 The impacts occur in areas where Investment-led Plan bus measures had not been required (which remove any retrofit buses), and concentrations are decreased by up to -10 ug/m3.

7.8.9 The Investment-led Plan improves with reduced concentrations and increased headroom. However, there are no forecast exceedances in 2025 and the compliance year isn't altered. The test has minimal impact on the last points of compliance (A57 Regent Road, A34 Quay Street and Great Bridgewater Street) which have had LTM measures implemented to improved traffic flow conditions.

7.8.10 The spatial distribution of the modelled impacts are very similar to those presented in **Figure 7-1**, but with reductions forecast.

7.8.11 This test has not been applied to the Base Year verification process, but there are not believed to have been any retrofitted buses operating in GM in 2016.

Table 7-19: Air Quality Impacts: Bus Retrofit Low Emissions

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.3 → 40.2
Change in no. of exceedances in 2025	DM: na DS: No change
Forecast Compliance Year	DM: na DS: 2025 → 2025
Impact	Decreased risk

7.9 Sensitivity Test 8: Removal of EV car forecast / Older fleet

Introduction

7.9.1 This test is a pessimistic scenario with a more polluting fleet than the core run. This test reduces the assumptions that electric car penetration into the private car fleet will increase in the future.

Methodology and Assumptions

7.9.2 DfT TAG Databook update 1.19 set future fleet mix projections which increased the proportions of electric cars, but this is not available within EFT. GM then analysed the prevalence of electric cars locally based ANPR data, and developed a methodology agreed with JAQU and described in the December 2023 submission (Technical Note 42 - Modelling the Impacts of the Increased Uptake of Electric Cars (T3 Appendix B). This method increased the proportion of electric cars in future year scenarios for 2025/2026.

7.9.3 This sensitivity test removes the application of this updated method step, leaving a greater proportion of internal combustion engine (specifically petrol) vehicles in the fleet.

7.9.4 The narrative is based on the testing that was undertaken for Technical Note 42, which was limited to the DS scenario only.

Air Quality Impacts

7.9.5 CAP core modelling includes the benefit of increased electric car penetration, with the 2025 forecast increased from 5.4% to 10.8%. The GM methodology assigned the increase to a switch from petrol to electric cars, based on the ANPR evidence, which reduces the magnitude of emissions reduction, because petrol cars typically have lower emissions than diesel.

7.9.6 The DS modelling shows that there is a 6.4% reduction in NO_x emissions at the GM level, but the greatest AQ impacts will be on roads with high car volumes.

7.9.7 The application of the electric car forecast methodology at A57 Regent Road reduced modelled NO_2 concentrations by 0.1 ug/m3, in the December 2023 Investment-led Plan scenario submission. Therefore, excluding this methodology for this sensitivity test would increase concentrations under the Investment-led Plan scenario to 40.5 ug/m3, which would still be marginally in exceedance in 2025.

7.9.8 The A57 Regent Road is one of the busiest roads in GM for car traffic volumes, and therefore impacts on roads elsewhere would be expected to be smaller.

Table 7-20: Air Quality Summary Impacts: Removal of EV car forecast / Older Fleet

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.4 → 40.5
Change in no. of exceedances in 2025	DM: na DS: 0 → 1?
Forecast Compliance Year	DM: na DS: 2025 → 2026
Impact	Increased risk

7.10 Sensitivity Test 9: Comparison of zonal and full model domain verification and canyon effects

Introduction

7.10.1 GM applied a zonal approach to verifying the AQ model, splitting the Regional city centre into a zone with the canyon effects in the model, and a secondary zone for the rest of GM without the canyon.

7.10.2 JAQU/TIRP requested analysis of this approach in response to the OBC AQ3.

Methodology and Assumptions

7.10.3 Apply a whole domain approach, including all monitoring in the verification methodology as one verification set without zoning. This methodology has been applied in the Base Year verification as no extra model runs were required, only calculations that produce the verification adjustment factors.

Air Quality Impacts

7.10.4 The core modelling differentiates GM spatially by applying two zones (excluding roads on the SRN) for:

- the area of IRR where there is a predominance of tall buildings and street canyons; and
- the remainder of GM.

7.10.5 This approach meant that the canyons module could be used inside the IRR, but not used for the wider GM road network modelling which meant model runtimes were manageable. It also tailored the model results to the locations of greatest AQ risk, around the regional centre.

7.10.6 Using one model domain means monitoring sites that are within the IRR where under-prediction was greatest (due in part to street canyons) are included in the whole domain model adjustment factors. This has the effect of depressing modelled concentrations in the IRR and increasing them across wider GM in this sensitivity test. The verification performance stats also show a poorer Root Mean Square Error (RMSE) and more sites outside of ± 25% of monitored concentrations, than the approach selected and approved for the Target Determination process. This analysis is set out in AQ3 Appendix 1, with an excerpt of the verification statistics below:

Table 1: Modelled verification results for roadside locations

Annual mean conc. bands ($\mu g/m^3$)	No adjustm't: Whole Domain	Whole Domain	No adjustm't: Wider GM	Wider GM	No adjustm't: IRR	IRR
No. sites	147	**126**	118	118	8	8
Mod NO_x Rd v Mon NO_x Rd Factor	n/a	**2.069**	n/a	1.98	n/a	1.494
Mod NO_2 Rd v Mon NO_2 Rd Factor	n/a	**0.977**	n/a	1.002	n/a	0.936
RMSE	12.5	**8.4**	10.9	8.3	8.5	7.0
Fractional Bias	0.27	**0.06**	0.26	0.07	0.12	0.02
Correlation Coefficient	0.68	**0.61**	0.55	0.52	0.80	0.78
No. sites within ±25%	78	**100**	64	94	7	7

7.10.7 When applied to the CAP modelling, new DM exceedances are forecast in wider GM, including extra locations in Bury, Oldham and Stockport, but maximum concentrations are reduced. In the Investment-led Plan, there 4 exceedances (two in Manchester, one in Salford and one in Bury), with adjustment factors uplifting locations where Investment-led Plan measures weren't applied.

7.10.8 However, it has been agreed with JAQU that the approach used in the core modelling is the most robust and appropriate methodology.

Table 7-21: Air Quality Summary Impacts: Whole Domain Verification

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 49.1 DS: 40.3 → 41.4
Change in no. of exceedances in 2025	DM: 26 → 23 DS: 0 → 4
Forecast Compliance Year	DM: Not known DS: 2025 → 2026?
Impact	Increased risk, with greater uncertainty

7.11 Sensitivity Test 10: f-NO_2 and verification

Introduction

7.11.1 The fraction of primary NO_2 (f-NO_2) is a significant source of uncertainty in roadside air quality modelling and can only be directly measured by Continuous Monitors (CMs).

7.11.2 Verification of road NO_x based only on measured NO_x from the GM CMs [n = 7] available in 2016 for verification, with NO_2 then verified against all DT and CM measurements [n = 118] in the wider GM zone.

7.11.3 This methodology has been applied in the Base Year verification as no extra model runs were required, only calculations that produce the verification adjustment factors.

Methodology and Assumptions

7.11.4 GM had seven CMs in the wider GM verification zone, but only one CM inside the IRR which is located on the A34 Quay Street which has high bus flows which will subsequently have been affected by the bus retrofit issue which is known to impact the f-NO_2 proportion from buses. Therefore, the test has only been applied to the wider GM zone.

Air Quality Impacts

7.11.5 JAQU Sensitivity Testing guidance states that: "*The fraction of primary NO_2 (f-NO_2) is a significant source of uncertainty in roadside air quality modelling, LAs should acknowledge that this effect is a limitation in the modelling process, although unavoidable given that limited data is available from roadside CMs*".

7.11.6 Overall, the RMSE and number of outliers sites were poorer using this approach, whilst the Fractional Bias and Correlation Coefficient were slightly better. The test was not considered to significantly improve overall model performance in the Base Year, and the subsequent bus retrofit issues have been more effectively addressed using remote sensing data. The verification statistics are set out in **Table 7-22** below.

Table 7-22: Modelled verification results for roadside locations – Continuous Analyser for NOx Rd Adjustment Test

Annual mean concentration bands (μg/m³)	No adjustment: Wider GM Zone	Wider GM Zone (Sens Test)	Wider GM Zone (Core)
No. sites	CM: 7 DT: 111		
Mod NO_x Rd v Mon NO_x Rd Factor	n/a	**2.200**	1.980
Mod Total NO_2 v Mon Total NO_2 Factor	n/a	**0.984**	1.002
RMSE	10.9	**8.4**	8.3
Fractional Bias	0.26	**0.04**	0.07
Correlation Coefficient	0.55	**0.51**	0.52
No. sites within ±25%	64	**92**	94

7.11.7 The impacts in the DM increase concentrations and number of exceedances outside the IRR (which is where the test is applied), but the maximum concentration is still inside the IRR so unaffected. For the Investment-led Plan scenario there are 10 exceedances (in seven districts, excluding Manchester, Trafford & Tameside), with adjustment factors uplifting locations where Investment-led Plan measures weren't applied.

7.11.8 It should be noted that bus emissions form a significant proportion of emissions, and the government funded retrofit programme has left GM with a large number of retrofit vehicles. Separate JAQU monitoring has directly measured f-NO_2 from buses and confirmed that the value for OEM vehicles are in-line with modelled values, whereas retrofit vehicles are subject to high variability, but this has also been accounted for in the 2025 forecast modelling process.

Table 7-23: Air Quality Summary Impacts: Whole Domain Verification

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 49.5 DS: 40.3 → 42.2
Change in no. of exceedances in 2025	DM: 26 → 41 DS: 0 → 10
Forecast Compliance Year	DM: No change? DS: 2025 → 2027?
Impact	Increased risk, but increased uncertainty & limitations more relevant

7.12 Sensitivity Test 11: Meteorology

Introduction

7.12.1 Meteorology can have a significant impact on NO_2 concentrations. The CAP modelling has used a consistent meteorological dataset (2016 base year), for all Base and Forecast years as is standard for roads and DMRB appraisals. Testing of meteorological data from the same station for the GM Wide-CAZ FBC scenarios was undertaken (but not submitted because the project was paused at this stage) using 2015, 2017 and 2018 datasets.

Methodology and Assumptions

7.12.2 This test has not been modelled, and the narrative is based on the meteorological data year tests for the 2023 DS scenario (previous GM CAP i.e. GM-wide CAZ C), which were only applied to the forecast year assumptions and not the Base year.

Air Quality Impacts

7.12.3 It is a well-established fact that inter-annual variability in meteorology can have a significant impact on NO_2 concentrations (though potentially less significant at the roadside where variations in vehicle emissions is likely to be the key driver of inter-annual differences in NO_2 concentration). Part of the model verification process is accounting for the simplification of meteorological data (which includes uncertainty in the measurements themselves and relevance to dispersion modelling site) for a dispersion model, along with any systematic effects that all model input parameters create in the final outputs. The predicted model response in NO_2 is a function of all of these issues, and the inter-year variability is in part due to model uncertainty itself and not simply how meteorological conditions themselves vary according to purely the meteorological data inputs.

7.12.4 The meteorological data year tests were only applied to the forecast year assumptions, for the 2023 DS scenario of the GM-wide CAZ. These showed that a 2015 meteorological year reduced concentrations, whilst a 2017 and 2018 met year increased concentrations, by similar ranges to those set out in the examples in the JAQU Sensitivity Testing guidance.

7.12.5 These tests show that the GM CAP is sensitive to assumptions about meteorological conditions. It is clear that more or less favourable conditions could affect the number of exceedances in any given year or the year of compliance. This cannot be meaningfully mitigated but monitoring will ensure that the real-world impact of meteorological conditions on the GM CAP can be assessed. JAQU have developed statistical analysis tools within their monitoring and evaluation team to enable analysis of the meteorological impacts on measured concentrations, which will be used to ascertain the success of clean air plans.

7.13 Sensitivity Test 12: Low ZEC taxi uptake

Introduction

7.13.1 It has been assumed that a small proportion of taxis (around 3%) will upgrade to a ZEC vehicle, with the remainder staying as their current fuel. This test assumes that all upgrading taxis stay with their current fuel (0% increased ZEC taxis)

Methodology and Assumptions

7.13.2 This test has not been modelled, and the narrative is based on testing carried out for an earlier phase of the GM CAP (i.e. GM-wide CAZ C) analysis.

Air Quality Impacts

7.13.3 The previous sensitivity testing indicated a +0.1 ug/m3 increase in maximum concentrations for a 2023 fleet, which is likely to over-estimate the impacts for the 2025 scenarios.

7.13.4 Overall, the GM CAP is not overly sensitive to lower rates of ZEC upgrade because the modelled ZEC upgrade component at 3% is a small proportion as a starting position, and this impact is only affecting a very small subset of the taxi fleet.

7.13.5 It seems more likely that ZEC upgrades will exceed the core forecasts than be below them; survey data from elsewhere suggests that 16% of taxi drivers may upgrade to ZEC and GM's funding offer for ZEC matches the London scheme, which has seen strong uptake.

Table 7-24: Air Quality Summary Impacts: Low ZEC Taxi Uptake

Metric	Impact
Change in max concentration in 2025	DM: na DS: 40.4 → 40.5?
Change in no. of exceedances in 2025	DM: na DS: 0 → 1?
Forecast Compliance Year	DM: na DS: 2025 → 2026?
Impact	Increased risk

7.14 Sensitivity Test 13: ZEB delivery programme risks

Introduction

7.14.1 The delivery of Zero Emission Buses (ZEBs) is a complex process, requiring both the provision of electric buses, together with the associated electrification of the relevant depots.

7.14.2 The Investment-led Plan bus measure includes the delivery of ZEBs, plus the electrification of several depots, both as part of the CAP but also the wider DM, in order to address those exceedance sites which can be addressed with a bus-based solution.

7.14.3 Should there be delays to either the delivery of ZEBs or electrification of depots this could impact on the timescales for achieving air quality compliance.

7.14.4 Where risks are identified the consequential redeployment of buses across GM in the context of the remaining exceedance sites is considered a key first step to addressing any materialised risk in ZEB delivery for GM CAP.

Methodology and Assumptions

7.14.5 This test now considers the impact of a 1-year delay to delivery of the Queens Road depot electrification programme, from January 2025 to January 2026. This is the depot where the CAP funds are deployed to install ZEB charging infrastructure, and has the greatest number of services passing areas of poor air quality.

7.14.6 Replacement of ZEBs operated from the Queens Road depot with retrofitted Euro V vehicles in 2025.

Air Quality Impacts

7.14.7 The Queens Road depot electrification is an important measure to delivering compliance at a number of sites of exceedance. This would pose a significant challenge to achieving compliance in 2025, as 73 ZEBs are to be operated out of the Queens Road depot. The issue would affect 12 services, which run through 17 forecast DM exceedance sites in 2025.

7.14.8 Assuming that the Queens Road depot is operational and electrified in early 2026, then the Investment-led Plan would deliver compliance in that year which would still meet the requirements of the Direction, which is to be compliant by 2026 at the latest.

Table 7-25: Air Quality Summary Impacts: ZEB Delivery Programme Risks

Metric	Impact
Change in max concentration in 2025	DM: No change DS: Not known
Change in no. of exceedances in 2025	DM: No change DS: Not known
Forecast Compliance Year	DM: No change DS: 2025→2026
Impact	Material risk of delay to modelled compliance

7.15 Sensitivity Test 14: Extra 40% non-GM licensed PHV taxis

Introduction

7.15.1 This test involves increasing the taxi proportion of demand based on evidence that non-GM licensed private hire vehicles (PHVs) operating in GM represent an additional 40% of PHVs beyond the GM-licensed vehicles.

7.15.2 The purpose of this test is to assess the impact of an increase in non-GM licensed PHVs operating in GM and its potential impacts on GM CAP.

Methodology and Assumptions

7.15.3 A review of out-of-area licenses was undertaken, which considered the numbers of PHVs licensed to authorities outside of GM, though with a registered address in GM.

7.15.4 Data was collated in 2019 and 2023 which identified an increase in taxi licensed to a non-GM authority, though with a registered address in GM. The data showed this to be an additional 40% of PHVs operating in GM in 2023.

7.15.5 Taxi trips are represented as 7% of the private car demand in the GM modelling method, based on ANPR evidence. Therefore, a 40% increase in taxi movements would switch approximately 3% of the private car demand over to taxi giving a 10% mode share.

7.15.6 This test has not been modelled and the narrative is based on evidence determined from other similar test evidence, notably Test 3: High City Centre Proportions of Taxi Demand and Test 17: Regional Centre Traffic Demand Test.

Air Quality Impacts

7.15.7 Approximately 20% (2,342 vehicles in the GM fleet at end of 2023) of PHVs remain non-compliant. For these vehicles there could be a risk that a proportion of these may switch to licensing with other out-of-area authorities such as Wolverhampton, instead of upgrading to a compliant vehicle and remaining with a GM authority.

7.15.8 In 2025, private cars are forecast to be 46% diesel vehicles, whereas 93% of PHVs would be diesel (including hybrids that are assumed to be diesel in the modelling as a pessimistic assumption).

7.15.9 Therefore, the general impact of the test will be to increase the proportion of total modelled car movements from petrol to diesel. The result will be an increase in the forecast emissions, because compliant diesel vehicles typically emit between 3 to 10 times the amount of NO_x as petrol equivalents.

7.15.10 The location of greatest air quality risk is in the regional centre. The impact of this test 40% PHV growth test, increasing overall taxi demand from 7% to 10%, is lower than that for Test 3 (High City Centre Proportions of Taxi Demand) which applied a 25% proportion. The indicative breakpoint analysis for Test 3 indicated that a 10% proportion of taxi could lead to a risk of delay to compliance at one site (King Street), but also noted that the modelling approach was not applied to the Base Year verification and applied pessimistic assumptions and should be treated with additional caution.

7.15.11 Analysis produced for Test 17 (Regional Centre Traffic Demand) showed car trip demand for the regional centre and wider GM had not increased in line with national forecasts, therefore whilst there may be more PHVs in operation as a result of out-of-area licensing, this has not created additional trip demand.

7.15.12 Therefore, whilst there is a risk of an increase to modelled emissions from increasing the proportion of car movements to PHV, this is not likely to lead to a material change in concentrations, except potentially at King Street.

7.15.13 However, uncertainty associated with taxi flows means that delivery of the CAP taxi measure would reduce risks of delayed compliance, which cannot be readily modelled due to the complex nature of representing the diversity of taxi operation within the modelling process. It would also provide greater CAP resilience for roads without bus measures.

Table 7-26: Air Quality Summary Impacts: Extra 40% non-GM licensed PHV taxis

Metric	Impact
Change in max concentration in 2025	DM: Not known DS: Not known
Change in no. of exceedances in 2025	DM: No known DS: Not known
Forecast Compliance Year	DM: No known DS: Not known
Impact	Increased risk

7.16 Sensitivity Test 15: ANPR Projection Methodology

Introduction

7.16.1 At project inception, GM had to develop a 'roll-over' method to forecast fleet age based on the local ANPR data from 2016, to the appraisal years. This has subsequently had adjustment applied to reflect known impacts of reduced vehicle sales as a result of Covid and the associated impacts on vehicle supply and valuations.

7.16.2 The rate of reduction in emissions year-on-year as a result of the natural fleet turnover predicted by EFT projections or the GM tools highlight that the CAP is sensitive to the fleet mix assumptions. The GM CAP is still based on the 2016 dataset, so the projection covers a relatively long time period.

7.16.3 ANPR from 2020-2022 was considered to be unrepresentative due to the influence of Covid on traffic and economic behaviours. DfT TAG now confirms that 2023 can be used as a base year from transport appraisal.

7.16.4 ANPR data for 2023 has been processed using the approved GM roll-over projection methodology to the 2025 forecast year, and the emissions calculated by vehicle type using the EMIGMA tools based on EFT v9.1a. These have then been modelled to compare against the emissions used in the CAP appraisal.

Methodology and Assumptions

7.16.5 ANPR data from 2023 covers a range of different camera locations to that available in 2016 (which were operated by GMP).

7.16.6 The test was undertaken by re-running the 2025 Core modelling using updated demand matrices and road traffic emission factors based on revised fleet mix projections from the 2023 ANPR data. The test was implemented as follows:

- Calculate an updated fleet mix forecast by applying the EFT fleet age projection to the 2023 ANPR data;
- Update the petrol\diesel splits for cars and taxis based on the new projection;
- Re-build the demand matrices for 2025 and update the generalised cost parameters (PPM and PPK values) used during the assignments based on the new fleet mix;
- Re-run the assignments;
- Re-calculate the road traffic emission factors that are input to ENIGMA based on the new fleet mix;
- Re-run the ENIGMA and dispersion modelling; and
- Process the outputs from the dispersion model to calculate updated air quality concentrations.

EMIGMA Results

7.16.7 Details of the projected 2025 fleet composition from the 2016 and the 2023 ANPR data are shown below in **Table 7-27.** The forecast proportions of compliant petrol cars and taxis are very similar, with 99% of petrol cars forecast to be compliant in 2025 using the 2016 ANPR data and 99.3% of petrol cars forecast to be compliant in the projection derived from the 2023 ANPR data. 99% of petrol taxis are forecast to be compliant in both forecasts.

7.16.8 The forecast proportions of compliant diesel cars are slightly lower in the updated projection from the 2023 ANPR data, with an overall compliance rate of approximately 72% for the new forecast compared to a figure of approximately 79% in the projection from the 2016 ANPR data. The forecast proportions of compliant diesel LGVs are slightly higher, however, with an overall compliance rate of approximately 81% for the new forecast compared to a figure of 78.5% in the projection from the 2016 ANPR data. The forecast proportion of compliant HGVs is also slightly greater in the updated projection, with an overall compliance rate of approximately 97% for the new forecast compared to a figure of 91% in the projection from the 2016 ANPR data.

Table 7-27: 2025 Fleet Composition by Euro Standard from 2016/2023 ANPR data

Euro Standard	Projection from 2016 ANPR Data						
	Petrol Car	Diesel Car	Petrol Taxi	Diesel Taxi	Petrol LGV	Diesel LGV	Diesel HGV
Euro VI/6d	0.0%	46.9%	0.0%	31.9%	0.0%	49.4%	0.0%
Euro VI/6c	46.8%	20.1%	65.1%	37.2%	0.0%	18.1%	0.0%
Euro VI/6a	13.4%	11.9%	16.9%	15.6%	0.0%	10.9%	91.2%
Euro V/5	31.0%	17.5%	15.0%	14.4%	0.0%	19.6%	7.1%
Euro IV/4	7.8%	2.8%	3.0%	0.8%	0.0%	1.7%	1.2%
Euro III/3	0.8%	0.7%	0.1%	0.1%	0.0%	0.3%	0.4%
Euro II/2	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Euro I/1	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pre-Euro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All	100%	100%	100%	100%	0%	100%	100%
% Compliant	**99.0%**	**78.9%**	**99.9%**	**84.7%**	**N/A**	**78.5%**	**91.2%**

Euro Standard	Projection from 2023 ANPR Data						
	Petrol Car	Diesel Car	Petrol Taxi	Diesel Taxi	Petrol LGV	Diesel LGV	Diesel HGV
Euro VI/6d	42.6%	22.0%	0.0%	30.5%	0.0%	45.8%	0.0%
Euro VI/6c	19.6%	31.8%	61.9%	33.4%	0.0%	24.5%	0.0%
Euro VI/6a	9.9%	18.5%	12.1%	15.9%	0.0%	11.1%	97.4%
Euro V/5	18.4%	22.4%	18.3%	18.8%	0.0%	12.5%	2.4%
Euro IV/4	8.9%	5.1%	7.6%	1.4%	0.0%	5.5%	0.2%
Euro III/3	0.7%	0.2%	0.1%	0.0%	0.0%	0.6%	0.0%
Euro II/2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Euro I/1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pre-Euro	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All	100%	100%	100%	100%	0%	100%	100%
% Compliant	**99.3%**	**72.3%**	**99.9%**	**79.8%**	**N/A**	**81.4%**	**97.4%**

7.16.9 The projected 2025 petrol\diesel car\taxi splits from the 2016 and the 2023 ANPR data are shown below in **Table 7-28**. The updated forecasts produce a small increase in the proportion of petrol cars and a small reduction in the proportion of petrol taxis.

Table 7-28: 2025 Percentage Petrol/Diesel Cars/Taxi from 2016/2023 ANPR Data

Source	Cars		Taxis	
	Petrol	Diesel	Petrol	Diesel
2016 ANPR Forecast	57.7%	42.3%	8.2%	91.8%
2023 ANPR Forecast	59.6%	40.4%	4.6%	95.4%

7.16.10 The EMIGMA results for the test are presented below in **Table 7-29**, which shows calculated 2025 NO_x Emission Totals for the test and percentage changes relative to Core forecasts for the DM and DS scenarios. Results are presented separately for Greater Manchester as-a-whole and roads within the Regional Centre (as illustrated in **Figure 7-3**)

Table 7-29: Fleet Projection Sensitivity Test 2025 NOx Emission Totals (Tonnes by Year, Percentage changes Relative to Core Do-Minimum)

Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Regional Centre						
Car	11.6	12.9	10.5%	11.7	12.9	10.7%
LGV	6.5	6.2	-4.6%	6.5	6.2	-4.2%
HGV	2.5	1.9	-23.9%	2.4	1.8	-23.1%
Taxi	1.7	1.8	7.0%	1.5	1.6	3.9%
Bus	21.3	21.2	-0.2%	13.5	13.5	0.0%
Total	**43.6**	**44.0**	**1.0%**	**35.6**	**36.0**	**1.4%**
Greater Manchester						
Car	2,468	2,662	7.9%	2,468	2,662	7.9%
LGV	1,601	1,535	-4.1%	1,601	1,535	-4.1%
HGV	529	337	-36.2%	529	338	-36.1%
Taxi	294	314	7.0%	259	269	3.6%
Bus	381	381	0.0%	316	316	0.0%
Total	**5273**	**5230**	**-0.8%**	**5173**	**5120**	**-1.0%**
Notes: Percentage changes may differ due to rounding.						

7.16.11 The results for Greater Manchester as-a-whole show that NO_x emissions from cars are forecast to increase by approximately 8% relative to the Core scenario, with an increase in emissions from taxis (including private hire vehicles) of approximately 4%. NO_x emissions from HGVs for the test are forecast to fall by approximately 36%, with a reduction in total road traffic emissions (from all vehicles combined) of approximately 1%. The influence is greater for HGVs because the emissions reduction between Euro standards is greater than for cars/LGVs.

7.16.12 The emission impacts for the Regional Centre are similar to those for Greater Manchester, although the percentage increase in NO_x emissions from cars is slightly greater at 11%, with an approximate 23% reduction in emissions from HGVs. Total road traffic emissions (from all vehicles combined) are forecast to increase by approximately 1%.

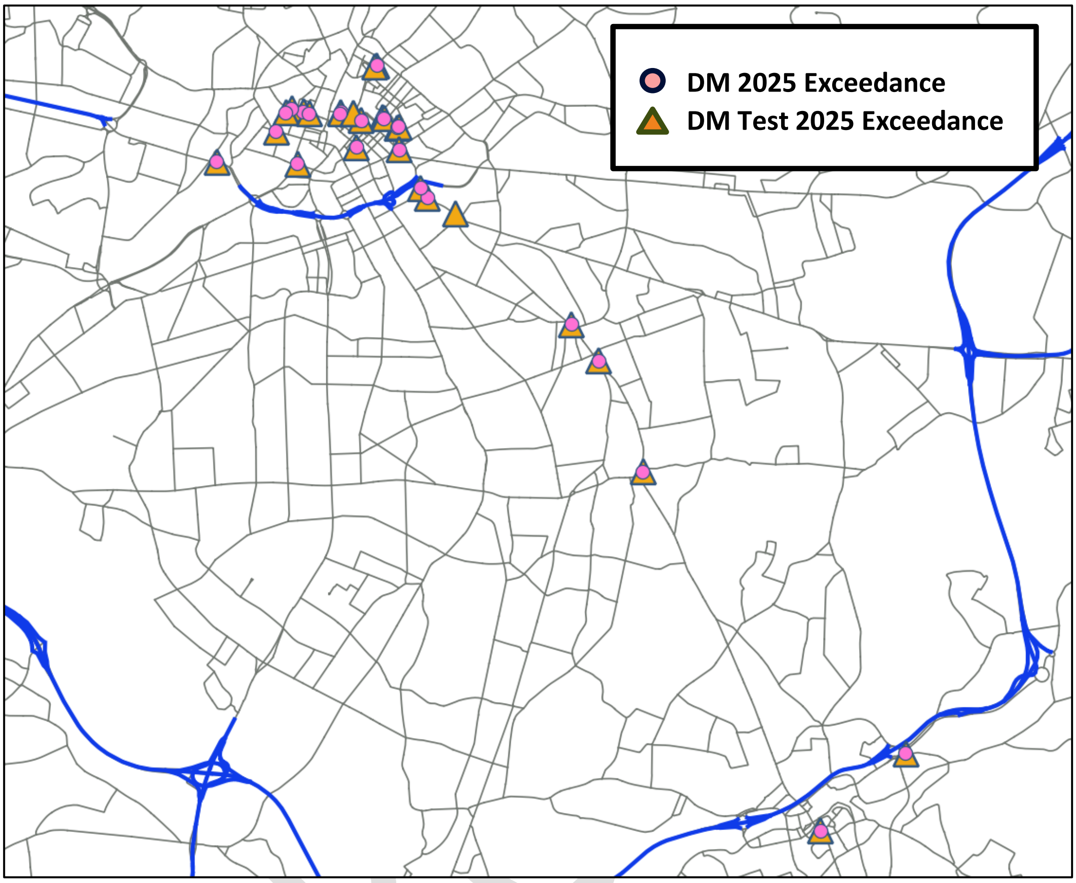
7.16.13 In summary, the difference between the core fleet projection methodology based on 2016 data (which has been adjusted to account for impacts from Covid on vehicle sales and the increased penetration of electric cars), and a post-Covid 2023 ANPR dataset rolled to 2025 is less than 1% in the DM. By comparison, the annual rate of NO_x emission decrease is ~9%, so the discrepancy is comparable with approximately 1 month of natural fleet change. Whilst there is variability in the scale of impacts this creates at roads with differing car vs freight usage, this is considered a close agreement.

7.16.14 It also needs to be borne in mind that the fleet projection methodology is not applied to buses within the modelling, as information about the bus fleet mix is provided by TfGM's bus team based on the rollout of bus franchising. Furthermore, for most of the exceedance sites, bus emissions comprise a significant proportion of total road traffic NO_x emissions, typically between 25%-90% in the DM scenario. The impacts of the fleet projection are therefore likely to be less significant at these sites.

Air Quality Impacts

7.16.15 In the DM, there is a reduction in emissions at the maximum location which has a higher proportion of freight (A6 Whitworth St, -0.9 ug/m3), but an increase in the number of exceedances where car traffic is the dominant source. Generally, there are increases in modelled concentrations, at worst case locations of 0.5ug/m3, leading to 4 new DM exceedances in Manchester x2, and in Bolton and Bury. **Figure 7-11** shows the change in DM exceedances forecast by the test in Manchester (but the Bolton and Bury sites aren't shown).

Figure 7-11: Change in Do-Minimum Exceedances with the ANPR Fleet Age Projection Test 2025



7.16.16 In the Investment-led Plan, the maximum location becomes the A58 Bolton Street, Bury which has high car flows, and there are two forecast exceedances in 2025.

Table 7-30: Air Quality Summary Impacts: Whole Domain Verification

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 48.6 DS: 40.3 → 40.6
Change in no. of exceedances in 2025	DM: 26 → 32 DS: 0 → 2
Forecast Compliance Year	DM: No change? DS: 2025 → 2026
Impact	**Increased risk**

7.17 Sensitivity Test 16: Impact of EFTv12 / Future emission standards

Introduction

7.17.1 This test investigates the impacts of the version of the EFT used in the CAP (v9.1a), which has been locked in agreement with JAQU to avoid undermining the Target Determination process and associated base year verification, versus the most recent released version of EFT (v12.1).

7.17.2 The GM CAP has used EFT 9.1a, which is based on Copert 5 speed-based emission functions (EEA, Sept 2016). This is the last EFT version to have an input option for 2016. The most recent version of EFT (v12.1) was released in November 2023 and is based on Copert 5.6 emission functions (EEA, Sept 2022). There have also been a wide range of updates to the EFT, which affect both the emissions functions derived from Copert, and some of the underpinning fleet mix assumptions.

Methodology and Assumptions

7.17.3 This test appraises the changes to the Copert emissions functions (and any inherent weighting by vehicle engine size distribution), with vehicle/fuel bespoke fleet mixes set at the GM specific projections by Euro standard.

7.17.4 Updates to the EFT that might affect the outputs from the tool are documented in the current version of the User Guide. Key updates to the software between versions 9 and 12 that may have implications for the CAP modelling include:

- Updated speed-based emission functions for NO_x, which are derived using COPERT v5.6 equations in EFTv12, updated from COPERT 5.0 coefficients in version 9.1;
- Updated f-NO2 values based on more recent Primary NO_2 factors from the National Air Emissions Inventory (NAEI, 2020);
- Changes to the Road Traffic Input format, which has been modified to allow users to explicitly define the proportion of Electric Cars within fleet forecasts, as described below.

7.17.5 The emission factors that were developed for the Core modelling of the CAP assumed an increased uptake of electric cars based on revised forecasts of the vehicle fleet mix published in version 1.21 of the TAG Data Book (May 2023), which were not available when version 9.1a of the EFT was released. A simple method for representing the impacts of the new electric car forecasts in the modelling was therefore adopted, which was implemented by reducing the emission factors for petrol cars in line with the forecast increase in electric car mileage between versions 1.18 and 1.19 of the TAG Data Book.

7.17.6 The method for modelling the increased uptake of electric cars in the EFT sensitivity test has been revised to make use of the new functionality in version 12 of the software, which allows users to explicitly define the proportion of Electric Cars in the forecast fleet within the input traffic data for each run, as noted above. This simplifies the procedure for representing the uptake of electric cars in the modelling and was applied by inputting the proportion of electric car mileage from the TAG v1.21 forecast into the EFT traffic data for petrol cars, suitably adjusted so that the total forecast of electric car mileage was included in the petrol car emission factors. (This is a simplifying assumption, as some travel in electric cars will be undertaken in diesel hybrids. It is considered to be reasonable, however, as travel in diesel hybrid cars represents only about 12% of hybrid car travel in the EFT fleet forecasts for 2025 and will therefore provide a conservative estimate of the benefits of electric cars in reducing traffic emissions).

7.17.7 Elsewhere, the same fleet mix assumptions have been applied as far-as possible, although some adjustments were required as a result of changes to the Euro 6 classifications for cars in the EFT v12 and the introduction of the Euro 6a/b/c, Euro 6d and the Euro 6d-temp sub-categories, which were not represented in version 9.1 of the software.

7.17.8 The key changes to the EFT v12 emission factors for compliant vehicles in the Test (travelling at a speed of 40kph) are as follows:

- Reductions in the NO_x factors for compliant diesel cars of around 20%
- Reductions in Primary NO_2 factors for compliant diesel cars of around 35%
- Reductions in the NO_x factors for compliant diesel LGVs of around 33%
- Reductions in the Primary NO_2 factors for compliant diesel LGVs of around 46%
- Increases in the Primary NO_2 factors for compliant Rigid and Articulated HGVs of around 200%
- Reductions in Primary NO_2 factors for compliant diesel Taxis\PHVs of around 20%

7.17.9 The key changes to the emission factors for non-compliant vehicles were as follows:

- Increases in the NOx factors for non-compliant petrol cars of around 20% with a reduction in Primary NO_2 factors of around 66%
- Reductions in Primary NO_2 factors for non-compliant diesel cars of around 50%
- Reductions in Primary NO_2 factors for non-compliant diesel LGVs of around 68%
- Reductions in the Primary NO_2 factors for non-compliant Rigid and Articulated HGVs of around 46%

- Reductions in the Primary NO_2 factors for non-compliant petrol and diesel Taxis/PHVs of around 50%

7.17.10 The changes to the emission factors for buses were modest, with emission rates typically changing by less than 1% between the EFT9.1a and EFT12.1 runs. The bus emission factors for the test include the impacts of JAQU's bus retrofit guidance (published in 2023) which advised that NO_x emissions from retrofitted buses should be calculated using the emission factors for pre-retrofitted vehicles, with f-NO2 emissions increased to 35.8%, as was the case for the Core scenarios.

EMIGMA Results

7.17.11 Separate model runs have been undertaken for the DM and DS scenarios for 2025. The tests were implemented as follows:

- Re-calculate the road traffic emission factors that are input to EMIGMA using version 12 of the EFT and the Core modelling fleet mix;
- Re-run the EMIGMA and dispersion modelling; and
- Process the outputs from the dispersion model to calculate updated air quality concentrations

7.17.12 No other changes were made for the EMIGMA runs and all other inputs were held constant, including the road traffic flows and speeds from the Core model runs, the forecast petrol\diesel splits and the bus flows, services and fleet compositions.

7.17.13 Summary results from the EMIGMA modelling for the test are presented below in **Table 7-31**, broken down by vehicle type and for all vehicles combined. Results are presented separately for the DM and DS tests, for the Regional Centre and for Greater Manchester as-a-whole.

7.17.14 The results for the Regional Centre show that NO_x emissions from cars and LGVs have fallen by approximately 12 and 18 percentage points respectively relative to the Core scenarios. Emissions from HGVs have reduced by approximately 5%, with reductions in total NO_x emissions from all vehicles combined of approximately 6% for the DM test and 8%for the DS test.

7.17.15 The results for Greater Manchester as a whole show that NO_x emissions from cars have fallen by approximately 6% relative to the Core scenarios, with reductions in mass emissions from LGVs reducing by around 18%. Total NO_x emissions from all vehicles combined have been reduced by approximately 7% for both the DM and DS tests.

Table 7-31: EFTv12 Emission Factor Test Forecast Road Traffic NOx Emissions with Percentage Changes from the Core Model Run (2025, Tonnes per Year)

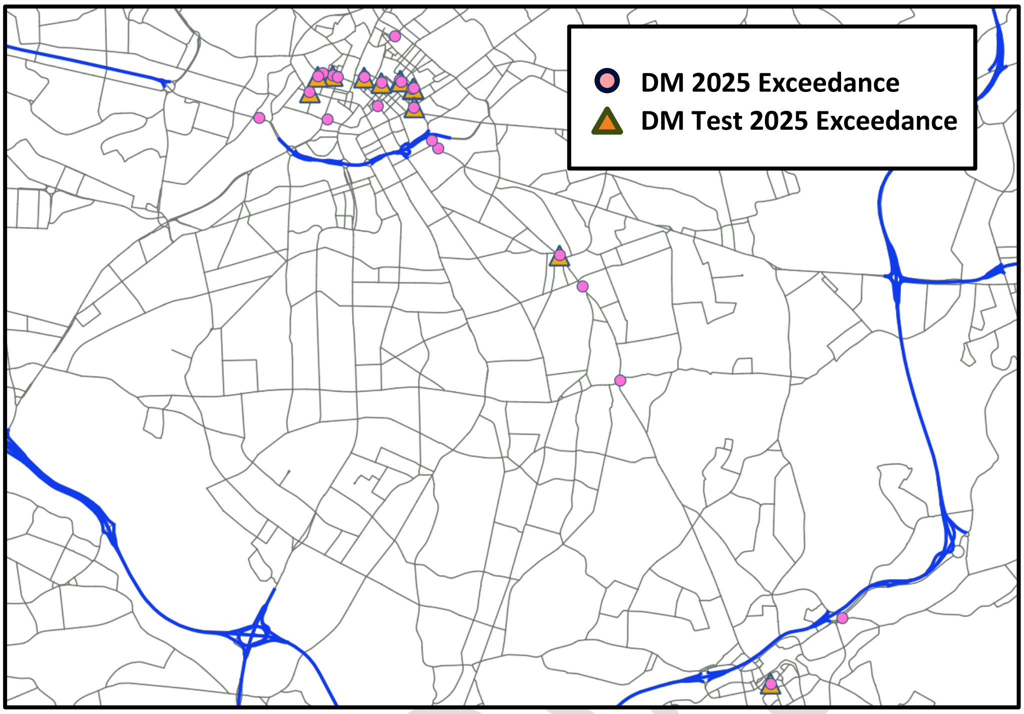
Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Regional Centre						
Car	11.6	10.2	-12.1%	11.7	10.3	-12.1%
LGV	6.5	5.3	-17.8%	6.5	5.3	-17.8%
HGV	2.5	2.3	-4.7%	2.4	2.3	-4.9%
Taxi	1.7	1.7	-1.0%	1.5	1.5	-2.0%
Bus	21.3	21.2	-0.4%	13.5	13.4	-0.3%
Total	**43.6**	**40.8**	**-6.4%**	**35.6**	**32.8**	**-7.8%**
Greater Manchester						
Car	2,468	2,321	-6.0%	2,468	2,320	-6.0%
LGV	1,601	1,309	-18.2%	1,601	1,309	-18.2%
HGV	529	603	14.1%	529	604	14.1%
Taxi	294	291	-0.9%	259	254	-1.9%
Bus	381	380	-0.4%	316	315	-0.4%
Total	**5273**	**4904**	**-7.0%**	**5173**	**4803**	**-7.2%**
Notes: Percentage changes may differ due to rounding.						

<u>Air Quality Impacts</u>

7.17.16 The application of EFT12 emission factors reduces forecast year concentrations at all locations.

7.17.17 The DM improves with reduced concentrations and exceedances, and the first year of natural compliance may be brought forward from 2030, but this is primarily driven by retrofit buses operating from the Stockport depot. There are 14 exceedances removed including A57 Regent Road, Great Bridgewater Street, Shudehill, A6 corridor and A58 Bury as shown in **Figure 7-12.**

Figure 7-12: Change in Do-Minimum 2025 Exceedances with the EFTv12 Emissions Factors



7.17.18 The Investment-led Plan also improves with reduced concentrations and increased headroom at key locations such as A57 Regent Road and inside the IRR where concentrations reduce by up to -4 ug/m3. However, there are no forecast exceedances in 2025 and the compliance year is not altered.

7.17.19 There are a range of changes between the emissions factors from EFT v9.1a vs v12.1, but the overall effect is a reduction in emissions for all vehicle types, at the aggregate for compliant and non-compliant fleet. Bus emissions are essentially unaffected between EFT versions, but the retrofit vehicle emissions issue is not represented directly in the EFT and these are uplifted separately by the JAQU guidance.

Table 7-32: Air Quality Summary Impacts: EFTv12 Emission Factors

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 47.9 DS: 40.3 → 38.8
Change in no. of exceedances in 2025	DM: 26 → 12 DS: No change
Forecast Compliance Year	DM: 2030 → 2028? DS: No change
Impact	**Reduced risk**

7.18 Sensitivity Test 17: Regional Centre traffic demand trends / NTEM v8.0

Introduction

7.18.1 The purpose of this test is to consider uncertainty in the age of the model, in particular in relation to the growth assumptions for trips to and from the Regional Centre.

7.18.2 The test was implemented by comparing Regional Centre model traffic growth assumptions (DM 2016 to 2025) to the most recent available observed count data and applying demand adjustments in the modelling to reflect this position.

Methodology and Assumptions

7.18.3 A review of the historical data dating back to 2002 in the context of access to/from the Regional Centre indicated that the number of car trips accessing the Regional Centre has decreased significantly between 2002 and 2019.

7.18.4 A comparison of 2024 Automatic Traffic Counters (ATC) observed data for a cordon in the vicinity of the Regional Centre was compared to the modelled flows (DM 2025 – minus 1 year of growth) as shown in **Table 7-33** for the same locations.

7.18.5 This shows the model to be over-forecasting demand in the 2025 DM model, in particular in the AM Peak (likely to be due to changing travel patterns, Regional Centre measures, and impacts of post COVID-19 increase in homeworking among office workers).

7.18.6 The model demand was updated for trips with an origin / destination inside the cordon, or through trips passing through the cordon.

Table 7-33: Observed vs Modelled - 2024

Observed vs Modelled - 2024									
Total Vehicles	AM Peak			IP			PM Peak		
	Observed	Modelled	Diff	Observed	Modelled	Diff	Observed	Modelled	Diff
Inbound	12,659	17,486	4,827 (38%)	9,314	10,748	1,433 (15%)	9,575	11,414	1,839 (19%)
Outbound	8,518	11,310	2,792 (33%)	9,570	10,578	1,008 (11%)	12,459	13,917	1458 (12%)

Traffic Impacts

7.18.7 The traffic flows reduced across the Regional Centre and along key radial routes with most significant impacts shown in the AM Peak.

7.18.8 Flow reductions of up to 300pcus identified on some links in the AM Peak and similar changes in demand also identified when applied to Investment Led Plan model. **Figure 7-13, Figure 7-14** and **Figure 7-15** show the actual flow difference plots between DM Adjusted Demand vs DM model.

Figure 7-13: Do-Minimum Adjusted Demand vs Do-Minimum Model Actual Flow Difference - AM

Figure 7-14: Do-Minimum Adjusted Demand vs Do-Minimum Model Actual Flow Difference - IP

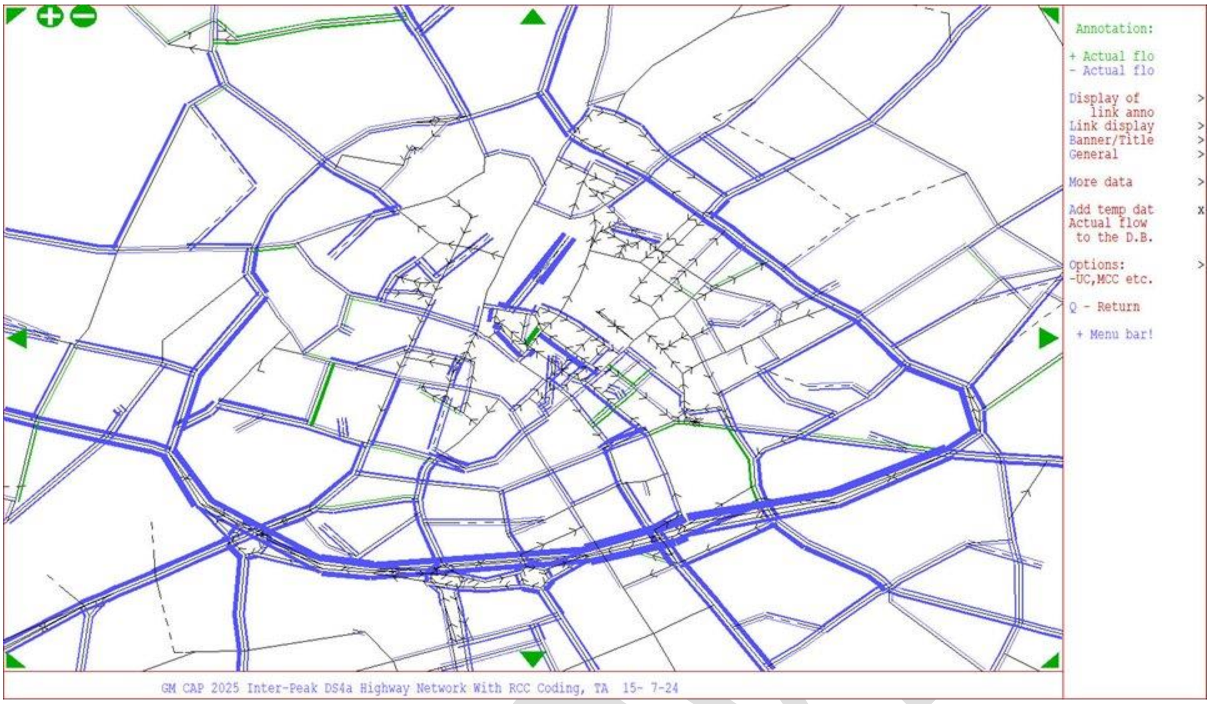
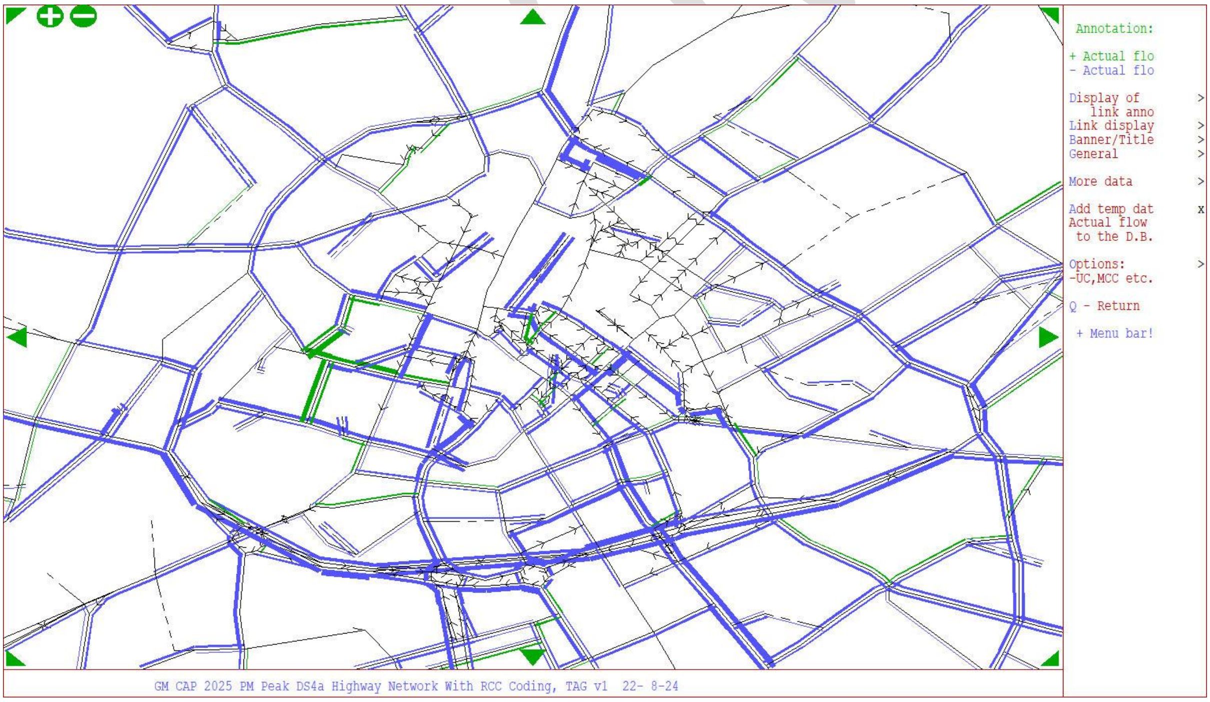


Figure 7-15: Do-Minimum Adjusted Demand vs Do-Minimum Model Actual Flow Difference - PM



7.18.9 The last remaining sites of exceedance (A57 Regent Road / A34 Quay Street / Great Bridgewater Street) generally experience traffic flow reductions under the adjusted demand scenario as shown in **Table 7-34**. A significant two-way flow reduction is identified at A57 Regent Road and a slight increase in certain flows at the A34 Quay Street, this is likely due to reduced delay along the corridor which attracts an increase in demand to the corridor. Similar impacts are identified in the Investment-led Plan.

Table 7-34: Flow Difference at exceedance sites - Do-Minimum

Flows (PCU/hr)	Direction	AM		IP		PM	
		DM	Difference (Adjusted DM)	DM	Difference (Adjusted DM)	DM	Difference (Adjusted DM)
Regent Road	Eastbound	2,289	-245	1,629	-111	1,754	-13
	Westbound	2,427	-182	2,339	-152	2,357	-67
Quay Street	Eastbound	813	-90	521	18	362	148
	Westbound	602	70	438	-13	436	-34
Great Bridgewater Street	Eastbound	586	-133	474	-39	386	-57
	Westbound	206	-14	253	16	604	-1

<u>EMIGMA Results</u>

7.18.10 The demand adjustments described above were applied equally to the DM and DS SATURN assignment matrices for 2025 without making changes to the compliant\non-compliant vehicle splits.

7.18.11 The test was applied in the EMIGMA modelling as follows:

- Assign the adjusted demand matrices and converge the SATURN networks
- Feed the traffic flows from the updated SATURN assignments into EMIGMA to calculate mass emissions for input to the dispersion model.
- Re-run the dispersion modelling to calculate air quality concentrations for the test

7.18.12 No other changes were made for the EMIGMA runs and all other inputs were held constant, including the road traffic emission factors, petrol\diesel splits and bus flows and services. There are, however, modest changes to bus emissions for the test associated with speed changes in the updated models, which will vary by location.

7.18.13 Summary results from the EMIGMA modelling for the test are presented below in **Table 7-35**, broken down by vehicle type and for all vehicles combined. Results are presented separately for the DM and DS tests, for the Regional Centre (shown in **Figure 7-3**) and for Greater Manchester as-a-whole.

7.18.14 The results for the Regional Centre show that NO_x emissions from cars, LGVs, HGVs and taxis are forecast to reduce by between 12 and 18 percentage points relative to the Core DM scenario, and by approximately 12 to 13 percentage points relative to the DS forecast. (The percentage reduction in HGV emissions is slightly greater for the DM test, as a result of re-routing and minor differences in modelled speeds between the assignments, although the absolute difference is relatively small). NOx emissions from all vehicles combined have reduced by 6.7% relative to the DM test and by 7.5% relative to the DS forecast. The emission impacts of the test are less significant for total traffic emissions due to the increased prevalence of buses in the City Centre, which have not changed for the test.

7.18.15 The results for Greater Manchester as a whole show that NOx emissions from all vehicles combined are forecast to reduce by approximately 1% relative to the Core scenarios for both the DM and DS tests. These reductions are lower than the those for Regional Centre as the demand adjustments for the tests were only applied for trips travelling to and from Manchester City Centre. They do, however, reflect the impacts of those changes on traffic flows and speeds in the wider area, on routes used by vehicles traveling to and from the central area.

Table 7-35: Regional Centre Demand Test Road Traffic NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Regional Centre						
Car	11.6	10.2	-12.2%	11.7	10.3	-12.0%
LGV	6.5	5.7	-13.0%	6.5	5.7	-12.1%
HGV	2.5	2.0	-18.5%	2.4	2.1	-13.1%
Taxi	1.7	1.5	-12.1%	1.5	1.3	-11.8%
Bus	21.3	21.3	0.1%	13.5	13.5	-0.1%
Total	**43.6**	**40.7**	**-6.7%**	**35.6**	**32.9**	**-7.5%**
Greater Manchester						
Car	2,468	2,441	-1.1%	2,468	2,441	-1.1%
LGV	1,601	1,584	-1.1%	1,601	1,583	-1.1%
HGV	529	522	-1.3%	529	522	-1.5%
Taxi	294	290	-1.3%	259	256	-1.3%
Bus	381	381	-0.2%	316	316	-0.2%
Total	**5,273**	**5,218**	**-1.0%**	**5,173**	**5,118**	**-1.1%**
Notes: Percentage changes may differ due to rounding.						

Air Quality Impacts

7.18.16 In general, the adjustment of the modelled demand led to reduction of flows and minor changes in the net speed in the Regional Centre across all time periods in both DM and Investment-led Plan models.

7.18.17 Traffic flows also reduced the last sites of exceedance (A57 Regent Road, A34 Quay Street, Great Bridgewater Street) in the DM and Investment-led Plan.

7.18.18 The reduction to the IRR demand reduces traffic flows and therefore forecast year concentrations at the vast majority of locations. However, as a result of the change to demand the SATURN assignment reallocates vehicle routing, which can lead to locations with increased flow or less optimal speeds (from an emissions perspective), but this is insignificant at locations with poor air quality and the majority are associated with model convergence noise and slight changes in slow modelled speed.

7.18.19 The DM improves with reduced concentrations and exceedances, and the first year of natural compliance may be brought forward from 2030, but this is primarily driven by retrofit buses operating from the Stockport depot.

7.18.20 The Investment-led Plan also improves with reduced concentrations and increased headroom at key locations such as A57 Regent Road and inside the IRR where concentrations reduce by up to -2.5 ug/m3. However, there are no forecast exceedances in 2025 and the compliance year isn't altered.

Table 7-36: Air Quality Summary Impacts: Regional Centre Traffic Demand

Metric	Impact
Change in max concentration in 2025	DM: 49.5 → 48.4 DS: 40.3 → 40.1
Change in no. of exceedances in 2025	DM: 26 → 22 DS: No change
Forecast Compliance Year	DM: 2030 → 2029? DS: No change
Impact	**Reduced risk**

8 Review of Impacts of Tests

8.1 Summary of all test results

8.1.1 This section sets out a summary of all the sensitivity testing commentaries in **Table 8-1**, and summary statistics in **Table 8-2.** Tests in **Table 8-1** which reduce risk are coloured green, those which increased risk are red whilst those tests marked in grey are procedural tests which are demonstrated to be sub-optimal or, in the case of meteorology, represent alternative historical datasets.

8.1.2 The air quality results from all of the modelled tests, at the locations that are predicted to be in exceedance in the DM 2025 scenario, are presented in **Appendix 1**.

Table 8-1: Summary of Isolated Sensitivity Test Results

Test No.	Test	Description	Comments
1	Emissions at low speeds	Emissions rise steeply at low speeds in the Government's Emissions Factor Toolkit (EFT) model so the impact of low speeds in the AQ modelling can be high, this assesses how sensitive the modelling is to this effect.	Reduces modelled concentrations in very congested locations. Would not alter compliance year.
2	Projections of f-NO_2	Primary NO_2 as a proportion of NOx emissions may be lower than forecast. f-NO_2 values are reduced by 40% in the future projected year.	Reduces modelled concentrations, especially where car flows are high. Would not alter compliance year.
3	High city centre taxi proportions of demand	Taxi flows in the Regional Centre may be significantly greater than in other parts of the GM. Adjust taxi trips on roads inside the Inner Ring Road so that they represent 25% of the combined car plus taxi flow.	Increases concentrations because more taxis are diesel than cars. Could delay compliance year, but methodology would need extending to Base Year verification to determine risk.
4	A57 Area LTM	A57 LTM measures run independently, and incremental testing LTM package (i.e. speed limit, signal times).	Shows that modelled interaction between A57 and A34 packages does not alter compliance year.
5	A34 Area LTM	A34 LTM measures run independently, which includes the consideration of the St John's Area measures.	Shows that modelled interaction between A57 and A34 packages does not alter compliance year.
6	High Retrofit Bus emissions	Adjust modelled bus emissions to JAQU guidance	Bus emissions at high end of range could delay compliance year.
7	Low Retrofit Bus emissions	Adjust modelled bus emissions to JAQU guidance	Bus emissions at low end of range would not alter compliance year.

Test No.	Test	Description	Comments
8	Removal of EV car projection / Older fleet	Fleet is older than modelled due, for example, to greater-than-expected impacts of Covid-19 pandemic or other factors. Removal of measured EV car penetration rates methodology.	Leads to slight increase in concentrations, and increased risk of delay to compliance.
9	Comparison of zonal and full model domain verification and canyon effects	GM applied a zonal approach to verifying the AQ model, splitting the Regional city centre into a zone with the canyon effects in the model, and a secondary zone for the rest of GM without the canyon. To check how this improved model performance, alters forecast year concentrations.	Adjusting the verification process increases the uncertainty of the modelled results, and delayed compliance.
10	f-NO2 and verification	The fraction of primary NO2 (f-NO_2) released direct from the tailpipe is a significant source of uncertainty in roadside air quality modelling. Use of continuous analyser measured f-NO_2 instead of EFT.	Adjusting the verification process increases the uncertainty of the modelled results, and delayed compliance.
11	Meteorology	Meteorology can have a significant impact on NO2 concentrations. The modelling has used a 2016 base year meteorological dataset, for all Base and Forecast years. Testing of meteorological data from the same station for 2015, 2017 and 2018 was undertaken at earlier phases of the CAP.	It is a well-established fact that inter-annual variability in meteorology can have a significant impact on NO_2 concentrations. Tests show that the GM CAP is sensitive to assumptions about meteorological conditions. This cannot be meaningfully mitigated but monitoring will ensure that the real-world impact of meteorological conditions on the GM CAP can be assessed.
12	Low ZEC taxi uptake	ZEC taxi uptake may be lower than forecast, for example because of pandemic impacts on the trade. Assumes 0% taxi upgrade to ZEC. The electric taxi proportion in the 2025 forecast is set at the current propulsion mix from the 2023 taxi database and does not reflect the general trend of increasing electrification of the PHV and Hackney Carriage fleet.	Overall, the GM CAP is not overly sensitive to low rates of ZEC upgrade because ZEC taxi upgrades are a small proportion of total emissions improvements but would increase risk.

Test No.	Test	Description	Comments
13	ZEB delivery programme risks	ZEBs mainly applied as a CAP measure, and not well represented in DM scenarios. Review depot electrification programme and risk to routes/exceedances, based on specific depots not being operational in 2025.	Delays to bus electrification, based on a 1-year delay to Queens Road depot electrification, likely to result in delay to achieving compliance to 2026 at sites served by ZEBs from Queens Road depot in the ILP.
14	Extra 40% Non-GM licensed PHV taxis	Increase taxi proportion of all car demand based on evidence of non-GM licensed PHVs from JAQU evidence at 40% greater than GM fleet.	Inclusion of additional out of area PHVs is expected to have a minimal increase in emissions due to additional diesel & diesel/hybrid vehicles.
15	ANPR Fleet Projection	GM 2023 ANPR rolled forward to 2025 using the approved methodology, then applied into the EFT9.1 EMIGMA modelling tools.	The ANPR rolled forwards from 2023 to 2025, vs the 2016 core data rolled to 2025 leads to an increase in emissions from private cars and a reduction in emissions from freight. At the GM level in 2025, the discrepancy is comparable with approx. 1 month of natural fleet change. Whilst there is variability in the scale of impacts created at roads with differing car vs freight usage, this is considered a very close agreement. However, for the A57 in 2025 this could delay compliance.
16	Impact of EFTv12 / Future emissions standards	GM's modelling applies version 9.1a of the Government's Emissions Factor Toolkit (EFT); EFTv12 is now available but is not compatible with GM's modelling process, because the base year of 2016 isn't available.	The application of EFTv12 emission factors reduces forecast year concentrations at all locations.

Test No.	Test	Description	Comments
17	Regional Centre traffic demand trends / NTEM V8.0	Compare Regional Centre model traffic growth assumptions to most recent available observed count data, which will be a reduction in van/car demand based on current knowledge.	Reflecting observed traffic flows reduces demand within the future year modelling, though no overall change to year of compliance

Table 8-2: Summary of Air Quality Outputs

Metric	1. Emissions at Low Speeds	2. Projections of f-NO2	3. High city centre taxi proportions of demand	4. A57 Area LTMs	5. A34 Area LTMs	6. High Retrofit Bus emissions	7. Low Retrofit Bus emissions
Change in max concentration in 2025	DM: 49.5 → 46.0 DS: No change	DM: 49.5 → 44.2 DS: 40.3 → 37.5	DM: 49.5 → 50.1 DS: 40.3 → 41.3	DM: na DS: 40.3 → 40.9	DM: na DS: 40.3 → 41.1	DM: na DS: 40.3 → 42.5	DM: na DS: 40.3 → 40.2
Change in no. of exceedances in 2025	DM: 26 → 14 DS: No change	DM: 26 → 9 DS: No change	DM: 26 → 30 DS: 0 → 2	DM: na DS: 0 → 1	DM: na DS: 0 → 2	DM: na DS: 0 → 6	DM: na DS: No change
Forecast Compliance Year	DM: 2030 → 2028? DS: No change	DM: 2030 → 2027? DS: No change	DM: Not known DS: 2025 → 2026?	DM: na DS: 2025 → 2026?	DM: na DS: 2025 → 2026?	DM: na DS: 2025 → 2027?	DM: na DS: No change
Impact	**Reduced risk**	**Reduced risk**	**Increased ILP exposure benefits / Increased risk to compliance date**	**No risk as LTM not implemented separately**	**No risk as LTM not implemented separately**	**Increased risk**	**Reduced risk**

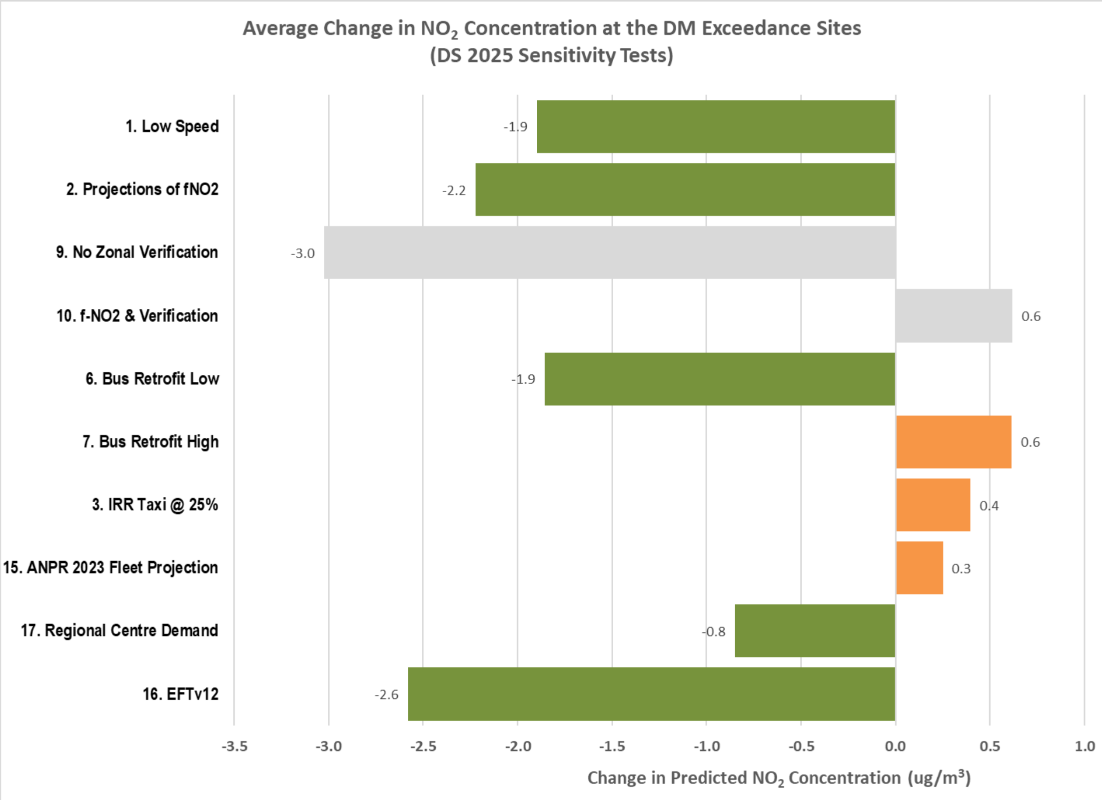
Metric	8. Removal of Electric Car Projection / Older Fleet *	9. Comparison of zonal & full model	10. f-NO2 and verification	11. Meteorology *	12. Low ZEC taxi uptake *	13. ZEB delivery programme risks	14. Extra 40% non-GM licensed PHV taxis *	15. ANPR 2023 Projection / Newer fleet	16. Impact of EFTv12 / Future emissions standards	17. Regional Centre traffic demand trends / NTEM V8.0
Change in max concentration in 2025	DM: Not known DS: 40.4 → 40.5?	DM: 49.5 → 49.1 DS: 40.3 → 41.4	DM: 49.5 → 49.5 DS: 40.3 → 42.2	DM: Not known DS: Not known	DM: n/a DS: 40.4 → 40.5?	DM: No change DS: Not Known	DM: Not known DS: Not Known	DM: 49.5 → 48.6 DS: 40.3 → 40.6	DM: 49.5 → 47.9 DS: 40.3 → 38.8	DM: 49.5 → 48.4 DS: 40.3 → 40.1
Change in no. of exceedances in 2025	DM: Not known DS: 0 → 1?	DM: 26 → 23 DS: 0 → 4	DM: 26 → 41 DS: 0 → 10	DM: Not known DS: Not known	DM: na DS: 0 → 1?	DM: No change DS: Not Known	DM: Not Known DS: Not Known	DM: 26 → 32 DS: 0 → 2	DM: 26 → 12 DS: No change	DM: 26 → 22 DS: No change
Forecast Compliance Year	DM: Not known DS: 2025 → 2026?	DM: Not known DS: 2025 → 2026?	DM: No change? DS: 2025 → 2027?	DM: Not known DS: Not known	DM: n/a DS: 2025 → 2026?	DM: No change DS: 2025 → 2026	DM: Not Known DS: Not Known	DM: No change? DS: 2025 → 2026	DM: 2030 → 2028? DS: No change	DM: 2030 → 2029? DS: No change
Impact	Increased risk	Increased risk, but greater uncertainty	Increased risk, but increased uncertainty & limitations more relevant	Not known	Increased risk	Material risk of delay to modelled compliance in 2025	Increased risk	Increased risk	Reduced risk	Reduced risk

Note: Test marked with an asterisk are not explicitly modelled from the CAP core modelling, and narratives have been developed from previous tests or evidence.

8.2 Consideration of Test Likelihood and Potential Combinations Impacts

8.2.1 The GM CAP has undertaken a range of sensitivity tests, which are summarised in **Figure 8-1** for those tests that were explicitly modelled and could influence the risk based of forecast of air quality compliance. Broadly, these comprise tests that are methodological, updating versions of underpinning tools and referencing the most recent observed trends.

Figure 8-1: Average change in NO2 concentration at the Do-Minimum Exceedance Sites (for the Do Something 2025 Sensitivity Tests)



8.2.2 It is also recognised that whilst these tests have been undertaken in isolation, with some tests considered more likely to occur in the future, and in reality, a combination of these could apply.

8.2.3 The tests can have a range of impacts, and because the majority are impacting on the full set of vehicle types, there is the potential for some tests to lead to both improvements and worsening across different locations. This can make it complex to analyse the key impacts of in-combination test scenarios. In addition, not all of the tests are able to be directly combined from the isolated test outputs, as a result of the sensitivity test methodology applied.

8.2.4 The approach to the test’s application, and their likelihood of occurrence versus the core methodology, is summarised in **Table 8-3**.

Table 8-3: Summary of Modelled Sensitivity Tests and Likelihood of Occurrence

Test	Approach to application	Discussion of Likelihood	Likelihood in 2025
1. Low Speed	Test would need to be applied to Base Year, which could impact adjustment factors depending on the location of monitoring data. Impacts could be magnified or compressed.	Methodological test, not relevant for forecasting.	n/a
2. Projections of f-NO_2	Can be applied directly to forecast years.	GM does not have any local information. However, in the JAQU queries it is noted that: "TIRP panellists feel the f-NO_2 sensitivity test (lower f-NO_2) is actually more like a realistic central scenario rather than exploring the limits of what might be expected."	More likely
8. No Zonal Verification	Testing concludes this is not the optimal method.	Methodological test, not relevant for forecasting.	n/a
10. f-NO_2 & Verification	Testing concludes this is not the optimal method.	Methodological test, not relevant for forecasting.	n/a
6. Bus Retrofit Low	Assumed to be insignificant retrofit fleet present in the base year, so can be applied directly to the forecast year.	JAQU monitoring indicates significant variability across buses of the same model, and also for the same bus at different samples. This means if poorer or better performing vehicles serve a specific route, either High or Low ranges are possible (noting that the JAQU sensitivity testing values are themselves averaging out the wider ranges of vehicle specific performance). A review of the GM specific data indicated that the application of the guidance appears to be conservative and there could be a small reduction in NO_x from retrofit vehicles on average so the Low test is more likely than the High test.	More likely
7. Bus Retrofit High			Less likely
3. IRR Taxi @25%	Test would need to be applied to the Base Year, which would impact adjustment factors depending on the location of monitoring data. This is likely to increase the DM concentrations,	ANPR evidence suggests there is a range in the elevated taxi frequencies between 15-29%, which vary spatially within the IRR. Results could also be scaled spatially	Very likely but spatially variable with 15-29%, but consideration applied

Test	Approach to application	Discussion of Likelihood	Likelihood in 2025
	but compress the impacts compared those in the modelled sensitivity test. This cannot be quickly tested.	based on the output locations and ANPR taxi frequency evidence.	for not updating verification
15. ANPR 2023 Fleet Projection	Can be applied directly to forecast years.	Test based on latest available evidence.	More likely
17. Regional Centre Travel Demand	Can be applied directly to forecast years. However, this test leads to some reassignment of traffic flows and changes to speeds which vary spatially.	Test based on latest available evidence from observed 2024 Automatic Traffic Count Data.	Very likely
16. EFT v12.1 Emission Factors	Majority of changes to the Copert emissions relate to Euro VI/6 vehicles. There are low proportions of these in the 2016 base year, so the impact on verification would be expected to be relatively small, compared to the impact in the forecast year when Euro VI/6 vehicles are more prevalent due to natural fleet turnover (and the impact of the Investment-led Plan on bus and taxis). Cannot be applied directly to forecast years, but results have greater methodological confidence.	Test based on latest available evidence.	Very likely, but consideration applied for not updating verification

8.2.5 The August 2024 Feedback from the TIRP has requested the consideration of analysis of the in-combination impacts of Test 15: ANPR Fleet Age Projection test and Test: 17: Regional Centre Travel Demand test. The TIRP have separately identified that Test 2: Projection of f-NO_2 test is considered to be 'more like a realistic central scenario' method than the core method that has been applied by the GM CAP.

8.2.6 These isolated test methodologies results cannot be directly combined because, for example, of non-linear responses caused by the NO_X to NO_2 calculator or because of potential re-routing. Therefore, in order to consider the combination of tests most robustly, GM has run models of these tests in-combination:

- Test 18 In-Combination: ANPR projection methodology & Regional Centre traffic demand trends
- Test 19 In-Combination: ANPR projection methodology & Regional Centre traffic demand trends & Projection of f-NO_2

8.3 Sensitivity Test 18: Combined Regional Centre Traffic Demand plus ANPR Projection Test

8.3.1 <u>Introduction</u>

8.3.2 The purpose of this test is to investigate the combined impacts of the Regional Centre demand and the ANPR projection tests. The test models the air quality impacts of Tests 15 and 17 in combination. The test was implemented by combining the updated fleet mix projections for Test 15 with the Regional Centre traffic growth adjustments from Test 17.

8.3.3 <u>Methodology and Assumptions</u>

8.3.4 The test was undertaken by re-running the 2025 Core modelling using updated demand matrices and road traffic emission factors based on the revised fleet mix projections from Test 15 and the adjusted demand matrices for Test 17. The test was implemented as follows:

- Apply the fleet mix forecasts from Test 15 to the demand matrices from Test 17 create updated trip matrices for compliant and non-compliant vehicle types for assignment;
- Update the generalised cost parameters (PPM and PPK values) used during the assignments based on the values calculated for Test 15;
- Re-run the assignments;
- Run the Emigma modelling for the Test applying the emission factors and petrol\diesel splits from Test 15;
- Re-run the dispersion modelling; and

- Process the outputs from the dispersion model to calculate updated air quality concentrations.

8.3.5 Bus flows, services and fleet compositions for the Test were unchanged.

8.3.6 EMIGMA Results

8.3.7 Separate model runs have been undertaken for the do-minimum and do-something scenarios for 2025.

8.3.8 Summary results from the EMIGMA modelling for the Test are presented below in **Table 8-4**, broken down by vehicle type and for all vehicles combined. Results are presented separately for the do-minimum and do-something tests, for roads within the Regional Centre (shown in Figure 3.3) and for Greater Manchester as-a-whole.

8.3.9 The results for the Regional Centre show that NO_x emissions from cars, are forecast to reduce by approximately 3% relative to the Core scenarios for both the do-minimum and do-something model runs. NO_x emissions from LGVs, HGVs and Taxis are forecast to reduce by 17%, 38% and 6% respectively for the do-minimum Test and by 16%, 34% and 8% for the do-something Test. NO_x emissions from all vehicles combined have reduced by approximately 6% relative to the Core model runs for both Scenarios.

8.3.10 The results for Greater Manchester as a whole show that NO_x emissions from cars, have increased by approximately 7% relative to the Core scenarios for both the do-minimum and do-something model runs, with reductions in emissions from LGVs, HGVs of approximately 5%, and 38% respectively. These changes are primarily associated with the fleet projection adjustments and are similar to the changes reported for Test 15 (the ANPR fleet projection Test), as would be expected. NO_x emissions for all vehicles combined are forecast to reduce by approximately 2% relative to the Core scenarios for both the do-minimum and do-something tests. These reductions. are lower than those for the Regional Centre as the demand adjustments for the Tests were only applied for trips travelling to and from Manchester City Centre. They do, however, reflect the impacts of those changes on traffic flows and speeds in the wider area, on routes used by vehicles traveling to and from the City Centre.

8.3.11 At an aggregate level the results are as expected, with changes in NO_x emissions representing an approximate linear combination of the outputs from Tests 15 and 17.

Table 8-4: Combined Fleet Age Projection and Regional Centre Demand Test Road Traffic NOx Emissions with Percentage Changes from the Core Model Runs (2025, Tonnes per Year)

Vehicle Type	Scenario					
	Core DM	Test	% Change	ILP DS	Test	% Change
Regional Centre						
Car	11.6	11.3	-2.9%	11.7	11.4	-2.8%
LGV	6.5	5.4	-16.6%	6.5	5.5	-15.8%
HGV	2.5	1.5	-38.2%	2.4	1.6	-33.7%
Taxi	1.7	1.6	-5.8%	1.5	1.4	-8.4%
Bus	21.3	21.3	0.1%	13.5	13.5	-0.1%
Total	**43.6**	**41.1**	**-5.6%**	**35.6**	**33.3**	**-6.5%**
Greater Manchester						
Car	2,468	2,634	6.7%	2,468	2,634	6.7%
LGV	1,601	1,519	-5.1%	1,601	1,519	-5.1%
HGV	529	332	-37.2%	529	332	-37.2%
Taxi	294	310	5.7%	259	265	2.3%
Bus	381	381	-0.2%	316	316	-0.3%
Total	**5,273**	**5,176**	**-1.8%**	**5,173**	**5,066**	**-2.1%**
Notes: Percentage changes may differ due to rounding.						

8.4 Sensitivity Test 19: Combined Regional Centre Traffic Demand plus ANPR Projection Test and Projections of f-NO_2

<u>Methodology and Assumptions</u>

8.4.1 This test builds on Test 18, by further incorporating the reduction in f-NO_2 test. This aspect is applied in the final air quality modelling calculation step, when dispersion model outputs of NO_x and f-NO_2 are combined with background concentrations to calculate the total NO2 concentration. At this point, the location specific f-NO_2 proportion is reduced by 40% before the NO_x to NO_2 calculator is run. Therefore, the EMIGMA emissions inventory and mass emissions as reported in the tables are not updated or re-calculated for reporting.

8.5 Air Quality Impacts of Test 18 and Test 19

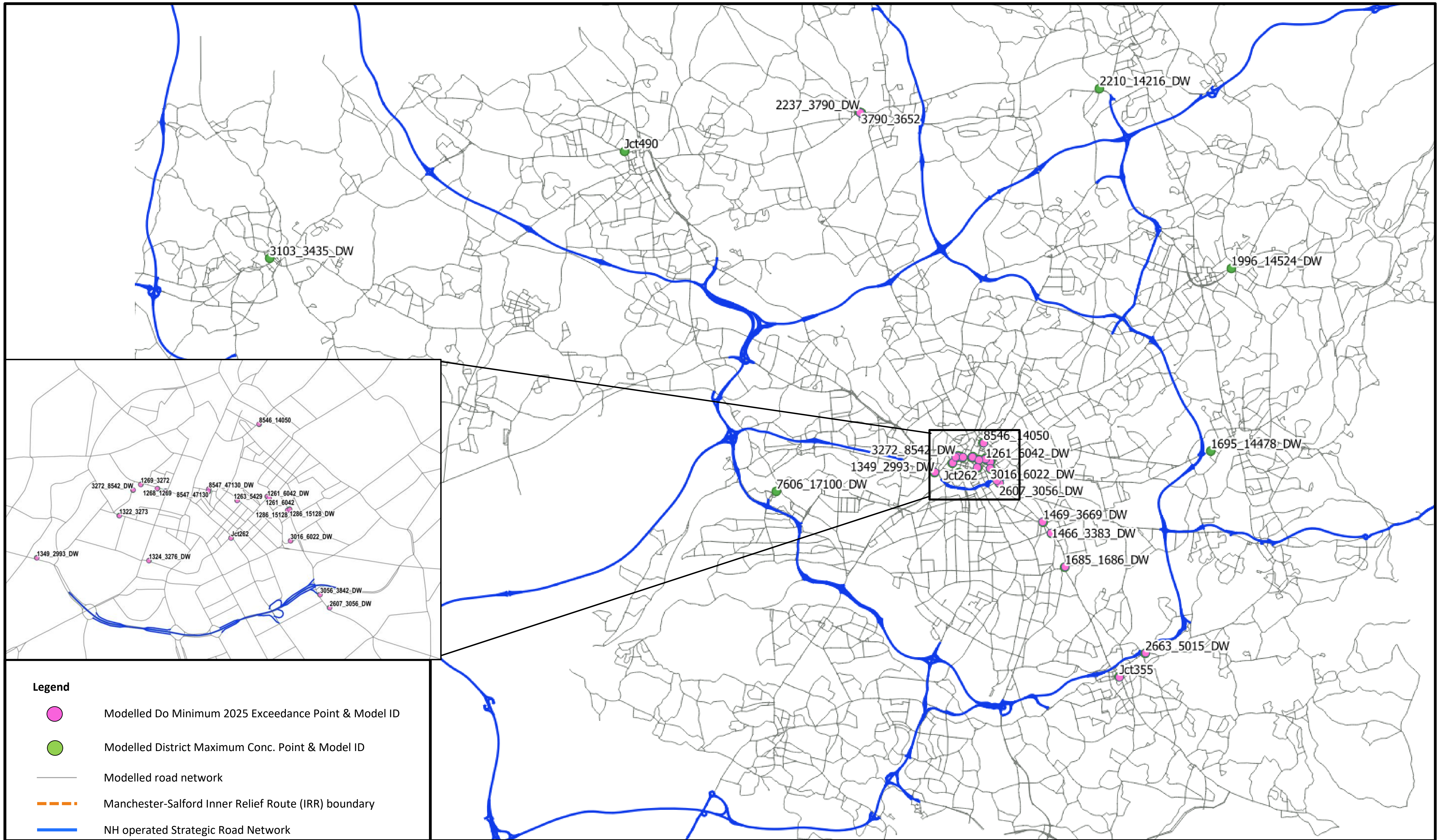
8.5.1 The impacts of the Test 18 and Test 19 in-combination tests have been collated for the sites predicted to be in exceedance in the DM scenario, and are set out in **Table 8-5** for the DM scenario tests and for the Investment-led Plan scenario tests.

8.5.2 The locations of the exceedance points are shown in **Figure 8-2**.

Table 8-5: In-combination analysis at Do Minimum Exceedance sites in 2025 - Do Minimum and Do Something ILP 2025 Test

			Do Minimum 2025			Do Something (Investment Led Plan 2025)		
Site	**LA**	**Road Name**	**DM core conc.**	**Test 18: In-combination Fleet Age & Travel Demand Conc.**	**Test 19: In-combination Fleet Age & Travel Demand & f-NO2 Conc.**	**ILP core conc.**	**Test 18: In-combination Fleet Age & Travel Demand Conc.**	**Test 19: In-combination Fleet Age & Travel Demand & f-NO2 Conc.**
2237_3790_DW	Bury	A58 Bolton St	**42.4**	**42.9**	38.5	40.1	**40.6**	36.7
3790_3652	Bury	A58 Bolton St	**40.7**	**41.1**	37.1	38.6	38.8	35.4
3016_6022_DW	Manchester	A6 Whitworth St	**49.5**	**47.7**	**42.9**	37.1	35.6	33.9
1322_3273	Manchester	A34 Quay St	**48.2**	**47.4**	**43.1**	37.9	37.8	35.7
1261_6042	Manchester	Portland St	**48.2**	**48.2**	**43.5**	32.8	32.8	31.6
1261_6042_DW	Manchester	Portland St	**47.8**	**47.7**	**43.2**	32.7	32.6	31.5
1286_15128	Manchester	A6 Piccadilly	**47.7**	**48.3**	**43.7**	32.4	32.4	31.4
3272_8542_DW	Manchester	Gartside St	**46.2**	**45.6**	**41.6**	37.2	36.5	34.6
8547_47130	Manchester	King St	**45.7**	**44.0**	**40.5**	40.0	38.2	36.0
1263_5429	Manchester	New York St	**45.3**	**44.3**	**40.7**	39.4	38.1	35.9
1286_15128_DW	Manchester	A6 Piccadilly	**44.9**	**45.5**	**41.5**	31.4	31.4	30.5
1469_3669_DW	Manchester	A6 Stockport Rd	**44.1**	**44.1**	39.4	33.8	33.7	31.5
1268_1269	Manchester	A34 Bridge St	**43.7**	**42.2**	39.1	39.1	37.1	35.1
2607_3056_DW	Manchester	A6 Ardwick Green	**43.0**	**42.5**	39.0	36.9	36.2	34.1
3056_3842_DW	Manchester	A6 London Rd	**42.9**	**42.2**	38.8	37.1	36.4	34.3
1685_1686_DW	Manchester	A6 Stockport Rd	**42.8**	**42.9**	38.4	33.6	33.6	31.4
NonPCM_207	Manchester	A34 Bridge St	**42.1**	**40.7**	37.9	37.9	36.0	34.2
1324_3276_DW	Manchester	Great Bridgewater St	**41.8**	39.3	36.5	37.5	36.1	33.8
8547_47130_DW	Manchester	King St	**41.7**	40.2	37.5	37.0	35.4	33.7
8546_14050	Manchester	A664 Shudehill	**41.6**	40.4	37.8	37.2	35.9	34.2
1466_3383_DW	Manchester	A6 Stockport Rd	**41.2**	**41.2**	37.2	31.9	31.8	29.8
Jct262	Manchester	Portland St	**40.7**	**40.5**	37.3	39.3	39.2	36.3
1269_3272	Manchester	A34 Bridge St	**40.6**	40.3	37.8	35.5	34.7	33.4
1349_2993_DW	Salford	A57 Regent Rd	**41.2**	39.6	36.2	40.3	38.1	35.1
Jct355	Stockport	A6 Wellington Rd South	**44.9**	**44.9**	40.0	38.8	38.6	35.3
2663_5015_DW	Stockport	B6104 Carrington Rd	**43.8**	**43.1**	38.2	37.5	36.6	33.4

Figure 8-2: Do Minimum 2025 Exceedance Points and Maximum Concentrations for each District



Transport for Greater Manchester

Key Exceedance Points across GM

Drawn by: NB	Scale: NTS	Date: 25-6-24	

8.5.3 The results for the isolated tests are presented in **Appendix 1**. These show that:

- Test 15: ANPR Fleet Age Projection test increases concentrations by up to 0.6 ug/m^3 in the DM and 0.7 ug/m^3 in the Investment-led Plan, although there are also locations with decreases of up to -0.9 ug/m^3 and -0.8 ug/m^3 in the DM and Investment-led Plan, respectively which are roads with a greater proportion of LGV and HGV traffic.
- Test 17: Regional Centre Travel Demand test decreases concentrations by up to -2.5 ug/m^3 and -2.2 ug/m^3 in the DM and Investment-led Plan, respectively at locations close to the Regional Centre. There are minimal impacts at sites further out from the Regional Centre in Bury and Stockport.
- Test 2: Projections of f-NO_2 test has the greatest influence on any test with reductions of up to -5.3 ug/m^3 and -3.7 ug/m^3 in the DM and Investment-led Plan, respectively. In the Investment-led Plan scenario, where total emissions have been reduced at the worst-case locations by the Investment-led Plan measures, this test has the greatest influence at roads with higher flows of car traffic, such as the A58 Bolton St, Bury and the A57 Regent Road, Salford.

8.5.4 The results of the in-combination tests for locations presented in **Table 8-6** for the DM scenario tests and for the Investment-led Plan scenario tests show that for Test 18, the impacts of ANPR Fleet Age Projection test are outweighed by the Regional Centre Travel Demand test for the majority of exceedances, which are located close to the regional centre. In the DM, five of those exceedances are removed, but the maximum concentration is now the 48.3 ug/m^3 at the A6 Piccadilly, Manchester which is worsened by 0.6 ug/m3. With the Investment-led Plan scenario, the main location of increased risk is at the A58 Bolton Street, Bury where the reduced travel demand has no effect, and an exceedance is predicted at 40.6 ug/m^3 due to the Fleet Age Projection test increasing emissions. Full compliance would be delayed until 2026.

8.5.5 With the inclusion of the Projections of f-NO_2 test in-combination with the ANPR Fleet Age Projection test and the Regional Centre Travel Demand test, there are reductions at all sites compared to the core modelling for both the DM and Investment-led Plan scenarios. In the DM, 10 additional exceedances are removed, with only sites in the regional centre remaining in exceedance, the maximum concentration is 43.7 ug/m^3 at the A6 Piccadilly, Manchester. With the Investment-led Plan scenario, there are no exceedances forecast, with the maximum concentration 36.7 ug/m^3 at A58 Bolton Street, Bury. The concentrations are reduced, and the headroom below the Limit Value is increased, with compliance forecast in 2025.

8.5.6 Of the other tests excluded from the in-combination test scenarios, the IRR Taxi Proportion test has the potential to increase concentrations at roads in the regional centre, as does the Bus Retrofit High test. However, these tests are less likely to occur, and are spatially limited. Conversely, the Bus Retrofit Low test and the EFT v12 test would reduce concentrations.

8.5.7 In-combination these tests show that there is a level of uncertainty associated with the modelling and forecast concentrations. However, overall they provide reassurance that the Investment-led Plan is more likely to achieve compliance than the core scenario assumptions forecast, because the concentrations are generally reduced.

Table 8-6: Air Quality Summary Impacts: In-Combination Tests

Metric	Test 18	Test 19
Change in max concentration in 2025	DM: 49.5 → 48.3 DS: 40.3 → 40.6	DM: 49.5 → 43.7 DS: 40.3 → 36.9
Change in no. of exceedances in 2025	DM: 26 → 22 DS: 0 → 1	DM: 26 → 9 DS: No change
Forecast Compliance Year	DM: 2030 → 2029? DS: 2025 → 2026	DM: 2030 → 2027? DS: No change
Impact	Increased risk	Reduced risk

9 Summary and Conclusion

9.1 Summary

9.1.1 This report has set out the results of sensitivity testing carried out for the GM CAP, the document summarises the results of the sensitivity testing and draws conclusions on the implications for the Investment-led Plan.

9.1.2 In order to inform the AAS and its assessment of the limitations, uncertainties and risks in the evidence base, GM has carried out a programme of sensitivity testing.

9.1.3 The purpose of the sensitivity testing has been to understand the possible impact of uncertainty in the appraisal of the Investment-led Plan. In particular, to understand whether variations in the assumptions underpinning the modelling, or the modelling methodology, would lead to a different decision or outcome or provide additional confidence in the conclusions.

9.1.4 For the GM CAP, the key questions are:

- Are there any plausible circumstances under which the GM CAP would no longer be required, or would not be required in its current form? How confident can GM be in the results of its analysis?
- Are there any plausible circumstances under which the GM CAP would not achieve compliance in the shortest possible time? How confident can GM be in the results of its analysis?

9.2 Conclusion

9.2.1 The GM CAP has undertaken a range of sensitivity tests. Broadly, these comprise tests that are methodological, updating versions of underpinning tools and referencing the most recent observed trends.

9.2.2 It is also recognised that whilst the majority of these tests have been undertaken in isolation, in reality a combination of these could apply, with some tests considered more likely to occur in the future than others.

9.2.3 The tests can have a range of impacts, and because the majority are impacting on the full set of vehicle types, there is the potential for some tests to lead to both improvements and worsening across different locations. This can make it complex to analyse the key impacts of in-combination test scenarios. Also, not all of the tests are able to be directly combined from the isolated test outputs, as a result of the sensitivity test methodology applied.

9.2.4 Based on the available evidence, the isolated tests have been assessed for the likelihood of occurrence, including local GM measured data where possible. Two in-combination tests were then also undertaken which firstly considered the impacts of ANPR Fleet projections and Regional Centre Traffic Demand, and then additionally the Projections of f-NO_2 test.

9.2.5 Of the other isolated tests excluded from the in-combination test scenarios, the High Regional Centre Taxi Proportion test has the potential to increase concentrations at roads in the Regional Centre, as does the Bus Retrofit High test. Conversely, the Bus Retrofit Low test and the EFT v12 test would reduce concentrations. Uncertainty associated with taxi flows means that delivery of the CAP taxi measure would reduce risks associated with the scheme and the complex nature of representing the diversity of taxi operation and upgrade within the modelling process.

9.2.6 The In-combination tests show that there is a level of uncertainty associated with the modelling and forecast concentrations. However, overall they provide reassurance that the Investment-led Plan is more likely to achieve compliance than the core scenario assumptions forecast, because the more likely tests (as tested in-combination) generally reduced concentrations compared to the core scenario values.

9.2.7 Also, the majority of tests would produce a generally similar scale of impact on the CAZ Benchmark. The testing does not indicate that the CAZ Benchmark could deliver compliance in an earlier year than the GM CAP for any likely sensitivity test, or combination thereof. This sensitivity testing therefore supports the development and selection of the Investment-led Plan in place of the Benchmark CAZ.

9.2.8 Whilst there is always uncertainty when forecasting air quality, the sensitivity testing demonstrates that the methodology and assumptions used in the core modelling are more likely to over-predict concentrations than under-predict, and compliance in 2025 is more likely than not. However, the Direction, requires compliance in the shortest time or by 2026 at the latest. Because NO_2 concentrations are improving over time as a result of wider influences, most notably the natural turnover of vehicle fleet with newer cleaner models replacing older ones, in 2026 there is expected to be increased margin available for uncertainty in the modelling forecasts (or headroom), and therefore increased confidence that compliance would occur and meet the requirements of the Direction.

9.2.9 The testing process has also highlighted the factors that the success of Investment-led Plan is most sensitive to, notably fleet mix projections, f-NO_2 and taxi demand. The monitoring and evaluation plan will include monitoring of these factors (either directly or through reviewing the evolving evidence base), and the adaptive planning process, as defined in a Performance Management Plan, will be targeted at the risks highlighted here.

Appendix 1: Results for All Tests

Note: The sites are the exceedances in the core DM 2025 scenario, plus the locations of maximum concentration in those districts without an exceedance, shown in Figure 8.2.

					Test 2		Test 9		Test 10		Test 1		Test 6	Test 7	Test 3		Test 16		Test 15		Test 17		Test 18		Test 19	
			Core Scenarios		Projection of f-NO2		No Zonal Verification		f-NO2 and Verification		Low Speed Emissions		Bus Retrofit Low	Bus Retrofit High	High city centre taxi proportions of demand		EFTv12		ANPR Fleet Projection		Regional Centre Traffic Demand		Combined: ANPR Projection & Regional Centre Traffic		Combined: ANPR Projection, Regional Centre Traffic & f-NO_2	
Site	**LA**	**Road Name**	**Core DM**	**Core DS (ILP)**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**	**DS**	**DS**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**	**DM**	**DS**
2237_3790_DW	Bury	A58 Bolton St	42.4	40.1	38.1	36.4	42.8	40.5	44.5	42.0	39.4	37.5	40.0	40.2	42.4	40.1	37.4	35.2	43.0	40.6	42.3	40.1	42.9	40.6	38.5	36.7
3790_3652	Bury	A58 Bolton St	40.7	38.6	36.9	35.2	41.1	38.9	42.7	40.4	36.7	35.1	38.5	38.6	40.7	38.6	36.4	34.3	41.1	38.9	40.7	38.6	41.1	38.8	37.1	35.4
3016_6022_DW	Manchester	A6 Whitworth St	49.5	37.1	44.2	35.2	42.3	34.0	49.5	37.1	40.0	31.0	34.4	38.1	50.1	37.6	47.9	35.6	48.6	37.3	47.4	35.3	47.7	35.6	42.9	33.9
1322_3273	Manchester	A34 Quay St	48.2	37.9	43.8	35.8	32.8	29.7	48.2	37.9	43.1	37.5	37.8	38.0	49.5	38.9	44.6	34.6	48.5	38.3	47.0	37.6	47.4	37.8	43.1	35.7
1261_6042	Manchester	Portland St	48.2	32.8	43.5	31.7	45.0	32.8	48.2	32.8	38.9	28.2	28.9	34.0	48.2	32.9	47.8	32.5	48.2	32.9	48.1	32.7	48.2	32.8	43.5	31.6
1261_6042_DW	Manchester	Portland St	47.8	32.7	43.2	31.6	49.1	34.4	47.8	32.7	38.7	28.1	28.8	33.9	47.8	32.8	47.4	32.4	47.8	32.8	47.7	32.6	47.7	32.6	43.2	31.5
1286_15128	Manchester	A6 Piccadilly	47.7	32.4	43.2	31.4	40.0	30.6	47.7	32.4	39.3	28.1	30.6	32.9	48.0	32.5	46.9	31.6	47.7	32.4	48.4	32.4	48.3	32.4	43.7	31.4
3272_8542_DW	Manchester	Gartside St	46.2	37.2	42.1	35.2	30.7	28.4	46.2	37.2	46.0	36.9	37.1	37.2	47.4	38.2	43.0	34.2	46.5	37.9	45.2	36.2	45.6	36.5	41.6	34.6
8547_47130	Manchester	King St	45.7	40.0	41.8	37.5	34.2	31.5	45.7	40.0	45.0	39.6	39.8	40.1	47.2	41.3	41.9	36.3	46.2	40.6	43.4	37.8	44.0	38.2	40.5	36.0
1263_5429	Manchester	New York St	45.3	39.4	41.5	36.9	32.1	30.1	45.3	39.4	45.0	39.1	38.9	39.6	46.7	40.5	41.5	35.8	45.8	40.1	43.7	37.7	44.3	38.1	40.7	35.9
1286_15128_DW	Manchester	A6 Piccadilly	44.9	31.4	41.1	30.5	45.2	32.5	44.9	31.4	37.4	27.6	29.8	31.8	45.1	31.5	44.2	30.7	44.9	31.4	45.5	31.4	45.5	31.4	41.5	30.5
1469_3669_DW	Manchester	A6 Stockport Rd	44.1	33.8	39.4	31.7	44.5	34.1	46.3	35.3	40.8	32.1	32.2	34.4	44.1	33.8	41.2	31.1	44.6	34.3	43.6	33.2	44.1	33.7	39.4	31.5
1268_1269	Manchester	A34 Bridge St	43.7	39.1	40.4	36.9	32.8	30.8	43.7	39.1	42.8	38.0	37.2	39.8	44.7	39.9	41.3	36.6	44.1	39.5	41.8	36.8	42.2	37.1	39.1	35.1
2607_3056_DW	Manchester	A6 Ardwick Green	43.0	36.9	39.5	34.7	43.4	37.2	44.9	38.3	42.9	36.8	35.7	37.3	43.1	36.9	39.9	33.9	43.4	37.3	42.1	35.9	42.5	36.2	39.0	34.1
3056_3842_DW	Manchester	A6 London Rd	42.9	37.1	39.4	34.9	43.3	37.4	44.7	38.5	42.5	36.8	36.0	37.5	43.0	37.2	39.8	34.2	43.3	37.5	41.9	36.1	42.2	36.4	38.8	34.3
1685_1686_DW	Manchester	A6 Stockport Rd	42.8	33.6	38.4	31.4	43.2	33.8	44.9	35.0	38.3	30.4	31.1	34.3	42.8	33.6	40.2	31.1	43.1	33.9	42.6	33.3	42.9	33.6	38.4	31.4
NonPCM_207	Manchester	A34 Bridge St	42.1	37.9	39.1	35.9	30.2	29.0	42.1	37.9	41.3	36.8	36.1	38.5	43.1	38.7	39.9	35.6	42.5	38.3	40.4	35.7	40.7	36.0	37.9	34.2
1324_3276_DW	Manchester	Great Bridgewater St	41.8	37.5	38.6	35.0	31.0	29.0	41.8	37.5	38.8	37.4	37.3	37.5	43.2	38.5	37.9	33.8	41.9	37.5	39.2	35.9	39.3	36.1	36.5	33.8
8547_47130_DW	Manchester	King St	41.7	37.0	38.7	35.0	38.1	34.4	41.7	37.0	41.0	36.6	36.7	37.1	43.0	38.0	38.6	34.0	42.0	37.4	39.7	35.1	40.2	35.4	37.5	33.7
8546_14050	Manchester	A664 Shudehill	41.6	37.2	38.8	35.3	34.2	31.4	41.6	37.2	37.5	34.4	35.4	37.8	42.4	37.8	39.5	35.2	41.9	37.4	40.1	35.6	40.4	35.9	37.8	34.2
1466_3383_DW	Manchester	A6 Stockport Rd	41.2	31.9	37.2	30.0	41.6	32.2	43.2	33.2	41.2	31.9	29.7	32.6	41.2	31.9	38.7	29.5	41.6	32.3	40.8	31.4	41.2	31.8	37.2	29.8
Jct262	Manchester	Portland St	40.7	39.3	37.5	36.4	34.0	33.0	40.7	39.3	40.1	38.8	29.6	42.5	40.9	39.5	39.8	38.4	40.7	39.4	40.4	39.2	40.5	39.2	37.3	36.3
1269_3272	Manchester	A34 Bridge St	40.6	35.5	38.0	34.0	34.0	31.1	40.6	35.5	36.0	32.5	34.4	35.9	41.3	36.0	38.8	33.8	40.8	35.7	40.2	34.6	40.3	34.7	37.8	33.4
1349_2993_DW	Salford	A57 Regent Rd	41.2	40.3	37.6	36.9	41.6	40.7	43.1	42.2	41.1	40.3	40.2	40.4	41.3	40.3	36.0	35.4	41.4	40.4	39.4	38.0	39.6	38.1	36.2	35.1
Jct355	Stockport	A6 Wellington Rd South	44.9	38.8	40.0	35.5	45.3	39.1	47.1	40.5	41.1	35.3	32.6	40.9	44.9	38.8	42.5	36.5	44.8	38.7	44.8	38.7	44.9	38.6	40.0	35.3
2663_5015_DW	Stockport	B6104 Carrington Rd	43.8	37.5	38.8	34.2	44.2	37.8	46.1	39.3	43.0	36.9	35.9	38.1	43.8	37.5	39.9	33.6	43.2	36.7	43.7	37.4	43.1	36.6	38.2	33.4
Jct490	Bolton	Vernon St	39.8	39.6	36.4	36.3	40.1	39.9	41.6	41.4	38.6	38.4	37.0	40.5	39.8	39.6	35.8	35.7	40.6	40.2	39.8	39.8	40.4	40.1	36.8	36.6
1996_14524_DW	Oldham	A62 Bottom o' th' Moor	40.2	40.1	36.7	36.5	40.6	40.4	42.1	41.9	40.1	39.9	35.5	41.7	40.2	40.1	36.6	36.5	40.5	40.4	40.2	40.0	40.5	40.3	36.8	36.7
2210_14216_DW	Rochdale	A664 Edinburgh Way	39.3	39.1	35.7	35.5	39.6	39.4	41.2	40.9	34.5	34.2	39.1	39.1	39.3	39.1	35.4	35.2	39.0	38.7	39.3	39.0	38.9	38.7	35.3	35.1
1695_14478_DW	Tameside	A635 Manchester Rd	37.6	37.4	34.8	34.6	37.9	37.7	39.2	39.0	37.6	37.4	37.4	37.4	37.6	37.4	33.4	33.3	37.6	37.3	37.4	37.2	37.3	37.2	34.5	34.4
7606_17100_DW	Trafford	B5214 Trafford Blvd	38.8	38.3	35.1	34.7	39.2	38.7	40.8	40.2	36.1	35.9	32.7	40.4	38.8	38.3	36.0	35.6	38.6	38.1	38.7	38.2	38.5	37.9	34.8	34.3
3103_3435_DW	Wigan	King St West	40.0	39.9	37.1	37.0	40.3	40.2	41.7	41.5	34.0	33.9	32.8	42.5	40.0	39.9	38.9	38.8	40.0	39.9	40.0	39.9	40.0	39.9	37.0	36.9