THIRD WAVE LOCAL AUTHORITIES – TARGETED FEASIBILITY STUDY TO DELIVER NITROGEN DIOXIDE CONCENTRATION COMPLIANCE IN THE SHORTEST POSSIBLE TIME

Local authorities covered	Stoke-on-Trent City Council & Newcastle-under-Lyme Borough Council

Part 1: Understanding the problem

The following sets out the targeted feasibility study for Stoke-on-Trent City Council & Newcastle-under-Lyme Borough Council. Parts 1 and 2 of the study were completed separately by the local authorities, whilst Parts 3, 4 and 5 were completed as a joint assessment.

Stoke-on-Trent

Stoke-on-Trent City Council has one road link, census ID: 26555, projected to have an EU exceedance. This link, and Newcastle-under-Lyme Borough Council road link, census ID: 74058, are managed by Stoke-on-Trent City Council Highways Authority.

The road link under consideration is the length of the A53 from Stoke-on-Trent's boundary with Newcastle-under-Lyme Borough Council, exceedance link census ID: 74058, to the A5010. The A53 forms a vital strategic road link connecting the neighbouring borough of Newcastle-under-Lyme, population of 123,871 with the city of Stoke-on-Trent, population of 249,008 and beyond to the town of Leek, population 20,768. The A500, managed by Highways England (HE) meets the A53 at Newcastle-under-Lyme, census ID: 74058, to the west and adjoining census ID: 26555. The A500 has also been identified as having exceedances.

The results from the PCM model show that the road link is projected to have the following annual mean NO_2 concentrations:

- 45 µg/m³ in 2018
- 43 µg/m³ in 2019
- 41 µg/m³ in 2020
- 38 µg/m³ in 2021

This feasibility study aims to identify additional measures which could reduce the concentration of NO_2 on this road link in order to bring forward compliance in the shortest possible time. Compliance with the EU objective would be achieved by reducing the NO_2 concentration in 2018 by at least 5 µg/m³. If this is not achievable, then compliance could be brought forward to 2019 by reducing the concentration in that year by at least 3 µg/m³ or by 2020 if the concentration was reduced by 1 µg/m³.

Local traffic data has been used to calculate the source apportionment of vehicles for this link. The data shows that in 2015 the contributors to total NOx concentrations on this road link were:

- Petrol cars: 6%
- Diesel cars: 29%
- Diesel LGVs: 18%
- Rigid HGVs: 11%
- Articulated HGVs: 3%
- Buses: 3%

- Remainder (background sources): 27%

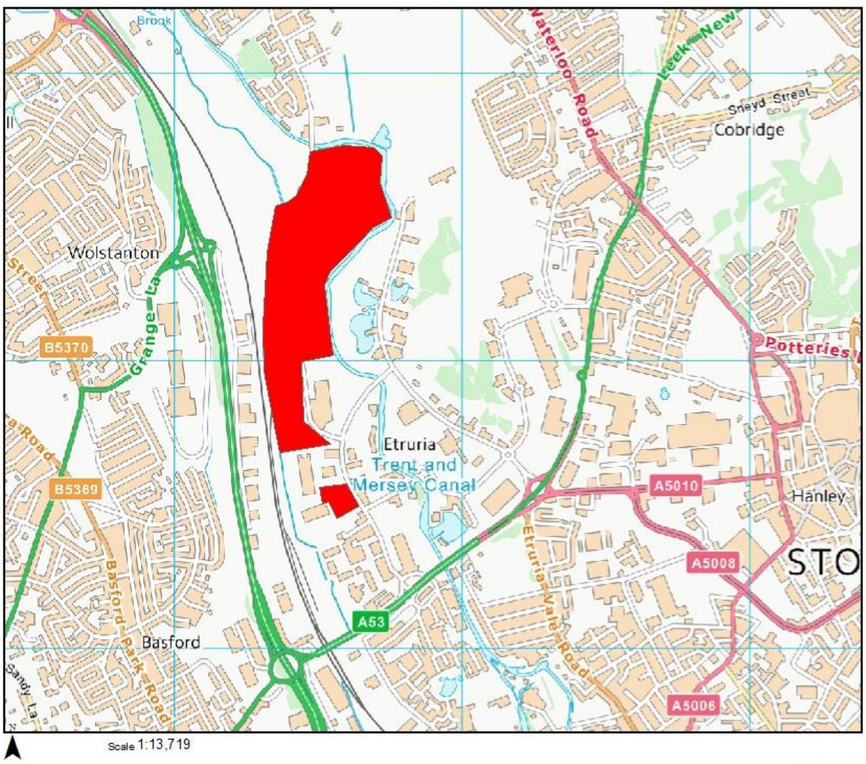
Adjacent to the link is the business, leisure and retail area of Festival Park. Businesses on this site include major employers bet365, Vodafone, facilities management service providers GSH, Wardell Armstrong, HSBC, Wade Ceramics Ltd, the Wedgwood and Royal Doulton Outlet Store (WWRD) and the city council's own customer access call centre. There is also a four star hotel, five restaurants, a multi-screen cinema, ten pin bowling, a ski slope and an indoor water complex. Retail businesses include Next, Boots, JD Sports, Argos, Mothercare, Outfit, River Island, First Choice, New Look, B&Q, River Island, Carpetright/ Sleepright Beds, Morrisons, Currys, PC World, Pets at Home, Halfords and Harveys. Previously, bet365 operated from five separate buildings at Festival Park. In 2016, they consolidated their workforce by moving into a newly built site, operating 24/7/365 and adding around 1000 parking spaces. The units previously occupied by bet365 became available to re-let, resulting in an increase in the number of people employed at Festival Park.

Road use on the A53 is typically made up of a mixture of local traffic and traffic from outside the area including commuters between Newcastle-under-Lyme, Festival Park, the city centre (Hanley) and Leek, access to schools at Cobridge and shoppers and visitors to the various retail and leisure outlets in the area.

Further commercial and residential development of land to the north of the link (east of the A500) is proposed at Etruria Valley. This area is one of seven key sites along the A500 corridor to accelerate investment in a range of employment sectors as part of the Ceramic Valley Enterprise Zone. The Air Quality Assessment submitted in support of the outline planning application 61494/OUT predicts that the development will increase concentrations of NO_2 by 3.5 µg/m³ in 2018. Details of the scheme are available online at https://planning.stoke.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_STOKE_DCAPR_67407

Preliminary discussions with the applicant have resulted in the request for a Damage Cost calculation to be completed and the submission of details of suitable mitigation measures. The location plan for the development is shown below.

Etruia Valley area of further development



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City of Stoke-on-Trent

To give better connectivity for the proposed Etruria Valley development, the planned Etruria Valley Link Road Infrastructure Project will give access directly to the A500 and provide a link westward to the Wolstanton Retail Park and Newcastle-under-Lyme. An Environmental Impact Assessment (EIA) will accompany the planning application. The air quality assessment submitted within the EIA will consider the effect of the development on the exceedance of the EU limit value on census links ID: 26555 and ID: 74058. A map showing the extent of the work is shown below.

AECOM

Stoke on Trent City Council — Etruria Valley Link Road Infrastructure Project (Phases 1 & 2)

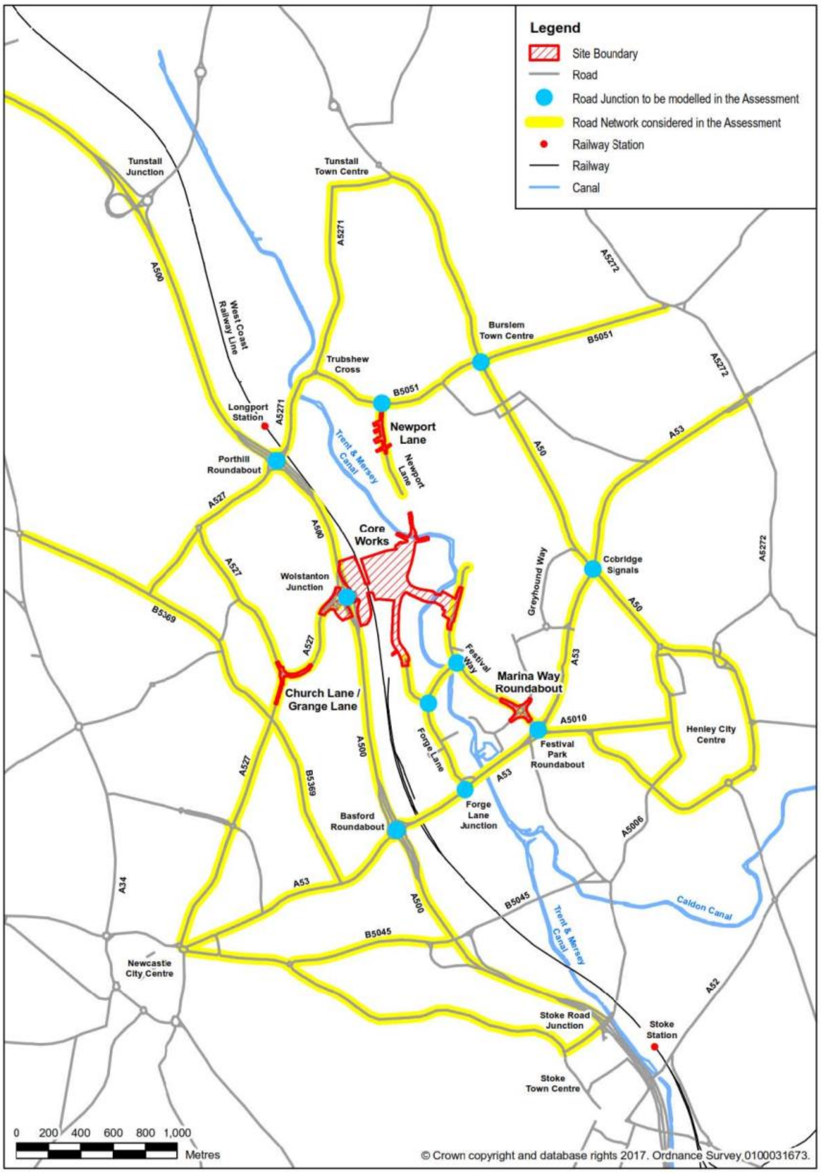

Figure 11.1 Transport Study Area

EIA SCOPING REPORT
February 2017

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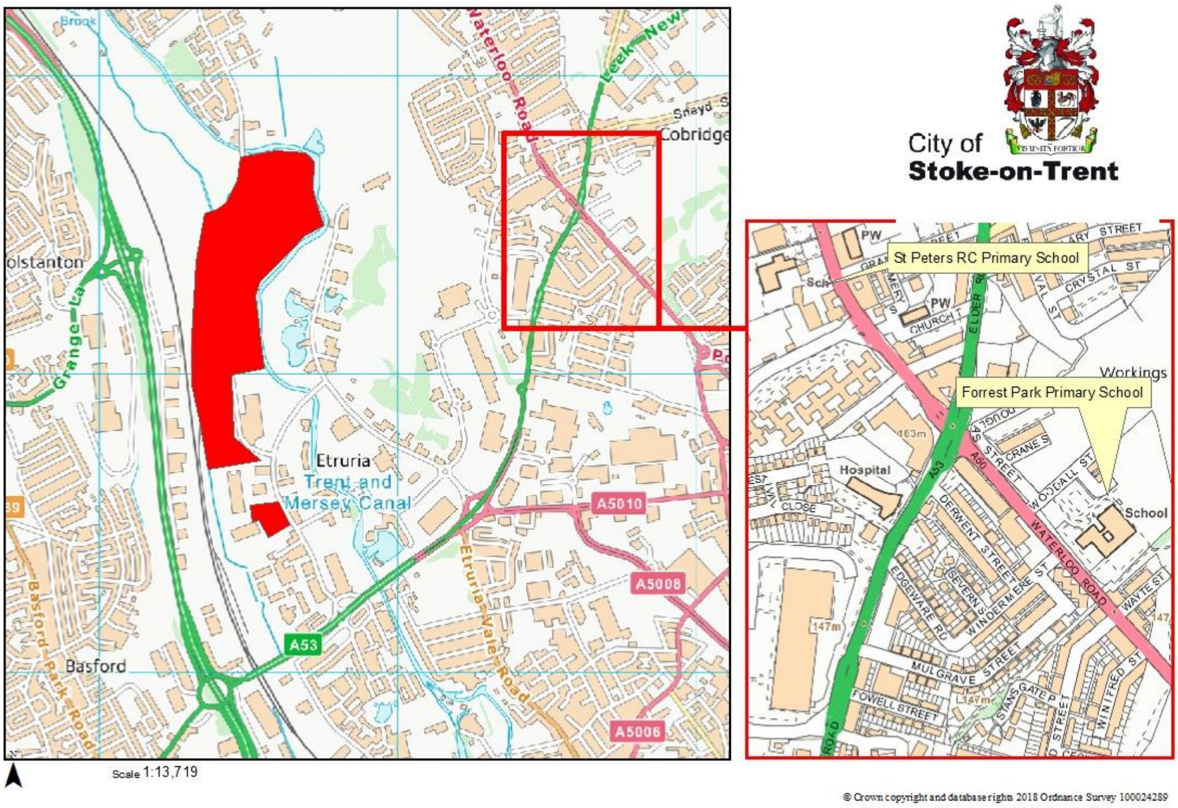
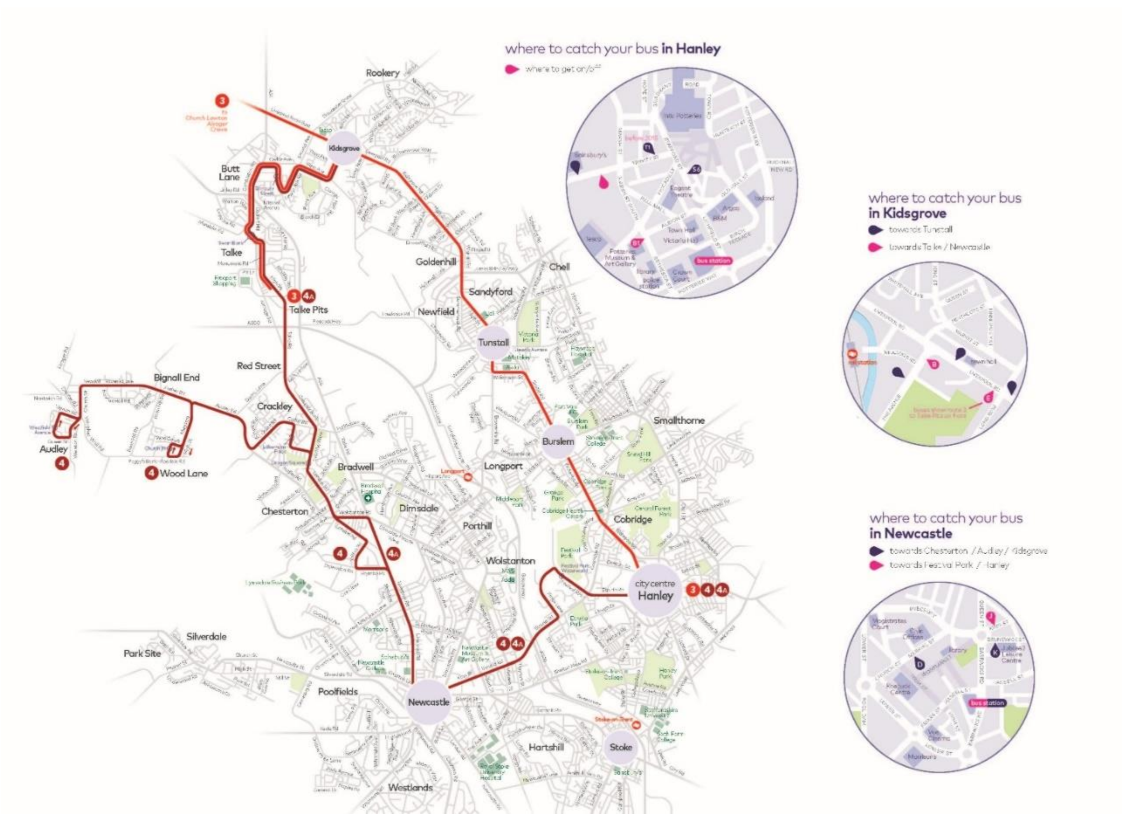
HE's A500 Porthill to Wolstanton Junction Improvement Scheme is planning to coincide with the Etruria Valley Link Road Infrastructure Project to facilitate improvements at the A500 Wolstanton junction. Stoke-on-Trent City Council understand that air quality modelling undertaken by HE has shown that the scheme will delay compliance with the EU limit value at links ID: 26555 and ID: 74058 by one year. Details of the scheme with a planned start in 2018/19 are available online at http://roads.highways.gov.uk/projects/a500-etruria-widening/.

There are two schools further to the north-east of the link at Cobridge, St Peters Catholic Academy and Forest Park Primary. A map showing the location of the schools in relation to the exceedance area is provided below.

Schools



There are two bus routes operating in the area - services 4 and 4a operated by First Bus, using older Euro 3 buses, and service 2 operated by D&G using Euro 3 buses. First bus operates over 20 buses per day and D&G operate four on this route. Buses from both routes operate from the city centre to Newcastle-under-Lyme town centre, via the A53. A route map for service 4 and 4a is included overleaf.



Newcastle-under-Lyme

The identified road of exceedance is the A53 which runs up to the administrative boundary between Newcastle-under-Lyme Borough Council (census ID: 74058) and Stoke on Trent City Council (census ID: 26555), The responsibility for managing the road from a Highway Authority perspective falls to Staffordshire County Council (SCC) and Stoke on Trent City Council (S-o-T CC) respectively.

The road link under consideration is a length of the A53 from the centre of the roundabout with the A500 to the Borough Boundary on the A53, this area then continues in SOTCC's area to the flyover at the A5010. The local authority boundary falls at the road edge of the A53/A500 roundabout.

The A53 performs a vital role as one of three strategic west-east road links connecting Newcastle under Lyme with Stoke on Trent, in particular to Hanley, one of the principal shopping centres in the City and the Festival Park shopping and employment area.

These road links between the two centres have to cross a valley in which the A500 is situated; it is also a road of concern but it is controlled by Highways England.

The results from the PCM show that the road link within Newcastle under Lyme is projected to have the following annual mean NO_2 concentrations:

- 44 µg/m^3 in 2018
- 42 µg/m^3 in 2019
- 40.2 µg/m^3 in 2020
- 38 µg/m^3 in 2021

This feasibility study aims to identify measures which could reduce the concentration of NO_2 on this road link as quickly as possible with the objective of bringing forward compliance in the shortest possible time. This objective could be achieved by reducing the NO_2 concentration in

2018 by at least 4 μg/m^3; if this is not achievable then compliance could be brought forward to 2019 by reducing the concentration in that year by at least 2 μg/m^3.

Roads in exceedance	**Census ID**	**2017**	**2018**	**2019**	**2020**	**2021**	**Source apportionment**
A53	74058	46	44	42	40.2	38	32% diesel cars; 14% LGV diesel; 13% HGVr; 7% cars petrol; 5% HGVa; 2% buses

We do not have any local data available to understand the source apportionment on this road link, and we have determined that it will not be possible to collect this data in time to be considered as part of this study. To understand the nature of the problem on this road link we have therefore used the source apportionment data from the national PCM model. This data shows that in 2015 the contributors to total NOX concentration on this road link were:

- Petrol cars: 5%
- Diesel cars: 32%
- Petrol LGVs: 0%
- Diesel LGVs: 14%
- Articulated HGVs: 5%
- Rigid HGVs: 13%
- Buses: 2%
- Remainder (background sources): 29%

Close to the road link there are two large retail parks (Wolstanton and Festival Park) and this road link is heavily used by commuters travelling east-west and west-east; from Newcastle and further afield to Hanley, Stoke and beyond (main route across the City to Leek, Buxton) and from the City / Moorlands to Newcastle under Lyme and out towards Shrewsbury.

There is also a relatively high concentration of logistics companies located within the overall conurbation of North Staffordshire resulting in significant movement of goods to and from the hubs of these national companies' distribution networks (APC, Fedex, New Look, TK Maxx, Sainsbury's, JCB) between Newcastle and Stoke and the adjoining wider road network. The A500 which traverses the A53 is the main link road between the M6 and M1 (via the A50) facilitating the movement of goods between the docks in the north-west and south-east of the UK.

There are several strategic bus routes that use this road; First Bus operates No. 4, No. 4A and No. 4E. D&G Bus operates No. 2, No. 2A, No.17 and largely using Euro 3 diesel engine buses.

There is also the region's hospital (University Hospital North Midlands) and there are universities in both towns (Keele and Staffordshire) and so some of the vehicle movements on the road are from people travelling to and from these venues.

As referred to above there are a number of retail, employment (notably including a concentration of logistics companies) and commercial venues in the areas around the road link which are generating trips contributing to the exceedance; this would also link to the high source apportionment for diesel vehicles.

Part 2: Developing a long list of measures for addressing the exceedances

The following sets out the long list of measures provided for Newcastle-under-Lyme and Stoke-on-Trent.

Newcastle-under-Lyme

Existing measures

- Driver training and ECO driving aids via Eco-stars.
- County wide project to explore travel (cycle, walk, bus, business) planning and electric vehicle project, 2-year project which commenced April 2018. (Staffordshire & Stoke-on-Trent City Council).

New measures

- Review likelihood of Etruria Valley link road providing an alternative route between Newcastle-under-Lyme, Etruria Valley, Festival Park and the city centre.
- Workplace Travel Planning with local employers
- Encourage/facilitate home-working
- Promotion of cycling/introduce public cycle hire scheme/improve cycle network/cycle training
- Promotion/facilitation of walking
- Bus based Park & Ride and more dedicated bus lanes
- Car and lift sharing schemes and/or APPs
- Priority parking for LEVs
- Improve alternative refuelling infrastructure
- Reallocate or restrict parking
- Bus retrofitting - Upgrade buses to Euro IV by retrofitting current Euro 3 buses
- Campaign to raise public awareness of air quality issues
- Travel plans for the Hospital, Universities and key tourist attractions.
- Urban Traffic Control systems, signalling improvement, congestion management
- Reduction of speed limits, introduction of more 20mph zones
- Anti-idling promotion and/or enforcement
- Etruria Valley link road development
- Investigate roundabout traffic light optimisation and Investigate options to change road layout/road discipline
- Promotion of electric vehicles including taxi and council fleet
- Traffic optimisation at King Street one way junctions
- Development of air quality developers' guide
- Development of comprehensive air quality strategy
- HGV routing strategy to and from major employment centres within Newcastle under Lyme promoting use of strategic highway network
- Working with Highways England to identify and secure further improvements to congestion management on the A500
- Explore use of smart traffic signs to promote alternative routes, transport options and to deliver air quality messages
- Investigate freight/logistics consolidation hub
- Investigate freight/logistics routing strategies
- Encourage change to electric taxis
- Encourage taxi drivers to complete eco-driving sessions
- Encourage cleaner buses (e.g. electric, hydrogen)

Stoke-on-Trent

Existing measures

- Review likelihood of Etruria Valley link road providing an alternative route between Newcastle-under-Lyme, Etruria Valley, Festival Park and the city centre.

New measures

- Provide access to a workplace travel adviser for businesses
- Review commitments of new businesses to adhere to travel plans
- Investigate employee travel expenses
- Consider introducing subsidised travel
- Explore if employers would charge employees to park on site
- Have priority car share parking spaces at businesses on Festival Park and Etruria Valley
- Encourage businesses to become members of Eco Stars or similar fleet recognition scheme
- Upgrade buses to Euro IV by retrofitting current Euro 3 buses
- Campaign to raise public awareness of air quality issues
- Install electric charging points on Festival Park and Etruria Valley
- Scope for improving EV charging network generally
- Priority parking for electric vehicles
- Investigate car share apps
- Investigate park and ride scheme
- Investigate freight/logistics consolidation hub
- Investigate freight/logistics routing strategies
- Investigate traffic light timings at A500 and Festival Park roundabouts
- Review traffic light operation times - switch off outside peak periods.
- Investigate options to change road layout/road discipline
- Install green walls
- Install living wall street furniture, bus shelters etc.
- VMS to inform drivers of alternative routes during periods of congestion at A500 and Festival Park roundabouts
- Erect signs on the flyover to highlight alternative route/entrance to Festival Park
- Display ‘turn off engine’ signs on approach to traffic lights at A500 and Festival Park roundabouts
- Examine traffic flow through junctions
- Investigate Festival Park retail delivery times - arrange outside peak period
- Review “click and collect” policies of retailers on Festival Park to reduce trips to area
- Examine Festival Park retail parking policy
- Investigate apps to warn of journey times/congestion
- Reinstate Etruria rail link and station
- Use of travel diaries/black boxes to understand journeys, especially start- stop-end
- Encourage change to electric taxis
- Encourage taxi drivers to complete eco-driving sessions
- Encourage electric buses
- Work with schools and ScienceScope to monitor air quality and educate parents on the impact of the school run
- Encourage sustainable travel to school through Modeshift Stars

Part 3: Assessing deliverability/feasibility and delivering a short list

Development of a short-list of measures

To assess the feasibility and deliverability of the measures identified in Part 2, the 61 measures identified by the two Local Authorities were grouped into 23 categories, as shown in the table below.

Grouped	Measure in long-list
AQ/LES Strategy	Development of comprehensive air quality strategy.
	Development of air quality developers' guide.
Priority parking	Priority parking for LEVs.
	Priority parking for electric vehicles.
Charging/refuelling infrastructure	Improve alternative refuelling infrastructure.
	Install electric charging points on Festival Park and Etruria Valley.
	Scope for improving EV charging network generally.
Electric taxis/vehicles	Encourage change to electric taxis.
	Promotion of electric vehicles including taxi and council fleet.
Park & Ride Scheme	Bus based Park & Ride and more dedicated bus lanes.
	Investigate park and ride scheme.
Low emission buses	Bus retrofitting - upgrade buses to Euro VI by retrofitting current Euro III buses.
	Encourage cleaner buses (e.g. electric, hydrogen).
	Upgrade buses to Euro VI by retrofitting current Euro III buses.
	Encourage electric buses.
Promotion of alternative transports	Promotion of cycling/introduce public cycle hire scheme/improve cycle network/cycle training.
	Promotion/facilitation of walking.
Car sharing scheme	Car and lift sharing schemes and/or APPs.
	Investigate car share apps.
Etruria Valley Link Road Development	Review likelihood of Etruria Valley link road providing an alternative route between Newcastle-under-Lyme, Etruria Valley, Festival Park and the city centre.
	Etruria Valley link road development.
Automatic traffic control systems	Urban Traffic Control systems, signalling improvement, congestion management.
	Investigate roundabout traffic light optimisation and investigate options to change road layout/road discipline.
	Explore use of smart traffic signs to promote alternative routes, transport options and to deliver air quality messages.
	Review traffic light operation times - switch off outside peak periods.
	Traffic optimisation at King Street one way junctions.
A500 improvements	Working with Highways England to identify and secure further improvements to congestion management on the A500.
	Investigate traffic light timings at A500 and Festival Park roundabouts.
Road layout changes	Investigate options to change road layout/road discipline.
	Examine traffic flow through junctions.
Improved driver awareness	VMS to inform drivers of alternative routes during periods of congestion at A500 and Festival Park roundabouts.

	Erect signs on the flyover to highlight alternative route/entrance to Festival Park.
	Investigate apps to warn of journey times/congestion.
Reduced speed limits	Reduction of speed limits, introduction of more 20 mph zones.
Business travel plans	Workplace Travel Planning with local employers.
	Encourage/facilitate home-working.
	Travel plans for the Hospital, Universities and key tourist attractions.
	Use of travel diaries/black boxes to understand journeys, especially start-stop-end.
	HGV routing strategy to and from major employment centres within Newcastle under Lyme promoting use of strategic highway network.
	Provide access to a workplace travel adviser for businesses.
	Review commitments of new businesses to adhere to travel plans.
	Investigate employee travel expenses.
	Investigate Festival Park retail delivery times - arrange outside peak period.
Freight consolidation centre	Investigate freight/logistics consolidation hub.
	Investigate freight/logistics routing strategies.
Employee parking strategies	Explore if employers would charge employees to park on site.
	Have priority car share parking spaces at businesses on Festival Park and Etruria Valley.
	Examine Festival Park retail parking policy.
	Reallocate or restrict parking.
	Consider introducing subsidised travel.
Business travel club	Encourage businesses to become members of Eco Stars or similar fleet recognition scheme.
	Review "click and collect" policies of retailers on Festival Park to reduce trips to area.
Public / school awareness campaign	Campaign to raise public awareness of air quality issues.
	Work with schools and ScienceScope to monitor air quality and educate parents on the impact of the school run.
	Encourage sustainable travel to school through Modeshift Stars.
Eco-driving campaign	Encourage taxi drivers to complete eco-driving sessions.
Anti-idling campaign	Anti-idling promotion and/or enforcement.
	Display 'turn off engine' signs on approach to traffic lights at A500 and Festival Park roundabouts.
Green infrastructure	Install green walls.
	Install living wall street furniture, bus shelters etc.
Reinstate rail link	Reinstate Etruria rail link and station.

The following paragraphs provide a summary of the discussions regarding the 23 new measure categories, held during the internal stakeholder workshop on Friday 18th May, at Stoke-on-Trent City Council's Civic Centre.

Further discussion of the reasoning of the scoring for each measure is described below, followed by a table of the results using the assessment tool; with a higher total representing a more favourable measure.

AQ/LES Strategy

A broader revised AQ Strategy for Stoke-on-Trent is currently under development. The Strategy is scheduled for adoption in 2019/2020, but will not directly target the area of EU exceedance.

Unable to model the effect of the Strategy on vehicle movements without a transport model, and there are uncertainties over the timescales of the actions and the level of uptake.

Priority parking, Charging/refuelling infrastructure & Employee parking strategies
There is a will and scope to improve the EV charging network generally across the region, with interest from a number of service providers. Potential to apply priority parking for employees and public at Festival Park. Funding is available from the AQ grant. There is potential for implementation in the short-term, however retailers may be reluctant to participate. Difficult to model/quantify behavioural responses, and potential conflict with current plans to attract new people and businesses to the area. Would require a transport model.

Electric taxis/vehicles
Meeting scheduled with supplier to explore the possibility of upgrading taxis to electric vehicles. S-o-T CC have received a proposal to put black boxes inside taxis to track their route and to identify locations where there's scope to set up electric vehicle charging points. These measures are quantifiable if the Council can provide taxi fleet numbers that would be upgraded and telemetry data of taxi routes. In order to achieve compliance through this measure, it is expected the majority of taxis would need to be upgraded/retrofitted, which is unlikely in the timeframe of the feasibility study. The taxi policy is up for review in 2019/2020, but the proposed upgrades may be met with some opposition due to the capital cost of upgrading.

Park & Ride Scheme
There are currently no Park and Ride schemes in the area, and although schemes have been considered as part of local development plans, there is currently no Park and Ride scheme under development, and any such scheme would not be achievable in a timeframe that would bring forward compliance. In addition, a scheme would be expected to have a high annual running cost. In the longer term, there is the potential that the Etruria Valley development could be used as a gateway to the city centre, however this is dependent on new link road infrastructure.

Low emission buses
Bus companies have indicated that they may be willing to upgrade the existing bus fleet to Euro VI, but not EV. It is expected this would be via retrofit rather than replacement, due to the high capital costs. Retrofitting would be possible prior to the deadline. There is a bus every 15 min, and 12 buses an hour (both directions), along the route in question, indicating that a change to the bus fleet has the potential to bring forward compliance. It would be necessary to put in a caveat that retrofitted buses would have to remain in the region and/or on specified routes. Relatively simple to quantify and model.

Promotion of alternative transports & Car sharing scheme
Alternative transport options, including EVs, cycling/walking and car share schemes, will be incorporated within the AQ Grant Scheme discussed above, however at present there is no formal regional scheme, with employers tending to organise car share arrangements independently. Unable to model the effect of such measures without a transport model, and there are uncertainties over the timescales of the actions and the level of uptake.

Etruria Valley Link Road Development
The construction of the link road is expected from 2020 to 2022, however this date has not been confirmed as this is not a committed development. The long-term effects on air quality along the exceedance route are potentially very positive, with additional co-benefits including regeneration, however the development will not occur in time to bring forward compliance.

Automatic traffic control systems, A500 improvements and Road layout changes
Controlled traffic lights are already in place on both roundabouts situated on the exceedance road. The lights (and UTC system) have been in place since before 2015, and would therefore be represented by the 2017 baseline model. There is the potential for a review of traffic light operation times, however there are limitations in terms of how any further changes would achieve compliance as they are already thought to be optimised, and it is likely there would be knock-on

effects for parallel congestion routes. Anti-idling campaigns at traffic lights would be expected to have limited affect, due to the time spent at the lights, and there is uncertainty over the level of compliance. A transport model would be required to assess the impact of automatic traffic control systems and changes to road infrastructure, beyond what is already in place, which cannot be completed within the timescale of this project.

Improved driver awareness
Signs to inform drivers of alternative routes during periods of congestion are planned, and are on the same timescale as Etruria Valley Scheme (2020 – 2022). These measures are complementary and can be combined with those for the Etruria Valley Link Road. There is also the potential for the introduction of 50 mph speed cameras on A500, which may result in steadier flow onto A53, however there are currently speed cameras on the exceedance route, and the effect of changes to incoming vehicle speeds will be difficult to predict without a transport model, which will not be available during the timescales of this assessment.

Reduced speed limits
Currently 40 mph speed limit on the A53. There is potential to go down to 30 mph on the A53 and it is already 30 mph on the flyover (East of road link). Possibility for reputational risk if the Council were to introduce speed limits while unsure of the benefits and the change resulted in no positive effects. There are also questions as to whether the lower speed limits would be able to reduce 'stop-start' movement of vehicles during peak times. It's possible these changes could be put in place by 2019. The impact of these changes can be modelled and quantified, however they may have limited effect on compliance with the objective.

Business travel plans & Business travel club
Most employers are likely to have established business travel plans (especially those located on new developments), and all existing plans will be included in the baseline model. A multi-business travel plan would be difficult to enforce, and would need to be targeted at businesses located in close proximity to the identified road link. Changes to HGV routing could be quantified, but it is expected this would require a flagship store to take the lead. No routing arrangements are in place. There's uncertainty regarding the rate of uptake, and an assessment would require the use of a transport model, which cannot be completed within the timescale of the feasibility study.

Freight consolidation centre
A freight consolidation centre would potentially be effective in redistributing HGVs away from the EU exceedance link. However, this would take a significant period of time to scope, negotiate and establish, which is likely to exceed the timeframe for the feasibility study. In addition, the prediction of changes to freight movements would require the use of a transport model.

Public / school awareness campaign, Eco-driving campaign & Anti-Idling campaign
Eco Stars is already in operation and a number of local companies are already signed up to the scheme. Potential to expand. Driver awareness campaigns are inexpensive, but can difficult to quantify due to uncertainties over behavioural responses. In order to estimate the impact of these measures a transport model would be required.

Green infrastructure
Potential to install green walls/living street furniture. Difficult to determine the effect on ambient concentrations, and would not impact traffic flows on the EU exceedance route. Not applicable to the feasibility study but something that the authorities may wish to consider as a complementary measure.

Reinstate rail link
Potential to reinstate rail link at Etruria, which would potentially reduce traffic to the area. However, there are no current plans in place and if the project were to proceed, it is highly unlikely this could become operational in time to bring forward compliance. In addition, any change to traffic flows

would require the use of a transport model.

A severity-weighted assessment tool was used to score each of the long-list of measures. A score between 1 and 3 (1 being the lowest impact/least feasible, and 3 being highest benefit/most feasible) was assigned against primary success factors of: bring forward compliance; effective (at reducing emissions); timescale (reduce emissions in time); deliverable (are systems in place to implement e.g. legislation); achievable (acceptable to the community); co-benefits (e.g. noise benefits); likely uptake; positive benefits (e.g. road safety/journey times); and negative benefits (e.g. social inequality or economic impacts).

The table below provides the results.

Measure category	**Bring forward compliance**	**Effective**	**Timescale**	**Deliverable**	**Total**
Existing measures	1	1	1	2	5
AQ/LES strategy	1	1	1	2	5
Priority parking	1	1	3	1	6
Charging/refuelling infrastructure	1	1	3	1	6
Electric taxis/vehicles	1	2	2	2	7
Park & Ride Scheme	1	2	1	1	5
Low emission buses	**1**	**2**	**3**	**2**	**8**
Promotion of alternative transports	1	1	1	2	5
Car sharing scheme	1	1	1	2	5
Etruria Valley Link Road Development	1	3	1	2	7
Automatic traffic control systems	1	1	3	1	6
A500 improvements	1	1	1	1	4
Road layout changes	1	1	1	1	4
Improved driver awareness	1	1	3	1	6
Reduced speed limits	**2**	**1**	**3**	**2**	**8**
Business travel plans	1	1	2	1	5
Freight consolidation centre	1	1	1	1	4
Employee parking strategies	1	1	2	1	5
Encourage best practice travel	1	1	2	2	6
Public / school awareness campaign	1	1	1	3	6
Eco-driving campaign	1	1	1	3	6
Anti-idling campaign	1	1	3	1	6
Green infrastructure	1	1	3	1	6
Reinstate rail link	1	1	1	1	4

Based on the discussion, scoring and overall ability to quantify each measure, the following short list of measures have been identified to take forward into Part 4:

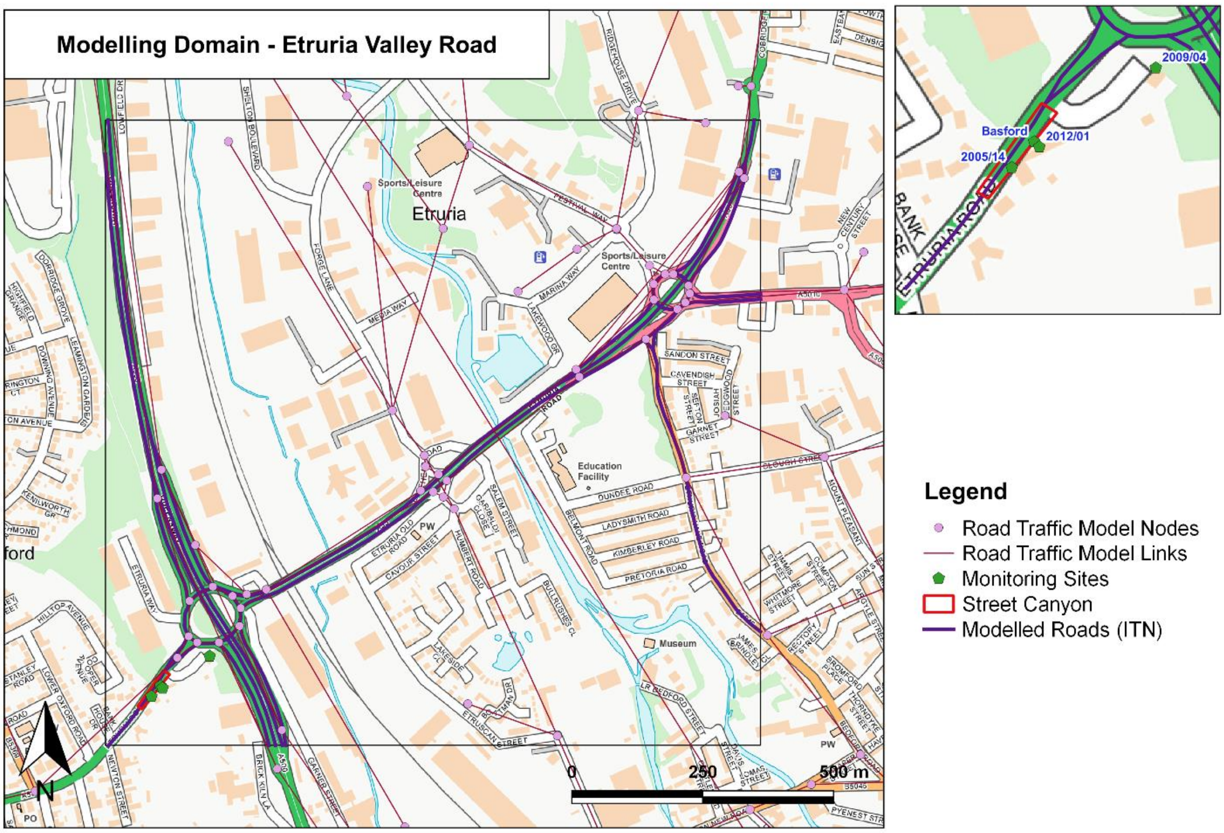
- Retrofitting of bus fleet to achieve Euro VI
- Reduction of speed limits on the A53 and on the flyover east of the road link to 30 mph

2017 Baseline modelling

In carrying out the modelling of the baseline air quality in 2017 in the concerned roads, a model domain is required. Therefore, the proposed model domain shown in Figure 1 has been chosen to cover the following:

- The parts of A53 (Etruria Road) that correspond with PCM Census IDs 26555 (Stoke-on-Trent) and 74058 (Newcastle-under-Lyme).
- The most important roads in the immediate vicinity of the before mentioned links of the A53.
- The closest relevant monitoring locations in the area.

Figure 1 – Modelling Domain



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Model Selection

RapidAir will be used for the study; this is Ricardo Energy & Environment's proprietary modelling system developed for urban air pollution assessment. The model produces high resolution concentration fields at the city scale (1 to 3 m scale), so is ideal for spatially detailed compliance modelling. A validation study has been conducted in London using the same datasets as the 2011 Defra inter-comparison study. Using the LAEI 2008 data and the measurements for the same time period the model performance is consistent (and across some metrics performs better) than other modelling solutions currently in use in the UK. RapidAir will be configured to consider street canyons and gradient effects for the relevant road links during calculations, following the recommendations made by LAQM.TG (16).

Base year and meteorological dataset

As previously mentioned, the base year in this analysis is 2017. Therefore, 2017 annual surface meteorological dataset measured at Leek Thorncliffe station (NOAA code 033300) has been processed and directly used by RapidAir.

Road traffic modelling

Average daily vehicle flows and speeds

Baseline annual average daily traffic (AADT) link flows for the concerned roads (Figure 1) have been provided by Stoke-on-Trent City Council, using outputs from the Newcastle-Stoke Transport Model (NSTM) which was run for the Etruria Valley Project in 2015. Traffic was adjusted to 2017 by using a growth factor of 1.0257, corresponding to an average day for the Staffordshire area for Urban Principal Roads. The transport model did not contain specific values of annual average daily flows (AADFs) for specific vehicle types, but rather a split between heavy duty vehicles (buses and HGVs) and remaining vehicles. The split between petrol and diesel passenger cars, light-goods vehicles (LGVs), rigid and articulated heavy-goods vehicles, buses, and motorcycles was taken from 2017 traffic count data made available by the Department for Transport (DfT) for the count points corresponding to the specific Census IDs of the study in the Staffordshire and Stoke-on-Trent Areas. These splits were applied directly on the traffic model outputs.

Vehicle fleet composition

Vehicle emission rates for the vehicle categories buses, taxis, coaches, rigid HGVs, articulated HGVs, LGVs, cars and motorcycles can be calculated using the latest COPERT v5 NO_x emission functions. Emission calculations for each vehicle category were based on vehicle age split by Euro classification. The Euro classification profiles for all the considered vehicle types were obtained from the National Atmospheric Emissions Inventory for 2017 and applied across the entire domain.

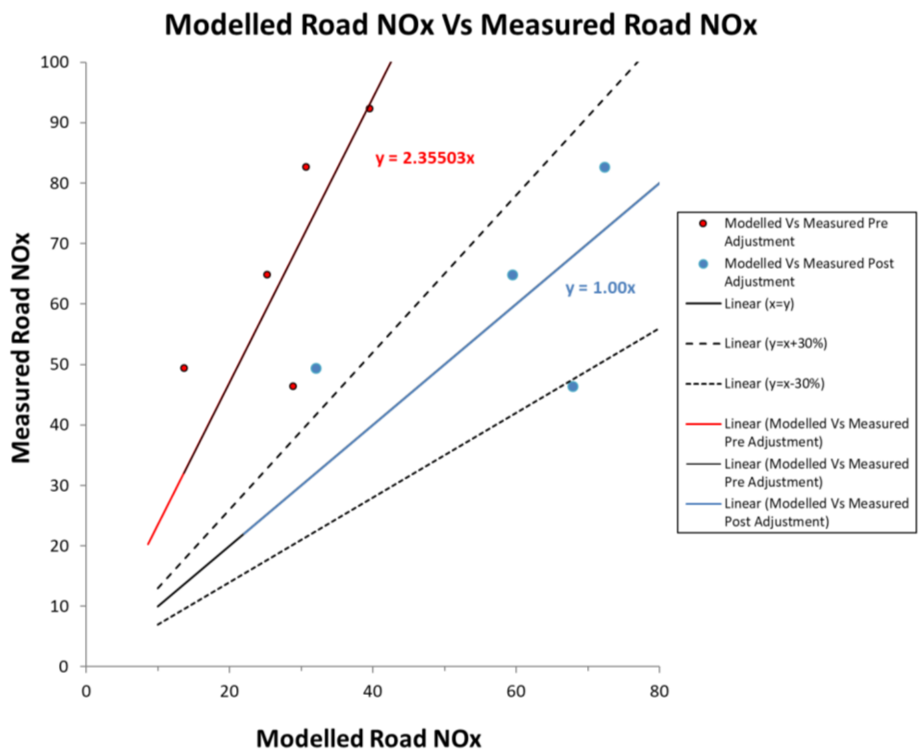
Measurement data for model calibration

The only data that was available to calibrate the model outputs came from three diffusion tubes placed along Etruria Road in the southwestern corner of the modelling domain (Figure 1), all of which were bias and distance adjusted by Newcastle-under-Lyme Borough Council. Additionally, annual means from the Stoke-on-Trent Basford monitoring station were also available.

Model verification

LAQM.TG (16) guidance on verification was followed with a total of 4 monitoring locations being used in the process. The model was verified against oxides of nitrogen (NO_x) and nitrogen dioxide (NO_2). The root mean square error (RMSE) was calculated to assess the model performance; in the case of this study, this indicator equalled **5.44 $\mu g/m^3$**, which is slightly above the 4.0 $\mu g/m^3$ threshold recommended by LAQM.TG (16). It should be noted that the number of monitoring locations was very small and only indicative of the road links located in the southwestern corner of the modelling domain.

Figure 2 – Modelled total NO_2 vs. measured total NO_2 (2017)



Definition of sensitive receptors

Roadside receptor locations in the PCM model are at a distance of 4m from the kerb and at 2m height. To represent this in our city scale modelling, a subset of the OS Mastermap GIS dataset provided spatially accurate polygons representing the road carriageway; receptor locations were then placed at 50m intervals along relevant road links using a 4m buffer around the carriageway polygons.

Model results for 2017 base year

Local model results

Table 1 – Maximum NO_2 concentrations predicted according to the local model and PCM (2017)

Census ID	Local Authority	NO_2 2017 (Local)	NO_2 2017 (PCM)
26555	Stoke-on-Trent	**52.9 µg/m³**	**46.8 µg/m³**
74058	Newcastle-under-Lyme	**66.6 µg/m³**	**46.3 µg/m³**

According to Table 1, both portions of Etruria Road in either Stoke-on-Trent or Newcastle-under-Lyme are reported to exceed the annual limit value of 40 µg/m³. In the case of the portion that falls within Stoke-on-Trent, it exceeds the annual limit value in 12.9 µg/m³, while the portion within Newcastle-under-Lyme exceeds by 26.6 µg/m³. While PCM also predicts exceedances for these Census IDs, the concentrations estimated with the local model are higher in both cases (Figures 3 and 4).

Figure 3 – NO_2 annual means predicted by PCM (2017)

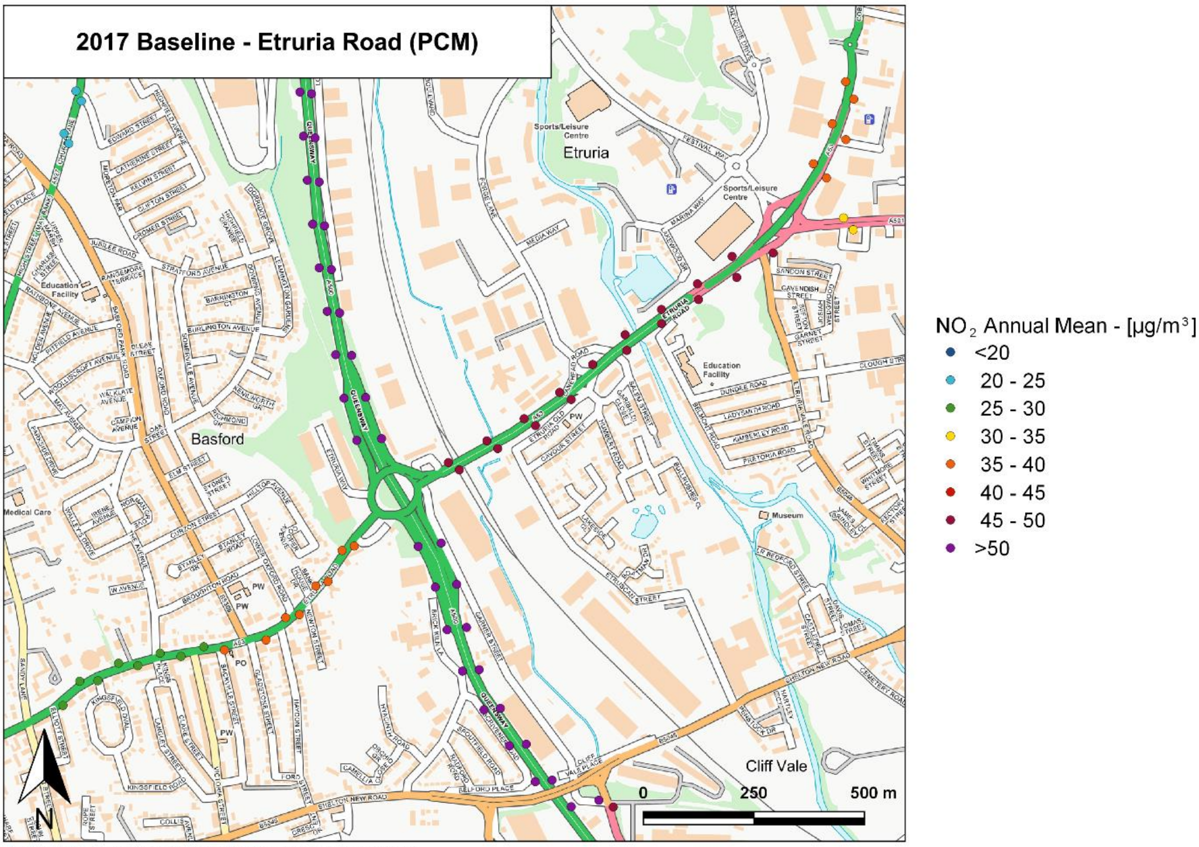
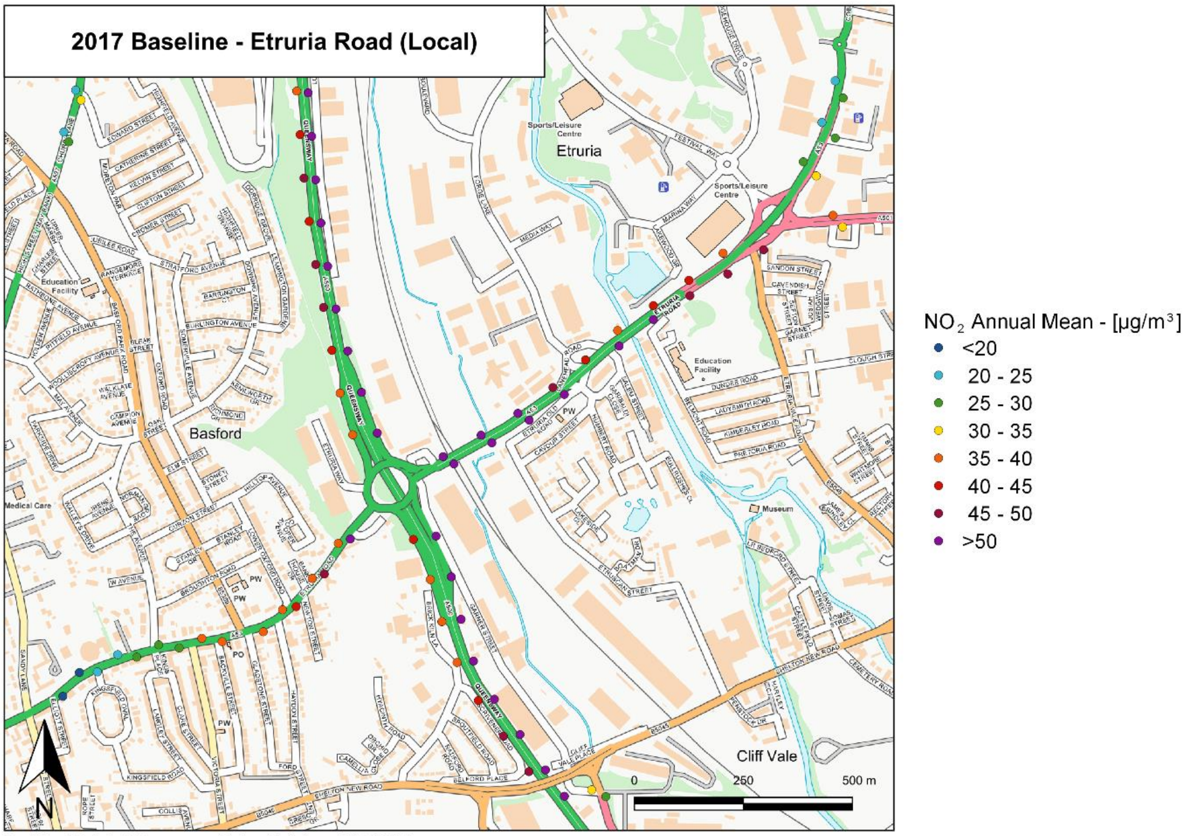


Figure 4 – NO_2 annual means predicted by the local model (2017)



It should be noted that within the modelling domain, there are five additional PCM Census IDs: 28732, 38230, 46563, 47243 and 81448. Although none of these is the focus of the present analysis, the maximum annual mean concentrations reported by both models are shown in Appendix 2. Table 2 shows the total annual emissions of CO_2, NO_x and PM_{10} (exhaust and non-exhaust) by vehicle type produced by all the roads modelled in the domain.

Table 2 – Total emissions by vehicle type of CO_2, NO_x and PM_{10} (exhaust and non-exhaust) in 2017

Vehicle Type	CO_2 – [Mg/yr]	NO_x – [Mg/yr]	PM_{10} – [Mg/yr]
Petrol Cars	41211[a]	3.67	1.40
Diesel Cars		22.64	1.45
LGVs	3234	15.45	0.83
Rigid HGVs	2326	6.22	0.54
Articulated HGVs	2457	3.34	0.39
Buses	523	3.28	0.14
TOTAL	49752	54.60	4.75

[a] *The CO_2 emissions are provided aggregated for petrol and diesel cars.*

Source apportionment results

Figure 5 – NO_2 source apportionment for the roads (2017)

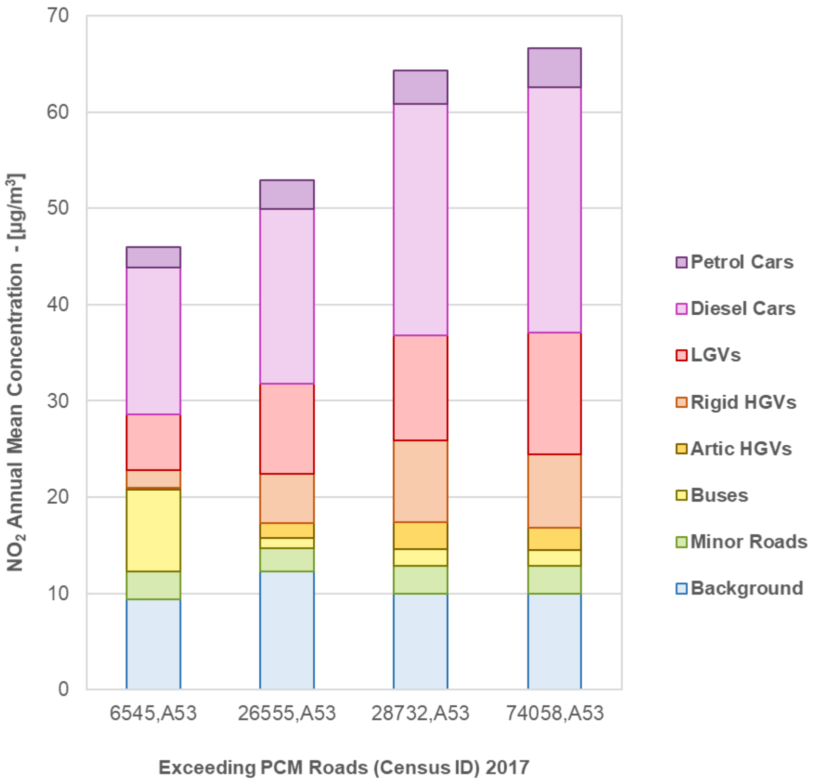


Figure 5 presents the NO_2 source apportionment for the four PCM roads that are the focus of the present modelling study: two for Etruria Road as well as Census IDs 6545 and 28732 which were reported to exceed the annual limit value of NO_2 by the city councils. In Etruria Road in Stoke-on-Trent (Census ID 26555), the most significant contribution is the one of diesel passenger cars, accounting for 18.13 µg/m^3 followed by LGVs (9.40 µg/m^3). There is also a significant contribution of the background (12.24 µg/m^3), which is composed of non-road sources. As for Etruria Road in Newcastle-under-Lyme, diesel passenger cars are also the most important source of emissions, accounting for 25.48 µg/m^3 of the total 66.6 µg/m^3. In this road, LGVs and rigid HGVs are the second and third most important sources, contributing with 8.75 µg/m^3 and 2.73 µg/m^3, respectively. A similar distribution of source contributions can be seen for the two additional roads that are being modelled. It should be noted that the NO_2 concentrations and source apportionment reported in Figure 5 for Census ID 6545 have already been scaled to the actual measured (and exceeding) concentration of 46 µg/m^3.

Modelling issues with road link 6545

It should be noted that the annual mean concentration of NO_2 reported for Census ID 6545 by the local air quality model is 37.0 µg/m^3, while the monitoring value equals 46.0 µg/m^3. The way the model has been configured does not currently allow identifying the sources that account for the difference between modelled and observed values. Therefore, the monitoring value will be used in preference and the absolute concentration reductions obtained for each of the measures will be applied only to the roadside component to ascertain potential compliance with the annual limit value, after an appropriate split of the diffusion tube value following the guidance in LAQM.TG16 is done.

Table 15: Expected compliance for Census ID 6545 based on monitoring value

Scenario	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Baseline	46.0	45.0	44.1	42.8	41.7	40.6	39.3	38.4	34.0	33.1	32.3
Measure 1	46.0	45.0	43.2	41.0	38.8	36.7	35.6	34.7	33.7	32.9	32.1
Measure 2	46.0	44.9	44.0	42.8	41.7	40.6	39.3	38.4	34.0	33.1	32.2
Measure 3	46.0	44.9	44.0	42.8	41.6	40.6	39.2	38.4	33.9	33.0	32.2
All Meas.	46.0	44.9	43.1	40.9	38.8	36.6	35.6	34.6	33.7	32.8	32.1

Conclusions

When the links of concern of Etruria Road (Census IDs 26555 and 74058) are modelled at a higher resolution with RapidAir and with the data from the local traffic model for 2017, the annual mean concentration is higher in both cases than the one estimated with the PCM (namely 52.9 μg/m^3 and 66.6 μg/m^3, respectively). In both cases, the differences can be attributed to more representative vehicle flows data and speeds, as well as a higher modelling resolution and a localised calibration. It should be noted however, that there was only data available for four monitoring sites, one of which is the Stoke-on-Trent Basford monitoring station. With the above in mind, the assessment of compliance under "business-as-usual" conditions for a number of subsequent years (2018-2027) is recommended for the two portions of Etruria Road.

Part 4: Evidencing the short-listed measures to identify options that could bring forward compliance

I. Impact of measures on traffic variables

The Excel document 'Template for part 4 of third wave studies_STCC+NLBC' details the baseline values for traffic variables for the modelling domain set out in Part 3. Under Part 4, it was decided to extend the modelling domain to include two further census IDs; 6545 and 28732. These links were identified as being close to exceedance using local monitoring data, and thus have been included in the study as per JAQU guidance. Values are projected for each year between 2017 and 2027 for all modelled measures as well as the baseline. The baseline values for each year are categorised by:

- Flow: annual average daily flow (AADF)
- Composition by vehicle kilometres: by vehicle type (buses, taxis, coaches, rigid HGVs, articulated HGVs, LGVs, cars and motorcycles), fuel type and Euro standard
- Speed: average speed of the traffic averaged over a year

Table 3 outlines how the proposed measures are estimated to affect the above variables and the sources of evidence used to inform the measures.

Table 3: Impact assumptions and evidence sources for each measure

Measure	Impact assumptions	Evidence sources
Measure 1: Retrofitting of bus fleet to achieve Euro VI	Change in traffic composition Renewal/retrofit of the bus fleet from Euro III to Euro VI	Euro standard of local bus fleet using road links provided by council.

<table>
<tr>
<td></td>
<td>Assume 25% upgrade of bus fleet by 2019 and 50% upgrade of bus fleet by 2020

Fleet composition was updated to reflect the following upgrade scheme:

<table>
<tr><th>Year</th><th>Euro III (%)</th><th>Euro VI (%)</th></tr>
<tr><td>2017</td><td>100</td><td>0</td></tr>
<tr><td>2018</td><td>100</td><td>0</td></tr>
<tr><td>2019</td><td>75</td><td>25</td></tr>
<tr><td>2020</td><td>50</td><td>50</td></tr>
<tr><td>2021</td><td>25</td><td>75</td></tr>
<tr><td>2022</td><td>0</td><td>100</td></tr>
<tr><td>2023</td><td>0</td><td>100</td></tr>
<tr><td>2024</td><td>0</td><td>100</td></tr>
<tr><td>2025</td><td>0</td><td>100</td></tr>
<tr><td>2026</td><td>0</td><td>100</td></tr>
<tr><td>2027</td><td>0</td><td>100</td></tr>
</table>
</td>
<td>The council have applied for funding under the Low Emission Bus Fund, to retrofit the existing fleet to achieve Euro VI. Assumptions have been applied on the potential implementation of this scheme.</td>
</tr>
<tr>
<td>Measure 2: Reduction of speed limits on the A53 and on the flyover east of the road link to 30 mph</td>
<td><u>Change in average speed on road</u>

Reduction of speed limit to 48.3 km/h in the A53 (Etruria Valley Road) and only for those road links which have a speed higher than the limit
<table>
<tr><th>Year</th><th>Speed limit (km/h)</th></tr>
<tr><td>2017</td><td>64.4</td></tr>
<tr><td>2018</td><td>48.3</td></tr>
<tr><td>2019</td><td>48.3</td></tr>
<tr><td>2020</td><td>48.3</td></tr>
<tr><td>2021</td><td>48.3</td></tr>
<tr><td>2022</td><td>48.3</td></tr>
<tr><td>2023</td><td>48.3</td></tr>
<tr><td>2024</td><td>48.3</td></tr>
<tr><td>2025</td><td>48.3</td></tr>
<tr><td>2026</td><td>48.3</td></tr>
<tr><td>2027</td><td>48.3</td></tr>
</table>

This corresponds to a change in average speed across the model domain from 36.7 (2017) to 36.1 (2018 – 2024)</td>
<td>Current speed limit information provided by Council. The reduced speed limit, in km per hour, was applied on those links of Etruria Road that had an average speed value higher than the limit, based on the Council’s vehicle speed data. Links where the average speeds were lower than the limit, remained unchanged.</td>
</tr>
<tr>
<td>Measure 3: Electric vehicle strategy</td>
<td><u>Increase the number of electric vehicles in the fleet (including cars and taxis)</u></td>
<td>The NAEI indicates EVs currently account for ~0.2 % of the vehicle mix and are forecast to account for 0.3 %</td>
</tr>
</table>

	Three scenarios modelled, including a central case, and high and low sensitivity cases. Under the central case, it has been assumed the rate of EV uptake would increase around Stoke and Newcastle, as a result of a broader package of measures introduced by the Councils (i.e. promotion of EVs, new charging infrastructure, marketing campaigns and priority taxi ranks), compared to the national average in recent years. This assumes an additional 0.2 % per annum – resulting in 0.6 % by 2020.The low sensitivity analysis assumes a 0.1 % increase per annum, which is in line with the NAEI forecast, whilst the high sensitivity analysis assumes a 0.3 % increase, resulting in 0.8 % of the fleet being EV by 2020.	in 2020 and 1.2 % in 2027.

II. Change in emissions of NO_x at the roadside

Vehicle emission factors for oxides of nitrogen (NO_x) were obtained from COPERT v5 emission functions.[1] Link specific emission factors were calculated for all vehicles up to and including Euro VI were calculated with Ricardo's emission calculation tool RapidEms, which links directly to the RapidAir dispersion modelling system. Tables 4 – 8 show the modelled change in emissions of NO_x at the roadside for the baseline scenario, Measure 1, Measure 2, Measure 3 and All Measures combined (incl. the Central scenario for Measure 3) respectively.

Table 4: Change in emissions of NO_x at the roadside: Baseline. Units: Mg/yr

Vehicle Type	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Petrol Cars	3.67	3.34	3.13	3.03	2.95	2.93	2.93	2.96	3.02	3.08	3.15
Diesel Cars	22.64	22.94	22.90	21.66	20.19	18.65	17.13	15.60	14.03	12.52	11.08
LGVs	15.45	14.15	12.95	12.16	11.04	9.91	9.12	8.39	7.69	7.03	6.44
Rigid HGVs	6.22	5.15	4.23	3.16	2.57	2.11	1.76	1.49	1.29	1.15	1.06
Articulated HGVs	3.34	2.56	1.98	1.55	1.24	1.03	0.90	0.82	0.76	0.74	0.72
Buses	3.28	3.22	3.17	3.13	3.09	3.06	2.77	2.77	2.77	2.77	2.78
TOTAL	54.60	51.36	48.35	44.68	41.07	37.68	34.61	32.01	29.56	27.29	25.22

[1] National Atmospheric Emissions Inventory, "Emission factors for transport", http://naei.beis.gov.uk/data/ef-transport, accessed 24/06/2018.

Table 5: Change in emissions of NO_x at the roadside: Measure 1. Units: Mg/yr

Vehicle Type	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Petrol Cars	3.67	3.34	3.13	3.03	2.95	2.93	2.93	2.96	3.02	3.08	3.15
Diesel Cars	22.64	22.94	22.90	21.66	20.19	18.65	17.13	15.60	14.03	12.52	11.08
LGVs	15.45	14.15	12.95	12.16	11.04	9.91	9.12	8.39	7.69	7.03	6.44
Rigid HGVs	6.22	5.15	4.23	3.16	2.57	2.11	1.76	1.49	1.29	1.15	1.06
Articulated HGVs	3.34	2.56	1.98	1.55	1.24	1.03	0.90	0.82	0.76	0.74	0.72
Buses	3.28	3.22	2.53	1.83	1.12	0.41	0.34	0.30	0.27	0.26	0.24
TOTAL	54.60	51.36	47.71	43.39	39.10	35.04	32.18	29.55	27.06	24.77	22.68
Delta Emissions[a]	0.00	0.00	0.64	1.30	1.96	2.65	2.44	2.46	2.49	2.52	2.53
%Reduction[a]	0.00	0.00	1.32	2.90	4.78	7.02	7.04	7.70	8.44	9.22	10.05

[a]Additional to the "business-as-usual" reductions accounted for in the baseline.

Table 6: Change in emissions of NO_x at the roadside: Measure 2. Units: Mg/yr

Vehicle Type	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Petrol Cars	3.67	3.32	3.12	3.01	2.93	2.91	2.91	2.94	3.00	3.06	3.13
Diesel Cars	22.64	22.80	22.75	21.53	20.06	18.53	17.03	15.50	13.94	12.45	11.01
LGVs	15.45	14.06	12.86	12.08	10.96	9.85	9.06	8.33	7.63	6.98	6.39
Rigid HGVs	6.22	5.13	4.22	3.15	2.56	2.10	1.76	1.49	1.29	1.15	1.05
Articulated HGVs	3.34	2.56	1.98	1.54	1.24	1.03	0.90	0.81	0.76	0.74	0.72
Buses	3.28	3.19	3.14	3.10	3.06	3.03	2.75	2.74	2.74	2.74	2.75
TOTAL	54.60	51.06	48.06	44.41	40.81	37.45	34.40	31.81	29.37	27.11	25.06
Delta Emissions[a]	0.00	0.31	0.29	0.27	0.25	0.23	0.22	0.20	0.19	0.17	0.16
%Reduction[a]	0.00	0.59	0.60	0.61	0.62	0.62	0.63	0.63	0.63	0.64	0.64

[a]Additional to the "business-as-usual" reductions accounted for in the baseline.

Table 7: Change in emissions of NO_x at the roadside: Measure 3 (Central). Units: Mg/yr

Vehicle Type	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Petrol Cars	3.67	3.34	3.13	3.02	2.94	2.91	2.92	2.94	3.00	3.05	3.12
Diesel Cars	22.64	22.89	22.84	21.60	20.13	18.58	17.06	15.51	13.94	12.42	10.97
LGVs	15.45	14.15	12.95	12.16	11.04	9.91	9.12	8.39	7.69	7.03	6.44
Rigid HGVs	6.22	5.15	4.23	3.16	2.57	2.11	1.76	1.49	1.29	1.15	1.06
Articulated HGVs	3.34	2.56	1.98	1.55	1.24	1.03	0.90	0.82	0.76	0.74	0.72
Buses	3.28	3.22	3.17	3.13	3.09	3.06	2.77	2.77	2.77	2.77	2.78
TOTAL	54.60	51.31	48.29	44.61	41.00	37.61	34.53	31.91	29.45	27.17	25.08
Delta Emissions[a]	0.00	0.05	0.06	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13
%Reduction[a]	0.00	0.10	0.13	0.17	0.17	0.20	0.25	0.31	0.37	0.45	0.53

[a]Additional to the "business-as-usual" reductions accounted for in the baseline.

Table 8: Change in emissions of NO_x at the roadside: All measures (Central). Units: Mg/yr

Vehicle Type	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Petrol Cars	3.67	3.31	3.11	3.00	2.92	2.89	2.89	2.92	2.97	3.03	3.09
Diesel Cars	22.64	22.75	22.70	21.46	19.99	18.45	16.94	15.40	13.83	12.33	10.88
LGVs	15.45	14.06	12.86	12.08	10.96	9.85	9.06	8.33	7.63	6.98	6.39
Rigid HGVs	6.22	5.13	4.22	3.15	2.56	2.10	1.76	1.49	1.29	1.15	1.05

Articulated HGVs	3.34	2.56	1.98	1.54	1.24	1.03	0.90	0.81	0.76	0.74	0.72
Buses	3.28	3.19	2.50	1.81	1.11	0.41	0.33	0.30	0.27	0.25	0.24
TOTAL	54.60	51.01	47.36	43.05	38.78	34.73	31.88	29.25	26.77	24.48	22.38
Delta Emissions[a]	0.00	0.36	0.99	1.63	2.28	2.95	2.74	2.76	2.79	2.81	2.84
%Reduction[a]	0.00	0.69	2.04	3.65	5.56	7.82	7.90	8.62	9.44	10.31	11.25

[a]Additional to the "business-as-usual" reductions accounted for in the baseline.

All measures were shown to achieve a reduction in total NO_x emitted from roadside sources. Measure 1 (retrofitting of the bus fleet) achieved a modelled reduction in total NO_x of 1.32% – 10.05% between 2019 and 2027. Measure 2 (reduction of speed limit) achieved a modelled reduction in total NO_x of 0.59% – 0.64% between 2018 and 2027. Measure 3 (electric vehicle strategy – central scenario) achieved a modelled reduction in total NO_x of 0.1% – 0.53% between 2018 and 2027. All measures combined achieved a modelled reduction in total NO_x of 0.69 – 11.25% between 2018 and 2027.

III. Change in concentration of NO_2 at the roadside

As discussed in Part 3, RapidAir has been used for the study; this is Ricardo Energy & Environment's proprietary modelling system developed for urban air pollution assessment. The model produces high resolution concentration fields at the city scale (1 to 3 m scale), so is ideal for spatially detailed compliance modelling. Table 9 details the roads concerned by the feasibility study and their PCM baseline results for 2017.

Table 9: Road link details

Census ID	Road Name	LA	Length (m)	X (m)	Y (m)	PCM baseline results 2017
6545	A53	NLBC	643	385625	346450	26.132
26555	A53	STCC	588	386983	347327	46.765
28732	A53	NLBC	545	386272	346794	36.516
74058	A53	NLBC	492	386450	346970	46.34

Tables 10 – 14 contain the maximum NO_2 concentrations modelled for the PCM receptors (by Census IDs) of roads concerned by the feasibility study for the baseline scenario, Measure 1, 2 and 3, and the combination of all Measures, respectively. As explained above, monitoring data is used in preference to modelling data for the baseline projections for road link 6545. The results show that the implementation of Measures 1, and all measures combined would result in compliance being achieved in all the roads in 2025 (Census ID 74058 being the last road to achieve compliance). Measures 2 and 3 implemented alone does not bring forward compliance. The combination of all measures also allows achieving compliance in 2025 with slightly improved NO_2 levels in the concerned roads. The order whereby the roads comply with the NO_2 annual limit value is as follows:

- 6545: 2023 in the baseline; 2021 with the application of all measures.
- 26555: 2022 in the baseline; 2022 with the application of all measures.
- 28732: 2025 in the baseline; 2024 with the application of all measures.
- 74058: 2026 in the baseline; 2025 with the application of all measures.

In conclusion, the application of all measures (or Measure 1 only) brings compliance forward one year for Census ID 28732 and 74058, except for Census ID 6545 in which compliance is brought forward two years. It does not bring forward compliance for Census ID 26555.

Table 10: NO_2 Local model (Baseline)

Census ID	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6545	46.0	45.0	44.1	42.8	41.7	40.6	39.3	38.4	34.0	33.1	32.3
26555	52.9	50.7	48.5	45.7	43.0	40.3	37.9	35.7	33.7	31.7	29.9
28732	64.4	60.8	57.6	53.6	50.0	46.6	43.4	40.7	38.2	35.8	33.6
74058	66.6	63.6	60.7	56.8	53.2	49.6	46.4	43.4	40.8	38.1	35.7

Table 11: NO_2 Local model (Measure 1)

Census ID	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6545	46.0	45.0	43.2	41.0	38.8	36.7	35.6	34.7	33.7	32.9	32.1
26555	52.9	50.7	48.2	45.0	41.9	38.9	36.5	34.3	32.1	30.2	28.4
28732	64.4	60.8	57.2	52.7	48.6	44.7	41.7	38.9	36.2	33.7	31.5
74058	66.6	63.6	60.4	56.3	52.3	48.3	45.2	42.2	39.3	36.6	34.1

Table 12: NO_2 Local model (Measure 2)

Census ID	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6545	46.0	44.9	44.0	42.8	41.7	40.6	39.3	38.4	34.0	33.1	32.2
26555	52.9	50.7	48.5	45.6	42.9	40.3	37.8	35.7	33.7	31.7	29.9
28732	64.4	60.6	57.4	53.4	49.8	46.4	43.3	40.5	38.1	35.7	33.5
74058	66.6	63.0	60.1	56.3	52.7	49.1	45.9	43.0	40.4	37.8	35.3

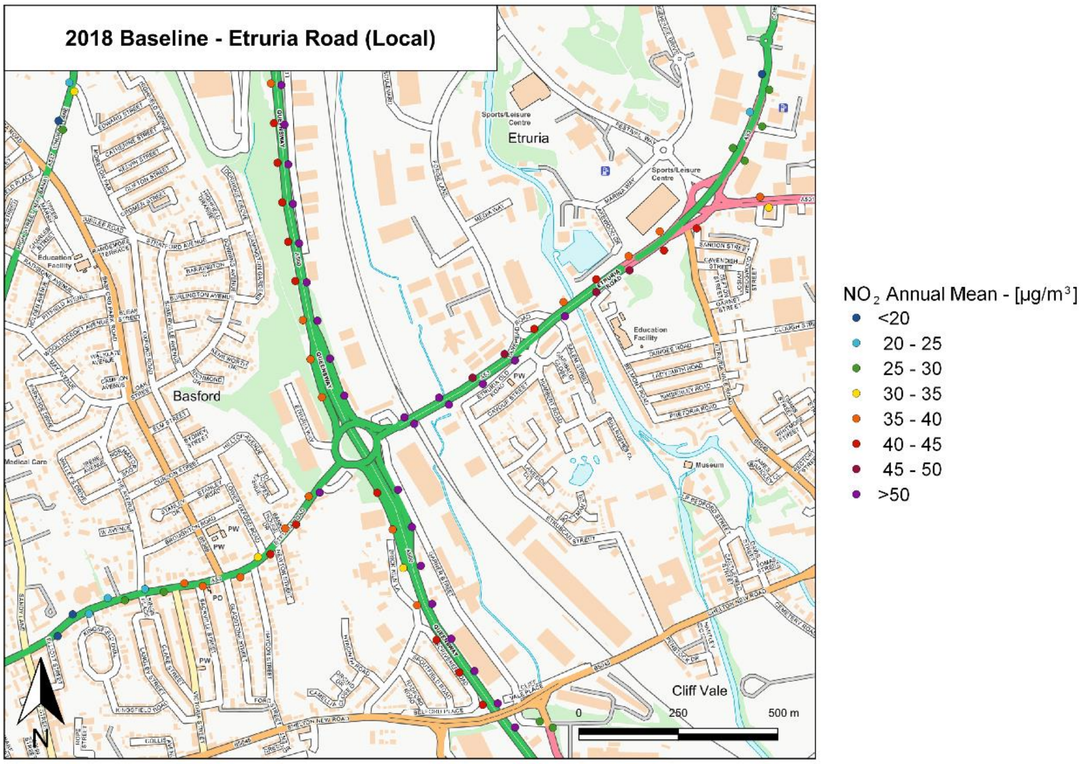
Table 13: NO_2 Local model (Measure 3 - Central)

Census ID	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6545	46.0	44.9	44.0	42.8	41.6	40.6	39.2	38.4	33.9	33.0	32.2
26555	52.9	50.7	48.5	45.6	42.9	40.3	37.8	35.6	33.6	31.6	29.8
28732	64.4	60.8	57.5	53.5	49.9	46.5	43.4	40.6	38.1	35.7	33.5
74058	66.6	63.5	60.6	56.8	53.1	49.5	46.3	43.3	40.6	38.0	35.5

Table 14: NO_2 Local model (All Measures - Central)

Census ID	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
6545	46.0	44.9	43.1	40.9	38.8	36.6	35.6	34.6	33.7	32.8	32.1
26555	52.9	50.6	48.1	44.9	41.9	38.8	36.5	34.2	32.0	30.1	28.3
28732	64.4	60.5	56.9	52.5	48.4	44.5	41.4	38.6	35.9	33.5	31.2
74058	66.6	63.0	59.8	55.7	51.7	47.8	44.6	41.7	38.8	36.1	33.7

Figure 6 – NO_2 annual means for 2018 Baseline



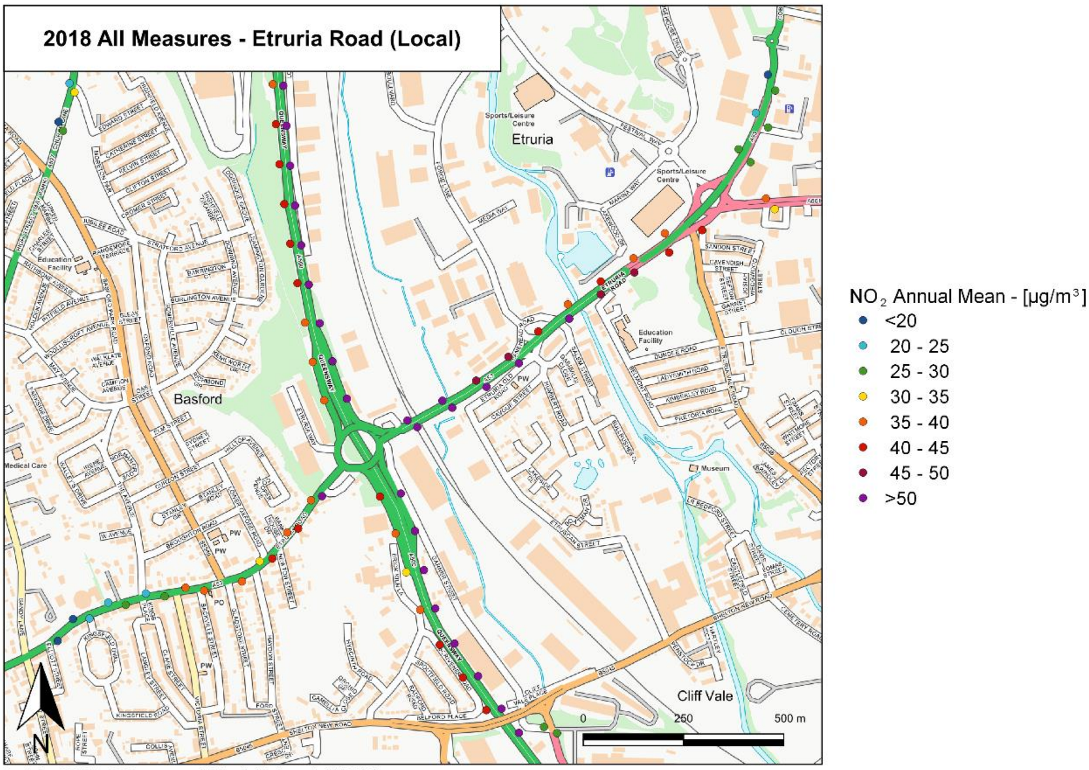
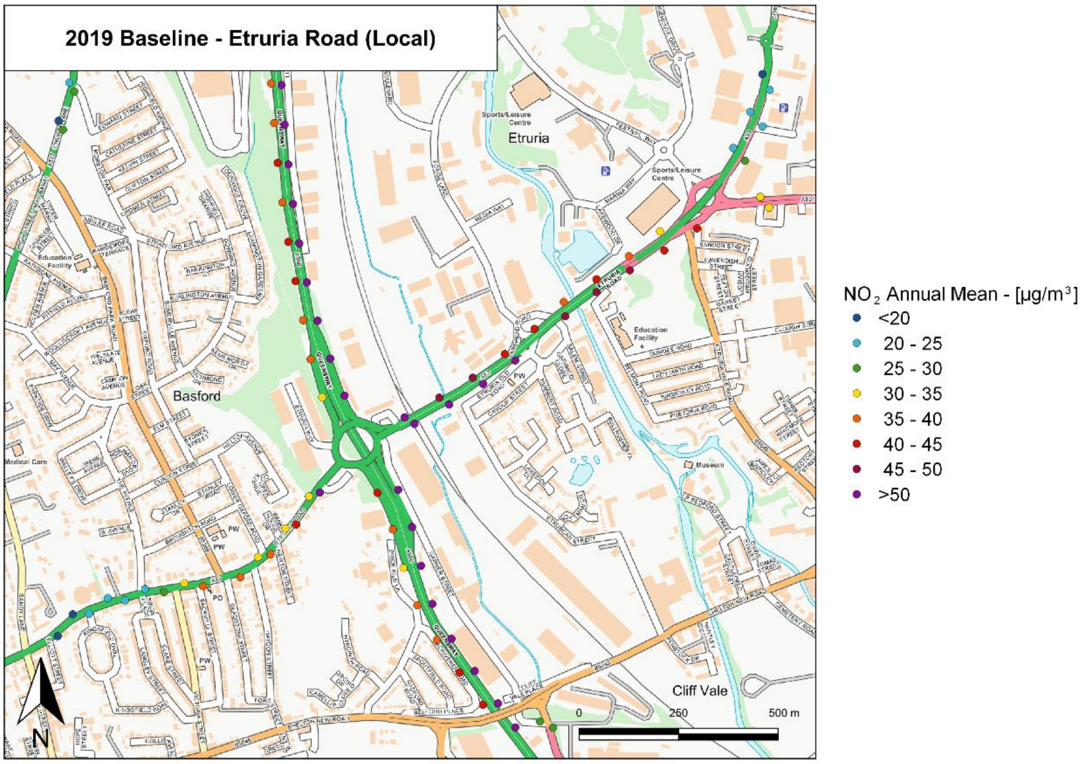


Figure 7 – NO_2 annual means for 2018 All Measures

Figure 8 – NO_2 annual means for 2019 Baseline



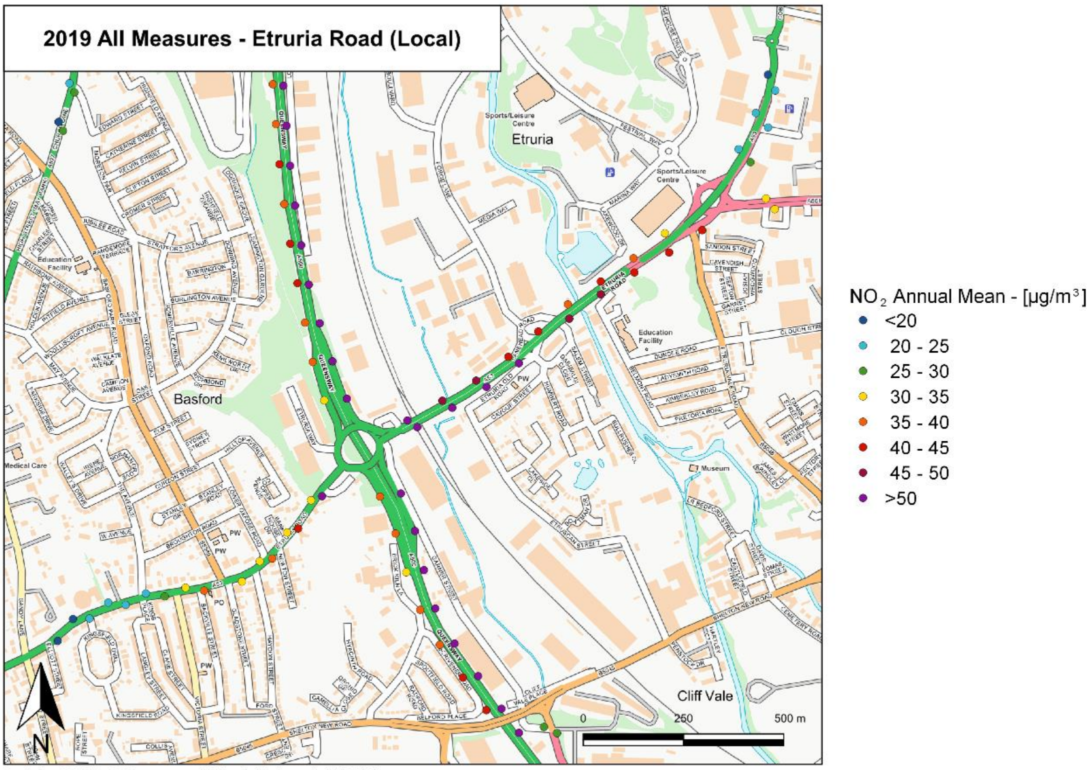
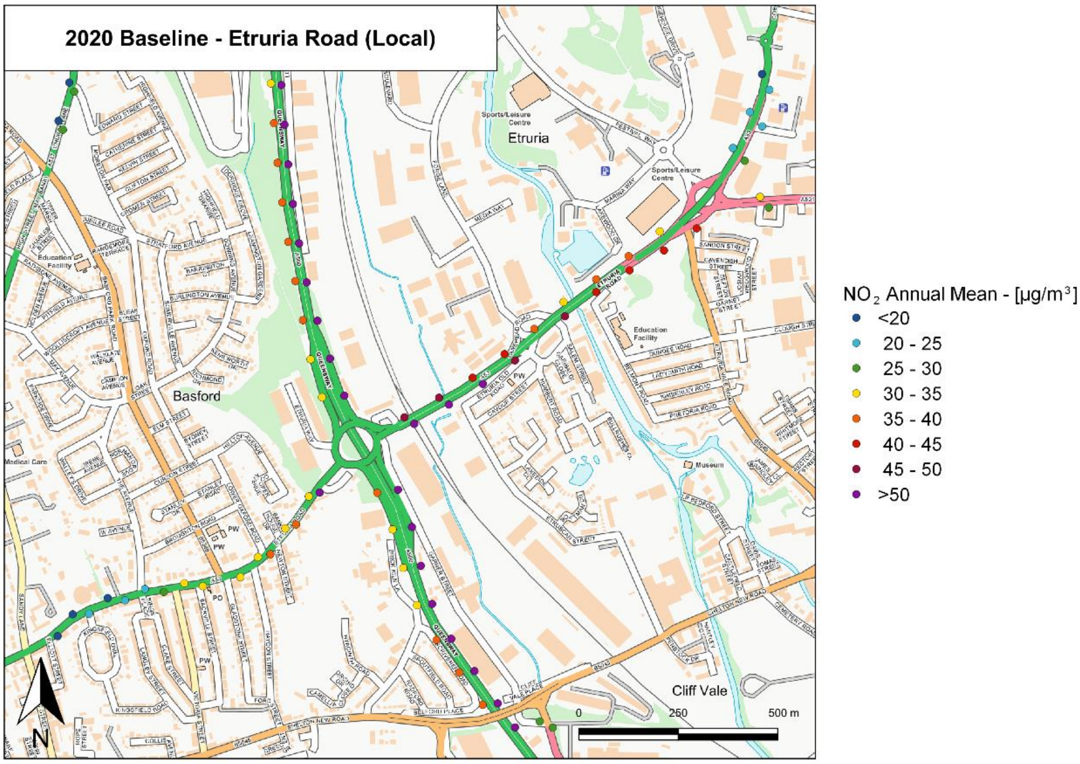


Figure 9 – NO_2 annual means for 2019 All Measures

Figure 10 – NO_2 annual means for 2020 Baseline



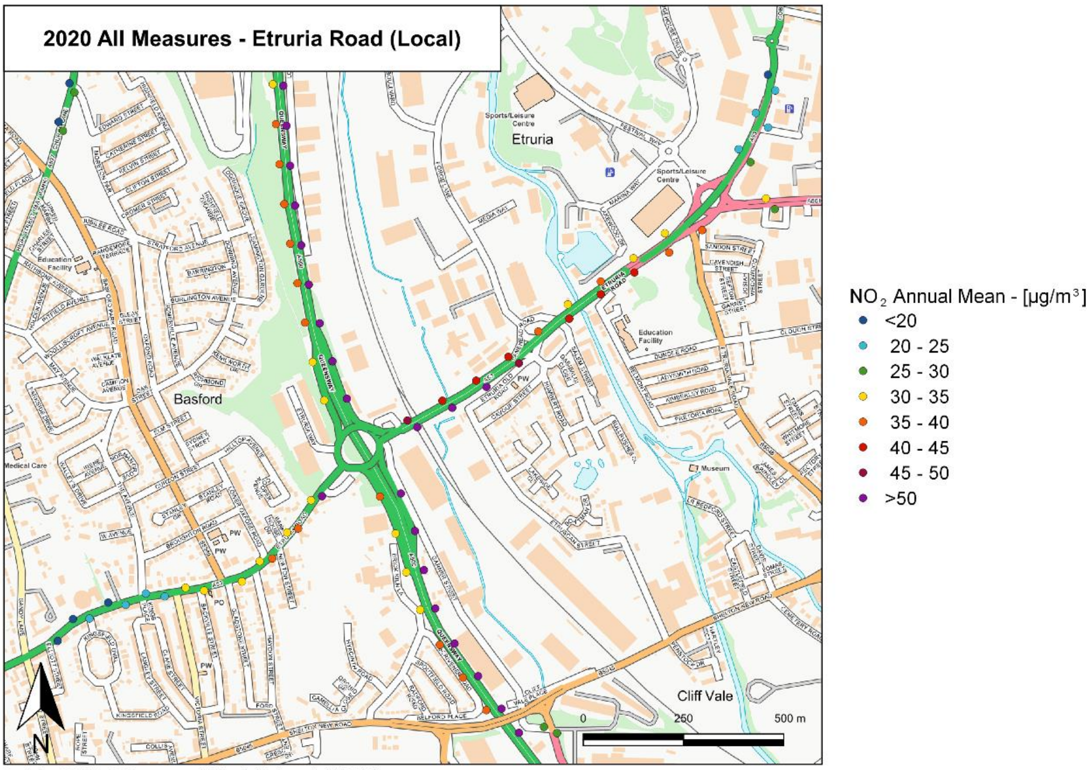
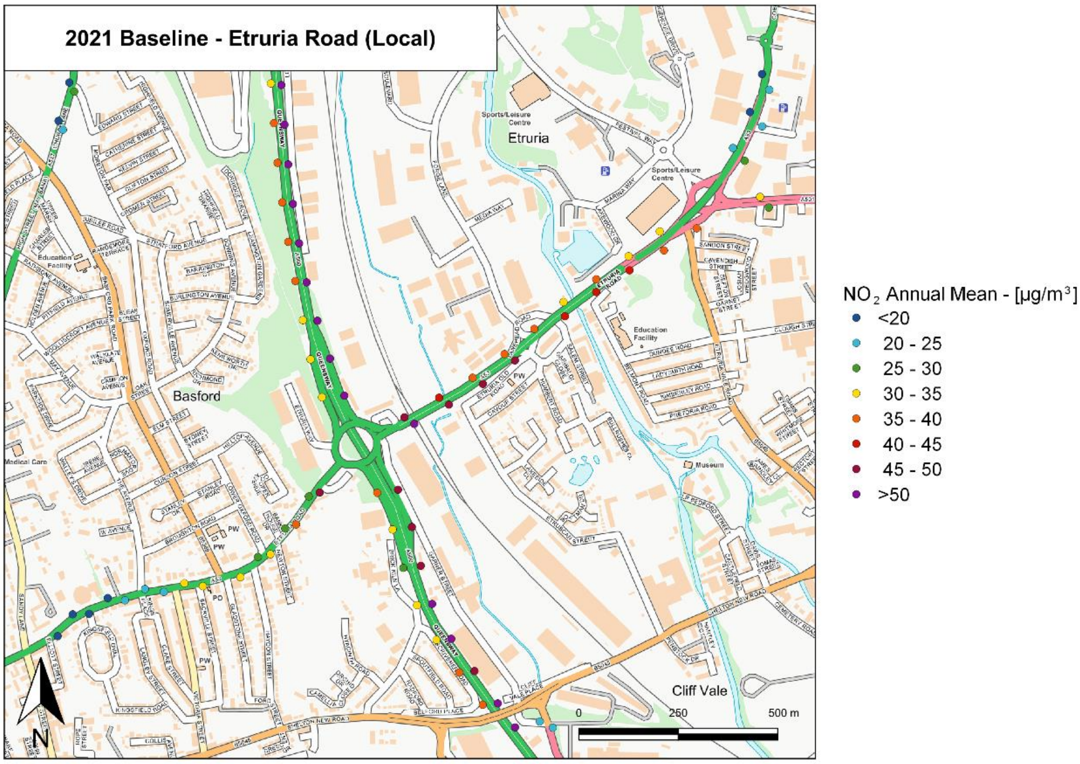


Figure 11 – NO_2 annual means for 2020 All Measures

Figure 12 – NO_2 annual means for 2021 Baseline



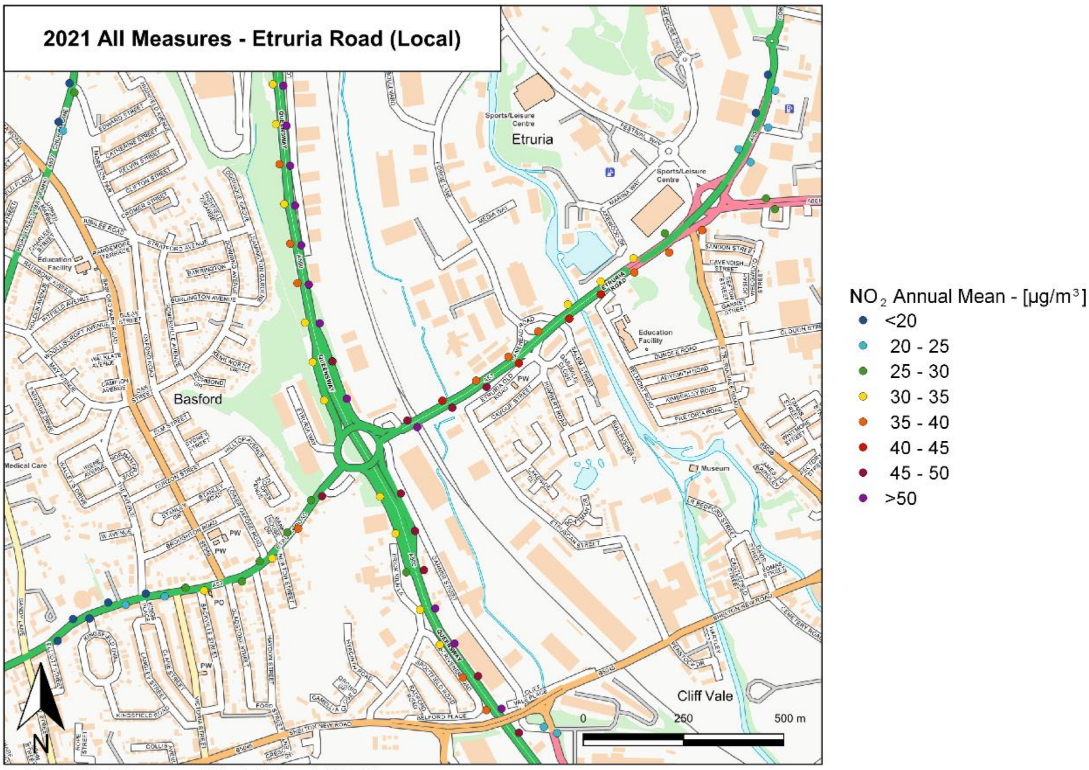
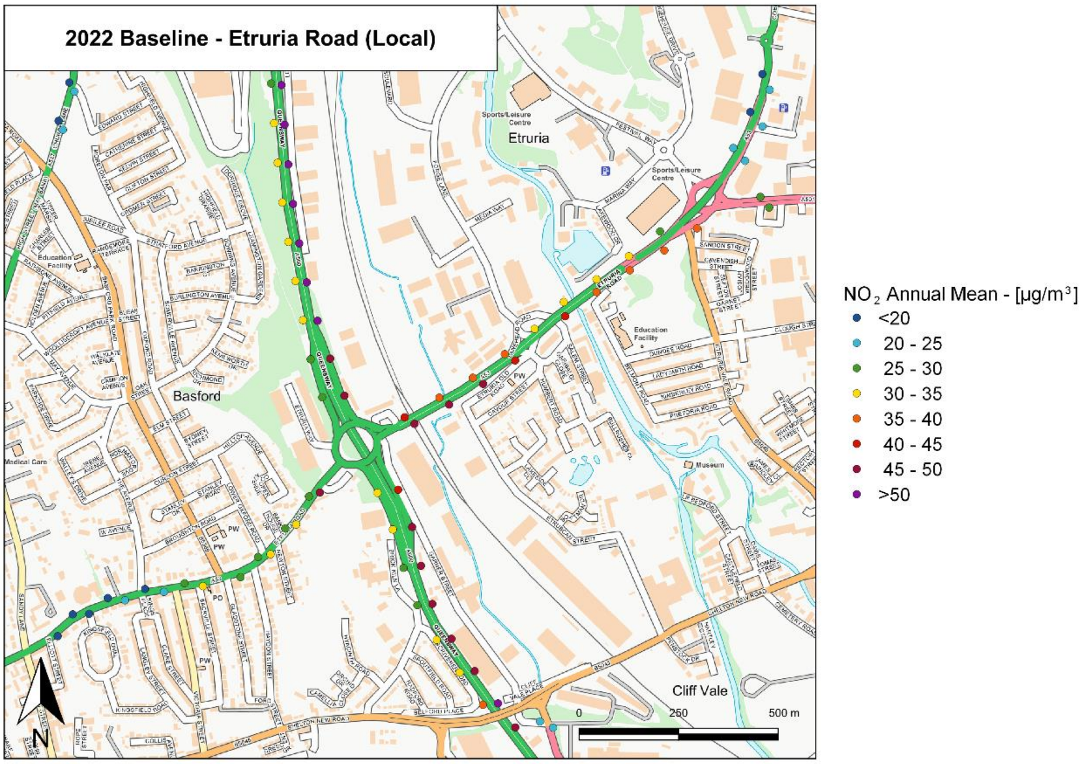
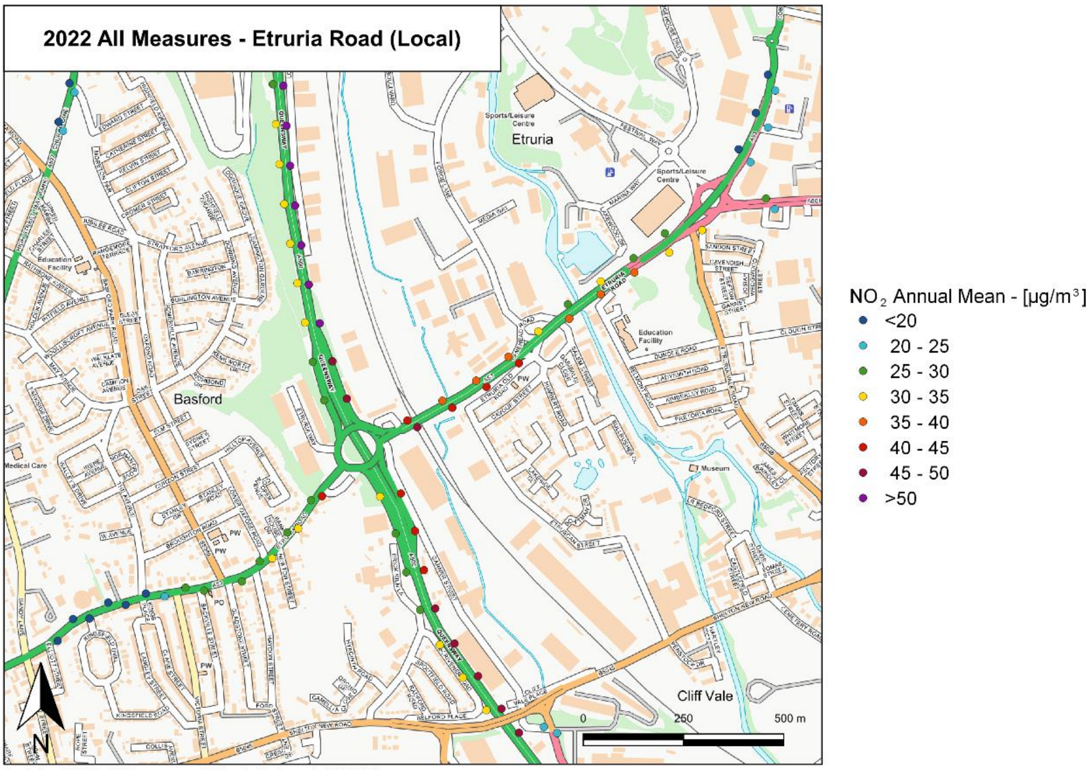


Figure 13 – NO_2 annual means for 2021 All Measures¶

Figure 14 – NO_2 annual means for 2022 Baseline



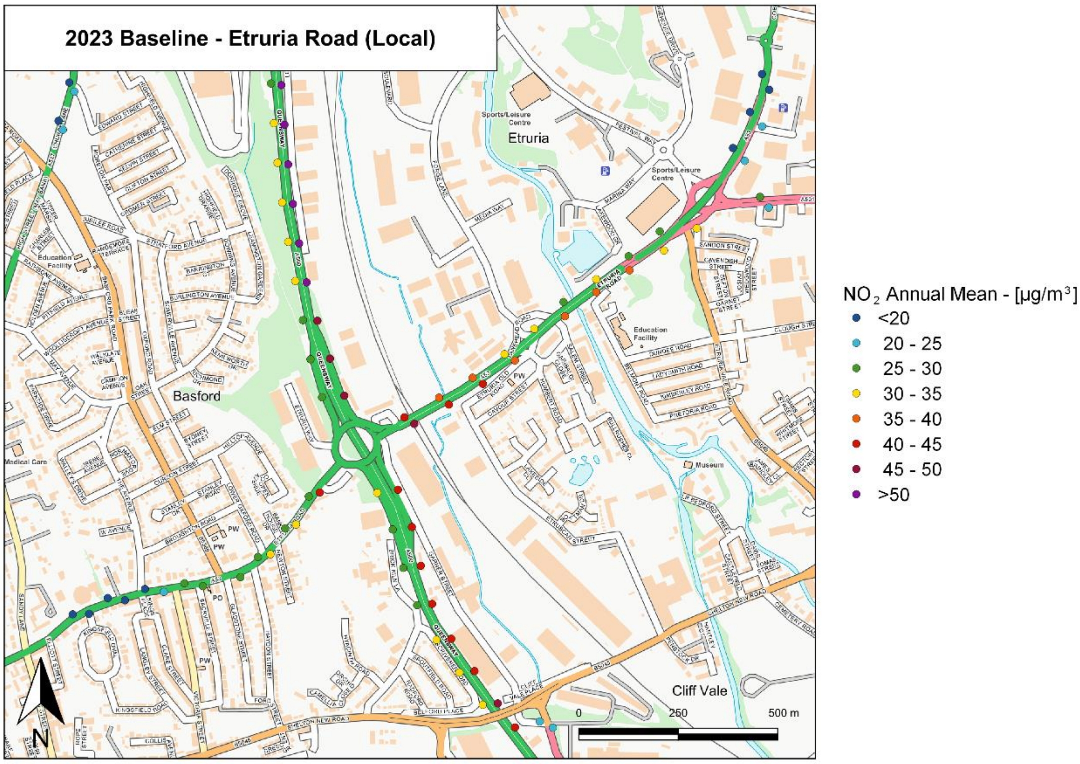
Contains OS data © Crown copyright and database right (2018)



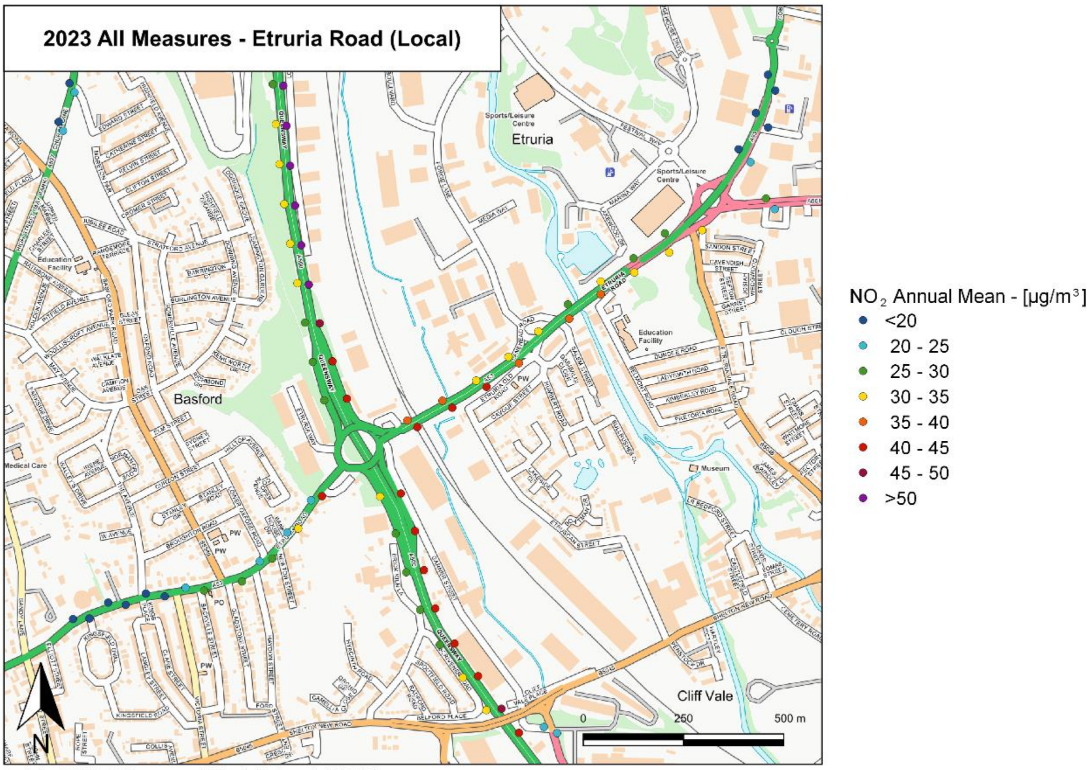
Contains OS data © Crown copyright and database right (2018)

Figure 15 – NO_2 annual means for 2022 All Measures¶

Figure 16 – NO_2 annual means for 2023 Baseline



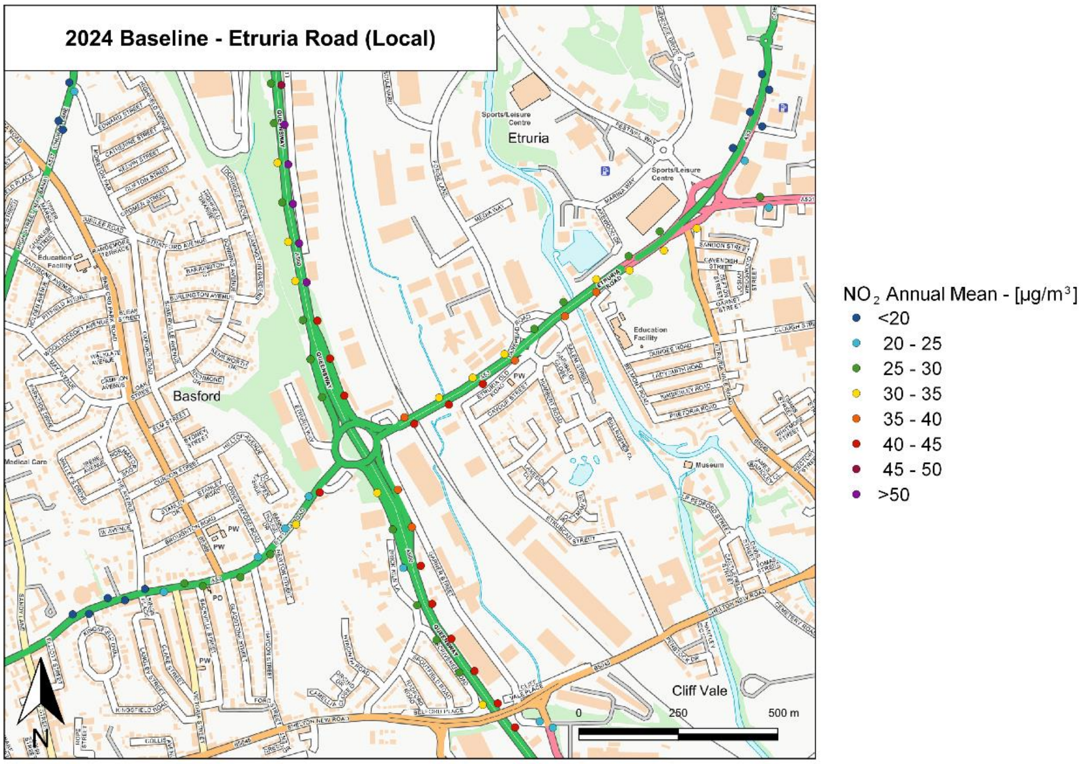
Contains OS data © Crown copyright and database right (2018)



Contains OS data © Crown copyright and database right (2018)

Figure 17 – NO_2 annual means for 2023 All Measures¶

Figure 18 – NO_2 annual means for 2024 Baseline



Contains OS data © Crown copyright and database right (2018)

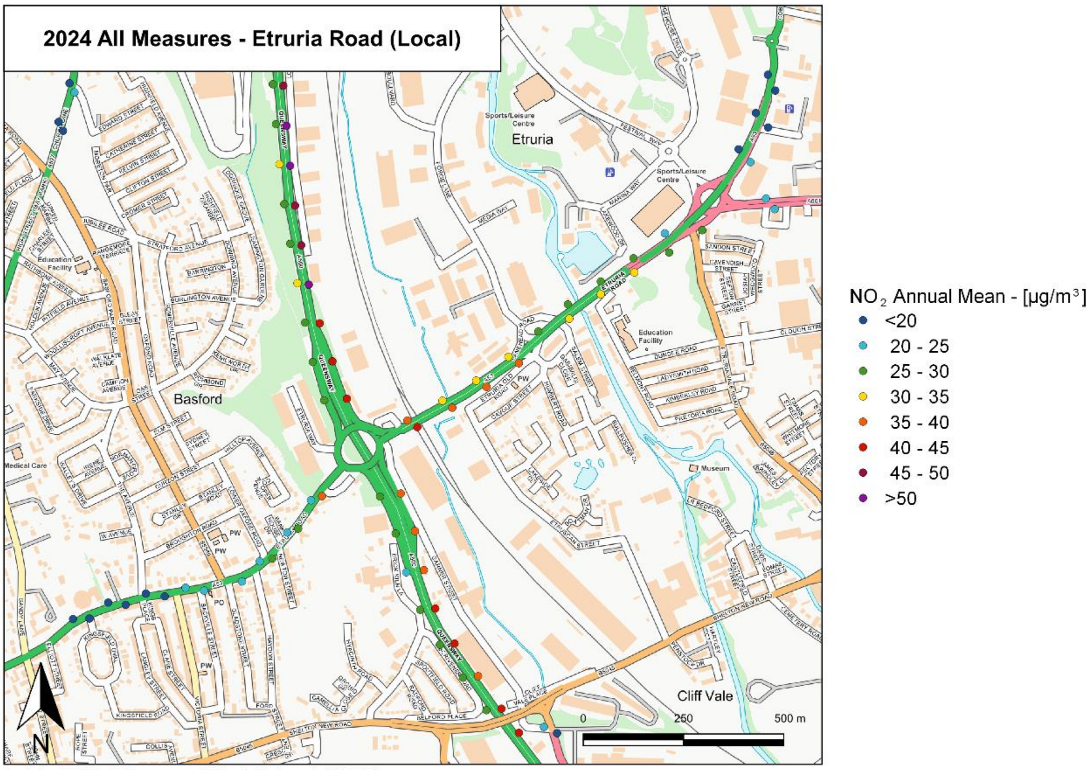


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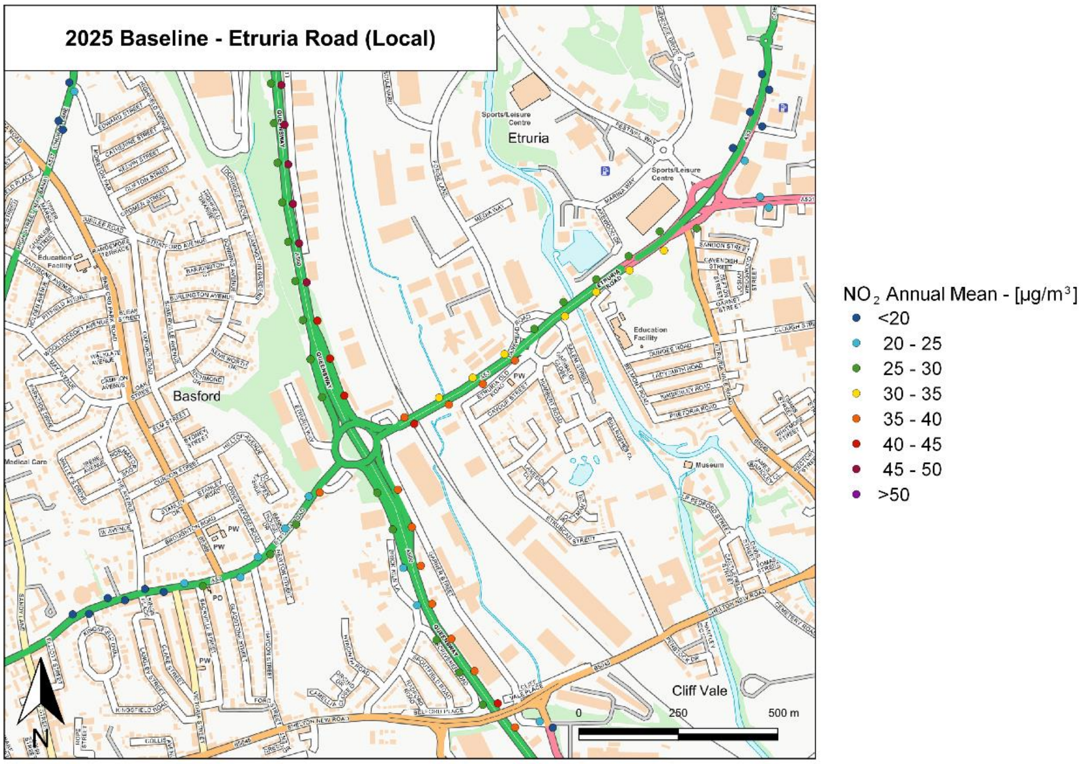
Figure 19 – NO_2 annual means for 2024 All Measures¶

Figure 20 – NO_2 annual means for 2025 Baseline



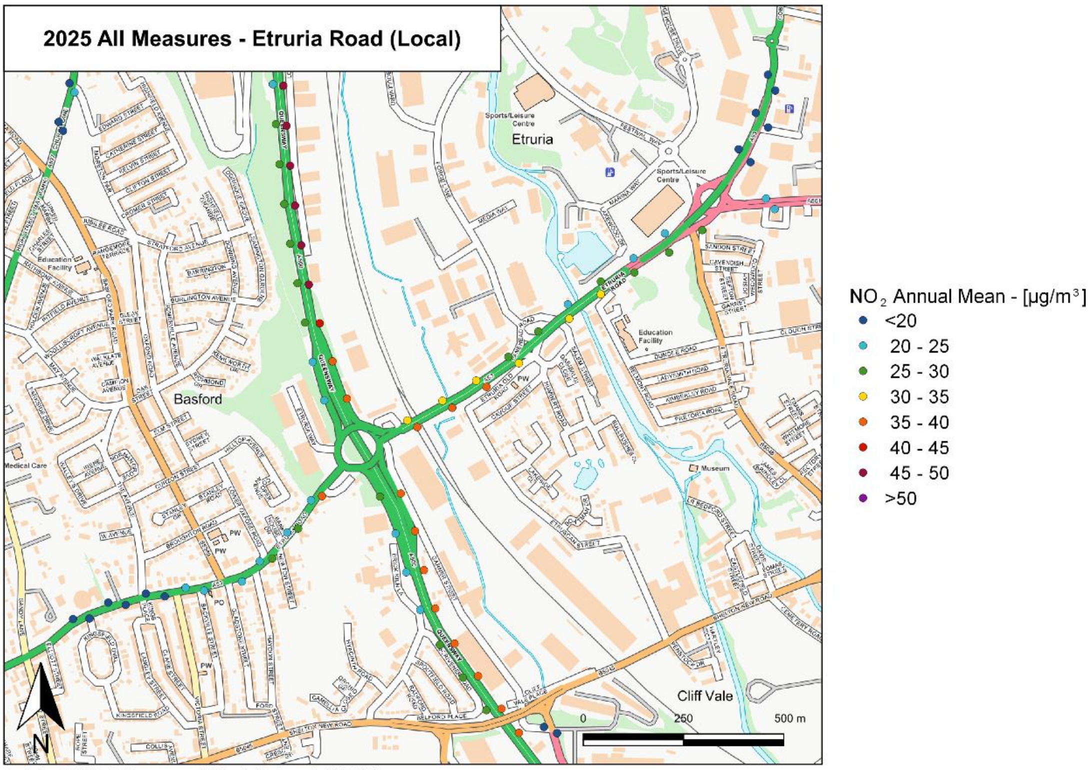
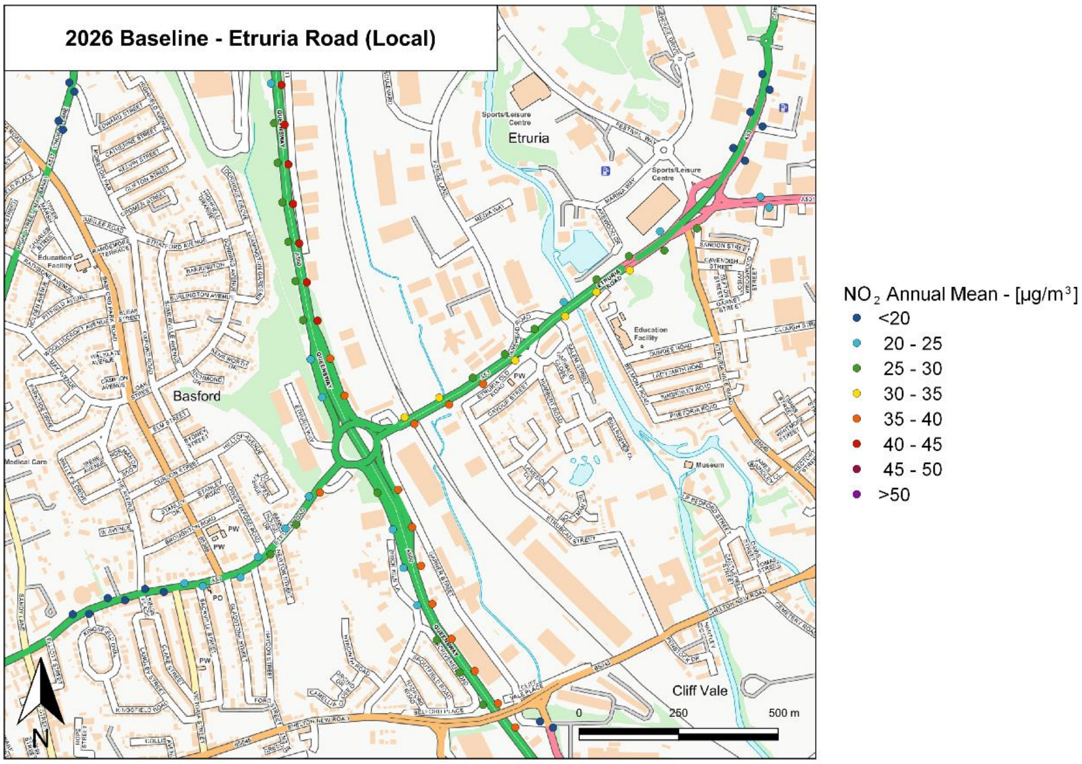


Figure 21 – NO_2 annual means for 2025 All Measures¶

Figure 22 – NO_2 annual means for 2026 Baseline



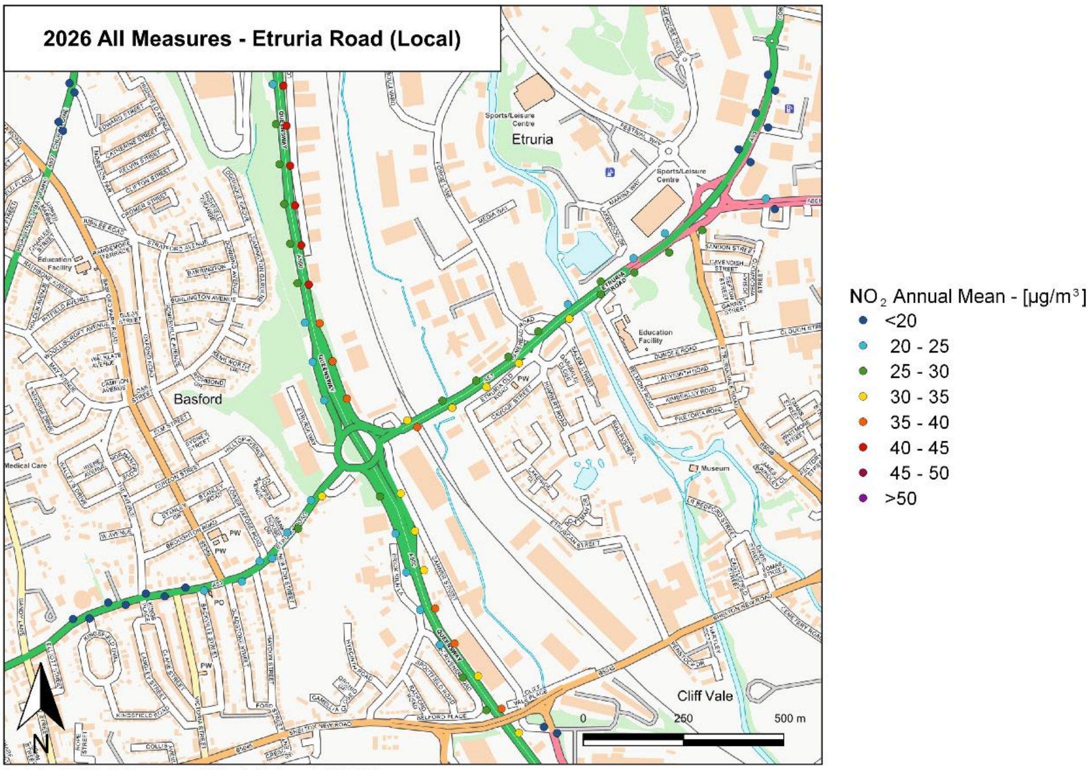
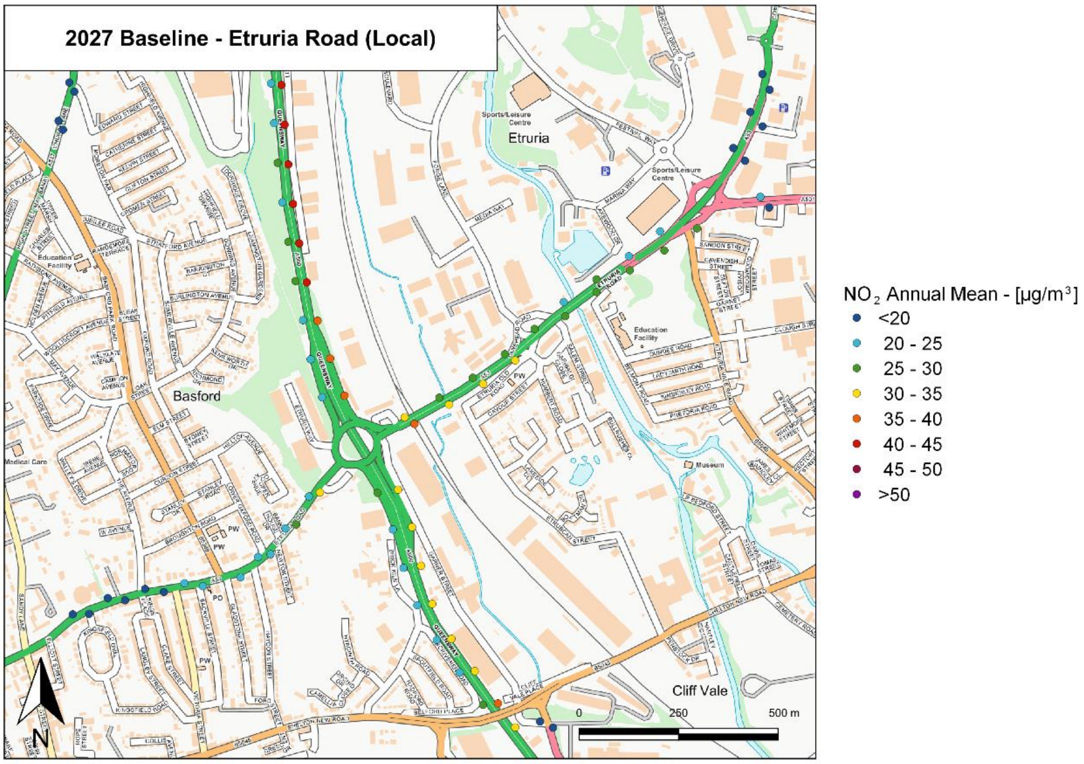
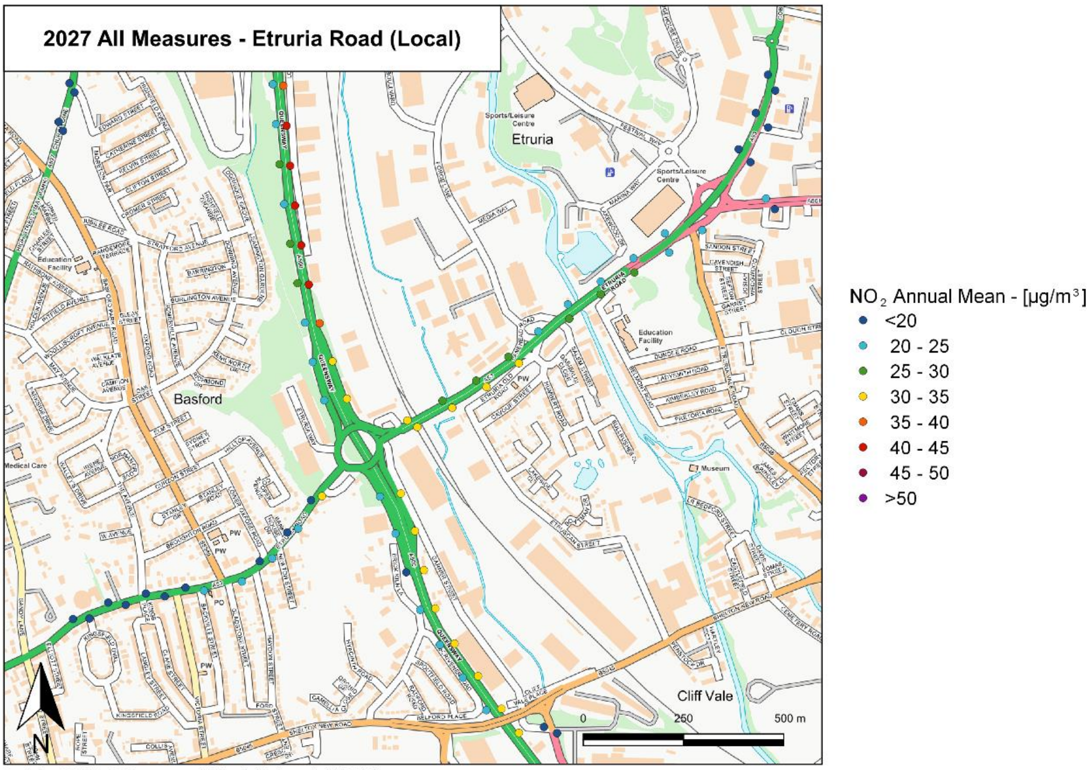


Figure 23 – NO_2 annual means for 2026 All Measures¶

Figure 24 – NO_2 annual means for 2027 Baseline



Contains OS data © Crown copyright and database right (2018)



Contains OS data © Crown copyright and database right (2018)

Figure 25 – NO_2 annual means for 2027 All Measures¶

Part 5: Setting out a preferred option

Two road links were identified by the PCM national model as being non-compliant with the annual average NO_2 limit value in 2018 (74058 and 26555), and a further two were identified as being in or close to exceedance using local monitoring data (6545 and 28732). All are situated along the A53.

A baseline modelling assessment, using Ricardo Energy & Environment's proprietary modelling system; RapidAIR, indicated that all roads except 6545 were exceeding the limit value of NO_2. Therefore, full compliance under "business-as-usual" conditions (baseline) could only be achieved in 2026 after road 74058 shows an NO_2 annual mean concentration below 40 $\mu g/m^3$. As mentioned above, for Census ID 6545 the monitoring value is used in preference. By reflecting the modelled reductions of the baseline on this value, road 6545 will achieve compliance in 2023.

A selection of measures, designed to bring forward compliance along the A53, were reviewed during a Council stakeholder workshop and three were identified as having the greatest potential to improve air quality:

- Measure 1: Retrofitting of bus fleet to achieve Euro VI
- Measure 2: Reduction of speed limits on the A53 and on the flyover east of the road link to 30 mph
- Measure 3: Electric vehicle strategy

The change in ambient concentrations of NO_2 resulting from the implementation of these measures were modelled using RapidAIR, for the years 2018 – 2027 for the three measures and for their simultaneous application.

The results show that the implementation of Measure 1, and all measures combined would result in compliance being achieved in the four roads by 2025. Measures 2 and 3 implemented alone do not bring about any additional benefit to the natural reductions that occur in the baseline (business-as-usual), as full compliance is achieved in 2026. In the case of Census ID 6545, compliance will be achieved as soon as 2021 through the implementation of Measure 1 or the combination of the three measures.

Feasibility of Measures and Wider Impacts

The application of speed limits on Etruria Road and/or the uptake of electric passenger cars do not bring forward compliance any sooner than the upgrade of the bus measure alone, therefore **the most effective option to bring forward compliance is the upgrade of the bus fleet**.

Upgrading the bus fleet brings forward compliance by 2 years in the case of Census ID 6545 and by 1 year in the case of Census IDs 28732 and 74058. The area's main bus operator has previously invested in some Euro IV vehicles and applied for grant funding in the past, although the bid was unsuccessful. Going forward, investment to retrofit to Euro VI is likely to be heavily dependent upon external funding being made available, given that the bus company have previously resisted full commitment.

Until a scheme can be developed in detail on costs for upgrade of the fleet via retrofit and new vehicles and the funding mechanism to support this it is not clear how much forward compliance this measure can bring. In addition, the supply chain for implementation would need consideration i.e. how quickly could this bus fleet be procured in consultation with the operators.

There is time available before 2025 to implement this option and bring forward compliance. The soonest a scheme could be implemented would be by the end of 2019. However, to progress things, a more detailed assessment and consultation exercise with the bus operators would be required.

The following table summarises outcome of the feasibility study.

Table 16: Summary of compliance status and measures for each road link

Road link	PCM identified link?	Summary of exceedance	Measures identified that could bring forward compliance	Costs and timeframe
74058	Yes	Updated baseline data using local modelled data shows the link is non-compliant and is predicted to remain non-compliant until 2026 (baseline); it will achieve compliance in 2025 (all measures). 2017 data: 66.6 µg/m^3 2026 data: 38.1 µg/m^3 Summary of NO_2 concentration projections (baseline): 2018: 63.6 µg/m^3 2019: 60.7 µg/m^3 2020: 56.8 µg/m^3 2021: 53.2 µg/m^3 2022: 49.6 µg/m^3 2023: 46.4 µg/m^3 2024: 43.4 µg/m^3 2025: 40.8 µg/m^3 2026: 38.1 µg/m^3 2027: 35.7 µg/m^3 Summary of NO_2 concentration projections (measure 1 bus upgrade): 2018: 63.6 µg/m^3 2019: 60.4 µg/m^3 2020: 56.3 µg/m^3 2021: 52.3 µg/m^3 2022: 48.3 µg/m^3 2023: 45.2 µg/m^3 2024: 42.2 µg/m^3 2025: 39.3 µg/m^3 2026: 36.6 µg/m^3 2027: 34.1 µg/m^3	The upgrade of the bus fleet following the assumptions listed in Part 4 will bring forward compliance for this link one year. In Part 5 of our study we have assessed these against secondary success criteria and have recommended a bus fleet upgrade.	Our recommended measure that brings forward compliance is the bus fleet upgrade. A full impact assessment is required for the preferred option, e.g. proportion of fleet that could be retrofitted/renewed, distributional impacts, displacement impacts, and value for money. Further consultation with the bus operators to specify the options is required to underpin a full business case, however, it is estimated approximately 25 buses will need to be retrofitted to Euro VI standard, to provide enough cover for maintenance. This would represent a total cost of £425,000, based on £17,000 for Eminox SCRT technology. It is estimated this measure could be implemented within 2 years, and thus would be in time to bring forward compliance from 2021. The full impact assessment would follow JAQU guidance and include a summary of the proposed approach to designing and implementing the measure, including roles and responsibilities, key project milestones, any key dependencies including assumptions made regarding involvement of/actions taken by other stakeholders in scheme delivery beyond the local authority.

26555	Yes	Updated baseline data using local modelled data shows the link is non-compliant and is predicted to remain non-compliant until 2022 (baseline); no measures bring forward compliance 2017 data: 52.9 µg/m^3 2022 data: 40.3 ug/m^3 Summary of NO_2 concentration projections (baseline): 2018: 50.7 µg/m^3 2019: 48.5 µg/m^3 2020: 45.7 µg/m^3 2021: 43.0 µg/m^3 2022: 40.3 µg/m^3 2023: 37.9 µg/m^3 2024: 35.7 µg/m^3 2025: 33.7 µg/m^3 2026: 31.7 µg/m^3 2027: 29.9 µg/m^3 Summary of NO_2 concentration projections (measure 1 bus upgrade): 2018: 50.7 µg/m^3 2019: 48.2 µg/m^3 2020: 45 µg/m^3 2021: 41.9 µg/m^3 2022: 38.9 µg/m^3 2023: 36.5 µg/m^3 2024: 34.3 µg/m^3 2025: 32.1 µg/m^3 2026: 30.2 µg/m^3 2027: 28.4 µg/m^3	No measures bring forward compliance	N/A
6545	No – this link was identified as being in exceedance using local monitoring data. A modelling checklist has been approved by JAQU	Updated baseline data using local modelled data shows the link is now compliant. Monitoring data is used in preference.	The upgrade of the bus fleet following the assumptions listed in Part 4 will bring forward compliance for this link two years. In Part 5 of our study we have assessed these against secondary success criteria and	Our recommended measure that brings forward compliance is the bus fleet upgrade. A full impact assessment is required for the preferred option, e.g. proportion of fleet that could be retrofitted/renewed, distributional impacts,

		2017 data: 46.0 µg/m^3 Summary of NO_2 concentration projections (baseline): 2018: 45.0 µg/m^3 2019: 44.1 µg/m^3 2020: 42.8 µg/m^3 2021: 41.7 µg/m^3 2022: 40.6 µg/m^3 2023: 39.3 µg/m^3 2024: 38.4 µg/m^3 2025: 34.0 µg/m^3 2026: 33.1 µg/m^3 2027: 32.3 µg/m^3 Summary of NO_2 concentration projections (measure 1 bus upgrade): 2018: 45 µg/m^3 2019: 43.2 µg/m^3 2020: 41 µg/m^3 2021: 38.8 µg/m^3 2022: 36.7 µg/m^3 2023: 35.6 µg/m^3 2024: 34.7 µg/m^3 2025: 33.7 µg/m^3 2026: 32.9 µg/m^3 2027: 32.1 µg/m^3	have recommended a bus fleet upgrade.	displacement impacts, and value for money. Further consultation with the bus operators to specify the options is required to underpin a full business case, however, it is estimated approximately 25 buses will need to be retrofitted to Euro VI standard, to provide enough cover for maintenance. This would represent a total cost of £425,000, based on £17,000 for Eminox SCRT technology. It is estimated this measure could be implemented within 2 years, and thus would be in time to bring forward compliance from 2021. The full impact assessment would follow JAQU guidance and include a summary of the proposed approach to designing and implementing the measure, including roles and responsibilities, key project milestones, any key dependencies including assumptions made regarding involvement of/actions taken by other stakeholders in scheme delivery beyond the local authority.
28732	No – this link was identified as being in exceedance using local monitoring data. A modelling checklist has been approved by JAQU.	Updated baseline data using local modelled data shows the link is non-compliant and is predicted to remain non-compliant until 2025 (baseline); it will achieve compliance in 2024 (all measures). 2017 data: 64.4 µg/m^3 2025 data: 38.2 µg/m^3 Summary of NO_2 concentration	The upgrade of the bus fleet following the assumptions listed in Part 4 will bring forward compliance for this link one year. In Part 5 of our study we have assessed these against secondary success criteria and have recommended a bus fleet upgrade.	Our recommended measure that brings forward compliance is the bus fleet upgrade. A full impact assessment is required for the preferred option, e.g. proportion of fleet that could be retrofitted/renewed, distributional impacts, displacement impacts, and value for money. Further consultation with the bus operators to specify the options is required to underpin a full business case, however, it is estimated approximately 25 buses will need to be retrofitted

		projections (baseline): 2018: 60.8 µg/m^3 2019: 57.6 µg/m^3 2020: 53.6 µg/m^3 2021: 50.0 µg/m^3 2022: 46.6 µg/m^3 2023: 43.4 µg/m^3 2024: 40.7 µg/m^3 2025: 38.2 µg/m^3 2026: 35.8 µg/m^3 2027: 33.6 µg/m^3 Summary of NO_2 concentration projections (measure 1 bus upgrade): 2018: 60.8 µg/m^3 2019: 57.2 µg/m^3 2020: 52.7 µg/m^3 2021: 48.6 µg/m^3 2022: 44.7 µg/m^3 2023: 41.7 µg/m^3 2024: 38.9 µg/m^3 2025: 36.2 µg/m^3 2026: 33.7 µg/m^3 2027: 31.5 µg/m^3		to Euro VI standard, to provide enough cover for maintenance. This would represent a total cost of £425,000, based on £17,000 for Eminox SCRT technology. It is estimated this measure could be implemented within 2 years, and would help to bring forward compliance from 2026. The full impact assessment would follow JAQU guidance and include a summary of the proposed approach to designing and implementing the measure, including roles and responsibilities, key project milestones, any key dependencies including assumptions made regarding involvement of/actions taken by other stakeholders in scheme delivery beyond the local authority.

Appendix 2 – Supplementary Results

Table A2.1 – Maximum NO_2 concentrations predicted according to the local model and PCM (2017)

Census ID	Local Authority	NO_2 2017 (Local)	NO_2 2017 (PCM)
6545	Newcastle-under-Lyme	37.0 µg/m^3	26.1 µg/m^3
8147	Stoke-on-Trent	29.4 µg/m^3	**47.5 µg/m^3**
28732	Newcastle-under-Lyme	**64.4 µg/m^3**	36.5 µg/m^3
38230	Stoke-on-Trent (HE managed road)	**66.5 µg/m^3**	**53.2 µg/m^3**
46563	Stoke-on-Trent	30.8 µg/m^3	37.7 µg/m^3
47243	Newcastle-under-Lyme (HE managed road)	**76.4 µg/m^3**	**51.5 µg/m^3**
47276	Newcastle-under-Lyme	32.6 µg/m^3	24.6 µg/m^3
81448	Stoke-on-Trent	37.8 µg/m^3	31.0 µg/m^3