Ricardo
Energy & Environment

Detailed Assessment of Air Quality at Broxburn, West Lothian

Report for West Lothian Council

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Executive summary

Ricardo Energy & Environment have been commissioned by West Lothian Council to undertake a Detailed Assessment of Air Quality at Broxburn, West Lothian.

An Air Quality Management Area (AQMA) encompassing a section of Broxburn was declared in March 2011 due to exceedances of both the Nitrogen dioxide (NO_2) and fine particulate (PM_{10}) annual mean air quality objectives.

Measured NO_2 and PM_{10} concentrations have declined over recent years. On this basis, West Lothian Council are currently considering revocation of the Broxburn AQMA. This Detailed Assessment aims to provide evidence that will aid the Council in deciding if revocation is appropriate, or if an AQMA is still required in Broxburn or may be required in the near future.

The assessment includes the following main elements:

- A review of measured NO_2, PM_{10} and $PM_{2.5}$ concentrations within the AQMA over recent years
- Detailed dispersion modelling of NO_2, PM_{10} and $PM_{2.5}$ concentrations for a baseline year of 2017
- A sensitivity analysis of potential fluctuations in annual mean pollutant concentrations attributable to meteorological conditions
- Detailed dispersion modelling of NO_2, PM_{10} and $PM_{2.5}$ concentrations in a future year of 2025 reflecting anticipated changes in traffic levels associated with projected growth or planned local developments.

Dispersion modelling was conducted with ADMS, using traffic data collected in a survey in Broxburn in 2017. Model results were verified with available local monitoring data.

The review of pollutant measurements over the last eleven years has concluded:

- For NO_2, annual mean concentrations in excess of the 40 µg.m^{-3} objective have not been measured in Broxburn since 2010 and have in general declined at all measurement sites over the last eleven years. In 2019 all measured concentrations were less than 70% of the annual mean objective.
- For PM_{10}, annual mean concentrations in excess of the 18 µg.m^{-3} objective have not been measured in Broxburn since 2011 and have in general declined at all measurement sites since then. However, due to uncertainties with particulate measurement techniques (pending ongoing further investigation), the Scottish Government currently recommends that Local authorities using Fidas analysers within the SAQD network should not consider revoking an AQMA for PM_{10} at this time.
- For $PM_{2.5}$, there have been no exceedances of the 10 µg.m^{-3} objective since monitoring began in 2017. Measured annual mean have also been consistently less than the 8 µg.m^{-3} uncertainty threshold currently recommended by the Scottish Government.

The dispersion modelling study of current and future road traffic emissions indicates that:

- In 2017, the NO_2, PM_{10} and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area.
- Based on a sensitivity analysis of modelled pollutant concentrations using annual meteorological datasets from 2007 to 2017; for all three pollutants, it's unlikely that the respective annual mean objectives will be exceeded in a year when poorer than average dispersion occurs due to weather conditions.

- For the 2025 future year baseline, the NO_2, PM_{10} and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area. No developments near the Broxburn study area are currently planned.

In light of this Detailed Assessment of Air Quality, West Lothian Council may wish to:

1. **Consider revocation of the Broxburn Air Quality Management Area for exceedances of the NO_2 annual mean objective**
2. **Delay revoking the AQMA for exceedances of the PM_{10} annual mean objective until Scottish Government guidance regarding AQMA revocation and the use of Fidas analysers for particulate measurements is updated.**

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1 Introduction

An Air Quality Management Area (AQMA) encompassing a section of Broxburn, West Lothian was declared in March 2011 due to exceedances of both the Nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}) annual mean air quality objectives.

Measured NO_2 and PM_{10} concentrations have declined over recent years. On this basis, West Lothian Council are currently considering revocation of the Broxburn AQMA and have commissioned Ricardo Energy & Environment to undertake a Detailed Assessment of Air Quality.

This Detailed Assessment aims to present evidence that will aid the Council in deciding if revocation is appropriate at this time; or if an AQMA is still required or may be required in the future based on anticipated traffic levels, e.g., when planned nearby housing and commercial developments become operational.

The assessment includes:

- A review of recent trends in NO_2, PM_{10} and $PM_{2.5}$ measurements in Broxburn
- Detailed dispersion modelling of emissions in both current and future years to establish if NO_2, PM_{10} or $PM_{2.5}$ concentrations are likely to be in excess of the air quality objectives at locations where relevant human exposure is present.
- An analysis of potential fluctuations and extremes in annual mean pollutant concentrations based on historical inter-annual variability in meteorological conditions.

Further information on each of these elements of the assessment is provided later in the report.

Please note: The modelling aspects of this detailed assessment were originally conducted in 2019 and verified using 2017 air quality measurements. Delays pending acquisition of information about likely future traffic activity meant that the assessment could not be completed in 2019. As the report has now been finalised in 2022, we have included the most recent air quality measurement data to provide additional evidence. Further information is provided in Section 3.

1.1 Policy background

The Environment Act 1995 placed a responsibility on the UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA), carry out a Further Assessment of Air Quality, and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future. The timetables and methodologies for carrying out Review and Assessment studies are prescribed in Defra's Technical Guidance - LAQM.TG(16)[1]. Table 1 lists the objectives relevant to this assessment that are included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

[1] https://laqm.defra.gov.uk/documents/LAQM-TG16-April-21-v1.pdf

Table 1: Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective Concentration	Measured as
Nitrogen dioxide (NO_2)	200 µg.m^{-3} not to be exceeded more than 18 times a year	1-hour mean
	40 µg.m^{-3}	Annual Mean
Particulate matter (PM_{10})	50 µg.m^{-3} not to be exceeded more than 7 times a year	24-hour mean
	18 µg.m^{-3}	Annual mean
Particulate matter ($PM_{2.5}$)	10 µg.m^{-3}	Annual mean

1.2 Locations where the objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be present and are likely to be exposed over the averaging period of the respective air quality objective. Table 2 summarises examples of where the air quality objectives for NO_2, PM_{10} and $PM_{2.5}$ should and should not apply.

Table 2: Where the Air Quality Objectives should and should not apply

Averaging Period	Pollutant	Objectives should apply at:	Objectives should not generally apply at:
Annual mean	NO_2, PM_{10}, $PM_{2.5}$	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
24-hour mean	PM_{10}	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
1-hour mean	NO_2	All locations where the annual mean and: 24-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer	Kerbside sites where the public would not be expected to have regular access

2 Detailed Assessment Study Area

The Detailed Assessment is concerned with the Broxburn AQMA which cover the Main Street area of Broxburn town centre.

The area comprises a mix of residential and commercial properties. At roadside locations residential properties are present at the ground floor and at first and second floor height above commercial properties. A map of Broxburn and the AQMA boundary is presented in Figure 1 below.

Figure 1: Detailed Assessment Study Area

3 Pollutant monitoring data in recent years

West Lothian Council currently measure NO_2, PM_{10} and $PM_{2.5}$ concentrations within the Broxburn AQMA at one continuous analyser site and three NO_2 diffusion tube sites. Maps showing the site locations are presented in Figure 2 and Figure 3. Further details regarding annual data capture and QA/QC information are available in the various West Lothian Council LAQM Annual Progress Reports published in recent years[2].

The LAQM guidance recommends; when considering revocation of an AQMA; authorities should examine measurements carried out over several years or more. The minimum requirement as evidence of continued compliance, will normally be three consecutive years where measured concentrations are below the objectives of concern.

Figure 2: Monitoring site locations Broxburn town centre

[2] Include link to West Lothian Council LAQM reports webpage

Figure 3: Monitoring site locations east of town centre

3.1 NO_2 measurements

Measured annual mean NO_2 concentrations from 2010 to 2021 are presented in Table 3 and Figure 4. No concentrations in excess of the 40 µg.m^{-3} objective have been measured in Broxburn since 2010 and concentrations have in general declined at all sites over the last eleven years.

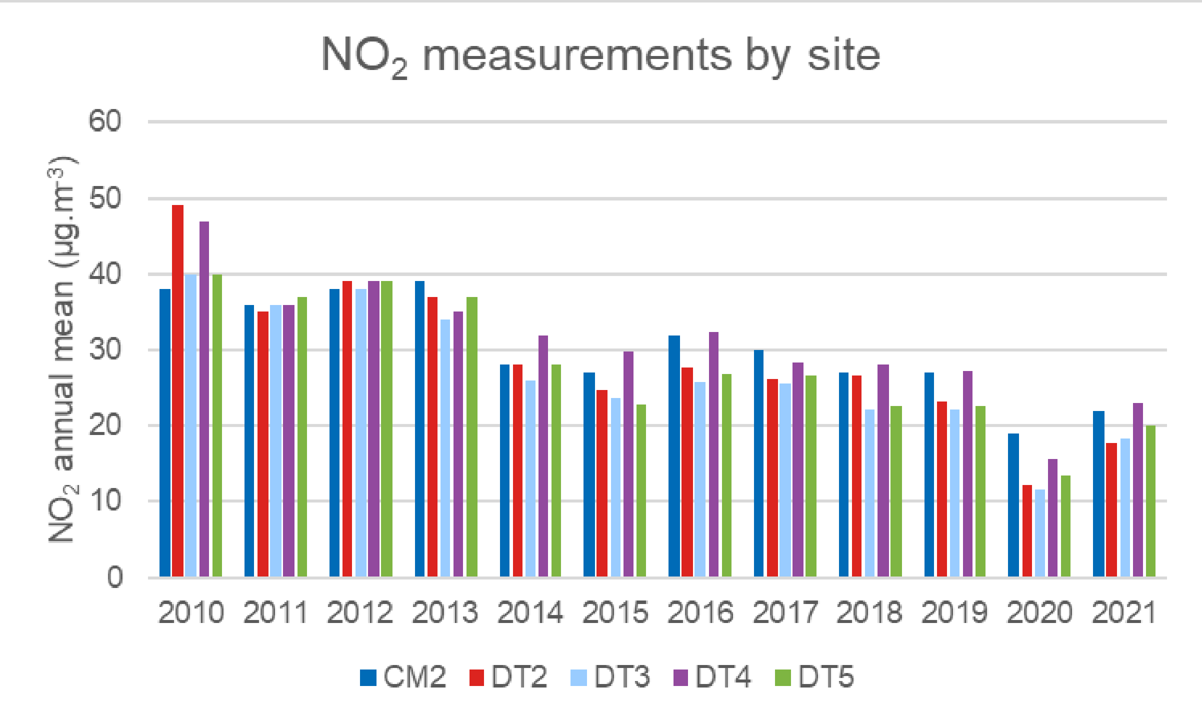
Measured NO_2 annual mean in 2020 reduced fairly significantly due to the effect of COVID-19 restrictions on traffic activity; this effect is also apparent but to a lesser extent in 2021. It is currently unknown if traffic activity will return to pre-pandemic levels in 2022 and future years.

In 2019 however, which can be considered as the most recent pre-pandemic business as usual year, all measured concentrations were less than 70% of the objective. This and the preceding decline in measured values provides reasonable evidence that measured NO_2 annual mean have been compliant with the 40 µg.m^{-3} objective in Broxburn for some time.

Table 3: NO_2 annual mean measurements 2010 to 2021 ($\mu g.m^{-3}$)

Site ID	Site Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CM2	Broxburn CNC	38.0	36.0	38.0	39.0	28.0	27.0	32.0	30.0	27.0	27.0	19.0	22.0
DT2	Broxburn WMS	49.0	35.0	39.0	37.0	28.0	24.7	27.7	26.2	26.5	23.2	12.3	17.7
DT3	Broxburn EMS	40.0	36.0	38.0	34.0	26.0	23.7	25.7	25.5	22.2	22.2	11.6	18.4
DT4	Broxburn CNC	47.0	36.0	39.0	35.0	32.0	29.7	32.4	28.4	28.0	27.2	15.5	22.9
DT5	Broxburn E Mains	40.0	37.0	39.0	37.0	28.0	22.7	26.9	26.7	22.5	22.6	13.5	20.1

Figure 4: Chart representing trend in NO_2 annual mean measurements 2010 to 2021



3.2 PM_{10} measurements

Measured annual mean PM_{10} concentrations from 2010 to 2021 are presented in Table 4. An annual mean concentration in excess of the 18 $\mu g.m^{-3}$ objective was last measured in Broxburn in 2011. Measured concentrations have in general declined since 2011. Similar to NO_2, measured PM_{10} in 2020 reduced fairly significantly due to the effect of COVID-19 restrictions on traffic activity; this effect is also apparent but to a lesser extent in 2021.

Table 4: PM_{10} annual mean measurements 2010 to 2021 ($\mu g.m^{-3}$)

Site ID	Site Name	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CM2	Broxburn CNC	19	21	18	16	17	15	15	14	13	14	11	12

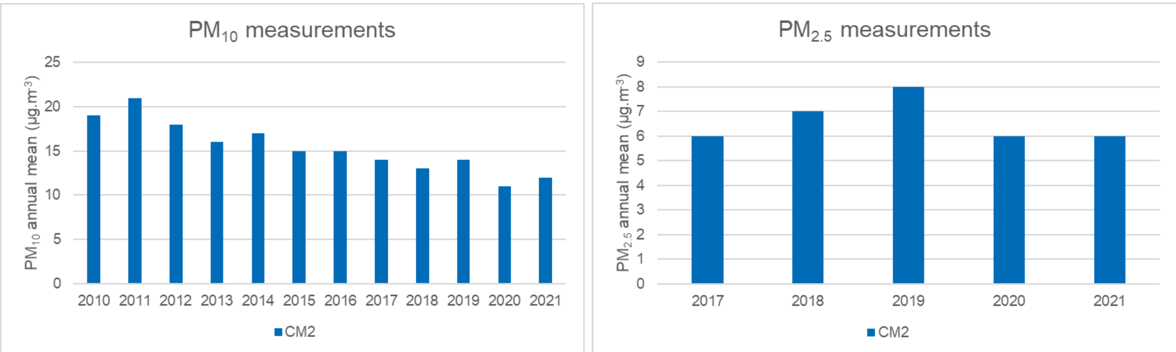
3.3 $PM_{2.5}$ measurements

West Lothian Council began monitoring $PM_{2.5}$ at the continuous analyser site in East Main Street, Broxburn in 2017. Measured annual mean $PM_{2.5}$ concentrations from 2017 to 2021 are presented in Table 5 and Figure 5. There have been no measured exceedances of the 10 $\mu g.m^{-3}$ $PM_{2.5}$ annual mean objective since monitoring began. The effect of COVID-19 restrictions on traffic activity in 2020 and 2021 is also apparent in the $PM_{2.5}$ measurements.

Table 5: $PM_{2.5}$ annual mean measurements 2017 to 2021 ($\mu g.m^{-3}$)

Site ID	Site Name	2017	2018	2019	2020	2021
CM2	Broxburn CNC	6	7	8	6	6

Figure 5: Trend in PM_{10} and $PM_{2.5}$ annual mean measurements over recent years



3.4 Current uncertainty around particulate Matter Monitoring Techniques in Scotland

The Scottish Government are currently investigating the relationship between automatic particulate matter (PM_{10} and $PM_{2.5}$) measurement techniques used in Scotland and the EU reference method. The requirement for a study of this type was identified following decreases in PM_{10} concentrations observed across Scotland's air quality monitoring network following the introduction of Fidas, which replaced TEOM, FDMS and BAM instruments.

The initial phase of this investigation[3] has indicated that current corrections for equivalence may not be accurately representing how the automatic monitoring methods respond at lower concentration levels and meteorological conditions, such as those observed in Scotland. The latest report makes the following recommendations which are relevant to this Detailed Assessment:

- Local authorities using Fidas within the SAQD network should not consider revoking an AQMA for PM_{10} until the results and recommendations from the next stage of the study are published.
- For $PM_{2.5}$, annual mean concentrations of greater than 8 $\mu g.m^{-3}$ using a Fidas might indicate that the annual mean objective of 10 $\mu g.m^{-3}$ has been exceeded.
- Local authorities using FDMS within the SAQD network should only consider revoking an AQMA for PM_{10} if the measured annual mean is consistently 16 $\mu g.m^{-3}$ or less.

In Broxburn, PM_{10} was measured up until 2016 using a TEOM FDMS analyser; and from 2017 using a Fidas analyser. PM_{10} annual means measured using the TEOM FDMS were consistently less than 16 $\mu g.m^{-3}$ for three years up to 2017. The Scottish Government report does however now recommend that Local authorities using Fidas within the SAQD network should not consider revoking an AQMA for PM_{10} at this time. On this basis West Lothian Council may wish to delay revoking the AQMA for exceedances of the PM_{10} annual mean objective.

$PM_{2.5}$ measurements in Broxburn have been consistently less than the 8 $\mu g.m^{-3}$ threshold recommended in the Scottish Government report; this indicates that there have been no measured exceedances of the 10 $\mu g.m^{-3}$ Scottish $PM_{2.5}$ annual mean objective to date.

[3] Ricardo Energy & Environment (2021) Pilot Research Study to Investigate Particulate Matter Monitoring Techniques in Scotland; Final Report; Report for Scottish Government; ED11195 Issue 1 Date 19/08/2021; Available to download here: https://www.scottishairquality.scot/news/pilot-research-study-investigate-particulate-matter-monitoring-techniques-scotland

4 Dispersion Modelling Assessment

In addition to the review of pollutant measurement data over recent years. The Detailed Assessment includes a dispersion modelling assessment of road traffic emissions. This aims to establish if NO_2, PM_{10} or $PM_{2.5}$ concentrations are likely to be in excess of the air quality objectives at locations where pollutant measurements are not being conducted but relevant human exposure is present.

This typically includes the assessment of emissions associated with traffic generated by planned developments in future years; however, no known developments are anticipated in the study area by 2025. An analysis of potential fluctuations and extremes in annual mean pollutant concentrations based on historical variability in meteorological conditions has also been conducted. The aim being to identify if there is a risk of the air quality objectives being exceeded again in Broxburn in future years.

4.1 Modelling method and supporting data

Annual mean pollutant concentrations have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 5). The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(16) were used throughout this study.

It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

4.1.1 Background concentrations

Background pollutant concentrations for a modelling study within an urban environment in Scotland can be sourced from either a local urban background monitoring location, or the background maps provided by the Scottish Government[4] or the Defra LAQM support website. The background maps provide estimates of annual mean background concentrations of key pollutants at a resolution of 1 x 1km projected from a base year and can be projected forward to future years up to 2030.

NOx, PM_{10} and $PM_{2.5}$ emissions are projected to decline over time as emissions are reduced by national policy implementation. The Defra background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

In this case as there are no local background measurement sites, the background maps were considered most appropriate to use. For the baseline year of 2017 and the future year assessed of 2025, the Scottish (NOx) and UK (PM_{10} and $PM_{2.5}$) background maps were used to provide estimated background annual mean concentrations of each pollutant for the 1km grid squares covering the study area. Baseline modelling of 2017 used the background maps with a base year of 2015, which were the most recent available maps at the time of baseline modelling. Future year modelling of 2025 used the most recent available background maps with a base year of 2018, as the Scottish background maps with a base year of 2015 were no longer available when modelling the future year scenario.

The sector contributions from road traffic emissions on A Class Roads were subtracted from the total background concentrations to avoid double counting of Road NO_x and PM from the road sources being explicitly modelled. The brake & tyre wear and road abrasion contributions were also discounted from the PM_{10} and $PM_{2.5}$ maps as these particulate emissions are calculated along with tailpipe emissions when using the emission factor toolkit (EFT) to calculate vehicle emission rates.

The background concentrations used in this study are displayed in Table 6.

[4] Background maps available at: http://www.scottishairquality.co.uk/data/mapping?view=data

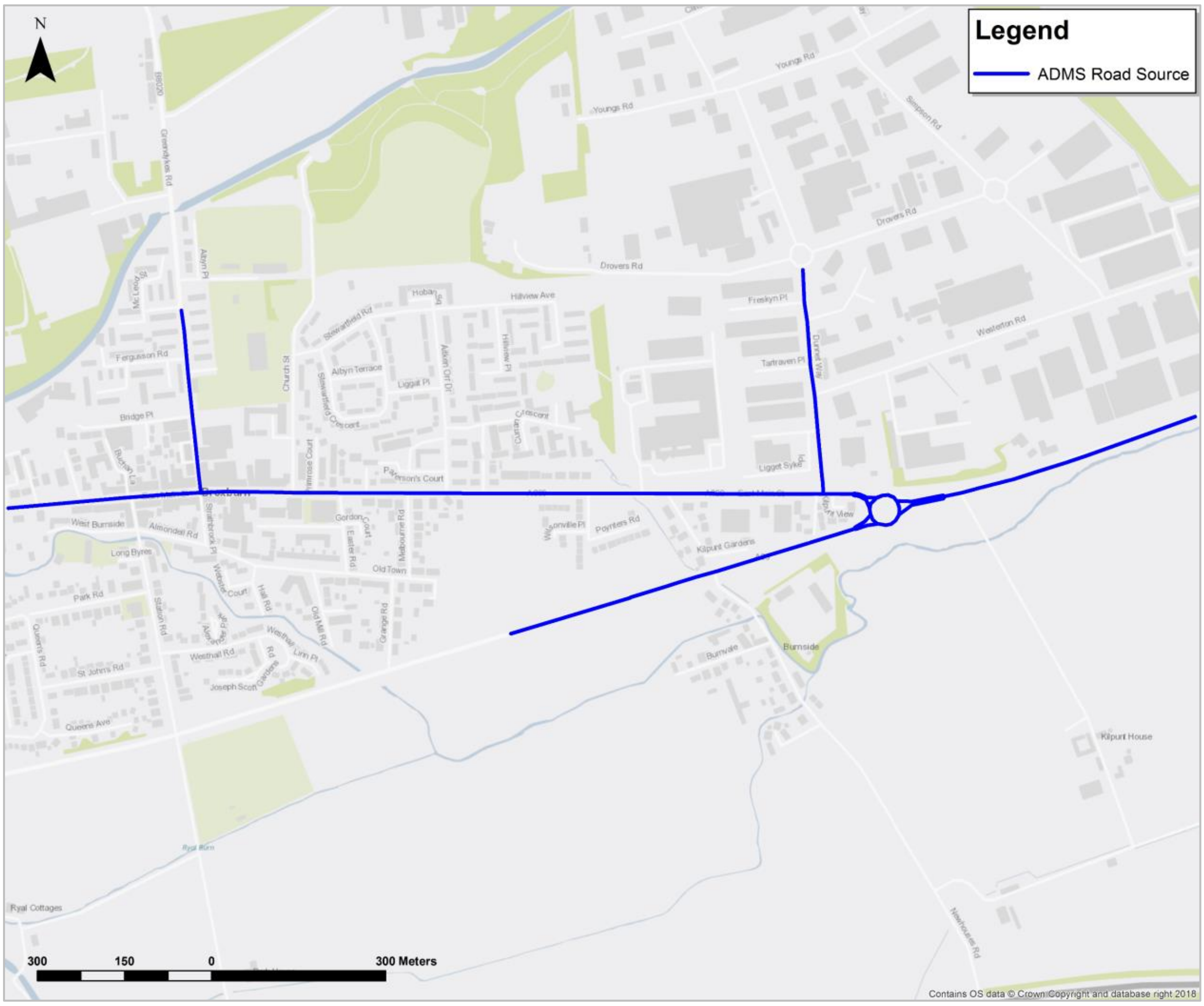
Table 6: Mapped 2017 background NOx, PM_{10} and $PM_{2.5}$ concentrations

1km grid square centroid	Year	NOx ($\mu g.m^{-3}$)	PM_{10} ($\mu g.m^{-3}$)	$PM_{2.5}$ ($\mu g.m^{-3}$)
308500, 672500	2017	24.3	12.0	6.8
308500, 672500	2025	15.2	10.1	5.9

4.1.2 Model domain

All major roads within the Broxburn AQMA have been included in the dispersion modelling assessment. A map showing the roads modelled is presented in Figure 6.

Figure 6: Roads included in the dispersion modelling assessment



4.1.3 Meteorological observations and model parameters

Hourly sequential meteorological data (wind speed, direction etc.) for 2017 from the Edinburgh Airport site was used for the modelling assessment. The meteorological measurement site is located approximately 6km to the east of the study area and has excellent data quality for the period of interest.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

A surface roughness of 0.5m was used in the modelling to represent the turbulence of a built up urban area within the model domain. A limit for the Monin-Obukhov length of 10m was applied to represent an urban area.

4.1.4 Mapping

Ordnance survey Master Map datasets were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined using a GIS.

4.1.5 Treatment of modelled NO_x road contribution

It is necessary to convert the modelled NO_x concentrations to NO_2 for comparison with the relevant objectives.

The Defra NO_x/NO_2 calculator v6.1[5] was used to calculate NO_2 for comparison from the NO_x concentrations predicted by ADMS-Roads. The model requires input of the background NO_x, the modelled road contribution and accounts for the proportion of NO_x released as primary NO_2. For the Broxburn, West Lothian area in 2017 with the "All other UK urban traffic" option in the model, the NO_x/NO_2 model estimates that 27% of NO_x from local road vehicles is released as primary NO_2.

4.1.6 Validation of ADMS-Roads

Validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications; this is usually conducted by the model developer.

CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out comparison studies on behalf of local authorities and Defra.

4.2 Road traffic data

4.2.1 Average flow, speed and fleet split

Traffic count data collected by Tracsis plc on behalf of West Lothian Council were used for the assessment, this included a one-day continuous count conducted on 28th February 2017 at 20 survey locations throughout Broxburn. Average daily traffic flow, vehicle type fleet split and average speeds at the survey location were recorded. At other locations, average vehicle speeds were estimated using local knowledge.

Appendix 1 summarises the traffic flow and fleet split data used for the road links modelled.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

4.2.2 Congestion

Traffic is known to be slow moving along Main Street, congestion occurs regularly throughout the day close to the junction with Greendykes Road and Dunnet Way. During congested periods, average vehicle speeds reduce when compared to the daily average; the combination of slower average vehicle

[5] https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

speeds and more vehicles lead to higher pollutant emissions during peak hours; it's therefore important to account for this when modelling vehicle emissions to estimate pollutant concentrations.

No queue observation data from traffic surveys was available for the assessment. The LAMQ.TG(16) guidance states that the preferred approach to representing the increase in vehicle emissions during peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, using average speeds and traffic flow observations for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hour diurnal emission profile which can be applied to that section of road.

In this case there was insufficient hourly resolution average speed data to calculate a 24-hour diurnal emission profile; we were however able to calculate an average diurnal traffic flow profile. To account for speed reductions during peak traffic periods, assumed average daily speeds were reduced at road sections where slow moving traffic is known to occur regularly.

4.2.3 Vehicle emission factors

The Emissions Factors Toolkit (EFT V8.0.1 December 2017 release) was used in this assessment to calculate pollutant emission factors for each road link modelled. The calculated emission factors were then imported into the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are entered into the EFT, and an emissions factor in grams of pollutant/kilometre/second is generated for input into the dispersion model. In this version of the EFT, NO_x emissions factors previously based on COPERT4 have been replaced by factors from COPERT 5. These emissions factors are widely used for the purpose of calculating emissions from road traffic in Europe. Defra recognise these as the current official emission factors for road traffic sources when conducting local, regional and national scale dispersion modelling assessments.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced at a renewal rate forecast by the DfT. Any inaccuracy in the projections or the COPERT 5 emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

4.3 Model Verification

The dispersion model performance (of road traffic emissions only) was verified by comparing the modelled predictions of road NOx with local diffusion tube monitoring results. The available 2017 NO_2 and PM_{10} measurements within the Broxburn AQMA were used to verify modelled concentrations.

Following initial comparison of the modelled concentrations with the available monitoring data, some refinements were made to the model input to achieve the best possible agreement with the monitoring results. A primary Road NOx adjustment factor (PAdj) of 1.2722 was derived.

Following adjustment, model uncertainty was evaluated by calculating the root mean square error (RMSE) of the modelled vs measured annual mean NO_2 concentrations. In this case the calculated RMSE was 2.52 µg.m^{-3} after adjustment, which is within the suggested value (10% of the objective being assessed) in the LAQM.TG16) guidance. The model has therefore performed reasonably well for use within this detailed assessment.

The adjustment factor was applied to the modelled road NO_x concentrations, and the adjusted total NO_2 concentrations were then calculated using the Defra NO_x/NO_2 calculator.

Verifying modelling data with diffusion tube monitoring data will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The model results should be considered in this context. Further detailed information on model verification including the linear regression plots is presented in Appendix 3.

A comparison of the modelled vs measured Road contribution to PM_{10} concentrations identified that the model was overestimating the road PM_{10} contribution. This is unusual for a study of this type and indicates that the background maps are potentially overestimating concentrations attributable to other sources of PM_{10} at this location. The calculated PM_{10} measured vs modelled ratio of **0.990** has not been used to adjust the modelled PM_{10} or $PM_{2.5}$ results.

$PM_{2.5}$ measurement data capture during 2017 (30%) was too low and therefore considered unreliable for use in model verification.

4.4 Model results

This section of the report present results for the following aspects of the Detailed Assessment:

- Assessment of the most recent year with available measurements (2017). This includes modelling of the spatial variation in concentrations across the entire AQMA to identify where any hotspots may be; and at a selection of receptors where the worst-case concentrations are modelled.
- A sensitivity analysis of inter-annual variability in predicted annual mean pollutant concentrations attributable to meteorological conditions at a selection of receptors.
- Future year (2025) assessment of emissions associated with baseline traffic.

4.4.1 Assessment of the most recent year with available measurements (2017)

4.4.1.1 NO_2 annual mean contour plot

Annual mean NO_2 concentrations have been predicted across a grid of receptor points covering the entire study area at a grid resolution of approximately 10m. The source oriented gridding option was enabled in the ADMS Roads model to provide a more resolved receptor grid close to the road sources being modelled. The modelled concentrations for each receptor point on the grid were then interpolated to produce contour plots showing the spatial variation of predicted concentrations across the study area.

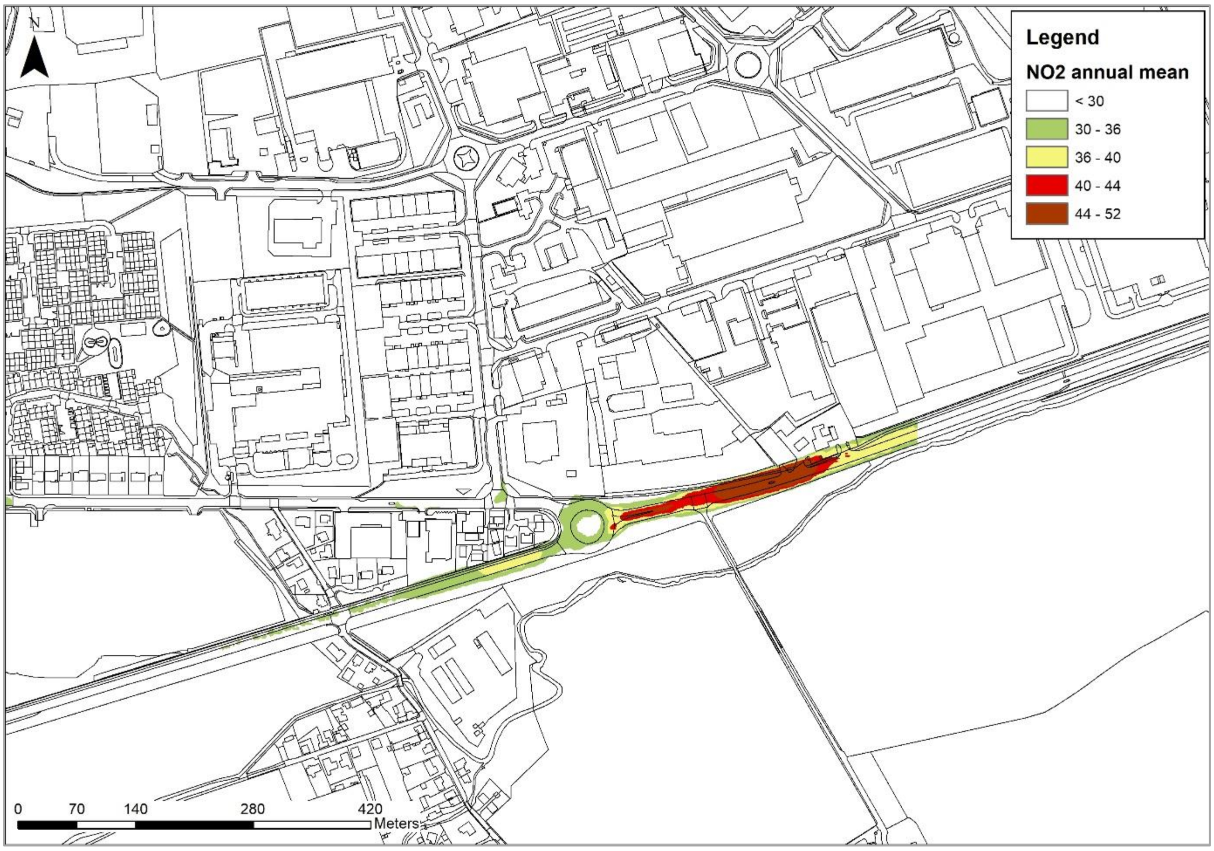
Contour plots representing the predicted 2017 annual mean NO_2 concentrations across the study area at ground floor level (1.5m) are presented in Figure 7 and Figure 8.

The NO_2 annual mean contours indicate:

- The 40µg.m^{-3} objective is not being exceeded at any locations where relevant exposure is present within the study area.
- The greatest annual mean NO_2 concentrations at locations where relevant exposure is present are in the town centre at the junction of East Main Street, Greendykes Road and West Main Street. This is therefore the most suitable place to model concentrations at discrete receptor locations.

Figure 7: Modelled annual mean NO_2 concentrations (μg.m^{-3}) at 1.5 m height West

Figure 8: Modelled annual mean NO_2 concentrations (μg.m^{-3}) at 1.5 m height East



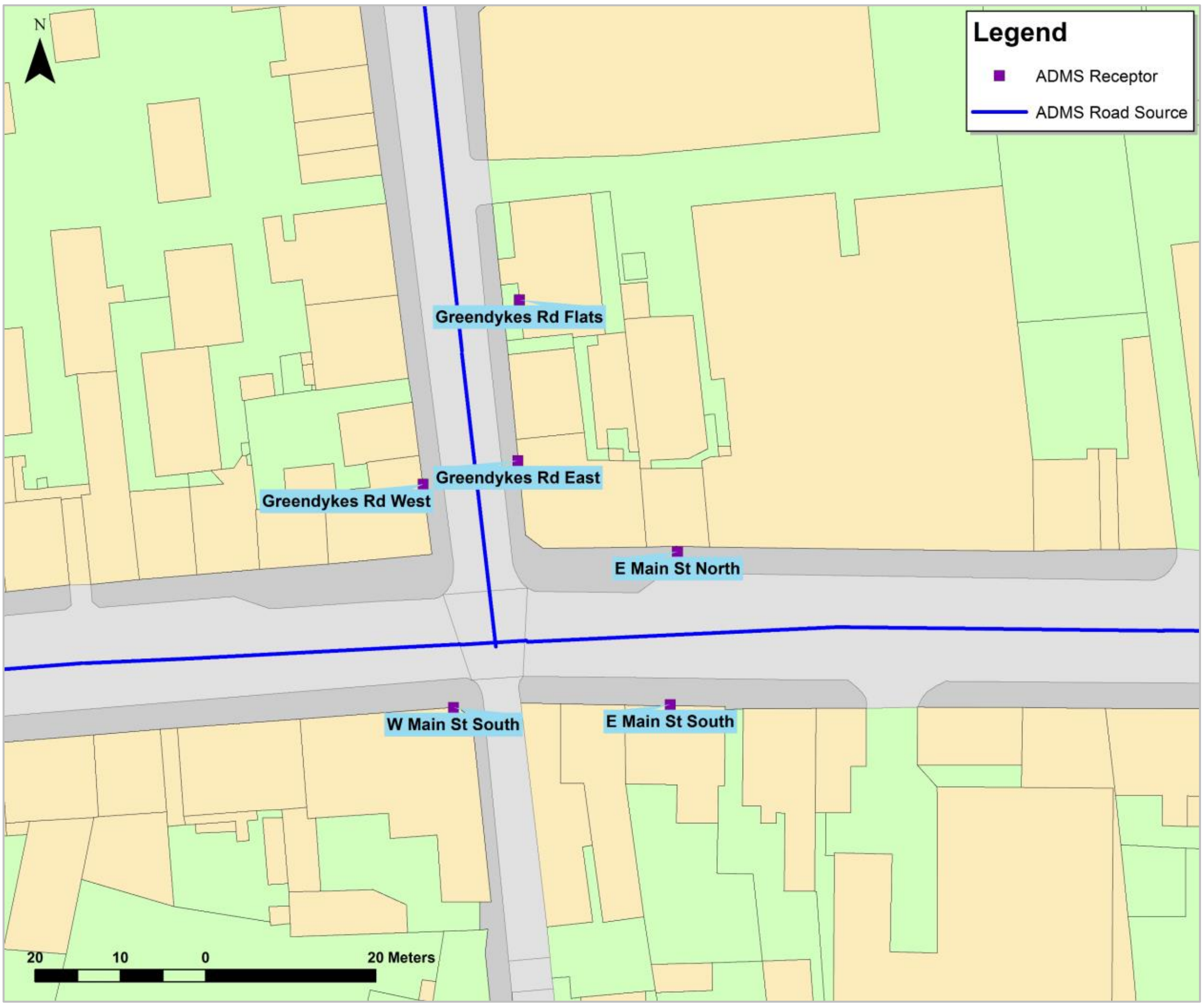
4.4.1.2 NO_2 results at receptor locations

The adjusted model has been used to predict NO_2, PM_{10} and $PM_{2.5}$ concentrations at a selection of discrete receptors within the study area in addition to the diffusion tube sites.

Model receptors have been placed at the façade of buildings in the model domain where relevant exposure exists within the pollution hotspots identified from the pollutant contour plots. In this case, the receptors are all located in the town centre at the junction of East Main Street, Greendykes Road and West Main Street.

The receptors have been modelled at both ground level (1.5m) and at first floor level (4m) where residential properties are located above commercial properties (4m). The receptor locations are presented in Figure 9.

Figure 9: Receptor locations



The predicted annual mean NO_2 concentrations at each of the specified receptors are presented in Table 7. The maximum predicted concentration of 30.5 µg.m^{-3} which is predicted at the receptor on the south side of West Main Street is significantly less than the 40 µg.m^{-3} objective.

Table 7: Predicted annual mean NO_2 concentrations at receptors 2017

Receptor	Easting	Northing	Height (m)	NO_2 Annual Mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	30.5
Greendykes Rd Flats	308300.5	672263.3	1.5	25.4
Greendykes Rd West	308289.2	672241.7	4	26.6
Greendykes Rd East	308300.4	672244.5	4	24.1
E Main St North	308319.1	672234.4	4	25.8
E Main St South	308318.3	672215.7	4	27.6

4.4.1.3 Predicted NO_2 concentrations in comparison with the 1-hour short-term objective

It is difficult to accurately predict if the NO_2 1-hour mean objective is being exceeded using dispersion modelling of vehicle emission rates calculated using daily average flows and speeds; and annual average background concentrations. LAQM.TG(16) states that if an annual mean NO_2 concentration in excess of 60µg.m^{-3} is measured, an exceedance of the 1-hour mean objective may be occurring.

Annual mean NO_2 concentrations in excess of 60µg.m^{-3} are not predicted at any locations where anyone is likely to spend an hour or more within the study area. On this basis it is considered unlikely that the short term NO_2 objective is being exceeded at locations where there is relevant exposure.

4.4.1.4 PM_{10} annual mean contour plots

Contour plots showing the spatial variation of the predicted 2017 annual mean PM_{10} concentrations across the study area at ground floor level (1.5m) are presented in Figure 10 and Figure 11.

The contours indicate that the Scottish 18 µg.m^{-3} annual mean PM_{10} objective is not being exceeded at any locations at ground floor height.

Figure 10: Modelled PM_{10} annual mean concentrations ($\mu g.m^{-3}$) at 1.5 m height West

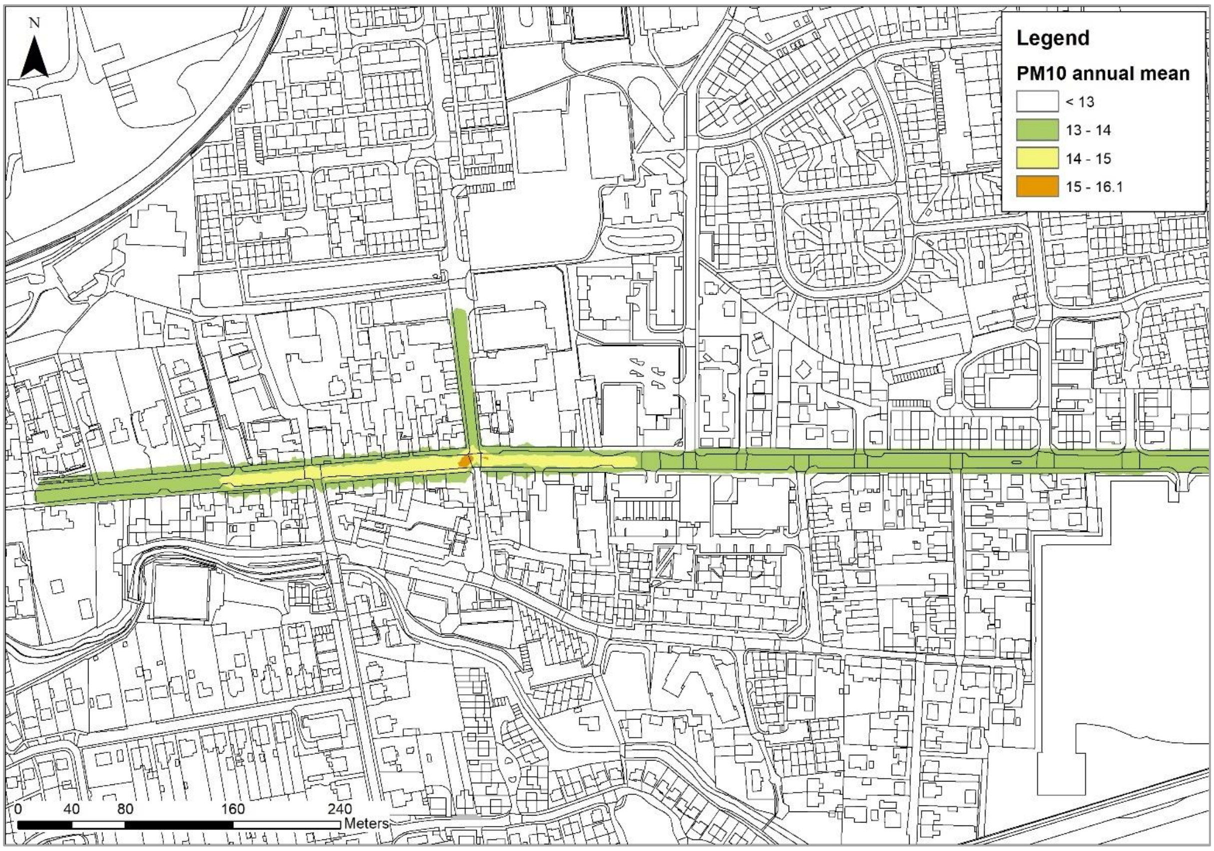
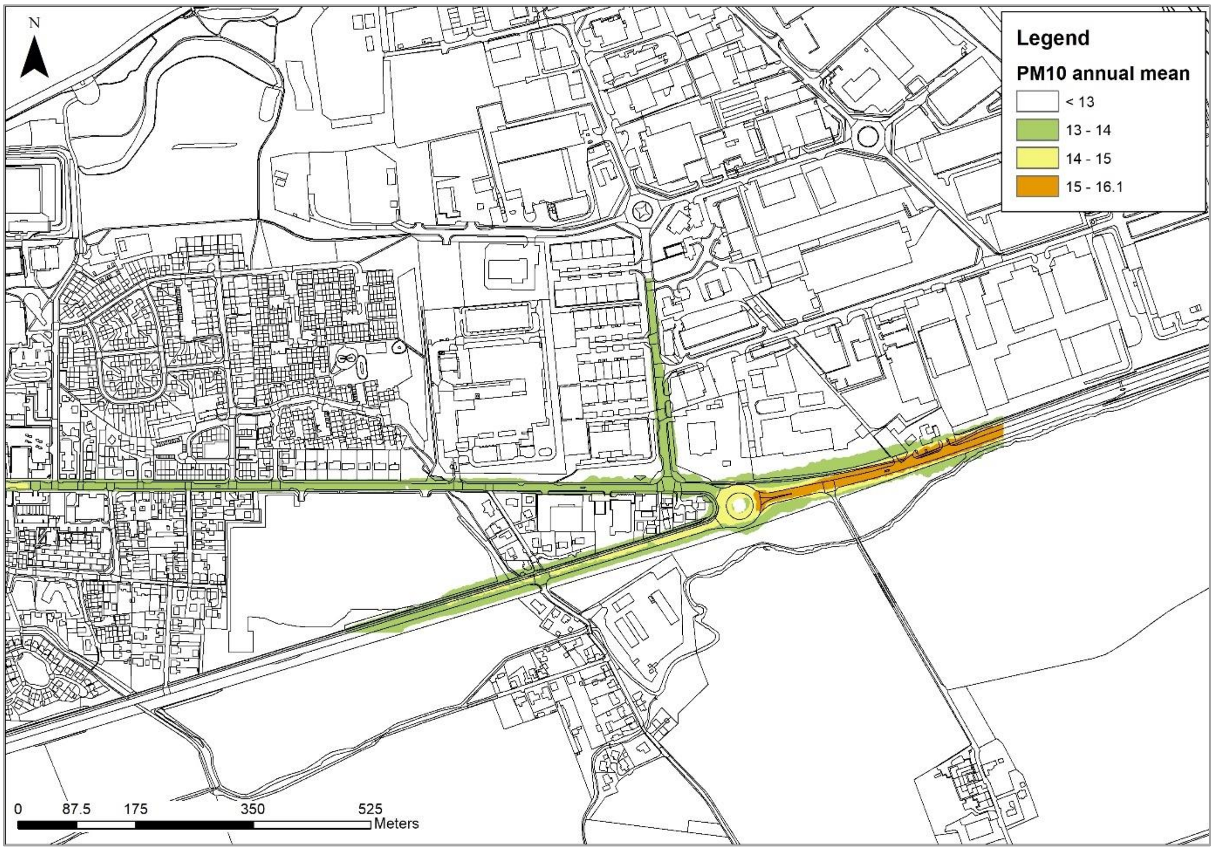


Figure 11: Modelled PM_{10} annual mean concentrations ($\mu g.m^{-3}$) at 1.5 m height East



4.4.1.5 PM_{10} results at receptor locations

The predicted annual mean PM_{10} concentrations at each of the specified receptors are presented in Table 8. No annual mean PM_{10} concentrations in excess of the 18 µg.m^{-3} Scottish objective were predicted at any of the modelled receptor locations. All predicted annual mean PM_{10} concentrations at receptors are significantly less than the 18 µg.m^{-3} objective.

Table 8: Predicted annual mean PM_{10} concentrations at specified receptors 2017

Receptor	Easting	Northing	Height (m)	PM_{10} Annual Mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	14.1
Greendykes Rd Flats	308300.5	672263.3	1.5	12.9
Greendykes Rd West	308289.2	672241.7	4	13.3
Greendykes Rd East	308300.4	672244.5	4	13.0
E Main St North	308319.1	672234.4	4	13.4
E Main St South	308318.3	672215.7	4	13.7

4.4.1.6 $PM_{2.5}$ annual mean contour plots

Contour plots showing the spatial variation of the predicted 2017 annual mean $PM_{2.5}$ concentrations across the study area at ground floor level (1.5m) are presented in Figure 12 and Figure 13.

The contours indicate that the Scottish 10 µg.m^{-3} annual mean $PM_{2.5}$ objective is not being exceeded at any locations at ground floor height.

Figure 12: Modelled $PM_{2.5}$ annual mean concentrations ($\mu g.m^{-3}$) at 1.5 m height (West section of domain)

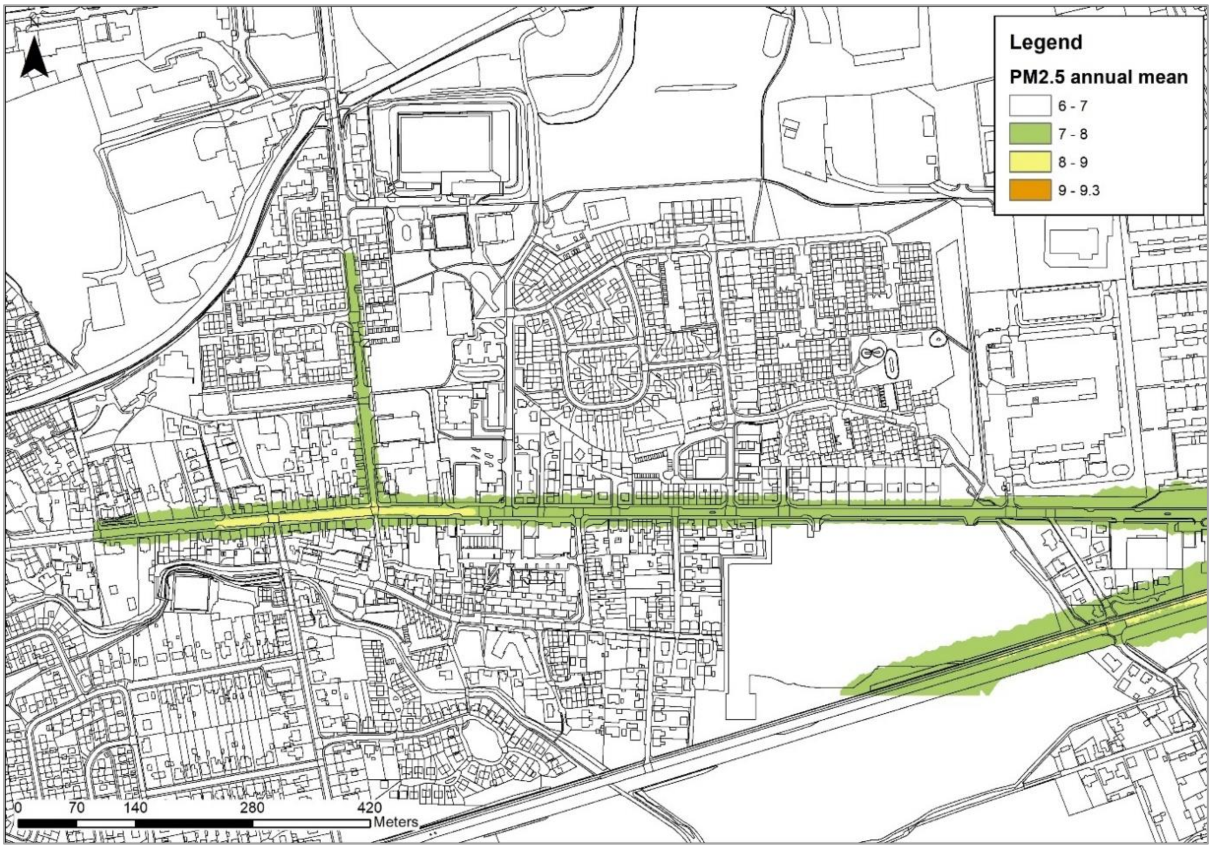
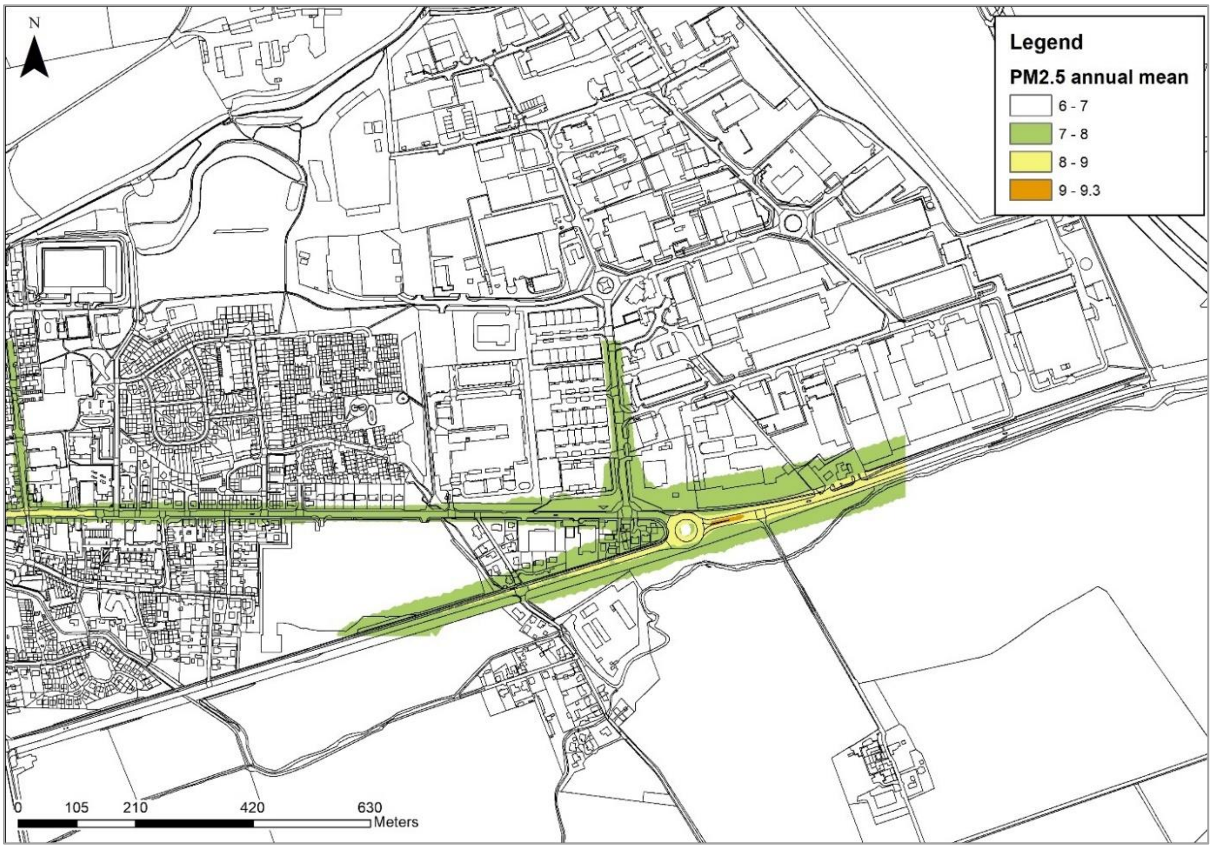


Figure 13: Modelled $PM_{2.5}$ annual mean concentrations ($\mu g.m^{-3}$) at 1.5 m height (East section of domain)



4.4.1.7 $PM_{2.5}$ results at receptor locations

The predicted annual mean $PM_{2.5}$ concentrations at each of the specified receptors are presented in Table 9. No annual mean $PM_{2.5}$ concentrations in excess of the 10 µg.m^{-3} objective were predicted at any of the modelled receptor locations.

Table 9: Predicted annual mean $PM_{2.5}$ concentrations at specified receptors 2017

Receptor	Easting	Northing	Height (m)	$PM_{2.5}$ annual mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	8.0
Greendykes Rd Flats	308300.5	672263.3	1.5	7.4
Greendykes Rd West	308289.2	672241.7	4	7.6
Greendykes Rd East	308300.4	672244.5	4	7.4
E Main St North	308319.1	672234.4	4	7.6
E Main St South	308318.3	6722157	4	7.8

4.4.2 Sensitivity analysis of meteorological conditions

The TG(16) guidance acknowledges that pollutant concentrations may vary significantly from one year to the next, due to the influence of meteorological conditions. The guidance goes on to state that it is important that authorities avoid cycling between declaring, revoking and declaring again, due simply to these variations. Before revoking an AQMA on the basis of measured pollutant concentrations, the authority therefore needs to be reasonably certain that any future exceedances (that might occur in more adverse meteorological conditions) are unlikely.

To assess the risk of weather conditions potentially leading to exceedances of the air quality objectives in future years, a sensitivity analysis of meteorological conditions measured at Edinburgh Airport from 2007 to 2017 has been included in the dispersion modelling assessment. 2017 baseline traffic activity data were used to calculate emissions The sensitivity analysis was used to determine the annual dataset that produced the maximum ambient pollutant concentrations, and to quantify the inter-year variability in predicted concentrations attributable to differences in the various annual meteorological datasets.

The results have been presented in accordance with the guidelines for presenting the variability of dispersion modelling results published by the UK Atmospheric Dispersion Modelling Liaison Committee[6] as mean of all met years modelled ± twice the standard deviation. This represents a variability range within which 97.5% of the values are expected to be found over the likely range of annual weather conditions that could occur.

The results of the sensitivity test for NO_2, PM_{10} and $PM_{2.5}$ are presented in Table 10, Table 11 and Table 12 respectively. More detailed tables containing model results at receptors for all years modelled are presented in Appendix 4.

Based on an analysis conducted using the weather conditions observed between 2007 and 2017; the results indicate that for all three pollutants, it's unlikely that the respective annual mean objectives will be exceeded in a year when poorer than average dispersion occurs due to weather conditions.

[6] ADMLC (2004) Guidelines for the Preparation of Dispersion Modelling Assessments for Compliance with Regulatory Requirements – an Update to the 1995 Royal Meteorological Society Guidance

Table 10: Sensitivity analysis of the effect of different annual meteorological conditions 2007 – 2017: NO_2 annual mean concentrations (µg.m^{-3})

Receptor	Minimum	Maximum	Mean	Standard Deviation x 2	Mean + 2xSD
W Main St South	29.5	32.1	30.8	1.7	32.5
Greendykes Rd Flats	24.6	27.8	26.0	2.2	28.2
Greendykes Rd West	24.4	27.2	26.0	1.8	27.7
Greendykes Rd East	23.5	26.3	24.6	1.8	26.4
E Main St North	25.8	30.1	27.5	2.5	30.0
E Main St South	26.9	29.2	28.0	1.6	29.6

Table 11: Sensitivity analysis of the effect of different annual meteorological conditions 2007 – 2017: PM_{10} annual mean concentrations (µg.m^{-3})

Receptor	Minimum	Maximum	Mean	Standard Deviation x 2	Mean + 2xSD
W Main St South	13.9	14.3	14.1	0.3	14.4
Greendykes Rd Flats	12.8	13.1	12.9	0.2	13.1
Greendykes Rd West	13.0	13.4	13.2	0.2	13.4
Greendykes Rd East	12.9	13.3	13.1	0.2	13.3
E Main St North	13.4	14.0	13.7	0.4	14.0
E Main St South	13.6	13.9	13.7	0.2	13.9

Table 12: Sensitivity analysis of the effect of different annual meteorological conditions 2007 – 2017: $PM_{2.5}$ annual mean concentrations (µg.m^{-3})

Receptor	Minimum	Maximum	Mean	Standard Deviation x 2	Mean + 2xSD
W Main St South	8.0	8.2	8.1	0.1	8.2
Greendykes Rd Flats	7.3	7.5	7.4	0.1	7.5
Greendykes Rd West	7.4	7.6	7.6	0.1	7.7
Greendykes Rd East	7.4	7.6	7.5	0.1	7.6
E Main St North	7.6	8.0	7.8	0.2	8.0
E Main St South	7.7	7.9	7.8	0.1	8.0

4.4.3 Future Year Baseline Scenario

A future year baseline in 2025 has been modelled to assess potential changes in traffic flows and pollutant concentrations. No developments within the area surrounding Broxburn are currently anticipated by West Lothian Council, hence an estimate of likely traffic growth has been assessed.

2025 traffic volumes have been projected from the 2017 baseline traffic data using a TEMPro[7] growth factors for the West Lothian Council area. Projected vehicle emission rates in 2025 were calculated using the EFT.

4.4.3.1 NO_2 annual mean – 2025 baseline

NO_2 annual mean concentrations at receptor locations have been presented in Table 13. No exceedances of the 40 µg.m^{-3} NO_2 annual mean objective were predicted, and annual mean concentrations were well below the limit value.

It is considered unlikely that the short term NO_2 objective will be exceeded at locations where there is relevant exposure, as no predicted annual mean concentrations exceed 60 µg.m^{-3}.

Table 13: Predicted annual mean NO_2 concentrations at receptors – 2025 baseline

Receptor	Easting	Northing	Height (m)	NO_2 Annual Mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	17.6
Greendykes Rd Flats	308300.5	672263.3	1.5	14.6
Greendykes Rd West	308289.2	672241.7	4	15.4
Greendykes Rd East	308300.4	672244.5	4	14.1
E Main St North	308319.1	672234.4	4	15.1
E Main St South	308318.3	672215.7	4	16.0

4.4.3.2 PM_{10} annual mean – 2025 baseline

The predicted annual mean PM_{10} concentrations in 2025 at each of the specified receptors are presented in Table 14. No annual mean PM_{10} concentrations in excess of the 18 µg.m^{-3} objective were predicted at any of the modelled receptor locations. All predicted annual mean PM_{10} concentrations at receptors are significantly less than the 18 µg.m^{-3} objective.

Table 14: Predicted annual mean PM_{10} concentrations at receptors – 2025 baseline

Receptor	Easting	Northing	Height (m)	PM_{10} Annual Mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	12.2
Greendykes Rd Flats	308300.5	672263.3	1.5	10.9
Greendykes Rd West	308289.2	672241.7	4	11.4
Greendykes Rd East	308300.4	672244.5	4	11.1
E Main St North	308319.1	672234.4	4	11.5
E Main St South	308318.3	672215.7	4	11.7

[7] https://www.gov.uk/government/publications/tempro-downloads

4.4.3.3 $PM_{2.5}$ annual mean – 2025 baseline

The predicted annual mean $PM_{2.5}$ concentrations in 2025 at each of the specified receptors are presented in Table 15. No annual mean $PM_{2.5}$ concentrations in excess of the 10 µg.m^{-3} objective were predicted at any of the modelled receptor locations.

Table 15: Predicted annual mean $PM_{2.5}$ concentrations at receptors – 2025 baseline

Receptor	Easting	Northing	Height (m)	$PM_{2.5}$ annual mean (µg.m^{-3})
W Main St South	308292.8	672215.5	4	7.0
Greendykes Rd Flats	308300.5	672263.3	1.5	6.4
Greendykes Rd West	308289.2	672241.7	4	6.6
Greendykes Rd East	308300.4	672244.5	4	6.4
E Main St North	308319.1	672234.4	4	6.7
E Main St South	308318.3	6722157	4	6.8

5 Conclusion

This report describes a Detailed Assessment of air quality in Broxburn, West Lothian. The assessment considers NO_2, PM_{10} and $PM_{2.5}$ concentrations within the Broxburn air quality management area (AQMA)

The Detailed Assessment aims to provide evidence that will aid the Council in deciding if revocation of the AQMA is appropriate at this time, or if the AQMA is still required, or may be required in the future based on projected traffic activity levels.

The review of pollutant measurements over the last eleven years has concluded:

- For NO_2, annual mean concentrations in excess of the 40 $\mu g.m^{-3}$ objective have not been measured in Broxburn since 2010 and have in general declined at all measurement sites over the last eleven years. In 2019 all measured concentrations were less than 70% of the annual mean objective.
- For PM_{10}, annual mean concentrations in excess of the 18 $\mu g.m^{-3}$ objective have not been measured in Broxburn since 2011 and have in general declined at all measurement sites since then. However, due to current uncertainties with particulate measurement techniques (pending ongoing further investigation), the Scottish Government recommends that Local authorities using Fidas analysers within the SAQD network should not consider revoking an AQMA for PM_{10} at this time.
- For $PM_{2.5}$, there have been no exceedances of the 10 $\mu g.m^{-3}$ objective since monitoring began in 2017. Measured annual mean have also been consistently less than the 8 $\mu g.m^{-3}$ uncertainty threshold currently recommended by the Scottish Government.

The dispersion modelling study of current and future road traffic emissions indicates that:

- In 2017, the NO_2, PM_{10} and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area.
- Based on a sensitivity analysis of modelled pollutant concentrations using annual meteorological datasets from 2007 to 2017, for all three pollutants, it's unlikely that the respective annual mean objectives will be exceeded in a year when poorer than average dispersion occurs due to weather conditions.
- For the 2025 future year baseline, the NO_2, PM_{10} and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area. No developments near the Broxburn study area are currently planned.

In light of this Detailed Assessment of Air Quality, West Lothian Council may wish to:

1. **Consider revocation of the Broxburn Air Quality Management Area for exceedances of the NO_2 annual mean objective**
2. **Delay revoking the AQMA for exceedances of the PM_{10} annual mean objective until Scottish Government guidance regarding AQMA revocation and the use of Fidas analysers for particulate measurements is updated.**

Although we have attempted to minimise uncertainty in the modelling aspects of this assessment as much as possible, the results should be considered in context with the uncertainties regarding model input data discussed in the report.

6 Acknowledgements

Ricardo Energy & Environment gratefully acknowledges the support received from West Lothian Council when completing this assessment.

Appendices

Appendix 1 – Traffic Data

Table A1.1 summarises the Annual Average Daily Flows (AADT) of traffic and fleet compositions used within the model for each road link.

Traffic data for the assessment was available from local surveys commissioned by West Lothian Council. The local traffic surveys conducted in 2017 provided information on daily average flow and detailed fleet split i.e. petrol car, diesel car, LGV, rigid HGV, articulated HGV, buses and motorcycles.

Table A1.1: West Lothian 2017 – Annual Average Daily Flows

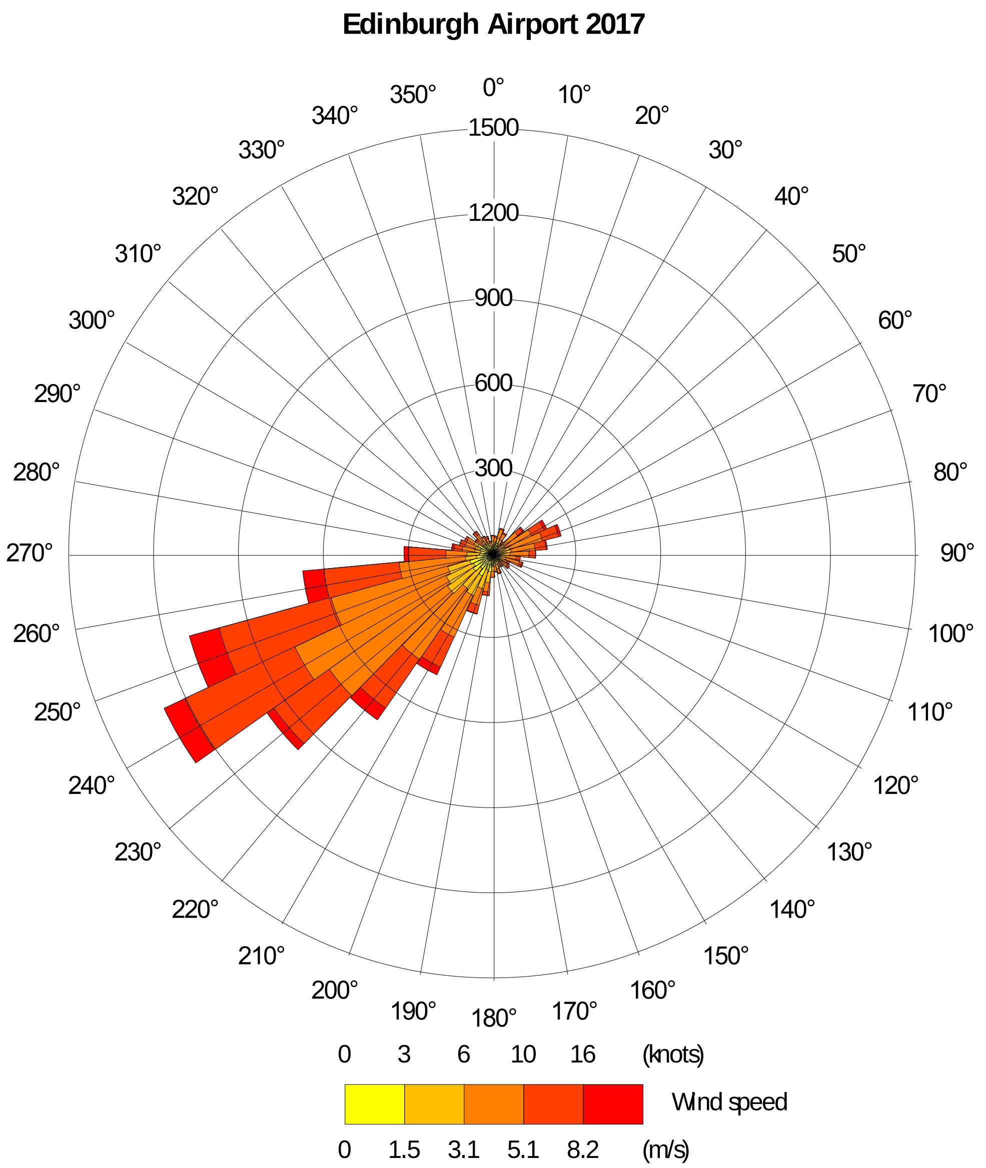
Street name	AADT	Petrol Car	Diesel Car	LGV	Rigid HGV	Articulated HGV	Bus	Motorcycle
1 - A89 East	25898	45.87	32.93	15.77	2.68	0.80	1.88	0.07
10 - A89 West RD off	7148	45.87	32.93	15.77	2.68	0.80	1.88	0.07
11 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
12 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
13 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
14 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
15 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
16 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
17 - E.MainSt	7838	45.87	32.93	15.77	2.68	0.80	1.88	0.07
18 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
19 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
2 - A89 East	25898	45.87	32.93	15.77	2.68	0.80	1.88	0.07
20 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
21 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
22 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
23 - E.MainSt	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
24 - Jnc_E/W.M.St	10477	45.87	32.93	15.77	2.68	0.80	1.88	0.07
25 - W.MainSt	11435	45.87	32.93	15.77	2.68	0.80	1.88	0.07
26 - W.MainSt	11435	45.87	32.93	15.77	2.68	0.80	1.88	0.07
27 - W.MainSt	11435	45.87	32.93	15.77	2.68	0.80	1.88	0.07
28 - W.MainSt	11435	45.87	32.93	15.77	2.68	0.80	1.88	0.07

Street name	AADT	Petrol Car	Diesel Car	LGV	Rigid HGV	Articulated HGV	Bus	Motorcycle
29a - Greendykes	5527	45.87	32.93	15.77	2.68	0.80	1.88	0.07
29b - Greendykes	5527	45.87	32.93	15.77	2.68	0.80	1.88	0.07
29c - Greendykes	5527	45.87	32.93	15.77	2.68	0.80	1.88	0.07
3 - A89 East	25898	45.87	32.93	15.77	2.68	0.80	1.88	0.07
30 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
31 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
32 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
33 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
34 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
35 - Dunnet Way	9107	45.87	32.93	15.77	2.68	0.80	1.88	0.07
36 - A89 West	14082	45.87	32.93	15.77	2.68	0.80	1.88	0.07
37 - A89 West	14082	45.87	32.93	15.77	2.68	0.80	1.88	0.07
38 - A89 West	14082	45.87	32.93	15.77	2.68	0.80	1.88	0.07
39 - A89 West	14082	45.87	32.93	15.77	2.68	0.80	1.88	0.07
4 - A89 East RD off	13388	45.87	32.93	15.77	2.68	0.80	1.88	0.07
40 - A89 West	14082	45.87	32.93	15.77	2.68	0.80	1.88	0.07
5 - A89 East RD on	12510	45.87	32.93	15.77	2.68	0.80	1.88	0.07
6 - A89 RDBT	12510	45.87	32.93	15.77	2.68	0.80	1.88	0.07
7 - E.MainSt (onRD)	4230	45.87	32.93	15.77	2.68	0.80	1.88	0.07
8 - E.MainSt (offRD)	3608	45.87	32.93	15.77	2.68	0.80	1.88	0.07
9 - A89 West RD on	6934	45.87	32.93	15.77	2.68	0.80	1.88	0.07

Appendix 2 – Meteorological Dataset

The wind rose for the Edinburgh Airport 2017 meteorological measurement site is presented below.

Figure A2.1: Meteorological dataset wind rose



Appendix 3 – Model Verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. This can be followed by adjustment of the modelled results if required. LAQM.TG(16) recommends making the adjustment to the road contribution only and not the background concentration these are combined with.

The approach outlined in Box 7.15 of LAQM.TG(16) has been used in this case.

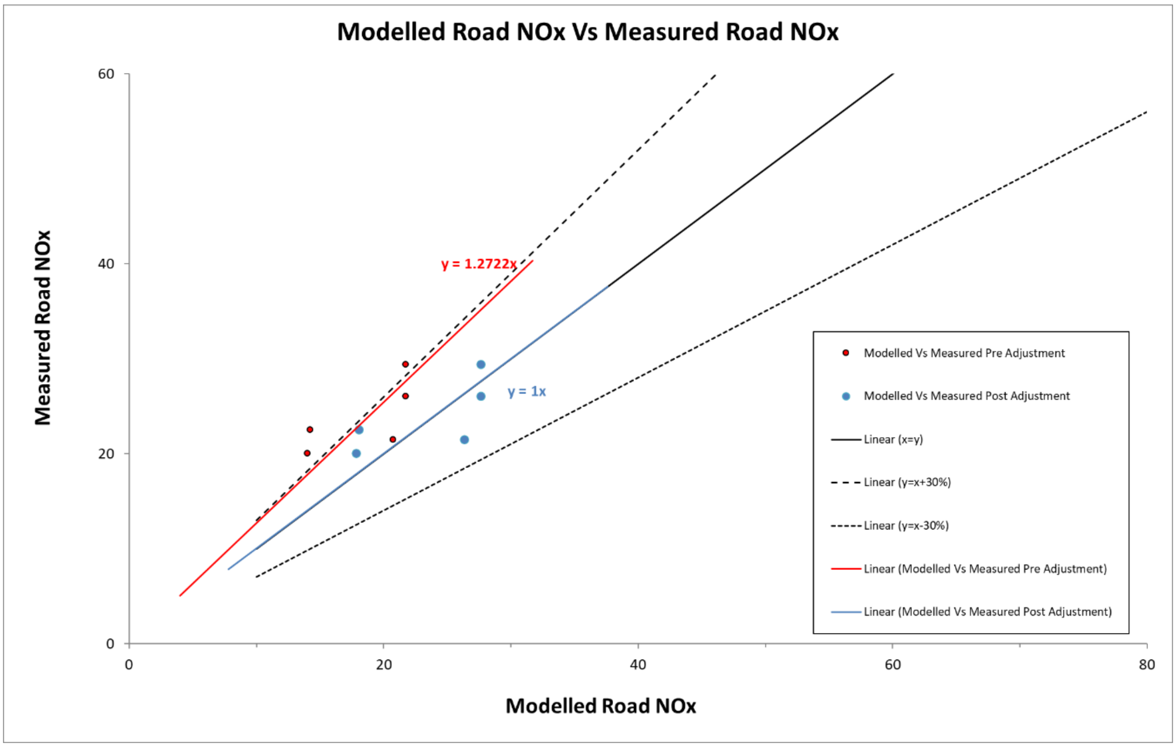
The modelled NO_x concentrations in this study were verified using the automatic site and the four available roadside diffusion tube measurements.

The following Road NO_x adjustment factor was derived**: 1.2722**.

The adjustment factor was applied to the modelled road NO_x concentrations, and the adjusted total NO_2 concentrations were then calculated using the Defra NO_x/NO_2 calculator.

The regression plot comparing modelled and monitoring Road NO_x concentrations before and after adjustment is presented in Figure A3.1.

Figure A3.1: Linear regression between measured and modelled Road NO_x before and after adjustment



Appendix 4 – Meteorological Analysis

Table A4.1 summarises the NO_2 meteorological analysis across eleven years. Table A4.2 summarises the PM_{10} meteorological analysis across eleven years. Table A4.3 summarises the $PM_{2.5}$ meteorological analysis across eleven years

Table A4.2: NO_2 met analysis results

Site ID	2007 ($\mu g.m^{-3}$)	2008 ($\mu g.m^{-3}$)	2009 ($\mu g.m^{-3}$)	2010 ($\mu g.m^{-3}$)	2011 ($\mu g.m^{-3}$)	2012 ($\mu g.m^{-3}$)	2013 ($\mu g.m^{-3}$)	2014 ($\mu g.m^{-3}$)	2015 ($\mu g.m^{-3}$)	2016 ($\mu g.m^{-3}$)	2017 ($\mu g.m^{-3}$)
W Main St South	30.5	31.0	31.8	32.1	30.4	30.0	29.5	30.3	30.9	32.1	30.5
Greendykes Rd Flats	26.3	27.8	25.7	27.8	25.1	25.7	24.6	25.7	24.7	26.9	25.4
Greendykes Rd West	26.4	26.9	26.1	27.2	25.6	25.3	24.4	24.9	25.6	26.7	26.6
Greendykes Rd East	24.7	25.7	24.5	26.3	23.8	24.5	23.5	24.3	23.6	25.4	24.1
E Main St North	26.5	27.6	28.4	30.1	26.7	27.5	26.6	27.3	27.6	29.0	25.8
E Main St South	27.6	28.1	29.0	29.2	27.5	27.3	26.9	27.5	28.1	29.1	27.6

Table A4.2: PM_{10} met analysis results

Site ID	2007 ($\mu g.m^{-3}$)	2008 ($\mu g.m^{-3}$)	2009 ($\mu g.m^{-3}$)	2010 ($\mu g.m^{-3}$)	2011 ($\mu g.m^{-3}$)	2012 ($\mu g.m^{-3}$)	2013 ($\mu g.m^{-3}$)	2014 ($\mu g.m^{-3}$)	2015 ($\mu g.m^{-3}$)	2016 ($\mu g.m^{-3}$)	2017 ($\mu g.m^{-3}$)
W Main St South	14.1	14.2	14.3	14.3	14.1	14.0	13.9	14.1	14.1	14.3	14.1
Greendykes Rd Flats	13.0	13.1	12.9	13.1	12.9	12.9	12.8	12.9	12.8	13.0	12.9
Greendykes Rd West	13.3	13.3	13.2	13.4	13.2	13.1	13.0	13.1	13.2	13.3	13.3
Greendykes Rd East	13.1	13.2	13.0	13.3	13.0	13.0	12.9	13.0	12.9	13.2	13.0
E Main St North	13.5	13.6	13.8	14.0	13.5	13.6	13.5	13.6	13.7	13.9	13.4
E Main St South	13.7	13.7	13.9	13.9	13.7	13.6	13.6	13.6	13.7	13.9	13.7

Table A4.3: $PM_{2.5}$ met analysis results

Site ID	2007 ($\mu g.m^{-3}$)	2008 ($\mu g.m^{-3}$)	2009 ($\mu g.m^{-3}$)	2010 ($\mu g.m^{-3}$)	2011 ($\mu g.m^{-3}$)	2012 ($\mu g.m^{-3}$)	2013 ($\mu g.m^{-3}$)	2014 ($\mu g.m^{-3}$)	2015 ($\mu g.m^{-3}$)	2016 ($\mu g.m^{-3}$)	2017 ($\mu g.m^{-3}$)
W Main St South	8.0	8.1	8.2	8.2	8.0	8.0	8.0	8.0	8.1	8.2	8.0
Greendykes Rd Flats	7.4	7.5	7.4	7.5	7.3	7.4	7.3	7.4	7.3	7.5	7.4
Greendykes Rd West	7.6	7.6	7.6	7.6	7.5	7.5	7.4	7.5	7.5	7.6	7.6
Greendykes Rd East	7.5	7.5	7.4	7.6	7.4	7.4	7.4	7.4	7.4	7.5	7.4
E Main St North	7.7	7.8	7.9	8.0	7.7	7.8	7.7	7.8	7.8	7.9	7.6
E Main St South	7.8	7.8	7.9	7.9	7.8	7.8	7.7	7.8	7.8	7.9	7.8

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