A9 DUALLING
PERTH TO INVERNESS

Appendix A16.1

Air Quality

TRANSPORT SCOTLAND
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1. Approach and Methods

1.1. Legislation, Policy and Guidance

Air Pollutants

1.1.1. Nitrogen dioxide (NO_2) is a secondary pollutant produced by the oxidation of nitric oxide (NO). NO and NO_2 are collectively referred to as NO_x. Just over a third of the UK NO_x emissions are from road transport. The majority of NO_x emitted from vehicles is in the form of NO, which oxidises rapidly in the presence of ozone to form NO_2. Whilst it was originally thought that the proportion of primary NO_2 was of the order of 5% of the total NO_x in vehicle exhaust, recent studies have indicated that values of up to 20% primary NO_2 may be assumed for diesel vehicles and vehicles with oxidising exhaust after treatment systems[i]. Concentrations of NO_2 tend to be highest in urban environments with high traffic levels and in the vicinity of large industrial sources. In high concentrations NO_2 can affect the respiratory system.

1.1.2. Particulate Matter (PM) in vehicle exhaust gases consists of carbon nuclei onto which a wide range of compounds are absorbed. These particles have an effective aerodynamic diameter of less than 10 micrometres (µm). Particles in this size range are referred to as PM_{10}. The principal sources of 'primary' polluting particles are combustion processes which include traffic and industry. Diesel engines produce the majority of particulate emissions from the vehicle fleet. About a quarter of primary PM_{10} emissions in the UK are derived from road transport. Particulate matter appears to be associated with a range of symptoms of ill health including effects on the respiratory and cardiovascular systems, on asthma and on mortality. Reviews by the World Health Organisation (WHO) and Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to a finer fraction of particles ($PM_{2.5}$ particles with a diameter of less than 2.5µm, which typically make up around two thirds of PM_{10} emissions and concentrations) give a stronger association with the observed ill health effects.

Dust

1.1.3. Dust is the generic term for solid particles that can be suspended in the atmosphere. Dust per se is not considered as a local air pollutant but is inevitably encountered in the outdoor environment. It is defined within the Institute of Air Quality Management (IAQM) Construction Dust Guidanceii as solid particles that are suspended in air or have settled out onto a surface after having been suspended in air. It includes particles that give rise to soiling (deposited dust) and to human health effects (particulate matter as discussed above) and ecological effects.

1.1.4. Dust that may deposit in the local area close to a source (such as a construction site) typically comprises particles between 10 and 75 micrometres (µm) in diameter, the larger size particles settling to the ground within a few tens of metres from the source. Small particles settle more slowly over a larger area and therefore contribute relatively little to the general ambient dust levels. Such particles are also more susceptible to being blown away. Excessive accumulations of dust on exposed surfaces, particularly in residential locations, may cause a perceived loss of amenity and give rise to public complaint.

1.1.5. The IAQM Construction Dust Guidance states that there is evidence that major construction sites can lead to an increase in annual mean PM_{10} concentrations and the number of exceedances of the short term (24-hour mean) objective for PM_{10}. In addition, demolition and construction activities have the potential to cause higher than normal levels of dust deposition in the surrounding area. Dust emissions from a site may be

mechanically generated due to land preparation (e.g. demolition, land clearing and earth moving) or as a result of release from site plant and movement of road vehicles on temporary roads, and open ground and haul routes.

Air Quality Criteria

1.1.6. The Government's Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland[iii] provides details of national air quality standards and objectives for a number of local air pollutants including NO_2 and particulates (PM_{10} and $PM_{2.5}$). These criteria are included in The Air Quality Standards (Scotland) Regulations 2010 (SSI 2010/204)[iv] and The Air Quality (Scotland) Amendment Regulations 2016 (SSI 2016/162)[v]. These regulations implement the EU Directive 2008/50/EC[vi] on ambient air quality and cleaner air for Europe (the Air Quality Directive).

1.1.7. The air quality standards define the level of pollution below which health effects are unlikely to be experienced even by the most sensitive members of the population. These are based upon recommendations of the Expert Panel on Air Quality Standards (EPAQS). The air quality objectives are targets for air pollution concentrations which take account of the costs and benefits of achieving the standard. In the case of short-term targets, the permissible number of hours or days above the objective concentration is also specified. The number of permissible "exceedances" is considered when determining compliance with the short-term objectives over an annual period. Local authorities are not legally obliged to achieve the air quality objectives. They are, however, required to work towards the objectives.

1.1.8. It should be noted that the air quality criteria only apply in locations where there may be a 'relevant exposure'. These human health objectives are applicable where members of the public may be exposed to pollutant levels for periods equal to or exceeding the averaging periods set for these criteria. Locations of relevant exposure include building façades of residential premises, schools, public buildings and medical facilities. Places of work, other than certain community facilities, are excluded.

1.1.9. The air quality criteria for the protection of human health in Scotland, for the key pollutants relevant to the assessment, are presented in Table A1.1 below.

Table A1.1: Relevant Air Quality Criteria (Human Health)

Pollutant	Objective	Compliance Date	
		AQS Objective	EU limit value
Nitrogen dioxide, NO_2	Hourly average concentration should not exceed 200µg/m^3 more than 18 times a year Annual mean concentration should not exceed 40µg/m^3	31 Dec 2005 31 Dec 2005	1 Jan 2010 1 Jan 2010
Particulate matter, PM_{10}	Daily average concentration should not exceed 50µg/m^3 more than 7 times a year Annual mean concentration should not exceed 18µg/m^3	31 Dec 2004 31 Dec 2004	1 Jan 2005 1 Jan 2005
Particulate matter, $PM_{2.5}$	Annual mean concentration should not exceed 10µg/m^3	31 Dec 2020 (Authorities in Scotland only)	-

Dust

1.1.10. There are no national standards or guidelines for dust deposition as a nuisance currently set for the UK, nor by the European Union or World Health Organisation. This is mainly due to the difficulty in setting a standard that would need to relate to dust being a perceptual problem rather than being specifically related to health effects. Typically there is a 'likelihood of complaint' in residential areas where measured dust deposition rates (as an average measured over a month using a passive deposition gauge) are 200 mg/m^2/day or greater[vii].

Ecological Criteria

1.1.11. The EU has set limit values for the protection of vegetation for oxides of nitrogen based on the work of the United Nations Economic Commission for Europe (UNECE) and WHO and these limit values have been incorporated into The Air Quality Standards (Scotland) Regulations 2010 (SSI 2010/204).

1.1.12. The limit value for oxides of nitrogen for the protection of vegetation is an annual mean of 30µg/m^3. This is the same as the AQS objective. The limit values for the protection of vegetation apply to locations more than 20km from towns with more than 250,000 inhabitants or more than five km from other built-up areas, industrial installations or motorways. This objective does not apply in those areas where assessment of compliance with the limit value is not required. However, as the UNECE and the WHO have set a critical level for NO_x for the protection of vegetation, the policy of the statutory nature conservation agency (in Scotland, Scottish Natural Heritage) is to apply the criterion as a benchmark, on a precautionary basis, in internationally designated conservation sites (Ramsar, Special Area of Conservation (SAC), Special Protection Area (SPA) and Sites of Special Scientific Interest (SSSIs)).

1.1.13. In addition, critical loads for nitrogen and acid deposition have been set by the UNECE, that represent (according to current knowledge) the exposure below which there should be no significant harmful effects on sensitive elements of the ecosystem. The critical loads vary by type of ecosystem, and are available from the Air Pollution Information System (APIS) website[viii].

Local Air Quality Review and Assessment

1.1.14. Under Part IV of the Environment Act 1995[ix] all local authorities are responsible for Local Air Quality Management (LAQM), the mechanism by which the Government's air quality objectives are to be achieved. As part of this LAQM role, local authorities are required to periodically review air quality in their area and to assess the present and likely future air quality against AQS objectives. The findings are reported and published following public consultation and review by the Department for Environment, Food and Rural Affairs (Defra). Where a local authority determines an AQS objective to be breached, it must designate an Air Quality Management Area (AQMA) and develop an action plan to improve pollution levels.

Planning Policy

1.1.15. The Scottish Government's planning guidance of general relevance for air quality is found within the National Planning Framework for Scotland (NPF3)[x]. This states that:

"Reducing the impact of the car on city and town centres will make a significant contribution to realising their potential as sustainable places to live and invest by addressing congestion, air pollution and noise and improving the public realm. Significant

health benefits could be achieved by substantially increasing active travel within our most densely populated areas."

1.1.16. NPF3 is supported by a Draft Action Programme for implementation of the NPF strategy. There are no actions specific to the improvement of air quality.

Local Planning Policy

1.1.17. The Highland-wide Local Development Plan published in April 2012[xi] contains a comprehensive policy approach for air quality. Policies relevant to air quality include:

- Policy 28: Sustainable design

"Proposed developments will be assessed on the extent to which they impact on air quality"

- Policy 72 Pollution; and

"Proposals that may result in significant pollution such as air, will only be approved where a detailed assessment report on the levels, character and transmission and receiving environment of the potential pollution is provided by the applicant to show how the pollution can be appropriately avoided and if necessary mitigated"

- Policy 73 Air Quality.

"Development proposals which, individually or cumulatively, may adversely affect the air quality in an area to a level which could cause harm to human health and wellbeing or the natural environment must be accompanied by appropriate provisions, such as an Air Quality Assessment, which demonstrate how such impacts will be mitigated."

1.2. Ecological Receptors

1.2.1. There was one designated ecological site identified within the study area. Transects of receptor points from the closest point within the designated site (50m) and at set distances of approximately 100m, 150m and 200m from the nearest road were assessed. Each transect point is listed in Table A1.2 below.

Table A1.2: Relevant Ecological Transect Receptors

Receptor	Distance to road centre/ m	Grid Reference	Description
E1	50	NH8239726495	Slochd SAC Transect Point 1
E2	100	NH8241126520	Slochd SAC Transect Point 2
E3	150	NH8243426565	Slochd SAC Transect Point 3
E4	200	NH8245826610	Slochd SAC Transect Point 4

1.3. Construction Dust Assessment Methodology

1.3.1. Assessment of the potential impact of the construction phase of the proposed development on air quality with regards dust and PM_{10} emissions has been carried out with reference to the four step process described in the IAQM Construction Dust Guidance. These steps are summarised below:

- Step 1 (screening) – Identification of the number of human receptors within 350m of the boundary of the Site and/or within 50m of the route(s) used by construction vehicles

on the public highway up to 500m from the Site entrance. Identification of ecological receptors within 50m of either the boundary of the Site and/or of the route(s) used by construction vehicles on the public highway up to 500m from the site entrance. No further assessment is required if there are no receptors.

  - 'Human' receptors include residential dwellings and other premises that may have a particular sensitivity to dust deposition or to the health effects of PM10 e.g. vehicle showrooms, museums, hospitals, schools and residential care homes.
  - 'Ecological' receptors include sites with statutory designations e.g. Ramsar sites, Special Protection Areas (SPA), Special Areas of Conservation (SAC) and Sites of Special Scientific Interest (SSSI), as well as non-statutory sites such as locations with very specific ecological sensitivities e.g. horticultural operations.

- Step 2 – Assessment of the risk of dust effects in the area around the Site in the context of potential dust impacts (demolition, earthworks, construction activities and trackout (mud deposits on the road from road vehicles leaving the site)) and distance to nearby receptors in relation to proposed activities.
  - Step 2A – Dust emission magnitude classes of 'large', 'medium' and 'small' are used to define the level of risk arising from each site depending on nature and scale of operation.
  - Step 2B – The sensitivity of the surrounding area is defined for each of the three different effects: dust soiling; human health; and ecological; as 'high', 'medium' and 'low' depending on the receptor sensitivity (as shown in Table A1.2) and the distance from the source. In addition, for the effect on human health, background PM10 concentrations are taken into account. The definitions are provided in Tables 2, 3 and 4 of the IAQM's Construction Dust Guidance.
  - Step 2C - Tables 6 to 9 in the IAQM's Construction Dust Guidance are used to define the risk of impact based on the dust emission magnitude and sensitivity of area. These are reproduced in Table A1.4 to Table A1.6.
- Step 3 – Determination of site specific mitigation in terms of the identified risks.
- Step 4 – Assessment of the significance of the dust impacts, after the application of the site specific mitigation. Once mitigation has been applied, there should not be any significant adverse effects.

Table A1.3: Examples of Sensitive Receptors

Type of Receptor	High Sensitivity	Medium Sensitivity	Low Sensitivity
Sensitive to Dust Soiling Effects	Dwellings, museums, long-term car parks, car showrooms	Parks, places of work	Playing fields, farmland, footpaths, short-term car parks
Sensitive to Health Effects of PM_{10}	Residential properties, hospitals, schools, residential care homes	Office and shop workers	Public footpaths, playing fields, parks and shopping streets
Sensitive to Ecological Effects	Locations with an international or national designation and the designated features may be affected by dust soiling	Locations with a national designation where the designated features may be affected by dust deposition	Locations with a local designation where the features may be affected by dust deposition

Table A1.4: Risk of Dust Impacts – Demolition

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible

Table A1.5: Risk of Dust Impacts – Earthworks and Construction

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table A1.6: Risk of Dust Impacts – Trackout[a]

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

[a] Trackout can be defined as the deposition of dust and dirt from the construction site onto the public road network, where it may then be resuspended by vehicles using the network.

1.4. Scheme Monitoring

1.4.1. A NO_2 diffusion tube monitoring survey was carried out for a period of six months from December 2015 until May 2016 in the vicinity of the proposed Scheme. Results from the baseline monitoring survey have been bias corrected by applying the national bias adjustment factor gained from the National Diffusion Tube Bias Adjustment Factor Spreadsheet. Following adjustment, the six month average diffusion tube results were annualised using a factor of 0.96 following analysis of data from three background AURN monitoring sites (Aberdeen, Dundee and Fort William) in accordance with guidance within LAQM.TG(16). The adjusted December 2015 to May 2016 period average and the annualised mean for 2015 are presented for the diffusion tube survey in Table A1.7.

Table A1.7: Monthly and Annualised Mean Concentrations (µg/m^3) at Diffusion Tube Survey Sites

Site ID	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	6 month average	Adjusted 6 month average (*0.91)	Annualised 2015 annual mean
TM01	9.0	n/a	9.3	9.5	5.6	4.8	7.7	7.0	7.3*
TM02	3.7	3.9	2.4	3.1	1.6	2.1	2.8	2.6	2.5
TM03	4.7	4.4	4.4	6.3	2.8	2.7	4.2	3.9	3.7
TM04	6.8	7.7	6.5	8.1	3.8	3.5	6.1	5.5	5.3
TM05	n/a	n/a	n/a	7.8	n/a	n/a	7.8	7.1	n/a
TM06	4.6	6.9	4.8	7.2	4.7	5.1	5.5	5.0	4.8

Site ID	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	6 month average	Adjusted 6 month average (*0.91)	Annualised 2015 annual mean
TM07	9.8	10.3	8.3	11.8	6.7	6.4	8.9	8.1	7.8
TM08	6.1	7.9	6.0	8.6	6.8	5.5	6.8	6.2	6.0
TM09	4.4	5.6	4.6	6.5	4.5	4.2	5.0	4.5	4.4
TM10	4.0	4.5	1.5	4.9	3.3	2.8	3.5	3.2	3.1
*annualisation factor of 1.04 used (period mean ratio excluding Jan monitoring periods)									

1.5. Background Data

1.5.1. The comparison of the 2016 Defra background mapped concentrations with the monitoring survey result for the background monitoring site TM02 is presented in Table A1.8 below.

Table A1.8: Comparison of Monitored and Mapped NO_2 Concentrations (µg/m^3)

Site ID	Monitored	Mapped	Monitored - Mapped	Monitored / Mapped	% Difference
TM02	2.1	2.5	0.38	1.18	18.5

1.5.2. The monitored annual mean NO_2 concentrations at Inverness, Aberdeen, Dundee and Fort William background AURN are presented below in Table A1.9.

Table A1.9: Annual Mean NO_2 Concentrations at AURN sites (µg/m^3)

Site	2012	2013	2014	2015	2016
Fort William	12	9	11	13	10
Inverness	29	21	21	27	24
Aberdeen	21	20	22	23	20
Dundee	10	n/a	13	10	n/a

1.6. Model Verification

1.6.1. It is good practice to compare modelled estimates of pollutant concentrations with real-world monitoring to assess the model's performance. This is undertaken for a base year and informs the interpretation of model results for future years. From the full survey of ten diffusion tubes, only those representative of selected sensitive receptor locations and with sufficient data capture were deemed suitable for the purpose of model verification. Following an evaluation of each monitoring location, seven diffusion tube sites were taken forward in the model verification. Table A1.10 lists the sites removed from the verification process and the reason why.

Table A1.10: Monitoring sites removed from the verification process

Site	Reason for exclusion from verification
TM02	Background site too far from road source signal
TM05	Low data capture (<75%)
TM07	Elevated concentration due to layby being used for parking and idling

1.6.2. Uncertainty in modelled estimates has been considered by calculating root mean square error (RMSE) and fractional bias statistics in accordance with Defra's Technical Guidance LAQM.TG(16). An air dispersion model can be considered to perform reasonably well if the majority of modelled concentrations are within 25% of measured concentrations. The RMSE should ideally be within 10% of the relevant air quality criterion, i.e. less than 4 $\mu g/m^3$ in relation to the 40 $\mu g/m^3$ objective concentration for annual mean NO_2, but is acceptable where it is within 25% of the relevant air quality criterion. The Fractional Bias (FB) has an ideal value of 0, but is acceptable between +2 and -2.

1.6.3. Unadjusted modelled estimates of total annual mean NO_2 concentrations were first compared against measured annual mean NO_2. Out of 7 comparisons, 4 modelled estimates are within +/- 25% of measured, as shown in Table A1.11. Substantial model underestimates of more than 25% were found at the remaining three sites; at one of the sites, the modelled concentration was within +/- 10% of measured.

Table A1.11: Comparison of Modelled and Measured NO_2 Concentrations ($\mu g/m^3$)

Site	Measured NO_2	Modelled Total NO_2	Modelled - Measured	Modelled / Measured	% Difference
TM01	7.3	5.7	-1.6	0.8	-22%
TM03	3.7	2.0	-1.7	0.5	-46%
TM04	5.3	2.5	-2.8	0.5	-53%
TM06	4.8	5.2	0.3	1.1	6%
TM08	6.0	4.7	-1.3	0.8	-21%
TM09	4.4	2.5	-1.8	0.6	-42%
TM10	3.1	2.3	-0.8	0.8	-25%

1.6.4. The RMSE for unadjusted modelled estimates of NO_2 compared to measured concentrations, is 1.65 $\mu g/m^3$, better than the recommended value in LAQM.TG(16). The overall performance (based on the majority of comparisons) of the unadjusted model can, however, still be improved.

1.6.5. Overall, the unadjusted model tends to underestimate total concentrations of NO_2, as indicated by a fractional bias value of 0.33.

1.6.6. The second stage of verification compares modelled estimates of road contributed annual mean NO_x with the road NO_x component derived from monitoring data. As only diffusion tube data are available for annual mean NO_2 and this analysis requires the estimation of the monitored road NO_x component, a conversion must be carried out using Defra's NO_2 to NO_x calculator. The comparison is presented in Table A1.12. The unadjusted model both underestimates and overestimates concentrations of road NO_x by 11 to -94%.

Table A1.12: Comparison of Modelled and Measured NO_x Concentrations ($\mu g/m^3$)

Site	Modelled Road NO_x	Measured Road NO_x	Modelled - Measured	Measured/ Modelled	% Difference
TM01	6.9	9.8	-2.8	1.4	-29%
TM03	0.2	3.2	-3.0	15.8	-94%
TM04	1.1	6.1	-5.0	5.6	-82%
TM06	5.9	5.4	0.6	0.9	11%
TM08	5.1	7.4	-2.3	1.4	-31%

Site	Modelled Road NO_x	Measured Road NO_x	Modelled - Measured	Measured/ Modelled	% Difference
TM09	1.1	4.3	-3.2	4.0	-75%
TM10	0.8	2.1	-1.3	2.6	-62%

1.6.7. Further examination suggests that the data can be divided into two distinct groups to improve model performance; within 100m of the A9 and further than 100m from the A9. Those locations within 100m of the A9 underestimated monitored road NO_x by an average -16% whereas all other locations underestimated monitored road NO_x by an average -78%.

1.6.8. Modelled road NO_x concentrations were adjusted by taking the slope of each linear regression line that has been forced through zero, as shown in Figure A16.1 and Figure A16.2. The model adjustment factors to apply to road NO_x are:

- within 100 metres of A9: 1.254
- beyond 100 metres of A9: 4.5119

Figure A16.1: Modelled vs. Monitored Road NO_x Before Adjustment - within 100 metres of the A9

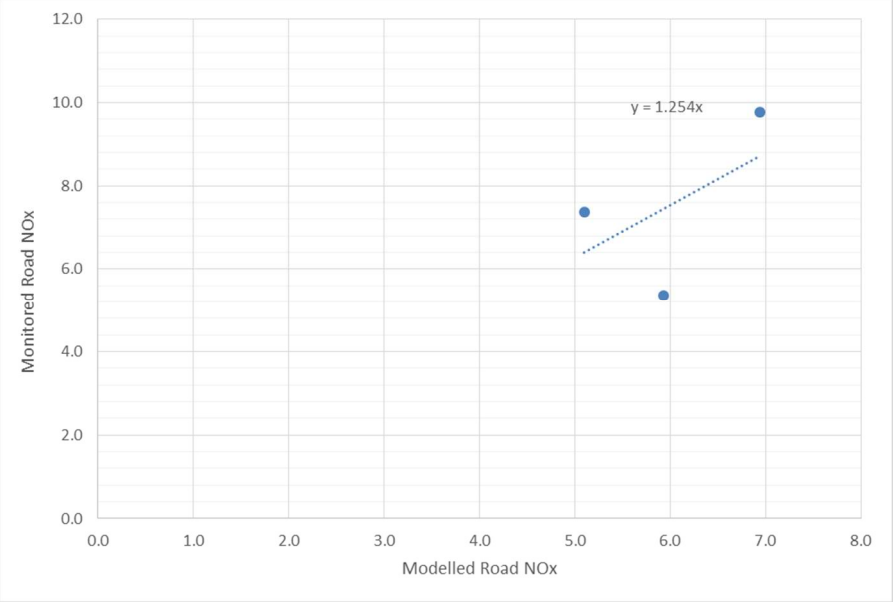
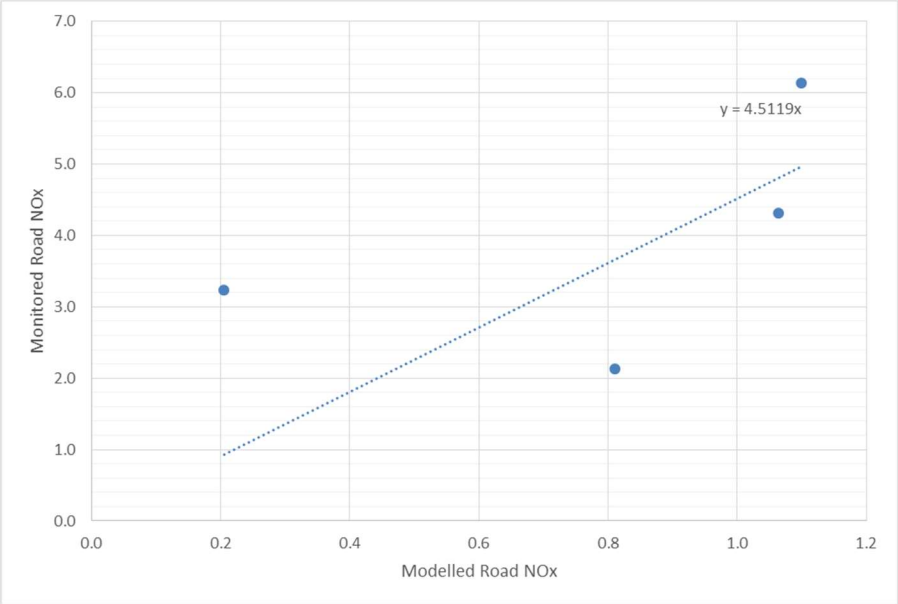


Figure A16.2: Modelled vs. Monitored Road NO_x Before adjustment - beyond 100 metres of the A9



1.6.9. The final stage of the verification process compares adjusted estimates of total annual mean NO_2 with measured concentrations. The findings are presented in Table A1.13 and shown graphically in Figure A16.3. The majority of estimated concentrations are within +/-25% of measured concentrations. Given the low measured concentrations of total NO_2, a relatively small difference between measured and modelled (as an absolute value) can appear to be a large difference when expressed as a percentage. Although two of the verification locations (TM03 and TM10) had modelled estimated concentrations greater than +/-25% of monitored concentrations, the absolute difference was less than 1.5 µg/m^3. The inclusion of the two sites in the verification represents a conservative approach, which results in the application of a "worst case" adjustment factor.

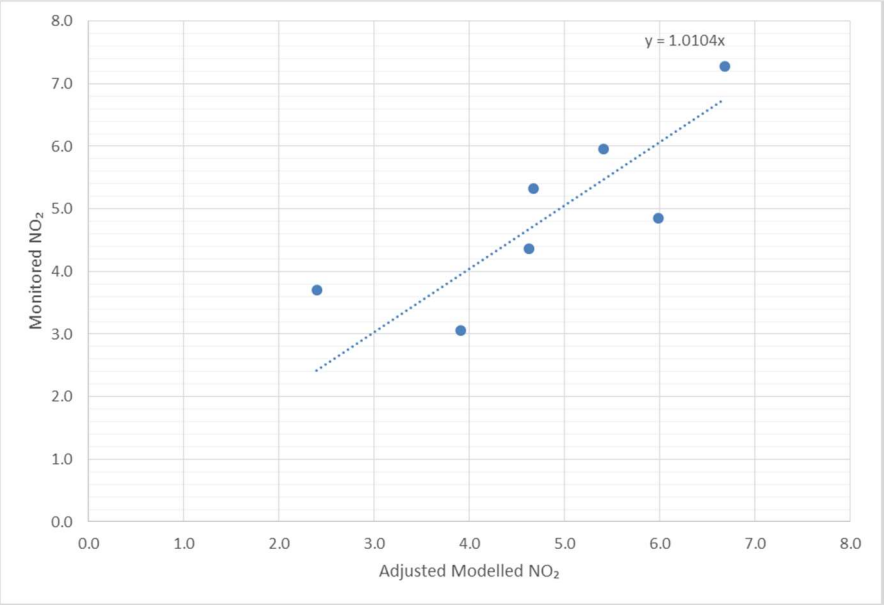
1.6.10. The RMSE for adjusted modelled NO_2 concentrations compared to monitored concentrations is 0.83 µg/m^3. The application of adjustment factors has therefore improved the overall model performance.

1.6.11. Overall, the adjusted model tends to slightly underestimate total concentrations of NO_2, as indicated by a fractional bias value of less than 0.03. The adjusted model therefore performs sufficiently well in accordance with LAQM.TG(16).

Table A1.13: Comparison of Adjusted Modelled and Measured NO_2 Concentrations (µg/m^3)

Site	Measured NO_2	Modelled Total NO_2	Modelled - Measured	Modelled / Measured	% Difference	Adjustment Area
TM01	7.3	6.7	-0.6	0.9	-8%	<100m A9
TM03	3.7	2.4	-1.3	0.6	-35%	>100m A9
TM04	5.3	4.7	-0.7	0.9	-12%	>100m A9
TM06	4.8	6.0	1.1	1.2	23%	<100m A9
TM08	6.0	5.4	-0.6	0.9	-9%	<100m A9
TM09	4.4	4.6	0.3	1.1	6%	>100m A9
TM10	3.1	3.9	0.9	1.3	28%	>100m A9

Figure A16.3: Modelled vs. Monitored Road Contributed NO_2 After Adjustment



1.6.12. Monitoring of particulate matter is not carried out within the study area; therefore the model performance for this pollutant has not been verified. Given the very low background concentrations and relatively small contribution of road traffic emissions to total concentrations, compared with emissions of NO_x, this is considered to be a reasonable approach and is in line with other scheme assessments.

1.7. Local Air Quality Assessment Results

1.7.1. The results for annual mean NO_2, PM_{10} and $PM_{2.5}$ are presented below in Table A1.14 to Table A1.16.

Table A1.14: Annual Mean NO_2 Concentrations (µg/m^3)

Receptor	Adjustment Area	Base	IAN 170/12 Gap Factors			Defra LAQM TG16 Gap Factors		
			DM	DS	Change	DM	DS	Change
1	<100m to A9	3.2	3.1	3.3	0.2	2.1	2.2	0.1
2	>100m to A9	3.0	3.0	3.3	0.3	1.9	2.2	0.3
3	>100m to A9	4.6	4.9	5.2	0.3	3.2	3.4	0.2
4	>100m to A9	3.4	3.3	3.9	0.6	2.2	2.5	0.3
5	>100m to A9	3.6	3.5	3.7	0.2	2.3	2.4	0.1
6	<100m to A9	5.3	5.5	4.9	-0.6	3.6	3.2	-0.4
7	<100m to A9	4.5	4.6	5.5	0.9	3.0	3.6	0.6
8	<100m to A9	3.1	2.9	3.0	0.1	1.9	2.0	0.1
9	>100m to A9	5.2	5.8	6.4	0.6	3.8	4.2	0.4
10	<100m to A9	5.8	6.1	7.2	1.1	4.0	4.8	0.8

Table A1.15: Annual Mean PM_{10} Concentrations (µg/m^3)

Receptor	Base	DM	DS	Change

1	6.5	6.3	6.3	0.0
2	6.1	5.9	5.9	0.0
3	6.5	6.3	6.3	0.0
4	6.4	6.3	6.3	0.0
5	6.4	6.3	6.3	0.0
6	6.7	6.5	6.4	-0.1
7	6.7	6.5	6.6	0.1
8	6.6	6.4	6.4	0.0
9	6.7	6.5	6.5	0.0
10	7.3	7.1	7.1	0.0

Table A1.16: Annual Mean $PM_{2.5}$ Concentrations (µg/m^3)

Receptor	Base	DM	DS	Change
1	4.7	4.5	4.5	0.0
2	4.5	4.3	4.3	0.0
3	4.7	4.5	4.5	0.0
4	4.7	4.5	4.5	0.0
5	4.7	4.5	4.5	0.0
6	4.8	4.7	4.6	-0.1
7	4.8	4.7	4.7	0.0
8	4.7	4.6	4.6	0.0
9	4.9	4.7	4.7	0.0
10	5.5	5.3	5.3	0.0

1.8. Designated Ecological Sites Results

1.8.1. The results for annual mean NO_x are presented below in Table A1.17.

Table A1.17: Annual Mean NO_x Concentrations (µg/m^3)

Receptor	Distance to Centreline	Base	IAN 170/12 Gap Factor		
			DM	DS	Change
E1	50	6.8	6.1	7.2	1.1
E2	100	3.6	3.0	3.3	0.3
E3	150	3.8	3.2	3.6	0.4
E4	200	2.9	2.4	2.5	0.1

1.9. Regional Air Quality Assessment Results

1.9.1. The results of the regional emissions assessment are presented below in Table A1.18.

Table A1.18: Summary of Regional Assessment Results

Pollutant	2016	2026		2041	
	Base	DM	DS	DM	DS
Total					
CO_2 (t/yr)	24,211	28,424	35,176	31,698	38,763
NO_x(kg/yr)	51,193	24,996	35,094	25,404	34,847
PM_{10} (kg/yr)	3,283	3,242	3,780	3,620	4,166
$PM_{2.5}$(kg/yr)	2,100	1,848	2,293	2,057	2,517
Vehicle km	291,708	375,370	451,148	426,878	503,424
% Change from Base					
CO_2	-	+17%	+45%	+31%	+60%
NO_x	-	-51%	-31%	-50%	-32%
PM_{10}	-	-1%	+15%	+10%	+27%
$PM_{2.5}$	-	-12%	+9%	-2%	+20%
Vehicle km	-	+29%	+55%	+46%	+73%
% Change from DM					
CO_2	-	-	+24%	-	+22%
NO_x	-	-	+40%	-	+37%
PM_{10}	-	-	+17%	-	+15%
$PM_{2.5}$	-	-	+24%	-	+22%
Vehicle km	-	-	+20%	-	+18

1.9.2. To put these results into context, total national emissions for Scotland for 2013 have been taken from the National Atmospheric Emissions Inventory (NAEI) website[xii]:

- NOx 93.8 ktonnes
- PM10 13.6 ktonnes
- CO2 52,961 ktonnes

2. References

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