Vale of Glamorgan Council

Penarth

Detailed Modelling Study

June 2019

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Executive Summary

Bureau Veritas have been commissioned by Vale of Glamorgan Council to complete a Detailed Modelling Study to assess the current pollutant concentrations experienced within the Councils' Windsor Road AQMA. The AQMA was declared in 2013 due to monitored and model predicted exceedances of the NO_2 annual mean Air Quality Strategy objective limit of 40 µg/m^3.

Since 2014, through the Review and Assessment annual reporting process, NO_2 annual mean concentrations within Penarth (specifically along Windsor Road) have stabilised below the AQS objective limit. Therefore, this has resulted in a requirement for further assessment as to whether concentrations are above Air Quality Strategy objective limits. The assessment focuses on concentrations of both NO_2 and PM_{10}, in accordance with the Welsh Air Quality Standards.

This Detailed Modelling Assessment focusses on the road network within and adjacent to the Windsor Road AQMA to establish any changes in the spatial extent of NO_2 and PM_{10} concentrations in order to identify any areas that are above, or within 10%, of the AQS annual mean objectives. The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 4.1.1) with vehicle emissions derived from the Emissions Factor Toolkit (Version 9.0), with annual mean NO_2 and PM_{10} concentration predictions produced at 28 discrete receptor locations for three scenario years (2018, 2023 and 2028).

All predicted concentrations of NO_2 and PM_{10} within Windsor Road AQMA, and adjacent to the modelled road network in Penarth are well below both the annual mean and short term AQS objectives for all modelled scenarios.

Based on the conclusions of the assessment above, the following recommendations are made:

- Revocation of the Windsor Road, Penarth AQMA; and
- Consider decommissioning and/or relocating of monitoring sites which have consistently reported NO_2 concentrations to be well below the respective AQS annual or short term mean objective.

1 Introduction

Bureau Veritas have been commissioned by The Vale of Glamorgan Council (the Council) to complete a Detailed Modelling Study to assess the current pollutant concentrations experienced within the Councils' Windsor Road Air Quality Management Area (AQMA). Windsor Road AQMA, located in Penarth, was declared in 2013 due to both monitored and model predicted exceedances of the NO_2 annual mean Air Quality Strategy (AQS) objective.

Since 2014, NO_2 annual mean concentrations within Penarth (specifically along Windsor Road) have stabilised below the annual mean AQS objective limit. Therefore, this has resulted in a requirement for further assessment as to whether concentrations are above Air Quality Strategy objective limits.

The assessment focuses on concentrations of both NO_2 and PM_{10}, in accordance with the Welsh Air Quality Standards[1].

Additionally, this report provides recommendations on matters related to NO_2 and PM_{10} exceedances within Penarth to inform the decision as to whether revocation of the Windsor Road AQMA is required.

1.1 Scope of Assessment

The assessment seeks to ascertain the extent of any exceedances of the AQS objectives for NO_2 and PM_{10} to inform the decision as to whether revocation of the Windsor Road AQMA is required.

The following are the objectives of the assessment:

- To assess the air quality at selected locations ("receptors") at façades of existing residential properties, representative of worst-case exposure, based on modelling of emissions of NO_2 and PM_{10} from road traffic on the local road network;
- To establish the spatial extent of any likely exceedances of the AQS objectives for NO_2 and PM_{10}, and also to identify the spatial extent of any areas within 10% of those objectives; and
- To put forward recommendations in relation to the re-assessment of the current Windsor Road AQMA boundary, and if necessary revocation.

The approach adopted in this assessment to assess the impact of road traffic emissions on air quality utilised the atmospheric dispersion model ADMS-Roads version 4.1.1, focusing on emissions of oxides of nitrogen (NO_x), which comprise of nitric oxide (NO) and nitrogen dioxide (NO_2), as well as PM_{10}.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments, as set out in the latest guidance provided by Defra for air quality assessment (LAQM.TG(16))[2], have been used.

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[1] The Air Quality Standards Regulations (Amendment) 2016, Statutory Instrument No 1184, The Stationary Office Limited.

[2] LAQM Technical Guidance LAQM.TG(16) – February 2018. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future pollutant concentrations can be assessed in relation to the national air quality standards and objectives established by Government. The Air Quality Strategy[3] (AQS) provides the over-arching strategic framework for air quality management in the UK and contains national air quality standards and objectives established by the UK Government and Devolved Administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from Limit Values prescribed in the EU Directives transposed into national legislation by Member States.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The CAFE Directive[4] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[5]. The Directive introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement of these standards.

The Air Quality Standards (Amendment) Regulations[1] 2016 came into force on 31 December 2016 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the new CAFE Directive.

The objectives for ten pollutants – benzene (C_6H_6), 1,3-butadiene (C_4H_6), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs), have been prescribed within the AQS[3].

The EU Limit Values are considered to apply everywhere with the exception of the carriageway and central reservation of roads and any location where the public do not have access (e.g. industrial sites).

The AQS objectives apply at locations outside buildings or other natural or man-made structures above or below ground, where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period. Typically these include residential properties and schools/care homes for long-term (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives. Table 2.1 taken from LAQM TG(16)[2] provides an indication of those locations that may or may not be relevant for each averaging period.

The assessment focuses on concentrations of both NO_2 and PM_{10}, in accordance with the Welsh Air Quality Standards[1]. Moreover, as a result of traffic pollution the UK has failed to meet the EU Limit Values for this pollutant by the 2010 target date. As a result, the Government has had to submit time extension applications for compliance with the EU Limit Values, which has since passed and its continued failure to achieve these limits is currently giving rise to infraction procedures being implemented. The UK is not alone as the challenge of NO_2 compliance at EU level includes many other Member States.

In July 2017, the Government published its plan for tackling roadside NO_2 concentrations[6], to achieve compliance with EU Limit Values. This sets out Government policies for bringing NO_2 concentrations within statutory limits in the shortest time period possible. Furthermore, the Clean

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[3] Defra (2007), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

[4] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[5] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons in ambient air.

[6] Defra, DfT (2017), UK plan for tackling roadside nitrogen dioxide concentrations

Air Strategy was published in 2019, which outlines how the UK will meet international commitments to significantly reduce emissions of five damaging air pollutants by 2020 and 2030 under the adopted revised National Emissions Ceiling Directive (NECD)

The AQS objectives for these pollutants are presented in Table 2.2.

Table 2.1 – Examples of where the Air Quality Objectives should apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed Building facades of residential properties, schools, hospitals, care homes etc.	Building facades 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 and 8-hour mean	All locations where the annual mean objectives would apply, together with hotels. Gardens or residential properties[1].	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	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-minute mean	All locations where members of the public might reasonably be expected to spend a period of 15 minutes or longer.	

Note [1] For gardens and playgrounds, such locations should represent parts of the garden where relevant public exposure is likely, for example where there is seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

Table 2.2 – Relevant AQS Objectives for the Assessed Pollutants in Wales

Pollutant	AQS Objective	Concentration Measured as:	Date for Achievement
Nitrogen dioxide (NO_2)	200 µg/m³ not to be exceeded more than 18 times per year	1-hour mean	31st December 2005
	40 µg/m³	Annual mean	31st December 2005
Particulate Matter (PM_{10})	50 µg/m³ not to be exceeded more than 35 times per year	24-hour mean	31st December 2005
	40 µg/m³	Annual mean	31st December 2005

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995[7] places a statutory duty on local authorities to periodically review and assess air quality within their area, and determine whether they are likely to meet the AQS objectives set down by Government for a number of pollutants – a process known as Local Air Quality Management (LAQM). The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, CO, Pb, NO_2, SO_2 and PM_{10}.

Local Authorities were formerly required to report on all of these pollutants, but following an update to the regime in 2016, the core of LAQM reporting is now focussed around the objectives of three pollutants; NO_2, PM_{10} and SO_2. Where the results of the Review and Assessment process highlight an exceedance of the health-based objectives, the Local Authority is required to declare an AQMA, a geographic area defined by high concentrations of pollution and exceedances of health-based standards.

Following a declaration of an AQMA, the Local Authority is subsequently required to develop an Air Quality Action Plan (AQAP), which will contain measures to address the identified air quality issue, and bring the location into compliance with the relevant objective as soon as possible.

One of the objectives of the LAQM regime is for local authorities to enhance integration of air quality into the planning process. Current LAQM Policy Guidance[8] recognises land-use planning as having a significant role in term of reducing population exposure to elevated pollutant concentrations. Generally, the decisions made on land-use allocation can play a major role in protecting and improving the health of the population, particularly at sensitive locations such as schools, hospitals and dense residential areas.

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[7] http://www.legislation.gov.uk/ukpga/1995/25/part/IV

[8] Local Air Quality Management Policy Guidance LAQM.PG(16). April 2016. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

3 Review and Assessment of Air Quality Undertaken by the Council

3.1 Local Air Quality Management

The most recent LAQM report completed by the Council was the 2018 Annual Progress Report (APR)[9]. The 2018 APR reported pollutant monitoring data, and progress made towards lowering pollutant concentrations within Vale of Glamorgan, throughout the preceding year of 2017. All monitoring results presented within this assessment have been sourced from the 2018 APR.

The Council currently has one AQMA (Windsor Road AQMA), declared in 2013 for the exceedance of the NO_2 annual mean UK AQS objective of 40 µg/m^3. This AQMA was declared in response to an assessment undertaken in 2012 which using dispersion modelling identified a stretch of Windsor Road to be in exceedance of the AQS objective limit. Windsor Road's strategic connection to several surrounding high capacity roads (A4055 – Barry Road, A4055 – Cardiff Road, A4160 – Penarth Road and A4232 – Ghrangetown Link), and subsequent vehicluar traffic, is detailed as a contributing factor to the declaration of the AQMA.

The 2018 APR recognises the need to assess current NO_2 concentrations within the Windsor Road AQMA due to compliance with the AQS annual mean NO_2 objective at all monitoring locations within the AQMA for the previous six years. This assessment is a part of this process, and the modelling results presented herein will inform the decision to revoke the AQMA.

3.2 Review of Air Quality Monitoring

3.2.1 Local Automatic Air Quality Monitoring

During 2018, the Council undertook automatic (continuous) monitoring at one site within the district, located along Windsor Road, Penarth, within the northern extent of the AQMA. The Windsor Road monitor records data for the following pollutants; NO_2 using a chemiluminescence analyser, PM_{10} using a Beta Attenuation Monitor (BAM) and O_3 using a UV absorption analyser.

Details of the automatic monitoring site are provided in Table 3.1, monitoring results for years 2014 to 2018 are presented in Table 3.2 - Table 3.5, whilst the location of the monitoring site is illustrated in Figure 3.2.

Table 3.1 – Automatic Monitor Penarth, Windsor Road

Site ID	Site Location	Site Type	OS Grid Ref (E, N)	In AQMA	Pollutants Monitored	Inlet Height (m)
Penarth, Windsor Road	Windsor Road, Penarth	Roadside	317600, 172399	Yes	NO_2, PM_{10} and O_3	1.5

Table 3.2 – Automatic Monitor Penarth, Windsor Road: NO_2 Annual Mean Concentrations

Site ID	Valid Data Capture for 2018 (%)	NO_2 Annual Mean Concentration (µg/m^3)				
		2014	2015	2016	2017	2018
Penarth, Windsor Road	99.7	27.7	26.5	28.3	26.5	24.3

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[9] Vale of Glamorgan Council (2018), 2018 Annual Progress Report

Table 3.3 – Automatic Monitor Penarth, Windsor Road: Number of NO_2 Hourly Mean Exceedances

Site ID	Valid Data Capture for 2018 (%)	Hourly Means in Excess of the 1-hour Objective (200 µg/m³)				
		2014	2015	2016	2017	2018
Penarth, Windsor Road	99.7	0	0	0	0	0

Table 3.4 – Automatic Monitor Penarth, Windsor Road: PM_{10} Annual Mean Concentrations

Site ID	Valid Data Capture for 2018 (%)	PM_{10} Annual Mean Concentration (µg/m³)				
		2014	2015	2016	2017	2018
Penarth, Windsor Road	95.0	17.5	20.8	21.4	15.6	21.7

Table 3.5 – Automatic Monitor Penarth, Windsor Road: Number of PM_{10} 24-Hour Mean Exceedances

Site ID	Valid Data Capture for 2018 (%)	Daily Means in Excess of the 24-hour Objective (50 µg/m³)				
		2014	2015	2016	2017	2018
Penarth, Windsor Road	95.0	0	4	1	2	0

Between 2014 and 2018, there were no recorded exceedances of either the annual mean or short term AQS objectives for NO_2 or PM_{10} at the automatic monitor located along Windsor Road, Penarth. Both annual mean NO_2 and PM_{10} concentrations have remained consistent with a range of ± 5 µg/m³ since 2014, with a reduction observed over the five year period for annul mean NO_2 concentrations.

3.2.2 Local Non-Automatic Air Quality Monitoring

The Councils' non-automatic monitoring programme during 2018 consisted of recording NO_2 concentrations using a network of 52 passive diffusion tubes, located across the district. 17 of these diffusion tubes are located within Penarth forming 15 sites (including the provision of a collocated triplicate site). The details and results of the diffusion tube monitoring within Penarth for 2018 are provided in Table 3.6 and Table 3.7, whilst the locations are illustrated in Figure 3.2.

Table 3.6 – Details of Council Diffusion Tube Monitoring Undertaken in Penarth

Site ID	Site Location	Site Type	Within AQMA	OS Grid Ref (X, Y)
22	Stanwell Road	R	N	318505, 171496
53	168 Windsor Road	R	N	317589, 172411
55	159 Windsor Road	R	Y	317595, 172435
56	134 Andrew Road	R	N	316814, 172443
62	154 Windsor Road	R	Y	317633, 172357
70	Ty-Isaf	R	N	316731, 172391
73*	Windsor Road Monitor	R	Y	317598, 172399
74	114 Windsor Road	R	N	317708, 172259
76	160 Windsor Road	R	&	317627, 172371

Site ID	Site Location	Site Type	Within AQMA	OS Grid Ref (X, Y)
79	Marine Scene	R	N	317549, 172572
82	98b Windsor Road	R	N	318061, 171944
88	134 Windsor Road	R	Y	317668, 172312
100	141 Plassey Street	R	N	317968, 172105
112	Cogan Hill Flats	R	N	317434, 172729
113	03 Plassey Street	R	N	317999, 172067

* = Triplicate Site
R = Roadside

Table 3.7 – 2018 Monitoring Results of VGC Operated Diffusion Tube Monitoring Undertaken in Penarth

Site ID	Valid Data Capture for 2018 (%)	NO_2 annual mean concentration (µg/m³)				
		2014	2015	2016	2017	2018
22	75.0%	24.4	23.7	23.6	21.8	20.3
53**	66.7%	31.2	30.8	31.5	29.8	27.7
55	91.7%	27.1	27.7	28.9	26.3	26.3
56	100.0%	33.9	40.3	17.5	23.2	20.5
62	83.3%	33.9	31.7	33.2	31.2	28.1
70	100.0%	21.9	23.2	24.6	20.3	22.3
73*	91.7%	28.3	30.0	31.4	30.7	29.7
74**	66.7%	29.6	28.0	28.2	28.4	22.7
76	83.3%	33.9	32.0	32.4	30.7	29.9
79	100.0%	39.6	37.5	44.4	38.3	37.9
82	83.3%	19.6	17.4	18.0	16.9	17.1
88	75.0%	33.5	30.7	31.4	29.8	27.6
100	100.0%	-	-	-	23.9	24.0
112	100.0%	-	-	-	-	19.4
113	91.7%	-	-	-	-	21.7

Notes

* Triplicate site

** Annualisation performed due to data capture less than 75%

All values reported are bias adjusted and represent the monitoring location (i.e. absence of distance correction calculations)

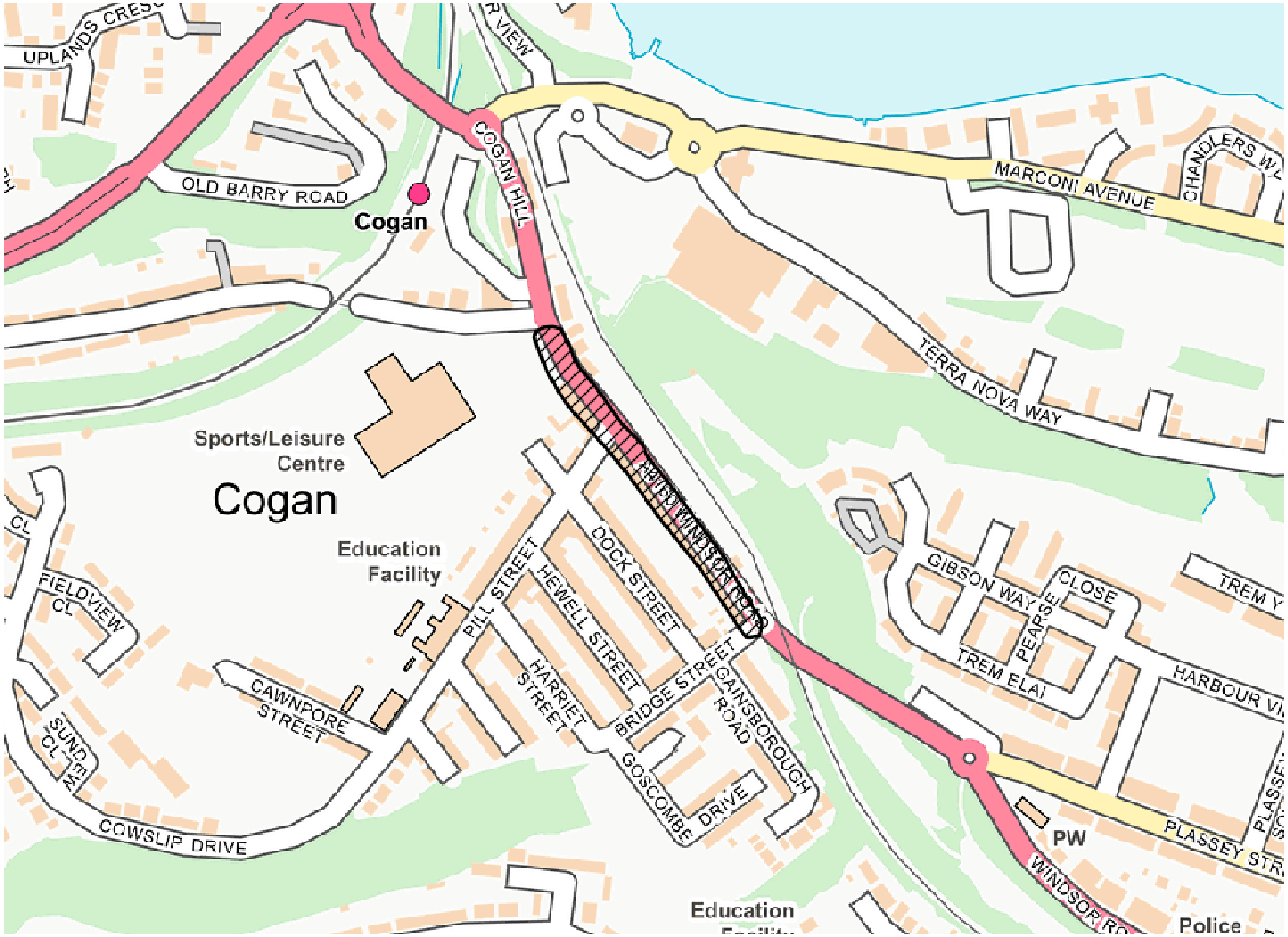
All monitoring locations during 2018, reported annual mean NO_2 concentrations to be below the AQS objective limit. Site 79, located north of the Windsor Road AQMA, along the A4160 (Cogan Hill) reported annual mean NO_2 concentrations to be within 10% of the AQS objective limit. However, Site 79 is not located at relevant exposure, and as a result distance correction was performed, resulting in the concentration of 31.6 µg/m³ at the nearest point of relevant exposure. Annual mean NO_2 concentrations observed at Site 79 have been within 10% or above 40 µg/m³ for all years since 2014, except 2016 when an exceedance observed. Site 79 is located along the A4160 (Windsor Road) north of the AQMA on a stretch of road likely to experience congestion.

Between 2014 and 2018 the maximum recorded NO_2 annual mean was 44.4 µg/m³ at Site 79 in 2016. In accordance with LAQM TG.16[2], this indicates that an exceedance of the 1-hour mean objective is unlikely to have occurred at any monitoring site between 2014 and 2018.

All non-automatic monitors located within the Windsor Road AQMA have reported annual mean NO_2 concentrations below 10% of the AQS objective limit since 2014, with the highest reported concentration recorded at Site 76 in 2014 (33.9 µg/m^3).

The Windsor Road AQMA boundary, alongside all 2018 council operated monitoring locations are presented in Figure 3.1 and Figure 3.2, respectively.

Figure 3.1 – Windsor Road, Penarth AQMA Boundary



Legend

▨ Windsor Road AQMA

Air Quality
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London, E1 8HG

Location

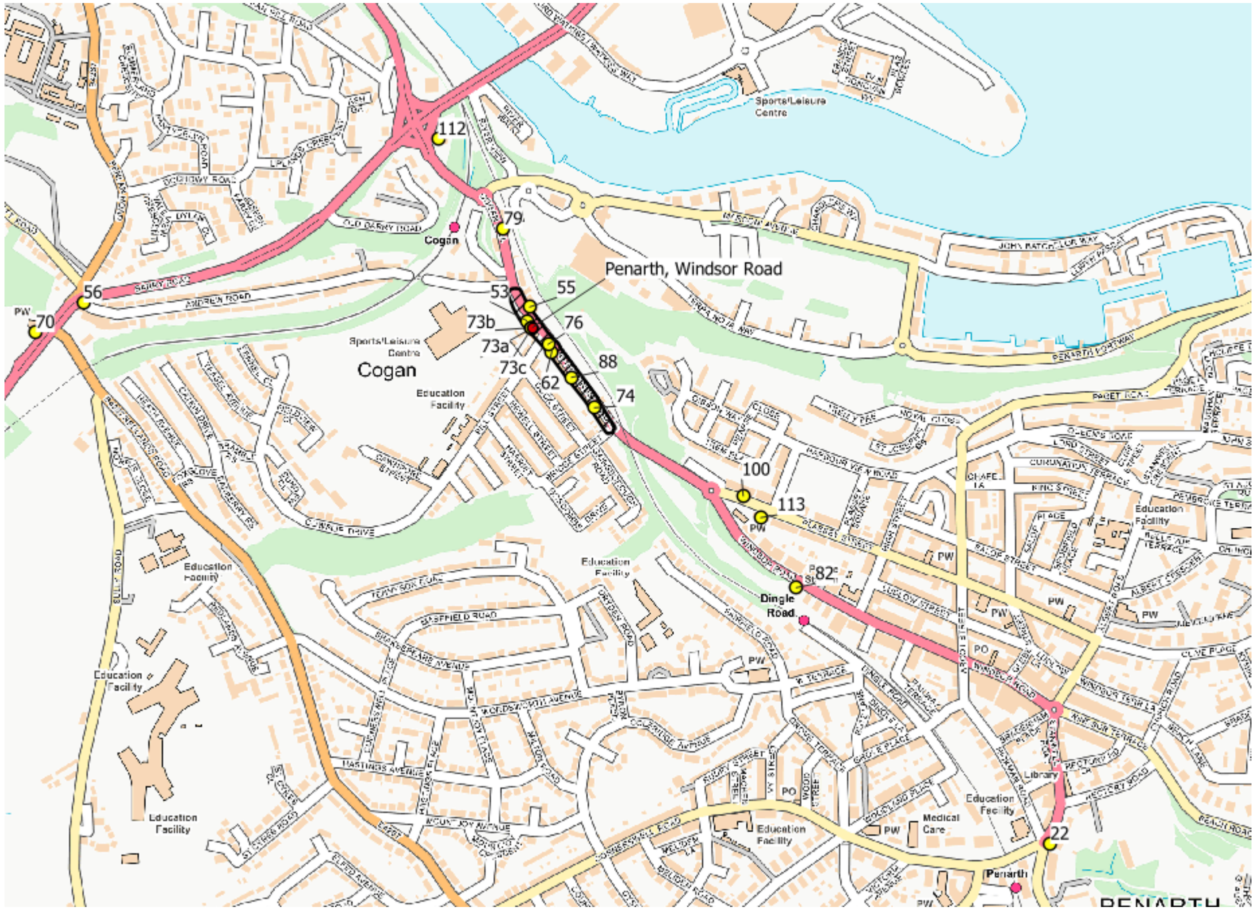
Penarth

Title

Windsor Road AQMA Boundary

By	**Approved**
BT	PB
Scale	**Job Ref**
Not to Scale	6486686
Date	**Figure No.**
May 2019	3.1

Figure 3.2 – Local Monitoring Locations



Legend

▨ Windsor Road AQMA

● Automatic Monitor

● Diffusion Tube

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Location

Penarth

Title

Local Monitoring Locations

By	**Approved**
BT	PB
Scale	**Job Ref**
Not to Scale	6486686
Date	**Figure No.**
May 2019	3.2

3.3 Defra Background Concentration Estimates

Defra maintains a nationwide model of existing and future background air pollutant concentrations at a 1km x 1km grid square resolution. This data includes annual average concentration for NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2017 (the year in which comparisons between modelled and monitoring are made). The model used to determine the background pollutant levels is semi-empirical in nature: it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model the concentrations of pollutants at the centroid of each 1km grid square, but then calibrates these concentrations in relation to actual monitoring data.

Annual mean background concentrations have been obtained from the Defra published background maps, based on the 1km grid squares which cover the modelled area and the affected road network. The Defra mapped background concentrations for base year of 2018, which cover the modelled domain, are presented in Table 3.8.

All of the mapped background concentrations presented are well below the respective annual mean AQS objectives.

Due to the absence of local background monitoring within Penarth, pollutant background concentrations used for the purposes of this assessment have been obtained from the 2017 Defra supplied background NO_x, NO_2 and PM_{10} maps for the relevant 1km x 1km grid squares covering the modelled domain. The relevant annual mean background concentration will be added to the predicted annual mean road contributions in order to predict the total pollutant concentration at each receptor location. The total pollutant concentration can then be compared against the relevant AQS objective to determine the event of an exceedance.

In order to avoid duplication of road sources within the model, contributions from 'Trunk A Roads' and 'Primary A Roads' have been removed from the overall background concentrations for NO_x, NO_2 and PM_{10}. As the relationship between NO_2 and NO_x is not linear, the most recent version of the NO_2 Adjustment for NO_x Sector Removal Tool[10] has been used. No adjustment for background concentration variability at different receptor heights has been made.

Table 3.8 – Defra Background Pollutant Concentrations Covering the Modelled Domain

Grid Square (E, N)	Year	Revised Annual Mean Background Concentration ($\mu g/m^3$)		
		NO_x	NO_2	PM_{10}
317500, 172500	2018	15.3	11.2	11.3
	2023	12.0	9.0	10.8
	2028	10.2	7.8	10.5
318500, 172500	2018	16.9	12.4	11.5
	2023	13.4	10.0	10.9
	2028	11.2	8.5	10.7
318500, 171500	2018	15.7	11.6	11.0
	2023	12.6	9.4	10.4
	2028	10.5	8.0	10.2
All values presented account for the removal of the identified road contributions. For NO_2, this has been calculated using the NO_2 adjustment for NO_x sector removal tool (V7.0)				

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[10] Defra NO_2 Adjustment for NO_x Sector Removal Tool version 7.0 (2019), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector

4 Assessment Methodology

To predict pollutant concentrations of road traffic emissions the atmospheric model ADMS Roads version 4.1.1 was utilised. The following scenarios have been assessed to reflect both NO_2 and PM_{10} concentrations in 2018, 2023 and 2028.

- 2018 Baseline (2018) – Baseline year predictions.
- 2023 Baseline (2023) – Future year predictions.
- 2028 Baseline (2028) – Future year predictions.

In order to provide consistency with the Council's previous work on air quality, the guiding principles for air quality assessments as set out in the latest guidance and tools provided by Defra for air quality assessment (LAQM.TG(16)[2] have been used.

The approach used in this assessment has been based on the following:

- Prediction of NO_2 and PM_{10} concentrations to which existing identified receptors may be exposed to, and a comparison with the relevant AQS objectives; and
- Determination of the geographical extent of any potential exceedances.

4.1 Traffic Inputs

The dispersion model utilised both 2017 Department for Transports (DfT) traffic count data[11] (due to the absence of published 2018 data at the time of writing), as well as Council monitored data comprising of Automatic Traffic Counts (ATC) collected in February 2015. Both datasets were adjusted to 2018, 2023 and 2028 using conversion factors derived from the DfT TEMPro Version 7.2[12]. Table 4.1 provides details of the TEMPro growth factors employed throughout the assessment.

Table 4.1 – TEMPro Growth Factors Employed

Scenarios	2015 Council ATC Data	2017 DfT Data
2018	1.00	1.00
2023	0.99	1.00
2028	0.99	0.99

The Emissions Factors Toolkit (EFT) version 9.0 developed by Defra[13] has been used to determine vehicle emission factors for input into the ADMS-Roads model.

Details of the traffic flows used in this assessment are provided Table 4.2, whilst the entire modelled road network across Penarth is presented in Figure 4.1.

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[11] DfT, Traffic Count Database. https://www.dft.gov.uk/traffic-counts/

[12] DfT, TEMPro Version 7.2.

[13] Defra, Emissions Factors Toolkit (2019). http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Table 4.2 – Traffic Data used in the Detailed Assessment

Road Name	AADT	Car (%)	LGV (%)	Rigid HGV (%)	Artic HGV (%)	Bus and Coaches (%)	Motorcycles (%)	Average Speed (kph)
Windsor Road [a]	11,967	86.4	11.2	0.7	0.1	1.2	0.3	48.3
Windsor Road 2 [b]	20,503	79.3	9.0	6.1	3.4	0.3	2.1	47.2
Windsor Road 3 (Cogan Hill) [b]	21,332	92.1	5.1	1.2	0.9	0.2	0.5	38.1
Barry Road [a]	23,757	85.2	12.0	1.5	0.5	0.3	0.5	64.4
Barry Road 2 [a]	33,357	87.7	9.7	1.4	0.5	0.3	0.3	64.4
Andrew Road [b]	2,313	92.7	5.7	0.7	0.1	0.1	0.8	30.7
Penarth Road [a]	15,404	76.7	19.3	1.8	0.3	1.4	0.5	64.4

Notes:

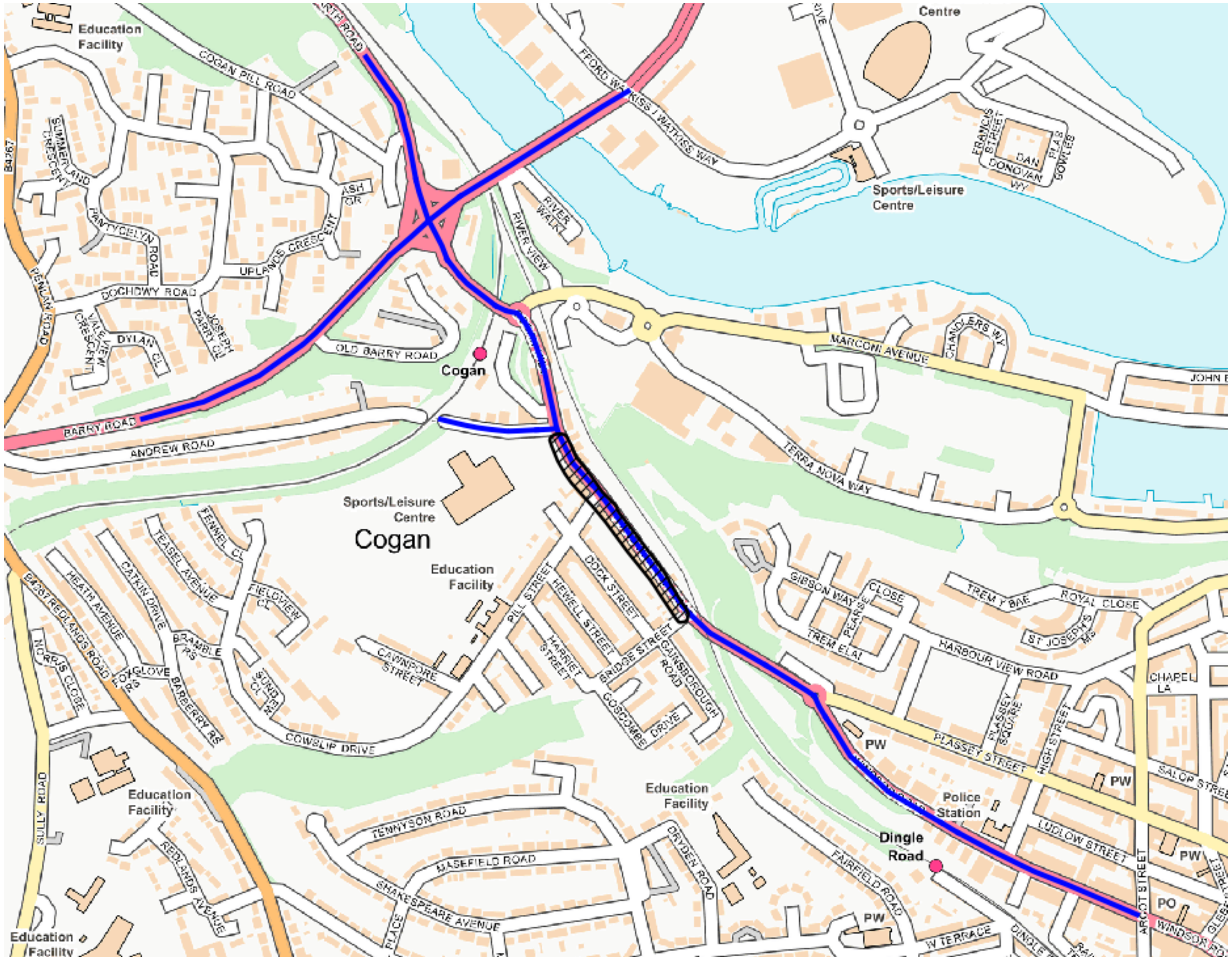
[a] DfT data (2017 reference year)

[b] Council ATC monitored data (2015 reference year)

[c] Speeds based upon National Speed Limits.

Traffic speeds have been reduced at junctions and stretches of roads where queues are thought to be prevalent in accordance with Defra's TG16[2]

Figure 4.1 – Modelled Roads in Penarth



Legend

▨ Windsor Road AQMA

▬ Modelled Road Link

Air Quality
Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location

Penarth

Title

Modelled Roads In Penarth

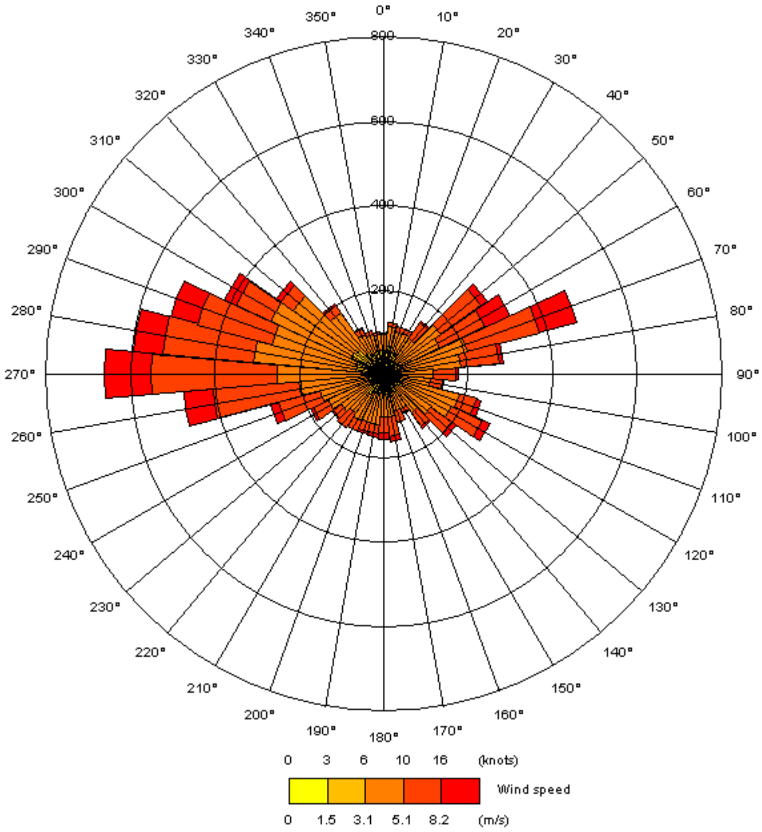
By BT	**Approved** PB
Scale Not to Scale	**Job Ref** 6486686
Date May 2019	**Figure No.** 4.1

4.2 General Model Inputs

A site surface roughness value of 0.6m was entered into the ADMS-roads model, consistent with the topographic nature of the modelled domain - an open urban environment. One year of hourly sequential meteorological data from a representative synoptic station is required by the dispersion model. 2018 meteorological data from Rhoose (Cardiff Airport) weather station, located approximately 12.0km southwest of Penarth, has been used in this assessment.

A wind rose for this site for the year 2018 is presented in Figure 4.2 below. A meteorological site surface roughness value of 0.5m was entered into the ADMS-roads model – reflective of the open rural environment surrounding Cardiff Airport.

Figure 4.2 – Wind rose for Rhoose (Cardiff Airport) Meteorological Data 2018

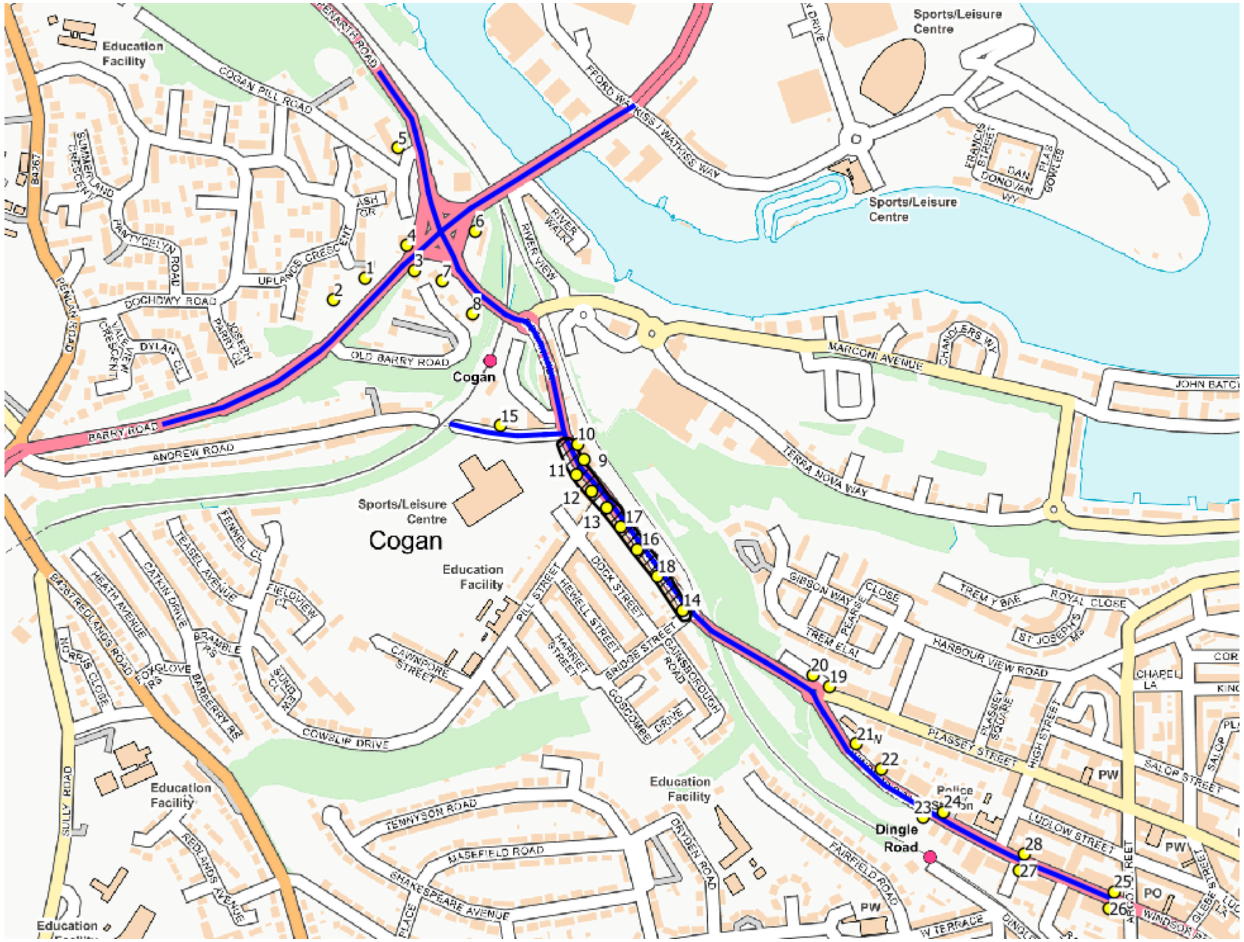


Most dispersion models do not use meteorological data if they relate to calm winds conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75m/s. It is recommended in LAQM.TG(16)[2] that the meteorological data file be tested within a dispersion model and the relevant output log file checked, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedances LAQM.TG(16) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%. 2018 meteorological data from Rhoose (Cardiff Airport) includes 8539 lines of usable hourly data out of the total 8,760 for the year, i.e. 97.5% usable data. This is therefore suitable for the dispersion modelling exercise.

4.3 Sensitive Receptors

Pollutant concentrations at 28 specific receptors have been predicted within the assessment to represent locations of relevant exposure within the study area (i.e. residential properties closest to the roadside). Details of the receptors are presented within Appendix 3 in Table A7, and their locations are illustrated in Figure 4.3.

Figure 4.3 – Receptor Locations Considered in the Assessment



Legend

● Receptor Location

— Modelled Road Link

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Air Quality
Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location

Penarth

Title

Receptor Locations Considered in the Assessment

By	**Approved**
BT	PB
Scale	**Job Ref**
Not to Scale	6475940
Date	**Figure No.**
May 2019	4.3

4.4 Model Outputs

The background pollutant values discussed in Section 3.3 have been used in conjunction with the concentrations predicted by the ADMS-Roads model to calculate predicted total annual mean concentrations of NO_x, NO_2 and PM_{10}.

For the prediction of annual mean NO_2 concentrations for the modelled scenarios, the output of the ADMS-Roads model for road NO_x contributions has been converted to total NO_2 following the methodology in LAQM.TG(16)[2], using the NO_x to NO_2 conversion tool developed on behalf of Defra. This tool also utilises the total background NO_x and NO_2 concentrations. This assessment has utilised version 7.1 (May 2019) of the NO_x to NO_2 conversion tool[14]. The road contribution is then added to the appropriate NO_2 background concentration value to obtain an overall total NO_2 concentration.

For the prediction of short term NO_2 impacts, LAQM.TG(16)[2] advises that it is valid to assume that exceedances of the 1-hour mean AQS objective for NO_2 are only likely to occur where the annual mean NO_2 concentration is 60 $\mu g/m^3$ or greater. This approach has thus been adopted for the purposes of this assessment.

Annual mean PM_{10} road contributions were also output from the model and processed in a similar manner, i.e. combined with the relevant background annual mean $PM_{10}/PM_{2.5}$ concentrations to obtain an overall total $PM_{10}/PM_{2.5}$ concentrations.

For the prediction of short term PM_{10}, LAQM.TG(16)[2] provides an empirical relationship between the annual mean and the number of exceedances of the 24-hour mean AQS objective for PM_{10} that can be calculated as follows:

$$Number\ of\ 24\ hour\ Mean\ Exceedences = -18.5 + 0.00145 * annual\ mean^3 + \frac{206}{annual\ mean}$$

This relationship has thus been adopted to determine whether exceedances of the short-term PM_{10} AQS objective are likely in this assessment.

Verification of the ADMS-Roads assessment has been undertaken using a number of local authority diffusion tube monitoring locations. All NO_2 results presented in the assessment are those calculated following the process of model verification - using a factor of 4.102, Concentrations of PM_{10} have been adjusted using a factor of 10.4. Full details of the verification process are provided in Appendix 1 – ADMS Model Verification.

4.5 Uncertainty

Due to the number of inputs that are associated with the modelling of the study area there is a level of uncertainty that has to be taken into account when drawing conclusions from the predicted concentrations of NO_2. The predicted concentrations are based upon the inputs of traffic data, background concentrations, emission factors, street canyon calculations, meteorological data, modelling terrain limitations and the availability of monitoring data from the assessment area.

4.5.1 Uncertainty in NO_x and NO_2 Trends

Historical monitoring data within the UK shows a disparity between measured concentration data and the projected decline in concentrations associated with emission forecasts for future years[15].

---

[14] Defra NO_x to NO_2 Calculator (2019), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

[15] Carslaw, D, Beevers, S, Westmoreland, E, Williams, M, Tate, J, Murrells, T, Steadman, J, Li, Y, Grice, S, Kent, Aand Tsagatakis, I. 2011, Trends in NO_x and NO_2 emissions and ambient measurements in the UK, prepared for Defra, July 2011.

Ambient concentrations of NO_x and NO_2 have shown two distinct trends over the past twenty five years:

- A decrease in concentrations from around 1996 to 2002/04; followed by
- A period of more stable concentrations from 2002/04 rather than the further decline in concentrations that was expected due to the improvements in vehicle emissions standards.

The reason for this disparity is related to the actual on-road performance of vehicles, in particular diesel cars and vans, when compared with calculations based on the Euro emission standards. Preliminary studies suggest the following:

- NO_x emissions from petrol vehicles appear to be in line with current projections and have decreased by 96% since the introduction of 3-way catalysts in 1993;
- NO_x emissions from diesel cars, under urban driving conditions, do not appear to have declined substantially, up to and including Euro 5. There is limited evidence that the same pattern may occur for motorway driving conditions; and
- NO_x emissions from HDVs equipped with Selective Catalytic Reduction (SCR) are much higher than expected when driving at low speeds.

This disparity in the historical national data highlights the uncertainty of future year projections of both NO_x and NO_2.

Defra and the Devolved Administrations have investigated these issues and have since published an updated version of the EFT (version 9.0) utilising COPERT 5 emission factors, which may go some way to addressing this disparity, but it is considered likely that a gap still remains. This assessment has utilised the latest EFT version 9.0 and associated tools published by Defra to help minimise any associated uncertainty when forming conclusions from the results.

Notwithstanding the above, consideration was given to the incorporation of two conservative scenarios to complement the future year studies (2023 and 2028), holding background concentrations and emission factors at 2018 (i.e. assuming that there is no improvement in vehicle emission factors or pollutant concentrations within Penarth for future years). However, a growth factor of 1.00 and 0.99 was obtained from TEMPro Version 7.2 to adjust 2018 traffic flows to 2023 and 2028 flows – as detailed in Table 4.1.

Therefore it is not necessary to undertake the supplementary conservative scenarios for 2023 and 2028 as the results would be identical (as a worst case) to the 2018 scenario. Notwithstanding this, 2023 and 2028 scenarios (with corresponding background concentrations and emission factors) will be assessed.

5 Results

The assessment has considered emissions of NO_x/NO_2 and PM_{10} from road traffic at 28 existing receptor locations representing locations of relevant exposure. The results of the dispersion modelling are summarised below, for those receptor locations detailed in Table A7 and illustrated in Figure 4.3.

5.1.1 Assessment of Nitrogen Dioxide (NO_2)

Table 5.1 presents the annual mean NO_2 concentrations predicted at existing receptor locations for 2018, 2023 and 2028 scenarios, and a comparison against the 40 µg/m^3 annual mean AQS objective.

The maximum predicted annual mean NO_2 concentration at existing receptor locations for the 2018 scenario was at receptor R6 with a predicted concentration of 31.6 µg/m^3, 79% of the annual mean NO_2 AQS objective. Similarly, the annual mean concentrations predicted for the future 2023 and 2028 scenarios at R6 was found to be the highest (22.8 µg/m^3 and 16.6 µg/m^3 respectively). Receptor R6 is located along Elizabeth Court, approximately 12m from the road junction where the A4055 Barry Road meets the A4160 Penarth Road and the A4160 Cogan Hill via a network of slip roads.

The empirical relationship given in LAQM.TG(16)[2] states that exceedances of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60 µg/m^3 or above. Given that the NO_2 annual mean concentrations predicted at all receptor locations are below this limit for all scenarios, exceedances of the 1-hour NO_2 AQS objective are unlikely.

The maximum annual mean NO_2 concentration predicted at existing receptor locations within the Windsor Road AQMA was at receptors R16 and R18 with a predicted concentration of 31.2 µg/m^3, 78% of the annual mean NO_2 AQS objective. Similarly, the maximum annual mean concentrations predicted in the future year scenarios (2023 and 2028) were at receptors R16 and R18 (21.4 µg/m^3 and 15.7 µg/m^3 respectively). Both receptors are located on the façade of a property bordering the A4160 (Windsor Road), located along the south-western extent of the AQMA.

Table 5.1 – Predicted Annual Mean Concentrations of NO_2

ID	Annual Mean NO_2 Concentration (µg/m^3)			
	AQS Objective	2018	2023	2028
R1	40	19.9	14.9	11.5
R2	40	17.3	13.1	10.4
R3	40	27.8	20.2	15.0
R4	40	15.9	12.1	9.7
R5	40	17.6	13.2	10.4
R6	40	31.6	22.8	16.6
R7	40	22.7	16.8	12.7
R8	40	19.2	14.4	11.2
R9	40	28.0	20.6	15.3
R10	40	27.9	20.5	15.2
R11	40	25.1	18.6	13.9
R12	40	25.4	18.7	14.0
R13	40	29.1	20.5	15.1
R14	40	31.0	21.3	15.6
R15	40	15.8	12.2	9.8
R16	40	31.2	21.4	15.7

R17	40	30.6	21.2	15.5
R18	40	31.2	21.4	15.7
R19	40	18.2	13.4	10.5
R20	40	18.6	13.5	10.6
R21	40	19.4	14.5	11.2
R22	40	20.8	15.7	12.0
R23	40	20.5	15.4	11.8
R24	40	21.8	16.3	12.3
R25	40	19.6	14.8	11.4
R26	40	17.7	13.5	10.6
R27	40	19.2	14.6	11.2
R28	40	20.9	15.7	12.0

5.1.2 Assessment of Particulate Matter (PM$_{10}$)

Table 5.2 presents the annual mean PM$_{10}$ concentrations predicted at existing receptor locations for 2018, 2023 and 2028 scenarios, and a comparison against the 40 µg/m^{3} annual mean AQS objective.

The maximum predicted annual mean PM$_{10}$ concentration at existing receptor locations for the 2018 scenario was at receptors R16 and R18 with a predicted concentration of 21.8 µg/m^{3,} 54.5% of the annual mean PM$_{10}$ AQS objective. Similarly, the maximum annual mean concentrations predicted in the future year scenarios (2023 and 2028) were at receptors R16 and R18 (20.6 µg/m^{3} and 20.1 µg/m^{3} respectively). Both receptors are located within the Windsor Road AQMA.

Table 5.3 shows the number of predicted exceedances of the 24-hour PM$_{10}$ 50µg/m^{3} AQS objective predicted at all receptor locations, for the 2018, 2023 and 2028 scenarios.

The number of days where PM$_{10}$ concentrations were predicted to be above the 24-hour PM$_{10}$ 50µg/m^{3} AQS objective was less or equal to 6 days for all modelled scenarios at all receptor locations. This is well below the 35 permitted exceedances.

Table 5.2 – Predicted Annual Mean Concentrations of PM_{10}

ID	Annual Mean NO_2 Concentration (µg/m3)			
	AQS Objective	2018	2023	2028
R1	40	15.3	14.5	14.2
R2	40	14.2	13.5	13.2
R3	40	18.1	17.0	16.6
R4	40	13.2	12.5	12.2
R5	40	14.2	13.4	13.1
R6	40	19.4	18.2	17.8
R7	40	16.1	15.2	14.9
R8	40	15.1	14.3	13.9
R9	40	19.7	18.6	18.2
R10	40	19.6	18.5	18.1
R11	40	18.1	17.2	16.8
R12	40	18.4	17.4	17.0
R13	40	20.6	19.4	19.0
R14	40	21.6	20.4	20.0
R15	40	13.4	12.7	12.5
R16	40	21.8	20.5	20.1
R17	40	21.5	20.2	19.8
R18	40	21.8	20.6	20.1
R19	40	14.6	13.9	13.6
R20	40	14.9	14.1	13.8
R21	40	15.2	14.4	14.1
R22	40	15.5	14.7	14.4
R23	40	15.1	14.3	14.0
R24	40	15.6	14.7	14.4
R25	40	14.8	14.0	13.7
R26	40	13.8	13.1	12.8
R27	40	14.6	13.8	13.5
R28	40	15.4	14.6	14.2

Table 5.3 – Predicted Number of Exceedances of 24-hour PM_{10} 50 µg/m^3 AQS objective

ID	Number of allowed exceedances of PM_{10} 50 µg/m^3 AQS Objective		
	2018	2023	2028
R1	1	1	1
R2	1	1	1
R3	1	1	1
R4	1	1	1
R5	1	1	1
R6	3	2	1
R7	1	1	1
R8	1	1	1
R9	3	2	2
R10	3	2	1
R11	2	1	1
R12	2	1	1
R13	4	3	2
R14	6	4	3

R15	1	1	1
R16	6	4	4
R17	5	4	3
R18	6	4	4
R19	1	1	1
R20	1	1	1
R21	1	1	1
R22	1	1	1
R23	1	1	1
R24	1	1	1
R25	1	1	1
R26	1	1	1
R27	1	1	1
R28	1	1	1

6 Conclusions and Recommendations

Bureau Veritas have been commissioned by Vale of Glamorgan Council to complete a Detailed Modelling Study to assess the current pollutant concentrations experienced within the Councils' Windsor Road AQMA. The AQMA was declared in 2013 due to monitored and model predicted exceedances of the NO_2 annual mean Air Quality Strategy objective limit of 40 µg/m^3.

Since 2014, NO_2 annual mean concentrations within Penarth (specifically along Windsor Road) have stabilised below the AQS objective limit. Therefore, this has resulted in a requirement for further assessment as to whether concentrations are above Air Quality Strategy objective limits.

This Detailed Modelling Assessment focusses on the road network within and adjacent to the Windsor Road AQMA to establish any changes in the spatial extent of NO_2 and PM_{10} concentrations in order to identify any areas that are above, or within 10%, of the AQS annual mean objectives. The road links defined as the modelled domain were modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 4.1.1) and latest emissions from the Emissions Factor Toolkit (Version 9.0), with annual mean NO_2 and PM_{10} concentrations predicted at 28 discrete receptor locations for three scenario years (2018, 2023 and 2028).

The predicted concentrations of NO_2 and PM_{10} at all modelled receptors within the Windsor Road AQMA, and adjacent to the modelled road network in Penarth are well below both the annual mean and short term AQS objectives for all modelled scenarios.

Based on the conclusions of the assessment, the following recommendations are made:

- Revoke the Windsor Road, Penarth AQMA;
- Consider decommissioning and/or relocating of monitoring sites which have consistently reported NO_2 concentrations to be well below the respective AQS annual or short term mean objective.

Appendices

Appendix 1 – ADMS Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM.TG(16)[2] guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the proposed development site. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- Background concentration estimates;
- Source activity data such as traffic flows and emissions factors;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties. The following were checked to the extent possible to ensure accuracy:

- Traffic data;
- Distance between sources and monitoring as represented in the model;
- Speed estimates on roads;
- Background monitoring and background estimates; and
- Monitoring data.

The traffic data for this assessment has been collated using a combination of data provided by the highways department at Vale of Glamorgan Council and DfT traffic count data, as outlined in Section 4.1.

NO_2 Model Verification

Concentrations of NO_2 are monitored at 15 sites across Penarth, comprising 17 diffusion tubes and one continuous monitor (Penarth, Windsor Road), with the provision of a triplicate colocation study (Table A1). Five diffusion tubes were sited outside of the modelled road network so were therefore removed from the verification process:

- Site 22;
- Site 56;
- Site 70;

- Site 100; and
- Site 113.

The details of the all the LAQM monitoring sites used for the purposes of model verification are presented in Table A1.

Table A1 - Local Monitoring Data Available for Model Verification

Site ID	OS Grid Reference		2018 Annual Mean NO_2 ($\mu g/m^3$)	2018 Data Capture (%)
	X	Y		
22	318505	171496	20.3	75.0
53	317589	172411	27.7	66.7
55	317595	172435	26.3	91.7
56	316814	172443	20.5	100.0
62	317633	172357	28.1	83.3
70	316731	172391	22.3	100.0
73*	317598	172399	29.7	97.2
74	317708	172259	22.7	66.7
76	317627	172371	29.9	83.3
79	317549	172572	37.9	100.0
82	318061	171944	17.1	83.3
88	317668	172312	27.6	75.0
100	317968	172105	24.0	100.0
112	317434	172729	19.4	100.0
113	317999	172067	21.7	91.7
Penarth, Windsor Road*	317600	172399	24.3	99.7
* Triplicate Colocation Site				

NO_2 Verification calculations

The verification of the modelling output was performed in accordance with the methodology provided in Chapter 7 of LAQM.TG(16)[2].

For the verification and adjustment of NO_x/NO_2, the 2018 monitoring data was used, as presented in Table A1. Two diffusion tubes reported data capture to be below 75% for the duration of 2018, with annualisation subsequently performed to derive the reported NO_2 annual mean concentration. On the basis of the added uncertaintiy annualisation adds to monitored values, both sites were removed from the verification process. These include:

- Site 53; and
- Site 74.

In addition the Windsor Road automatic monitor has also been removed from the verification process. Within 2018 a national bias adjustment factor (0.76), rather than a local bias factor derived from the colocation study, was used to adjust the diffusion tube data. Due to this the NO_2 annual mean concentrations reported at the triplicate Site 73 are higher than those reported at Windsor Road. Due to the application of a national bias adjustment factor to the 2018 diffusion tube concentrations, a conservative approach has been taken to verification by removing the Windsor Road site from the verification process

Verification was completed using the 2018 (2017 reference year) Defra background mapped concentrations for the relevant 1km x 1km grid squares within The Vale of Glamorgan (i.e. those within which the model verification locations are located), as displayed in Table 3.8. These values have been corrected to avoid duplication of road sources within the model (i.e. contributions from ‘Trunk A Roads’ and ‘Primary A Roads’ have been removed from the overall background concentrations for NO_X and NO_2). As the relationship between NO_2 and NO_x is not linear, the most recent version of the NO_2 Adjustment for NO_x Sector Removal Tool[16] has been used.

Table A2 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2018, in order to determine if verification and adjustment was required.

Table A2 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Background NO_2	Monitored total NO_2 (µg/m^3)	Unverified Modelled total NO_2 (µg/m^3)	% Difference (modelled vs. monitored)
55	11.2	26.3	15.9	-39.5
62	11.2	28.1	15.3	-45.3
73	11.2	29.7	15.7	-47.1
76	11.2	29.9	15.6	-47.9
79	11.2	37.9	17.7	-53.2
82	11.6	17.1	14.2	-17.1
88	11.2	27.6	15.9	-42.3
112	11.2	19.4	16.3	-16.1

The model was under predicting at all verification points, with the highest under prediction between the modelled and monitored concentrations observed at Site 79 (-53.2%). Following a review of the model inputs including road widths, prominence of urban canyons and monitoring locations no further improvement of the modelled results could be obtained on this occasion. At all sites apart from two, the difference between modelled and monitored concentrations was greater than ±25%, meaning adjustment of the results was necessary. The relevant data was then gathered to allow the adjustment factor to be calculated.

Model adjustment needs to be undertaken based for NO_x and not NO_2. For the Council operated monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2; these calculations were undertaken using a spreadsheet tool available from the LAQM website.

Table A3 provides the relevant data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution to NO_x.

Table A3 - Data Required for Adjustment Factor Calculation

Site ID	Monitored total NO_2 (µg/m^3)	Monitored total NO_x (µg/m^3)	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored road contribution NO_2 (total - background) (µg/m^3)	Monitored road contribution NO_x (total - background) (µg/m^3)	Modelled road contribution NO_x (excludes background) (µg/m^3)
55	26.3	45.1	11.2	15.3	15.0	29.8	8.8
62	28.1	48.9	11.2	15.3	16.8	33.6	7.7
73	29.7	52.4	11.2	15.3	18.4	37.1	8.4
76	29.9	52.9	11.2	15.3	18.6	37.6	8.2
79	37.9	71.3	11.2	15.3	26.6	56.0	12.4
82	17.1	26.2	11.6	15.7	5.5	10.5	4.8
88	27.6	48.0	11.2	15.3	16.4	32.7	8.9
112	19.4	30.9	11.2	15.3	8.2	15.7	9.5

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[16] Defra NO_2 Adjustment for NO_x Sector Removal Tool version 7.0 (2019), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector

Figure A.1 provides a comparison of the Unverified Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x, and the equation of the trend line based on linear regression through zero. The equation of the trend lines presented in Figure A.1 gives an adjustment factor for the modelled results of 3.742.

Figure A.1 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x across all verification points

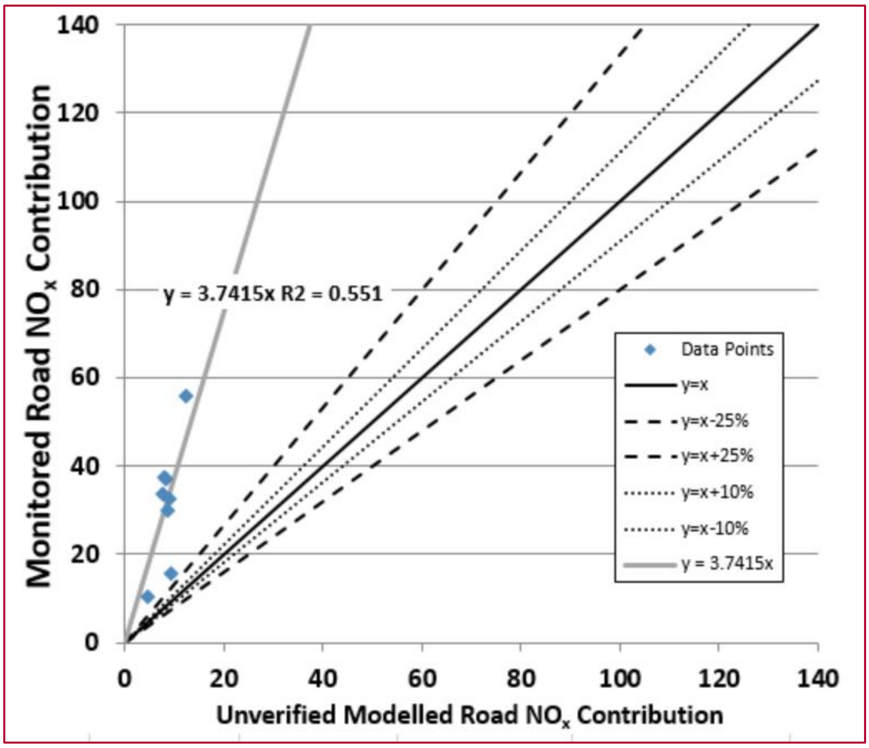


Table A4 and Figure A.1 show the ratios between monitored and modelled NO_2 for each monitoring location after using an adjustment factor of 3.742. LAQM.TG(16)[2] states that:

> *"In order to provide more confidence in the model predictions and the decisions based on these, the majority of results should be within 25% of the monitored concentrations, ideally within 10%."*

Although the model was performing well at most monitoring sites, the model was not performing well or was not showing consistency across similar monitoring sites, in particular at Site 112, where a 49.5% difference was observed. As a result, an adjustment factor of 3.742 could not be used. Site 112 is located along Elizabeth Court, adjacent to a major junction where the A4055 Barry Road meets the A4160 Penarth Road and the A4160 Cogan Hill via a network of slip roads. Due to the resolution of traffic data available, the emissions contribution from vehicles using the slips, have not been modelled. As a result, Site 112 was removed from the verification process

Table A4 - Adjustment Factor and Comparison of Verified Results against Monitoring Results (Initial)

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NOx	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
55	3.39	3.742	32.9	48.2	27.7	26.3	5.5
62	4.35		28.9	44.2	25.9	28.1	-7.8
73	4.41		31.5	46.8	27.1	29.7	-8.7
76	4.60		30.6	45.8	26.6	29.9	-10.8
79	4.52		46.4	61.6	33.8	37.9	-10.8
82	2.16		18.1	33.8	20.9	17.1	22.5
88	3.67		33.3	48.6	27.9	27.6	1.0
112	1.64		35.7	51.0	29.0	19.4	49.5

Figure A.2 provides a comparison of the Unverified Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x, and the equations of the trend line based on linear regression through zero with Site 112 removed (Final Verification). The equation of the trend line presented in Figure A.2 gives an adjustment factor of 4.076.

Figure A.3 show the ratios between monitored and modelled NO_2 for each monitoring locations in the Final Verification. All sites considered show acceptable agreement between the ratios of monitored and modelled NO_2 all being within ±25% (apart from Site 82 which marginally lays outside of this guideline). A verification factor of 4.102 was therefore used to adjust the model results. A factor of 4.102 reduces the Root Mean Square Error (RMSE) from a value of 13.2 to 2.5, within the recommended limit (4.0) highlighting there are consistencies in the model performance at all verification locations.

The adjustment factor of 4.102 was applied to the road-NO_x concentrations predicted by the model to arrive at the final NO_2 concentrations.

Table A.1 – Model Verification (Final)

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
55	3.39	4.102	36.1	51.3	29.2	26.3	11.0
62	4.35		31.7	47.0	27.2	28.1	-3.1
73	4.41		34.6	49.8	28.5	29.7	-4.0
76	4.60		33.5	48.8	28.0	29.9	-6.3
79	4.52		50.8	66.1	35.7	37.9	-5.8
82	2.16		19.8	35.5	21.8	17.1	27.5
88	3.67		36.5	51.8	29.4	27.6	6.3

Figure A.2 – Comparison of the Unverified Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x (Final)

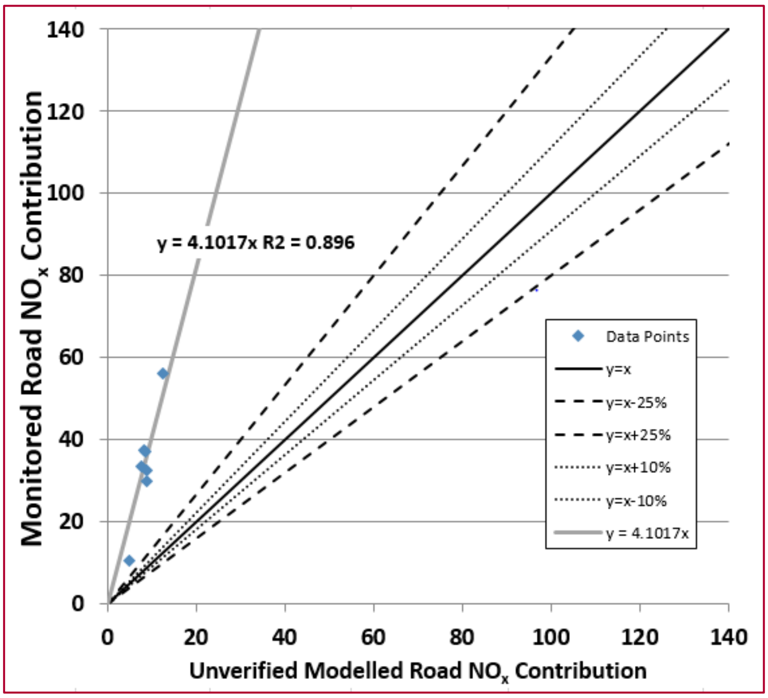
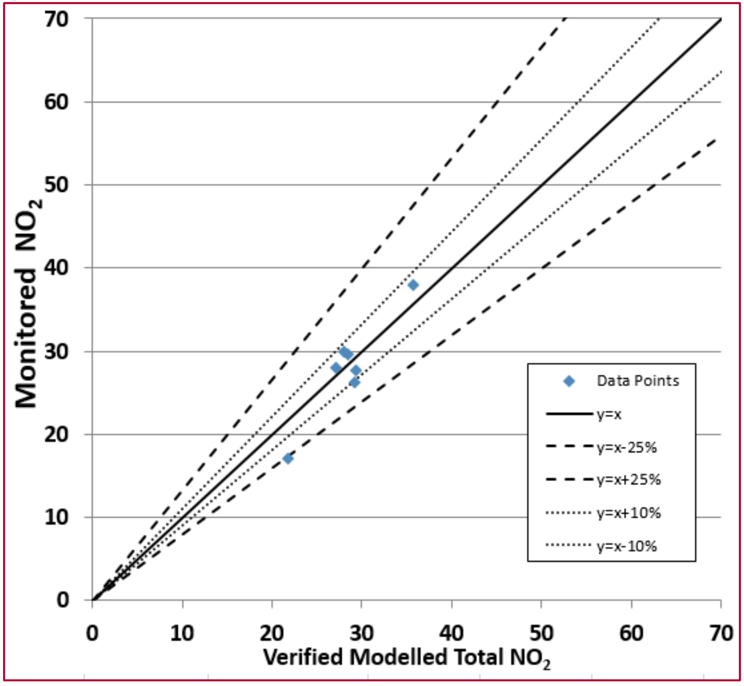


Figure A.3 – Comparison of the Verified Modelled Total NO_2 versus Monitored NO_2 (Final)



PM_{10} Verification

Vale of Glamorgan Council undertook PM_{10} monitoring within Penarth at one site during 2018 (Penarth, Windsor Road), a roadside site located adjacent to Windsor Road. Details of Penarth, Windsor Road for the purposes of PM_{10} are provided in Table A5.

Table A5 - Local PM_{10} Monitoring Data Available for Model Verification

Site ID	OS Grid Reference		2018 Annual Mean PM_{10} (µg/m^3)	2018 Data Capture (%)
	X	Y		
Penarth, Windsor Road	317600	172399	21.7	95.0%

Verification was completed using the 2018 (2017 reference year) Defra background mapped concentrations for the relevant 1km x 1km grid squares within The Vale of Glamorgan (i.e. those within which the model verification locations are located), as displayed in Table 3.8. These values have been corrected to avoid duplication of road sources within the model (i.e. contributions from 'Trunk A Roads' and 'Primary A Roads' have been removed from the overall background concentrations for PM_{10}).

As shown in Table A6, a ratio of 10.4 is derived from comparing ratio between monitored and modelled road contributed PM_{10} for Penarth, Windsor Road. The adjustment factor of 10.4 was applied to the road-PM_{10} concentrations predicted by the model to arrive at the final PM_{10} concentrations.

Table A6 – Modelled Output Comparison Against Monitored

Site ID	Monitored total PM_{10} (µg/m^3)	Background PM_{10} (µg/m^3)	Monitored road contribution PM_{10} (total - background) (µg/m^3)	Modelled road contribution PM_{10} (excludes background) (µg/m^3)	Ratio of monitored road contribution PM_{10} / modelled road contribution PM_{10}
Penarth, Windsor Road	21.7	11.3	10.4	0.8	10.4

Appendix 2 – Receptor Locations

Table A7 – Receptor Locations considered in the Assessment

Receptor ID	Within AQMA?	X	Y	Height
1	N	317289	172691	1.5
2	N	317245	172660	1.5
3	N	317357	172701	3.5
4	N	317347	172736	10.0
5	N	317334	172871	1.5
6	N	317442	172756	1.5
7	N	317396	172686	3.5
8	N	317438	172641	3.5
9	N	317594	172439	1.5
10	N	317584	172460	1.5
11	Y	317582	172418	1.5
12	Y	317603	172394	1.5
13	Y	317625	172371	1.5
14	Y	317731	172229	1.5
15	Y	317477	172485	1.5
16	Y	317668	172314	1.5
17	Y	317645	172345	1.5
18	Y	317696	172276	1.5
19	N	317935	172123	2.5
20	N	317912	172139	4.0
21	N	317973	172043	1.5
22	N	318007	172008	1.5
23	N	318065	171941	1.5
24	N	318094	171949	1.5
25	N	318331	171838	1.5
26	N	318325	171814	1.5
27	N	318200	171867	1.5
28	N	318207	171890	1.5