Dundee City Council

Local Air Quality Management – Detailed Assessment Report

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Client

Dundee City Council
Environmental Health
City Square
Dundee
DD1 3BY

Project Manager **Rachel Brooks**
Tel: **01382 434687**
Fax: **01382 434080**

Environmental Consultant

Casella Stanger
Great Guildford House
30 Great Guildford Street
London
SE1 0ES

Project Manager **Sharon Atkins**
Tel: **0207 9026167**
Fax: **0207 9026149**

Project Team ***Yvonne Brown*** ***Sharon Atkins***

Principal Author ***Yvonne Brown*** ***Sharon Atkins***

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EXECUTIVE SUMMARY

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government Guidance when undertaking such work. The Detailed Assessment is a requirement of the second round of review and assessment for local authorities that have identified areas for further assessment in their previously submitted Updating and Screening Assessment (USA). The Detailed Assessment has been undertaken in accordance with the Technical Guidance LAQM.TG (03).

Between 1998 and 2000, Dundee City Council undertook its first round of review and assessment of air quality. The first round assessments (Stages 1 and 2) concluded that UK Air Quality Objectives would be achieved for all pollutants and no further action was required. It was therefore deemed unnecessary to declare an Air Quality Management Area (AQMA) in Dundee at that time**.**

The first phase of the second round of review and assessment, the USA, was completed in May 2003 and this provided an update with respect to air quality issues within Dundee. The USA concluded that further assessment was required at 17+ pollution hotspots identified for nitrogen dioxide (NO_2) and fine particulates (PM_{10}) due to road traffic emissions. Of these, the USA and subsequent studies concluded that a Detailed Assessment was required for the following nine busy roads and junctions:

- Union Street/Nethergate
- Whitehall Street/High Street/Nethergate
- Seagate
- Logie Street/Loons Road/Muirton Road
- Strathmore Avenue.
- Nethergate/West Marketgait
- Dock Street
- Lochee Road
- Victoria Road/Hilltown

The need for further assessment of the short-term (15 minute) Air Quality Objective for sulphur dioxide (SO_2) and PM_{10} Objectives was also identified in the vicinity of the port/harbour area and Nynas AB UK (point source) due to new residential development proposed on the waterfront.

The Scottish Environmental Protection Agency (SEPA) and the Scottish Executive accepted the USA conclusions.

The Detailed Assessment for road traffic emissions considers the NO_2 and PM_{10} Objectives, through dispersion modelling using the ADMS-Roads model. Verification of the model has been undertaken using 2003 monitoring data.

The verified modelled annual mean NO_2 results for road traffic emissions in 2005 along Seagate, Nethergate/Marketgait, Dock Street, Victoria Road, Commercial Street and Lochee Road indicate annual mean nitrogen dioxide concentrations at relevant receptor locations will exceed the annual mean Objective of 40µg/m^3. Consequently, these locations should be designated for inclusion within one or more AQMAs.

In relation to PM_{10} the results of this detailed assessment are inconclusive because there is insufficient confidence in the modelled results for 2010. Additional monitoring and modelling will be required to determine whether an AQMA(s) is required.

Dispersion modelling of SO_2 emissions from the stacks at Nynas AB UK concluded that no AQMA for SO_2 would be required..

1 INTRODUCTION

1.1 Project Background

Part IV of the Environment Act, 1995, places a statutory duty on local authorities to periodically review and assess the air quality within their area. The Detailed Assessment is a requirement of the second round of review and assessment of air quality (the 'Second Round') for local authorities that have identified areas where there is a risk of exceedence of an air quality objective within their Updating and Screening Assessment (USA) or subsequent annual progress reports. Casella Stanger was commissioned by Dundee City Council to undertake their Detailed Assessment based on the information received from the local authority.

1.2 Summary of Review and Assessment

Guidelines for the 'Review and Assessment' of local air quality were published in the 1997 National Air Quality Strategy (NAQS) [1] and associated guidance and technical guidance. In 2000, Government reviewed the NAQS and set down a revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland[2] (AQS). This set down a revised framework for air quality standards and objectives for seven pollutants, which were subsequently set in Regulation in 2000 through the Air Quality Regulations 2000 (Scotland)[3]. These were subsequently amended in 2002[4].

1.3 The First Round of Review and Assessment

Dundee City Council undertook the first round of review and assessment (the 'First Round') between 1998 and 2000. The First Round was a staged process, which assessed the sources of seven air pollutants of concern to health: Benzene, 1,3 butadiene, carbon monoxide, lead, nitrogen dioxide (NO_2), fine particulates (PM_{10}) and sulphur dioxide (SO_2). The conclusions of the First Round were that Air Quality Objectives would be met in Dundee for all pollutants. It was therefore deemed unnecessary to declare an Air Quality Management Area (AQMA) in Dundee at that time.

1.4 The Second Round of Review and Assessment

The Second Round commenced in 2003. New Technical Guidance (LAQM.TG (03))[5], Policy Guidance (LAQM.PG (03))[6] and Progress Report Guidance (LAQM.PRG (03))[7] were issued on behalf of Defra in 2003. This guidance sets the framework for the requirements of review and assessment for future years, taking account of experiences from the previous round of review and assessment.

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[1] DoE (1997) The United Kingdom Nation Air Quality Strategy The Stationery Office
[2] DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland – Working together for Clean Air, The Stationery Office
[3] DETR (2000) The Air Quality Regulations 2000 (Scotland), The Stationery Office
[4] Scottish Executive (2002) Air Quality (Scotland) Amendment Regulations 2002
[5] Defra (2003) Technical Guidance LAQM.TG (03), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationery Office
[6] Defra (2003) Policy Guidance LAQM.PG(03), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationery Office
[7] Defra (2003) Progress Report Guidance LAQM.PRG(2003), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationary Office

The Updating and Screening Assessment (USA) was the first phase of the Second Round. Similar to stage one of the First Round, there was consideration of the seven pollutants of concern to health and an assessment was made as to whether Air Quality Objectives for these pollutants would be met. Dundee City Council completed this in May 2003, with the conclusion that further assessment was required for nitrogen dioxide (NO_2) and fine particulates (PM_{10}) at 17+ pollution hotspots identified due to road traffic emissions and possible street canyon[8] effects, as described in Section 2 of this report. Of these, the USA and subsequent studies concluded that a Detailed Assessment was required for the following nine busy roads and junctions:

- Union Street/Nethergate
- Nethergate/West Marketgait
- Whitehall Street/High Street/Nethergate
- Dock Street
- Seagate
- Lochee Road
- Logie Street/Loons Road/Muirton Road junction
- Victoria Road/Hilltown
- Strathmore Avenue.

The need for further assessment of the short-term (15 minute) Air Quality Objective for SO_2 and PM_{10} Objectives was also identified in the vicinity of the port/harbour area and Nynas AB UK (point source) due to new residential development proposed on the waterfront.

The Scottish Environmental Protection Agency (SEPA) and Scottish Executive accepted the USA conclusions. Their comments are included in Section 2 of this report.

1.5 Scope and Methodology of the Detailed Assessment

The approach to the Detailed Assessment is to provide the local authority with an opportunity to supplement the information they have gathered in their earlier review and assessment work and more accurately assess the impact of pollution sources on local receptors at identified hotspots, through dispersion modelling and analysis of further monitoring results. The aim of the dispersion modelling is to more accurately reflect the results from local monitoring sites across the whole assessment area and allow comparison of pollutant concentrations against the Air Quality Objectives. The Detailed Assessment will identify with reasonable certainty whether or not there is likely to be an exceedence of the objectives and if so, define the extent and magnitude of the exceedence.

Section 2 of the report details the additional work carried out to investigate those roads and junctions identified in the USA that required additional monitoring data and traffic counts so they could be assessed against the NAQS and objectives and determined if detailed assessment was necessary.

[8] A street canyon is defined as a narrow street with buildings on both sides, where the height of the buildings are greater than the width of the road

Sections 3 and 4 of this report, which was prepared on behalf of Dundee City Council by Casella Stanger Ltd, cover the detailed assessment of the potential NO_2 and PM_{10} hotspots identified in the USA and subsequent studies, and the SO_2 emissions from Nynas.

Detailed dispersion modelling of road traffic sources has been undertaken at the nine pollution hotspots identified using the ADMS-Roads dispersion model using the vehicle emission factors released by DEFRA in 2002. Nitrogen dioxide continuous and diffusion tube monitoring carried out within the assessment area has been used to verify and adjust the modelled results accordingly.

The bias adjustment factor for diffusion tubes has been estimated through a co-location study with the Dundee City Council automatic analyser, as described in later sections of this report along with full details of model verification procedures. Short term monitoring data has been annualised in accordance with methodology in the Technical Guidance (LAQM. TG (03)).

Pollutant concentrations based on road traffic emissions have been predicted for the current year, assumed to be 2003 (the last complete year for monitoring), and future years 2005 and 2010 for nitrogen dioxide, and 2004 and 2010 for fine particulates (PM_{10}) in line with the relevant air quality objectives and EU Air Quality Standards (Table 1.1).

The Detailed Assessment has been undertaken in accordance with the methodologies provided in the Technical Guidance (LAQM. TG (03)).

Table 1.1 Summary of Air Quality Objectives Assessed Within the Detailed Assessment

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen dioxide [a]	200 μg/m^3 not to be exceeded more than 18 times a year	1 hour mean	31.12.2005 [b]
	40 μg/m^3	annual mean	31.12.2005 [b]
Particles (PM_{10}) (gravimetric)[c] (All authorities)	50 μg/m^3 not to be exceeded more than 35 times a year	24 hour mean	31.12.2004
	40 μg/m^3	annual mean	31.12.2004
Particles (PM_{10}) (gravimetric)[b] (Scotland)	50 μg/m^3 not to be exceeded more than 7 times a year	24 hour mean	31.12.2010
	18 μg/m^3	annual mean	31.12.2010
Sulphur dioxide (All authorities)	350 μg/m^3 not to be exceeded more than 24 times a year	1 hour mean	31.12.2004
	125 μg/m^3 not to be exceeded more than 3 times a year	24 hour mean	31.12.2004
	266 μg/m^3 not to be exceeded more than 35 times a year	15 minute mean	31.12.2005

a The UK objectives for nitrogen dioxide are termed provisional within the Regulations, as they bring forward the requirement to meet the EU target date for health benefits.
b The EU Air Quality Standards (99/30) target date is 01/01/2010.
c Measured using the European gravimetric transfer sampler or equivalent.

2 ASSESSMENT OF NEW MONITORING AND TRAFFIC DATA OUTWITH THE SCOPE OF THE DETAILED ASSESSMENT

2.1 Summary of Updating and Screening Assessment

In 2003 Dundee City Council completed an Updating and Screening Assessment (USA)[9] of ambient air quality in Dundee, in accordance with statutory guidance and timetables. The USA concluded that several areas of the city were unlikely to meet the National Air Quality Standards (NAQS) and Objectives. In addition, changes to the statutory guidance[10] required the assessment of new areas where potential pollution hotspots may occur, e.g. street canyons and roads with high proportions of heavy-duty vehicles. Few of such areas had been studied before, and in many situations there was insufficient information to fulfil the assessment criteria.

Consequently, the council was obliged to carry out additional monitoring, modelling and traffic counts throughout the city to determine if any areas, additional to those already identified in the USA, required detailed assessment. The results of this work are present in this Section of the report.

2.2 Comments from Statutory Consultees on the USA

Comments were received from the Scottish Executive and SEPA; both agreed with the council's conclusions. SEPA also made the following comments in relation to nitrogen dioxide:

> *'Dundee City Council has committed a considerable amount of time, effort and resources into assessing the concentrations of nitrogen dioxide throughout the city and the main arterial routes in and out of the city centre. This work has established that emissions from road traffic is degrading the air quality of Dundee to such an extent that is likely to result in a breach of the annual mean objective set for 2005. For this reason, it has no alternative but to progress to detailed assessment.'*

> *'The Technical guidance document TG(0.3) recommends assessing roads with a proportion of HGV[11] and buses in excess of 25%. Experience has shown that as little as 12% (HDV[12]) can result in an exceedence of the standard for NO_2. The council is advised to be aware of this fact when undertaking it's detailed assessment of NO_2.'*

SEPA made the following specific comments in relation to PM_{10}.

> *'The assessment concluded that the local concentrations of PM_{10} are likely to meet the standards set for 2004, but it went on to express concerns about the annual mean standard that has been set for 2010.*

[9] www.dundeecity.gov.uk/publications/airquality.pdf
[10] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications.
[11] HGV = Heavy Goods Vehicles
[12] HDV= Heavy Duty Vehicles, i.e. Heavy goods vehicles and buses

The council is therefore proposing to undertake a detailed assessment to assess the concentrations of particulates in the vicinity of busy roads and road junctions.'

SEPA also made the following specific comments in relation to SO_2.

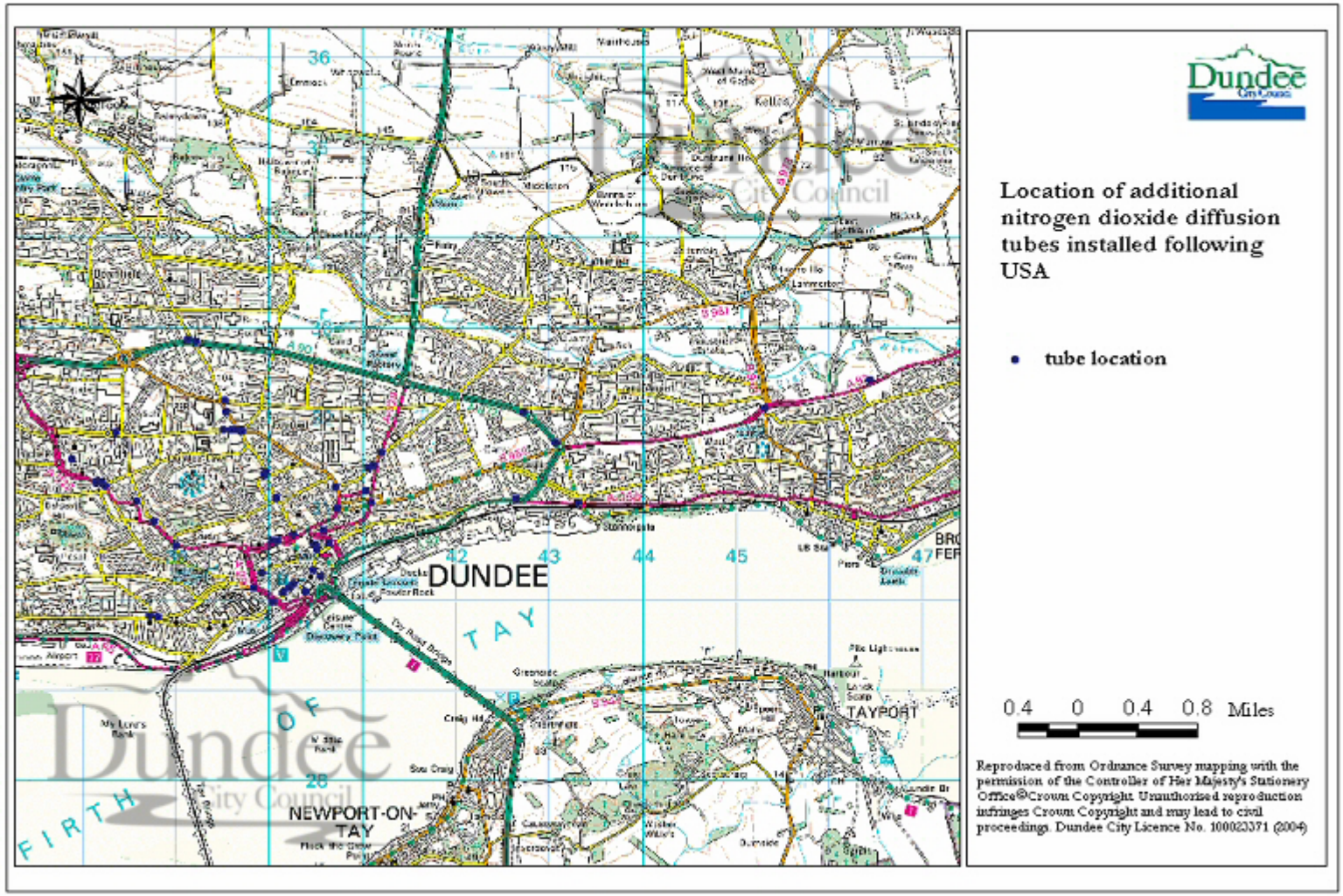
'….data suggests that the concentrations of SO_2 are unlikely to breach any of the standards; therefore there is no requirement to progress to detailed assessment. However, the council is proposing to commission an independent modelling study that will assess the emissions of SO_2 from the Nynas oil processing facility. This is in response to concerns about the concentrations of SO_2 in the vicinity of a new block of domestic dwellings that have recently been constructed close to Nynas. As this is a SEPA regulated process, SEPA will liaise closely with the council.'

2.3 Monitoring

2.3.1 Monitoring carried out since the USA

In response to the findings of the USA and changes to the statutory guidance, which extended the types of area requiring assessment, an additional 52 passive NO_2 diffusion tubes (giving a total of 95) were installed throughout the city (see Figure 2.1). The tubes were placed in potential hotspot areas e.g. street canyons, busy junctions, roads with potentially high percentage HDVs, and areas that had undergone traffic management changes since the USA was completed, where relevant public exposure to pollutants could be expected. Table 2.4 'NO_2 diffusion tube monitoring since the USA', summarises the reason for choosing each location and shows the results of the monitoring which was carried out, in general, between September 2003 and August 2004. In all cases the tubes were located kerbside (within 1 metre of the road) or roadside (between 1 and 5metres).

Figure 2.1 Location of additional nitrogen dioxide diffusion tubes installed following USA



2.3.2 Calculation of Bias

The diffusion tubes are supplied by Gradko International and analysed by Dundee City Council Scientific Services using the 20% Triethanolamine (TEA) in water method. The laboratory method is UKAS[13] accredited and, as the laboratory carries out diffusion tube analysis for the UK NO_2 Network, it is required to participate in the Health and Safety Laboratory's Workplace Analysis Scheme for Proficiency (WASP). The WASP scheme is an independent, internationally recognised performance testing programme. The results achieved by Dundee City Council Scientific Services were found to be consistently "good", in the most recent Network report[14].

The diffusion tube results have been ratified by removing any results that visually appear to be spurious, i.e., significantly outwith the expected range. The Dundee City Council Scientific Services diffusion tubes results are typically found to over-read compared with results from continuous analysers. Dundee City Council has four chemiluminescent analysers measuring NO_2 continuously at various points throughout the city. This is the reference method for measuring NO_2. Collocation studies of three diffusion tubes sited with a continuous analyser allow a bias adjustment factor to be calculated. For the period of this study (September 2003 to August 2004) the continuous analysers captured insufficient data (<90%) to allow the bias calculation to be made. However, two valid bias correction studies of tubes analysed by Dundee City Council Scientific Services exist and have been collated by Air Quality Consultants Ltd (AQC) on behalf of Defra and the devolved administrations[15]. AQC have calculated an overall factor using orthogonal regression to allow for uncertainty in both the automatic monitor and diffusion tube (the uncertainty of the diffusion tube has been assumed to be double that of the automatic monitor). Using this information the bias adjustment factor was taken to be 0.81.

2.3.3 Period Mean Adjustment

There are three short-term survey NO_2 diffusion tube sites that had less than 12 months monitoring data (Arbroath Road LTC – 4 months, Balmore Street – 4 months, Morgan St. / Pitkerro Rd. – 10 months). To annualise the data so that comparison with the annual mean objective can be made, a period mean adjustment factor has been calculated for each site, in accordance with the statutory guidance[16]. Dundee City Council has three long-term background diffusion tube sites at Balgavies Place, Birnam Place, and Woodside Avenue; these were used in the calculation of the period mean adjustment factor. Summaries of the calculations are shown in Table 2.1, Table 2.2 and Table 2.3.

[13] UKAS is the United Kingdom Accreditation Service
[14] UK Nitrogen Dioxide Network 2002 (AEAT/ENV/R/1578)
[15] www.uwe.ac.uk/aqm/review/diffusiontube240904.xls
[16] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications. Page A1-16.

Table 2.1 Calculation of Period Mean Adjustment Factor for Arbroath Road LTC, Feb - May 2003

Location	Annual Mean 2003	Period Mean Feb - May 2003	Ratio
Birnam Pl.	14.0	15.4	0.909
Balgavies Pl.	20.7	21.1	0.981
Woodside Ave.	20.7	22.3	0.928
Period Mean Adjustment Factor			**0.939**

Table 2.2 Calculation of Period Mean Adjustment Factor for Balmore Street, Jan - Apr 2004

Location	Annual Mean Mar '03 - Apr '04	Period Mean Jan '03 -Apr.'04	Ratio
Birnam Pl.	16.2	16.9	0.956
Balgavies Pl.	25.8	27.5	0.936
Woodside Ave.	23.2	23.1	1.002
Period Mean Adjustment Factor			**0.965**

Table 2.3 Calculation of Period Mean Adjustment Factor for Morgan St/ Pitkerro Rd, Sep 2003 -Jun 2004

Location	Annual Mean Jul '03 - June '04	Period Mean Sep '03 - June '04	Ratio
Birnam Pl.	17.9	19.7	0.909
Balgavies Pl.	24.6	27.9	0.882
Woodside Ave.	20.1	24.0	0.839
Period Mean Adjustment Factor			**0.877**

2.3.4 Prediction Forward to 2005 and Correction to Façade

Bias corrected results were then adjusted to the relevant future year using correction factors supplied in the technical guidance[17]. The results were further corrected to represent the level of exposure expected at the façade of the nearest receptor, using adjustment factors supplied by the Review and Assessment Helpdesk operated by Air Quality Consultants and University of West of England, Bristol[18].

[17] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications. Page 6-8
[18] www.uwe.ac.uk/aqm/review

2.3.5 Monitoring Results

The results in Table 2.4 are bias corrected, period adjusted (where necessary), predicted forward to 2005, and corrected to façade to allow direct comparison with the NAQS(2005) annual mean for NO_2 (40 μg/m^3).

Table 2.4 NO_2 diffusion tube monitoring since the USA (μg/m^3)

Name of tube location	Type	Reason for additional monitoring				Approx. distance kerb to building façade (m)	NO_2 bias corrected and predicted to 2005	
		Street canyon	Busy junction	High %HDV ?	Traffic changes /no data		At the tube location	Adjusted to façade
Albert Street (Fish)	kerbside	✔	✔		✔	2.9	33.3	31.6
Arbroath Road (13)	kerbside	✔			✔	3.26	38.9	37
Arbroath Road (LTC)	roadside				✔	~7.12	27.4	24.7
Arthurstone Terrace (10)	kerbside	✔			✔	2.56	26.6	25.3
Balmore St	kerbside	✔			✔	2.58	34.4	32.7
Broughty Ferry Road (141)	roadside		✔		✔	3.92	35.2	33.4
Broughty Ferry Road (240)	roadside		✔		✔	11.87	32.5	25.7
Claypotts Junction	roadside		✔		✔	11.69	24.8	24.8
Commercial Street (Waterstones)	kerbside	✔		✔		2.59	**40.7**	38.7
Commercial Street/Dock Street	roadside		✔	✔		4.48	**45.3**	**43**
Dens Road Crossing	roadside				✔	3.63	36.7	34.9
Dock St (14)	kerbside		✔	✔		3.51	**43**	**40.9**
Eastport Roundabout	roadside		✔	✔		1.9	33.4	33.4
Harefield Road (35)	kerbside			✔	✔	11.72	33	24.8
High Street Lochee (95)	kerbside	✔			✔	1.86	28.7	28.7
Hilltown (207/209)	roadside	✔	✔			3.52	27.6	26.2
Hilltown (Suites)	roadside	✔	✔			2.24	35.1	35.1
Hilltown/ Kinghorn Rd	kerbside		✔			3.96	25.9	24.6
King St (12 & 14)	kerbside		✔		✔	2.44	30.8	29.3
Kingsway E. Roundabout	roadside		✔		✔	16.98	34.5	27.2
Kingsway/ Strathmartine Rd (S)	kerbside		✔			18.79	38.8	29.1

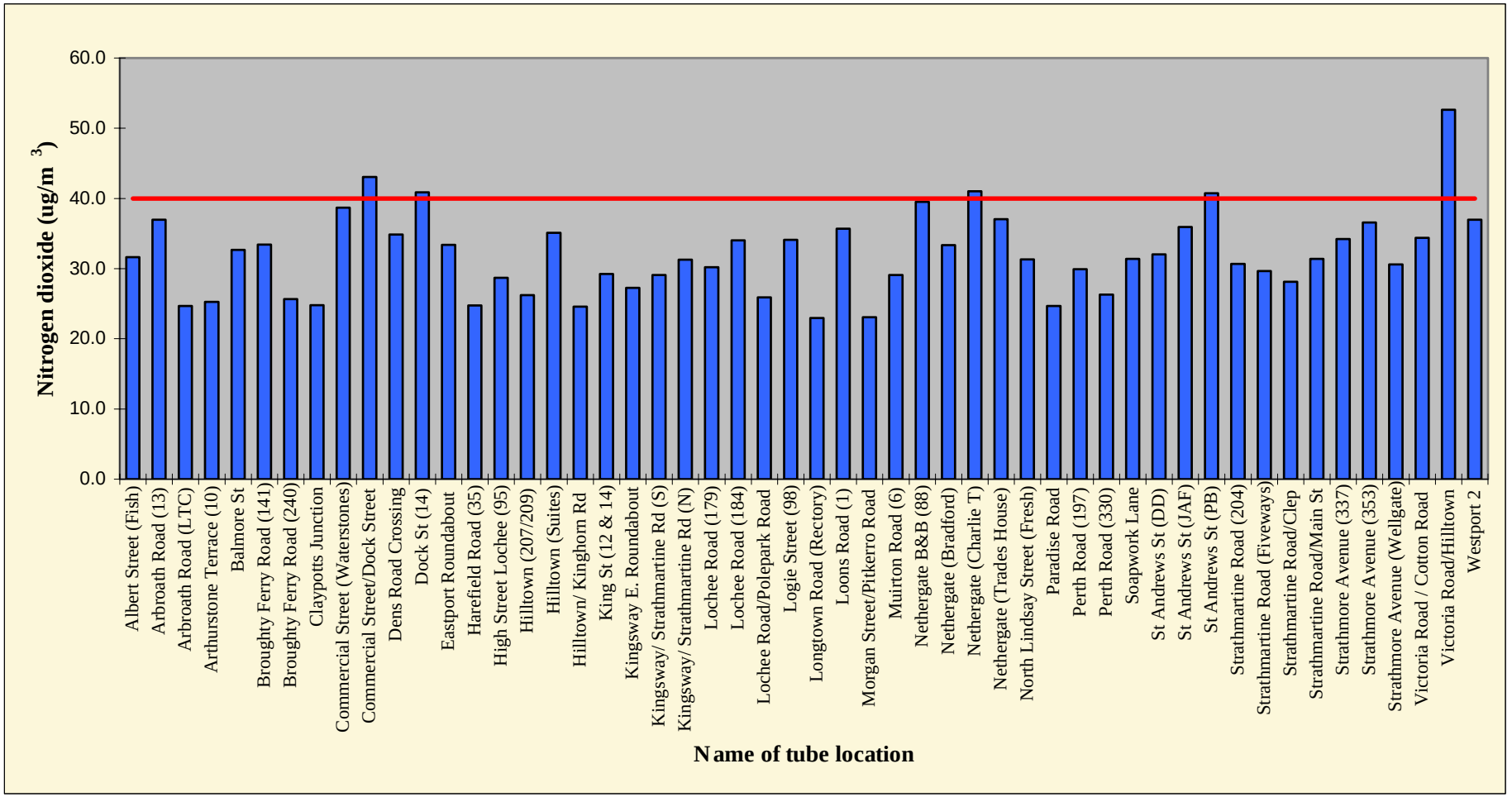
Name of tube location	Type	Reason for additional monitoring				Approx. distance kerb to building façade (m)	NO_2 bias corrected and predicted to 2005	
		Street canyon	Busy junction	High %HDV ?	Traffic changes /no data		At the tube location	Adjusted to façade
Kingsway/ Strathmartine Rd (N)	roadside		✔			27.55	**41.7**	31.3
Lochee Road (179)	kerbside				✔	4.15	31.8	30.2
Lochee Road (184)	kerbside	✔	✔			3.41	35.8	34
Lochee Road/Polepark Road	kerbside		✔			9.92	28.8	25.9
Logie Street (98)	kerbside		✔			2.36	35.9	34.1
Longtown Road (Rectory)	roadside				✔	13.7	30.6	23
Loons Road (1)	roadside		✔		✔	2.4	35.7	35.7
Morgan Street/Pitkerro Road	kerbside		✔		✔	2.88	24.3	23.1
Muirton Road (6)	roadside	✔	✔		✔	1.76	29.1	29.1
Nethergate B&B (88)	kerbside		✔			6.32	**43.9**	39.5
Nethergate (Bradford)	roadside			✔		3.76	35.1	33.3
Nethergate (Charlie T)	kerbside	✔	✔			2.63	**43.2**	**41**
Nethergate (Trades House)	roadside			✔		3.98	39	37.1
North Lindsay Street (Fresh)	kerbside	✔			✔	1.53	31.3	31.3
Paradise Road	roadside				✔	3.07	27.4	24.7
Perth Road (197)	kerbside	✔				2.63	31.5	29.9
Perth Road (330)	roadside		✔			8.77	29.2	26.3
Soapwork Lane	roadside		✔			3.84	31.4	31.4
St Andrews St (DD)	kerbside	✔		✔		2.64	33.7	32
St Andrews St (JAF)	kerbside	✔		✔		2.47	37.8	35.9
St Andrews St (PB)	kerbside	✔		✔		2.88	**42.9**	**40.8**
Strathmartine Road (204)	kerbside	✔				2.76	32.3	30.7
Strathmartine Road (Fiveways)	kerbside		✔			2.85	31.2	29.6
Strathmartine Road/Clep	kerbside		✔			2.38	29.6	28.1
Strathmartine Road/Main St	kerbside	✔				1.64	31.4	31.4

Name of tube location	Type	Reason for additional monitoring				Approx. distance kerb to building façade (m)	NO_2 bias corrected and predicted to 2005	
		Street canyon	Busy junction	High %HDV ?	Traffic changes /no data		At the tube location	Adjusted to façade
Strathmore Avenue (337)	kerbside	✔				2.09	36	34.2
Strathmore Avenue (353)	kerbside	✔				2.12	38.5	36.6
Strathmore Avenue (Wellgate)	kerbside	✔	✔			2.18	32.2	30.6
Victoria Road / Cotton Road	kerbside		✔			2.12	36.2	34.4
Victoria Road/Hilltown	roadside	✔	✔			3.16	**55.4**	**52.6**
Westport 2	kerbside		✔			2.96	38.9	37

*Short-term survey site; results have been adjusted by appropriate period mean adjustment factor

The results of the monitoring have been plotted in Figure 2.2. Of the 52 monitoring locations, five were found to record levels of NO_2 greater than the NAQS (2005) annual mean for NO_2 (shown as the red limit line).

Figure 2.2 NO_2 diffusion tube results (12 month mean, bias corrected and predicted to 2005) compared with NAQS (2005) NO_2 annual



mean, factored to represent exposure at façade

2.3.6 Conclusions of monitoring

The statutory technical guidance[19] introduced the requirement to assess and review new areas of the city not previously investigated for air quality. Also areas identified in the USA as potential hotspots for NO_2 as a result of traffic emissions required further investigation. Consequently 52 additional diffusion tubes were installed at locations throughout the city. After a twelve-month monitoring period the monitoring results have been compared with the NAQS (2005) annual mean for NO_2 (40µg/m³). Only five locations were found to record levels greater than the NAQS:

- Commercial Street/Dock Street;
- Dock St (14);
- Nethergate (Charlie T);
- St Andrews St (PB); and
- Victoria Road/Hilltown.

Of these locations, three are on main bus routes and have a high proportion of heavy duty vehicles, four are near busy junctions/roads and three are in areas where the built environment (street canyons) may influence the effective dispersion of traffic emissions.

These five locations have been added to those previously identified in the USA as requiring a detailed assessment. The further investigations of the impact of traffic emissions on air quality in these locations can be found in Part Three of this report.

2.4 DMRB Modelling

2.4.1 Modelling carried out since the USA

The Design Manual for Roads and Bridges (DMRB) Screening Model provides a means of estimating the impact of roads on local air quality. It is a useful tool for local authorities particularly for the assessment of PM_{10} from roads and junctions as, unlike NO_2, there is no suitable and cost effective means of monitoring PM_{10}. The model uses classified traffic flow data as a basis for its calculations. The DMRB modelling results reported in the USA were largely based on old traffic count data (1993 and 1994). The unavailability of classified road count data meant that many areas requiring assessment, according to the statutory technical guidance criteria, could not be assessed for PM_{10} at that stage.

2.4.2 DMRB Screening Model

Additional classified traffic counts (12-hour manual counts) were commissioned and carried out by contractors from April – June 2004, avoiding public, trade and university holidays. This data was adjusted to Annual Average Daily Traffic 24 hour (AADT24) flow using the national default factor taken from the statutory guidance[20]. The AADT24 was then projected forward for each vehicle

[19] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications.
[20] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications. Page A2-13.

classification and objective years (2005, 2010) using a low National Road Traffic Forecast (NRTF) factor as advised by Dundee City Council Planning and Transportation Department. This information was used to screen the areas of concern using the Design Manual for Roads and Bridges (DMRB) Screening Model (Highways Agency Version 1.02 – Nov 2003) to determine whether detailed assessment would be required. The results of this DMRB screening process are shown in Table 2.5. To account for the urban nature of the built environment and the way in which street canyons can interfere with the effective dispersion of traffic emissions, the NO_2 traffic component of the predicted level was doubled before adding to the background NO_2 level. The input data for the model are shown in Appendix 1.

Table 2.5 DMRB Screening Results

Junction/Street name	Receptor Grid Reference		DMRB Predicted Levels	
			NO_2 (2005) ug/m^3	PM_{10} (2010) ug/m^3
	Easting	Northing	at the receptor	at the receptor
King Street	340491	730651	18.8	14.1
Eastport Roundabout	340651	730625	n/a	17.4 (1excd)
Strathmore Avenue	339603	731870	28.3*	15.6
Kingsway/ Strathmartine Road	339236	732825	29.3	17.5 (1excd)
Ladywell Roundabout	340118	730654	n/a	16.4
Albert St/Dura St/Forfar Rd/Mains Loan	341142	731569	25.3*	16.4
Dens Rd/Victoria Rd/ Victoria St/Cotton Rd	340733	731005	27.5	16.8
Albert St/Arbroath Rd/ Princes St	341092	731081	36.3*	16.9
Clepington Rd/ Forfar Rd	341397	732125	n/a	17.4 (1excd)

Notes
* figures represent levels calculated in a street canyon / built-up urban area
excd exceedence (the NAQS allows up to 7 exceedences a year of (2010)24hr mean PM_{10} of 50 ug/m^3)
NAQS(2005)Annual mean NO_2 is 40 ug/m^3 ,and (2010)Annual mean PM_{10} is 18µg/m^3

2.4.3 Discussion of DMRB Screening Model Results

The results of the DMRB Screening Model can be compared directly with the NAQS for PM_{10} (2010) annual mean (18 µg/m^3) and the number of exceedences with the PM_{10} (2010) 24hr mean (50µg/m³ with 7 exceedences allowed). Also the results for NO_2 are comparable with the NAQS (2005) of 40 µg/m^3. The results indicate that each of the NAQS will be met at all the locations, which suggests that no further action is required at this stage. However, it should be noted that the results for three of the locations are close to the NAQS for PM_{10} (2010) annual mean

It is known that the DMRB model tends to under predict levels of NO_2 in an urban environment by up to 25%. Consequently a comparison of the modelled results with those predicted from actual monitoring of NO_2 (using NO_2 diffusion tubes) has been undertaken and is shown in Table 2.6

Table 2.6 Comparison of DMRB Predictions with Monitored Results

Junction/Street name	Diffusion tube grid reference		NO_2 (2005) ug/m^3		DMRB % Under-read
	easting	northing	Diffusion tube results^	DMRB Predicted levels at the tube	
Eastport Roundabout	340651	730623	33.4	27.8	16.8
Strathmore Avenue	339606	731872	38.5	28.5*	26
Kingsway/Strathmartine Road	339219	732832	41.7	31.4	24.7
Ladywell Roundabout	340100	730649	31.4	31.2*	0.6
Albert St/ Dura St/ Forfar Rd/ Mains Loan	341121	731542	33.9	30.7*	9.4
Dens Rd/Victoria Rd/Victoria St/Cotton Rd	340740	730996	36.2	35.3*	2.5
Albert St/ Arbroath Rd/ Princes St	341111	731070	38.9	32.1*	17.5
Clepington Rd/Forfar Rd	341385	732121	35.6	27.1	23.9

Notes

^ Monitoring results (Sept 03 – Aug 04) are bias corrected and predicted forward to 2005

* Figures represent levels calculated if you assume a street canyon / built-up urban area

This table indicates that in Dundee the DMRB Model is under predicting by between 0.6 and 26% for NO_2 in the areas studied. This is very close to the expected error range of the screening model. At present there are no PM_{10} monitoring results in the study areas to allow similar comparisons to be made.

2.4.4 Conclusions of DMRB Screening Model

In the USA nine potential hotspot areas were identified that had insufficient classified road count data to allow DMRB screening for PM_{10}. Classified road counts were commissioned for the 7 busy junctions and 2 roads with potentially high HDV. The results of the modelling indicate that the NAQS for NO_2 and PM_{10} will be met at all the locations, which suggests that no further action is required at this stage. However changes in traffic management at the borderline locations that increase vehicle flows or numbers of HDVs may necessitate further assessment in the future.

3 DETAILED ASSESSMENT FOR ROAD TRAFFIC SOURCES

3.1 Baseline Information

3.1.1 Traffic Data

Dundee City Council Planning and Transportation provided the traffic flows which were used in conjunction with classified manual turning counts, commissioned by Environmental Health and Trading Standards Department, to derive the annual average daily traffic flows (AADT) as used in this assessment.

Forecast factors for future years were derived using TEMPRO/NAEI low growth figures. These suggest that traffic growth in Dundee City is estimated to be 1.015% between 2003 and 2005, and 1.038% between 2003 and 2010.

In the absence of speed data, speeds have been based on speed limits, modified according to local conditions to take account of congestion and stop/start vehicle movements at junctions. Speeds were reduced at junctions to 20kph within 25m of junctions according to LAQM.TG (03) to reflect the higher emissions of queuing traffic.

The data used in this assessment, with the forecast vehicle flows for 2005 and 2010, are shown in Appendix 2.

The diurnal and monthly profiles for Dundee as derived from automatic traffic count (ATC) data are shown in Figure 3.1 and Figure 3.2 below.

The diurnal pattern information indicates that very similar patterns are experienced at the three different locations in Dundee and the average pattern was applied to the AADT. The diurnal pattern show clear AM and PM peaks in traffic, with much lower flows between the hours of 11pm and 7am.

Monthly patterns were also considered and showed that traffic flows were generally higher between October – November, and lowest in January. The average monthly pattern was also applied to traffic flows to reflect variation throughout the year.

Figure 3.1 Diurnal Traffic Profiles

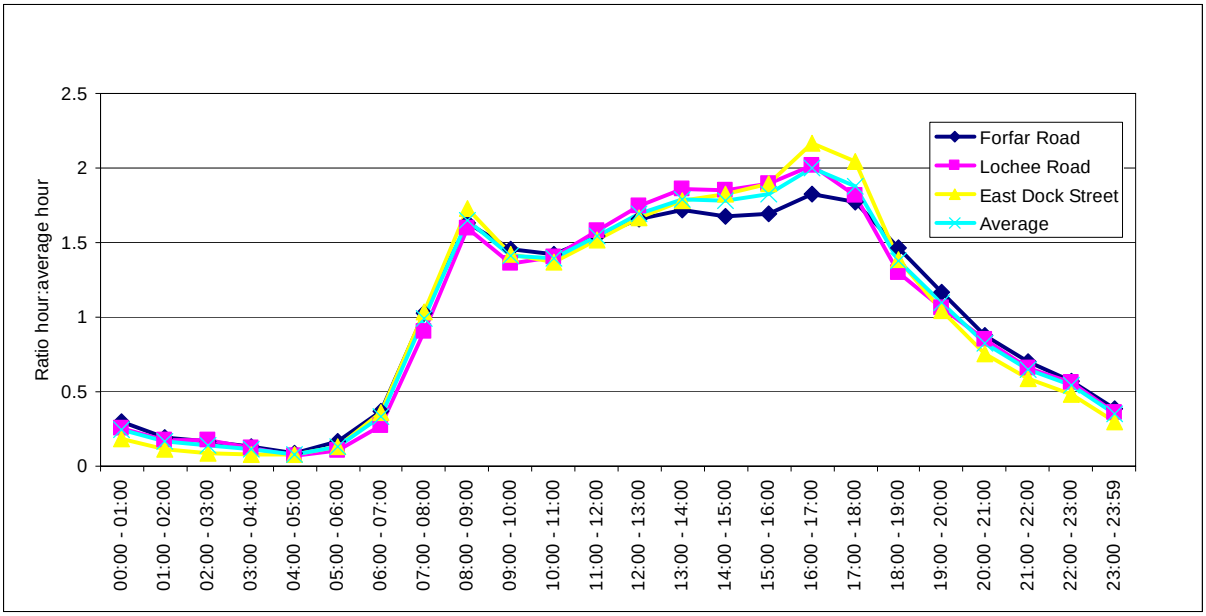
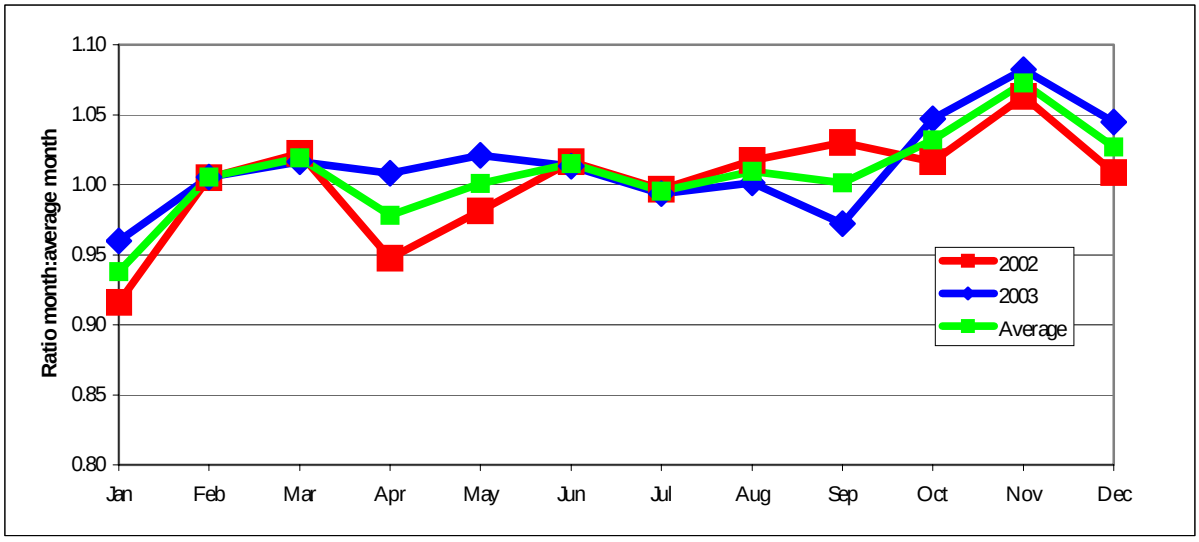


Figure 3.2 Monthly Traffic Profiles



3.2 Local Monitoring Data

Dundee City Council has a continuous air quality monitoring station within the city centre at a kerbside site in Union Street (grid reference x=340247, y=730078), which has been used in this Detailed Assessment to assess levels of NO_2 and PM_{10} and verify ADMS-Roads modelled results. Diffusion tubes have been co-located at this site since October 2000 and have been used to determine the bias adjustment factor for the diffusion tubes.

The annual mean NO_2 for 2003 at the Union Street site was 40.6µg/m^3 (38.4µg/m^3 projected to 2005). Continuous monitoring data for Union Street is summarised in Table 3.1, included in this table is data from Dock Street near to the port area of Dundee where there are industrial sources emitting SO_2 and PM_{10}.

Table 3.1 Summary of Continuous Monitoring in Dundee (2000-2004) in µg/m^3

	Union Street			Dock Street			
	2001	2002	2003	2001	2002	2003	2004
NO_2 annual mean	48.5	41.8	40.6				
Data Capture	93.3	86.6	86.8				
NOx annual mean	219.2	174.3	156.0				
Data Capture	99.5	99.7	99.9				
PM_{10} annual mean	22.3	23.1	24.2	n/a	21.1	21.1	19.4
Data Capture %	95.6	87.6	98.1		97.6	99.3	75.0
Number of 24-Hour Mean PM_{10} > 50	4	5	17		5	17	4

NO_2 concentrations are measured using a ML®9841A chemiluminescent analyser which is automatically calibrated every night using certified calibration gases. PM_{10} concentrations are monitored using a Tapered Element Oscillating Microbalance (TEOM Series 1400a) which is calibrated under software support using a single pre-weighed filter contained in the mass calibration verification kit as provided by the equipment suppliers as part of the maintenance contract. The TEOM results (in µg/m^3) have been converted to gravimetric equivalent using the multiplier of 1.3 in accordance with the technical guidance LAQM.TG(03).

The annual mean PM_{10} for the Union Street site was 24.2µg/m^3 i.e. below the current Objective levels for 2004 and 2005, but above the 2010 annual mean Objective for PM_{10}. Current monitoring for 2004 indicates that the 24-hour mean Objective is currently met at both Union Street and Dock Street, although there were exceedences measured in 2003.

Dundee monitoring data clearly shows that 2003 was a high pollution year for PM_{10} concentrations and it is recognised that prevailing meteorological conditions resulted in a number of exceedences across the UK. Preliminary data for 2004 indicates that the number of exceedences has reduced in 2004, and based on typical (i.e. non-2003) years of monitoring there seem to be 4-5 exceedences per year. Data derived from Defra's Automatic Urban and Rural network for Scotland also show a similar trend and a large increase in the number 24-hour mean exceedences in 2003 (Table 3.2).

Table 3.2 Summary of Scotland PM_{10} Data 2000-2003 (µg/m^3 Gravimetric)

Number of Exceedences of 24-Hour PM_{10}	2001	2002	2003	2004
Aberdeen	5	5	14	n/a
Glasgow Centre	16	13	13	n/a
Glasgow Kerbside	33	25	48	n/a
Grangemouth	3	1	11	n/a
Dumfries	0	18	22	n/a
Inverness	0	1	11	n/a
Annual Average PM_{10}	2001	2002	2003	2004
Aberdeen	16.1	19.2	22.2	
Glasgow Centre	22.8	22.7	21.3	
Glasgow Kerbside	29.2	26.5	31.2	
Grangemouth	19.4	15.7	19.1	
Dumfries	17.8	21.3	23.3	
Inverness	11.2	17.2	17.3	

In addition to the Union Street continuous air quality monitoring station, Dundee City Council also currently operate 36 NO_2 diffusion tubes sites within the assessment areas that are under consideration in this Detailed Assessment. Diffusion tubes used by Dundee City Council are analysed by Dundee City Council Scientific Services utilising the 20% Triethanolamine (TEA) in water preparation method. Dundee City Council participates in the Workplace Analysis Scheme for Proficiency (WASP) for NO_2 diffusion tube analysis and the Annual Field Inter-Comparison Exercise. These provide strict performance criteria for participating laboratories to meet, thereby ensuring NO_2 concentrations reported are of a high calibre.

The continuous analyser nitrogen dioxide data at Union Street (87% data capture) has been used with the co-located diffusion tube data to estimate the local bias adjustment factor for the diffusion tubes. Bias adjustment factors for 2002 and 2003 of 0.82 and 0.76 have been derived locally. The University of the West of England (UWE) national default factor for 2003 using this laboratory and method is 0.81. As this is more precautionary, this has been applied to the 2003 diffusion tube data. The corrected NO_2 diffusion tube monitoring results for 2003, with projection to 2005 for roadside and kerbside sites used for model verification, are shown in Table 3.3.

Diffusion tube monitoring indicates that a number of exceedences are monitored within Dundee City. Figure 3.3 to Figure 3.6 show the projected NO_2 annual mean Objective exceedences at diffusion tube monitoring sites in the assessment areas. It should be noted that many of the exceedences are at kerbside monitoring sites which represent the worse case concentrations where the annual mean Objective does not generally apply. However, placement of diffusion tubes is rarely possible on building façades, due to a lack of suitable tamperproof external structure/feature on which to attach them.

Monitoring data for 2003 at the diffusion tube roadside sites within the assessment areas have been collated and assessed for model verification purposes. A comparison of monitored and modelled predictions for NO_X/NO_2 is shown in Appendix 3 with a full description of the verification methodology.

Table 3.3 Diffusion tube results 2003 (µg/m^3) used in model verification, projected to 2005 (bias corrected)

Tube No.	Location	X	Y	Site Type	Annual mean NO_2 (2003)	2003 Annual mean NO_2 (2005) (projected)
107	Whitehall Crescent	340376	730109	K	30.9	29.3
11	Whitehall Street (BRJ)	340330	730106	K	36.3	34.4
26	Dock Street (14)*	340395	730086	K	**46.4**	**44.0**
83	Seagate (Yates 7-9)	340458	730367	R	**42.6**	**40.4**
21	Commercial St (Waterstones)*	340481	730325	K	39.0	37.0
22	Commercial St /Dock Street*	340567	730255	R	**48.2**	**45.7**
29	Dock Street (Unicorn)	340660	730348	R	39.3	37.3
86	St Andrews Street DD	340493	730608	K	35.8	33.9
87	St Andrews Street JAF	340514	730587	K	38.8	36.8
80/81/82	Seagate (Bond triplicate)	340490	730454	R	39.3	37.3
78	Seagate	340546	730534	R	**47.9**	**45.4**
105	Victoria Road/Hilltown*	340274	730714	R	**60.6**	**57.4**
103	Victoria Road	340212	730634	R	**40.5**	38.4
98/99/100	Union Street Rollalong	340235	730087	R	**40.6**	38.5
101	Union Street (Goodfellows)	340260	730083	K	38.7	36.7
102	Union Street (McIntyres)	340293	730051	K	37.2	35.3
72	Nethergate (Trades House)*	340230	730124	R	**42.4**	**40.2**
113	Whitehall Street (Deb A)	340265	730151	K	**48.1**	**45.6**
112	Whitehall Street (BUS)	340287	730130	K	**49.3**	**46.7**
115	Whitehall Street (TISO)	340293	730140	R	39.2	37.2
108/109/110	Whitehall Street (BBBS triplicate)	340277	730156	R	39.6	37.5
88	Nethergate B&B	340163	730061	K	**43.7**	**41.4**
73	Nethergate/Marketgait	340074	729984	R	34.7	32.9
70	Nethergate (Charlie T)*	340043	729968	K	**47.7**	**45.2**
114	Whitehall Street (DEB E)	340321	730096	K	**40.4**	38.3
63	Loons Road*	338211	731293	R	**41.0**	38.9
58	Lochee Road (184)*	338767	730856	K	36.7	34.8
54/55/56	Lochee Road (164)	338859	730776	K	**50.4**	**47.8**
51/52/53	Lochee Road (140)	338921	730692	K	**54.3**	**51.5**
59	Lochee Road/Polepark Road*	339016	730586	K	32.6	30.9
61	Logie Street (114)	338184	731293	R	**53.6**	**50.8**
66	Muirton Road (6)	338152	731294	K	32.8	31.1
60	Logie Street (98)*	338251	731259	K	38.9	36.9
94	Strathmore Avenue (337)*	339523	731875	K	37.6	35.6
95	Strathmore Avenue (353)	339606	731872	R	**42.7**	**40.5**
96	Strathmore Avenue (Wellgate)*	339670	731878	K	34.4	32.6

* Short-term monitoring sites started in September 2003 have been annualised using the methodology outlined in LAQM.TG (03). K=Kerbside; R=Roadside

Figure 3.3 Projected 2005 Annual Average NO_2 Objective Exceedences – Central Diffusion Tube Monitoring Sites

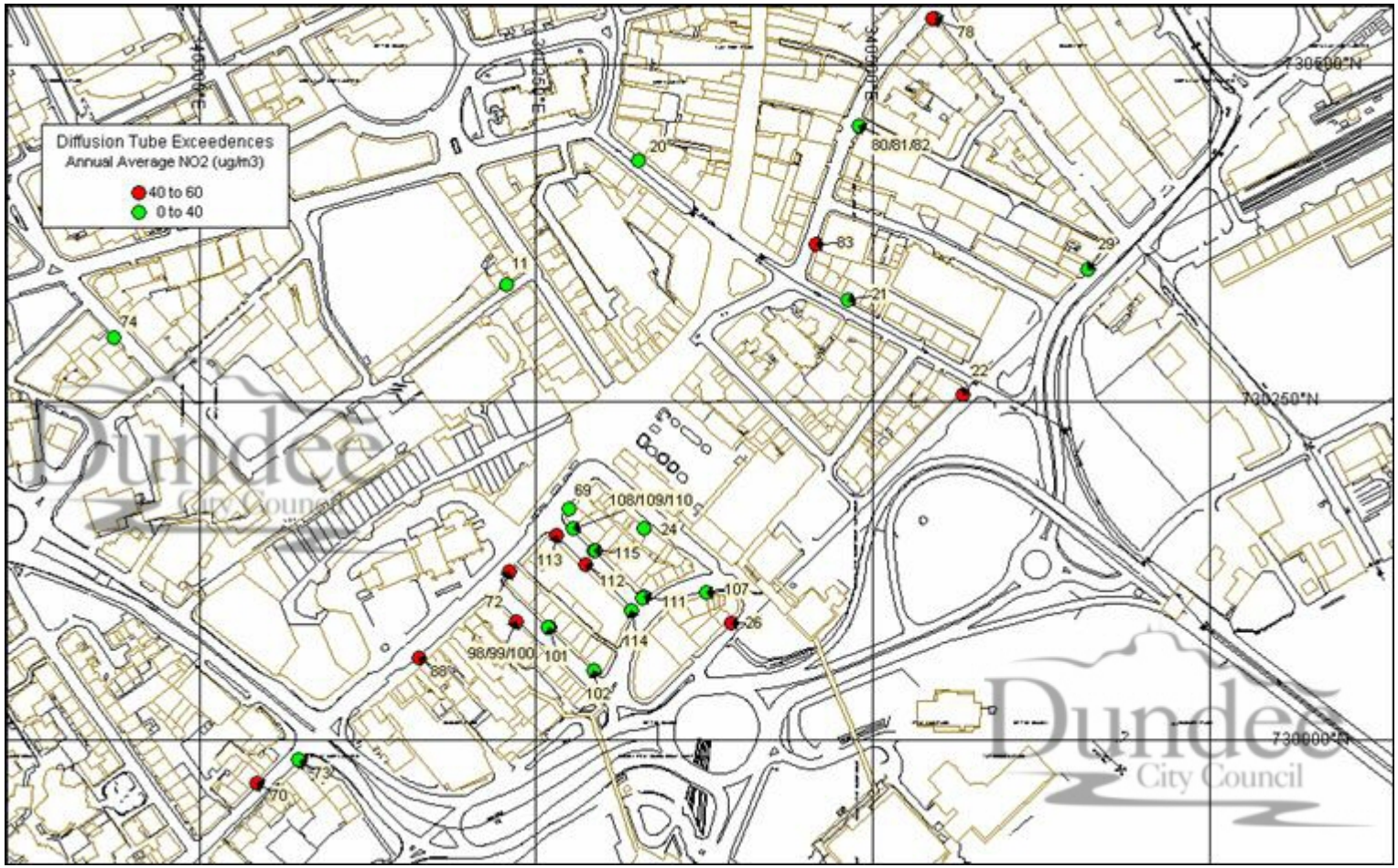


Figure 3.4 Projected 2005 Annual Average NO_2 Objective Exceedences – Lochee Road Diffusion Tube Monitoring Sites

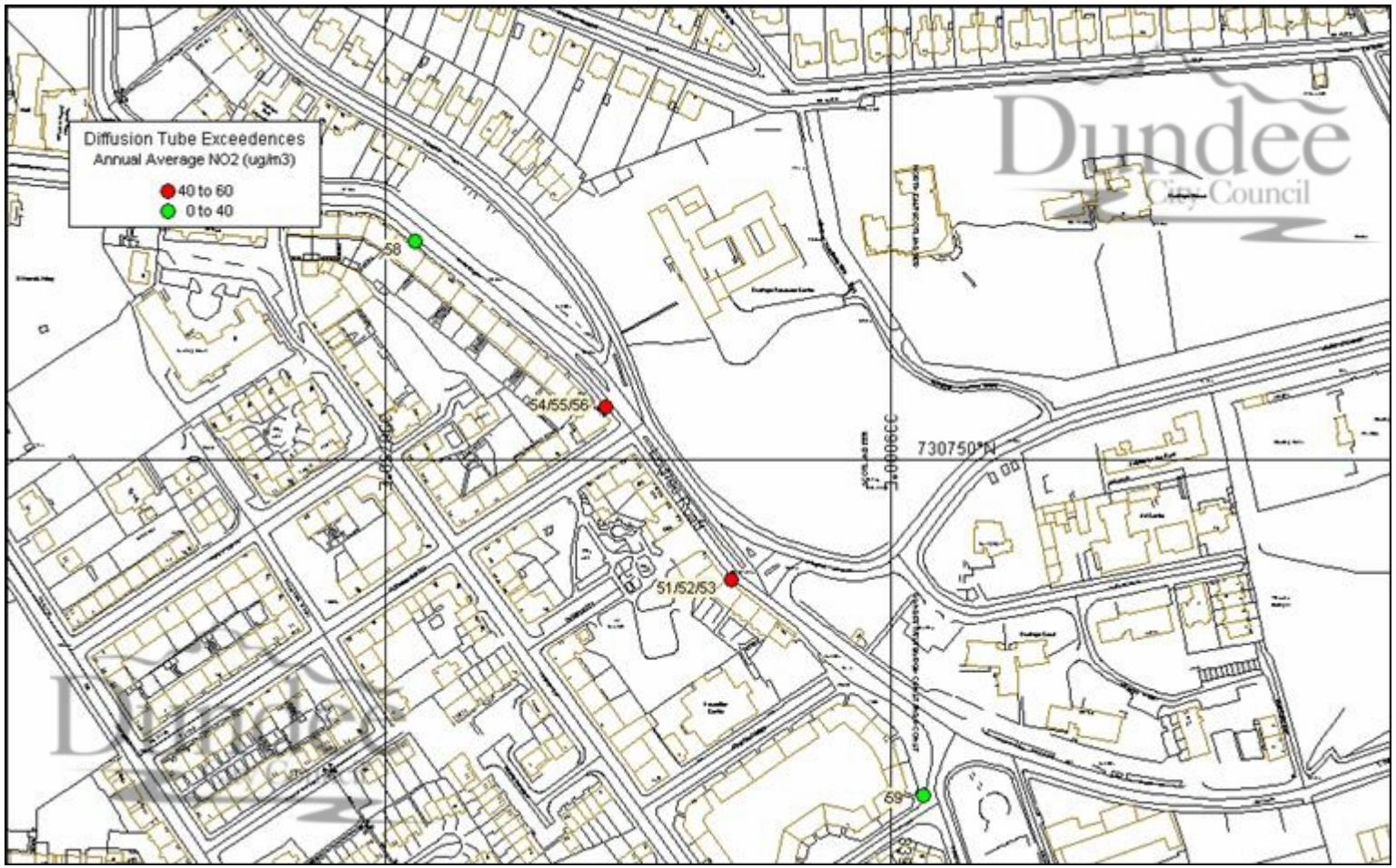


Figure 3.5 Projected 2005 Annual Average NO_2 Objective Exceedences – Logie Street Diffusion Tube Monitoring Sites

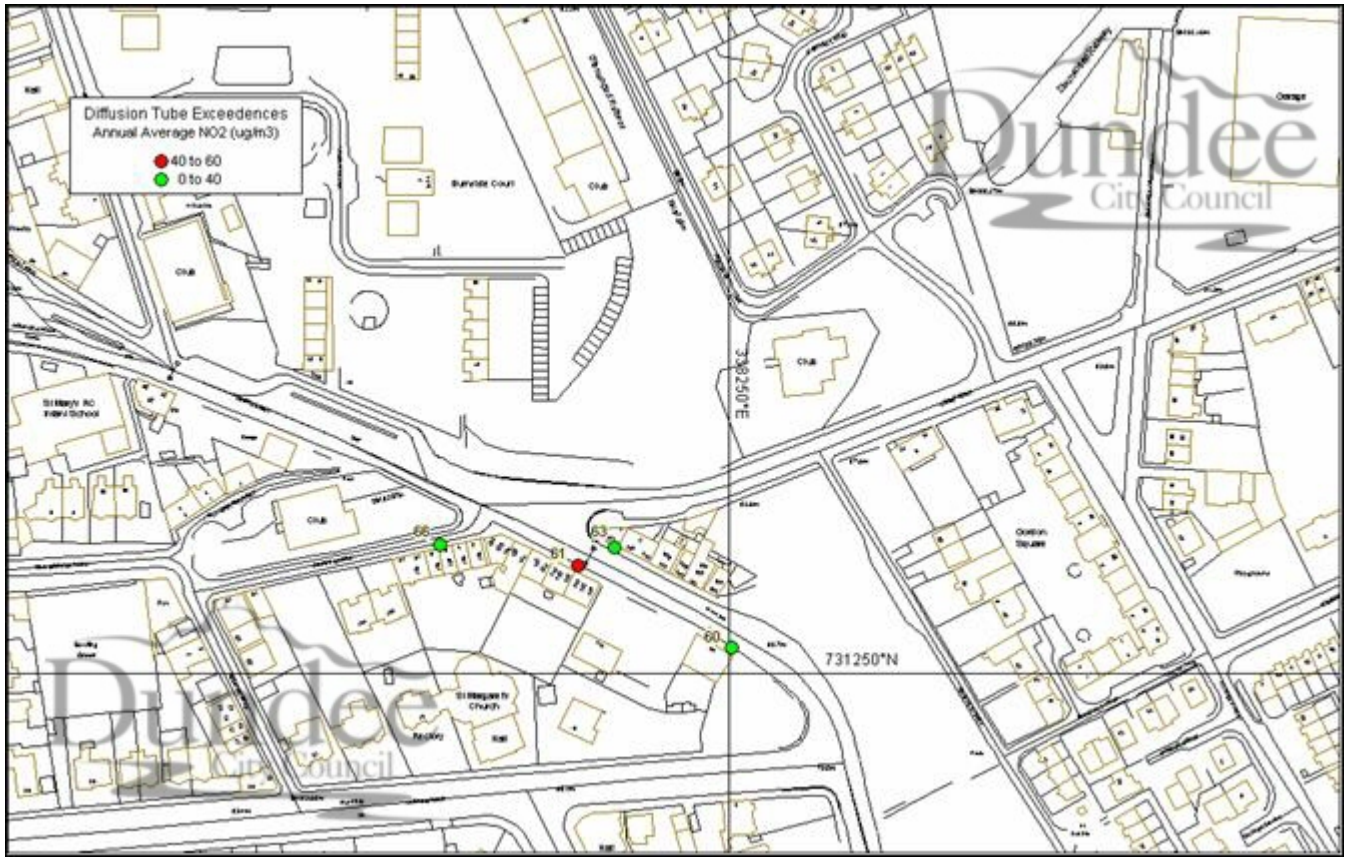
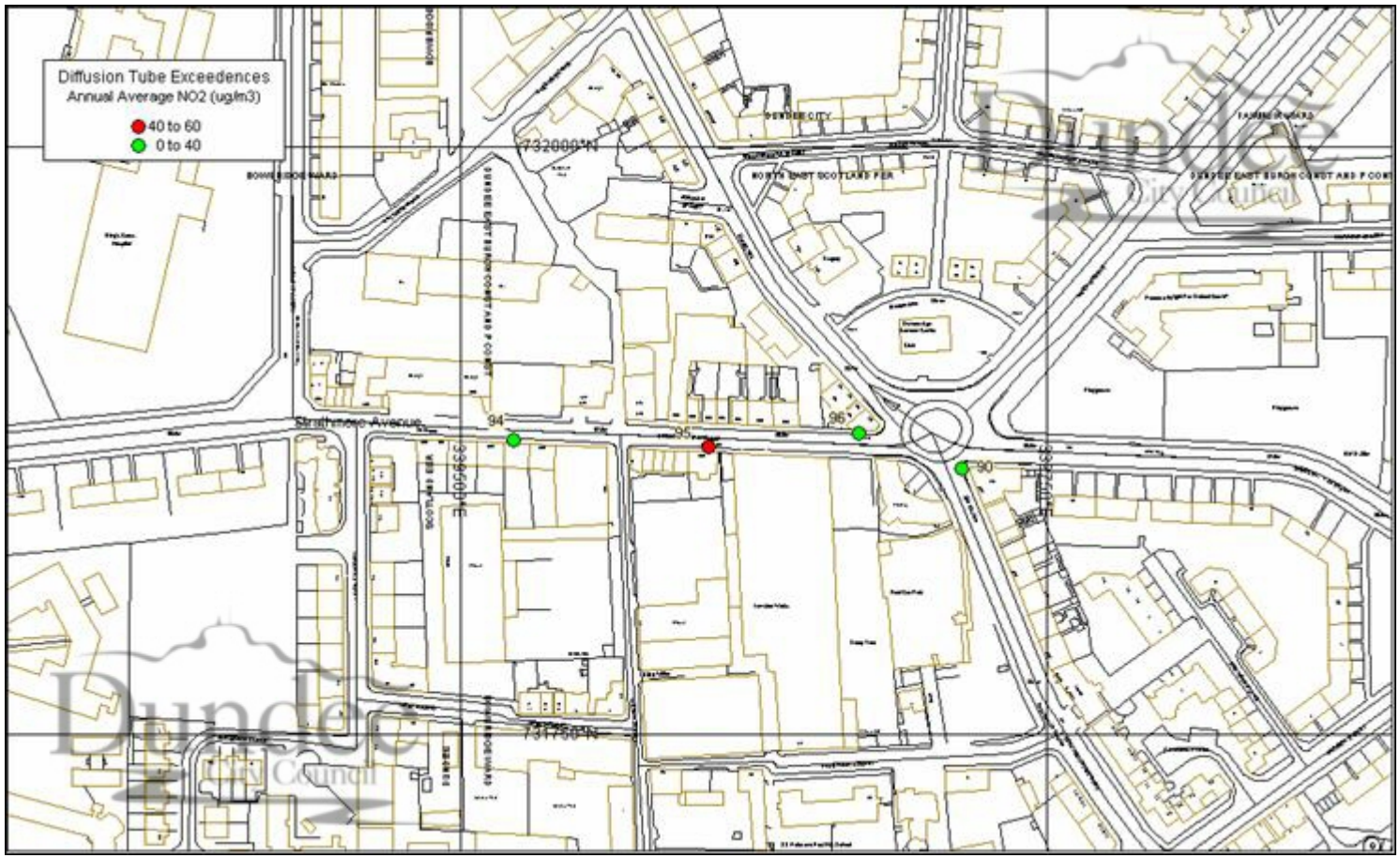


Figure 3.6 Projected 2005 Annual Average NO_2 Objective Exceedences – Strathmore Avenue Diffusion Tube Monitoring Sites



3.3 Background Concentrations

For the NO_2 and NO_X assessments, background concentrations have been derived from local background monitoring data (using the average of Woodside Avenue and Dykehead Place – with NOx derived from NO_2). Average PM_{10} background concentrations have been derived from NETCEN modelled concentration maps for receptors within the assessment areas (x=339500, y=730500). Projections of background concentrations to future years have been made using the guidance provided in LAQM.TG (03). The background concentrations used in the assessment are shown in Table 3.4.

Table 3.4 Background Concentrations in µg/m^3

Year	Background NO_X	Background NO_2	Background PM_{10}
2003	27.8	19.1	14.9
2004	-	-	14.7
2005	25.7	18.1	-
2010	20.7	15.5	13.8

3.4 Dispersion Modelling Methodology

Detailed dispersion modelling of NO_X and PM_{10} has been undertaken using the Cambridge Environmental Research Consultants (CERC) Ltd ADMS-Roads advanced Gaussian air dispersion model.

Three years meteorological data (2001- 2003) from the nearest Met Office station Leuchars and local meteorological data (2003) from the Dock Street station in Dundee were tested in the model and the final verified modelled results showed no significant variation (these results are presented in Appendix 4). The most recent year's meteorological data from Leuchars meteorological station (2003) has therefore been used within the ADMS-Roads model. The wind rose for the Leuchars meteorological data and local data from Dundee are shown in Figure 2.1.

The Leuchars' wind roses highlight a dominant westerly wind direction. The local meteorological data indicate that wind directions may be more south-westerly, perhaps influenced by the more coastal location of Dundee. The wind speeds for the local Dundee data are generally lower than those observed at Leuchars.

It should be noted that some additional manipulation of data for Dundee was undertaken following changes to instrument setup. For the purposes of road traffic modelling the most recent year of data for Leuchars 2003 has been used in this assessment and for the prediction of future concentrations.

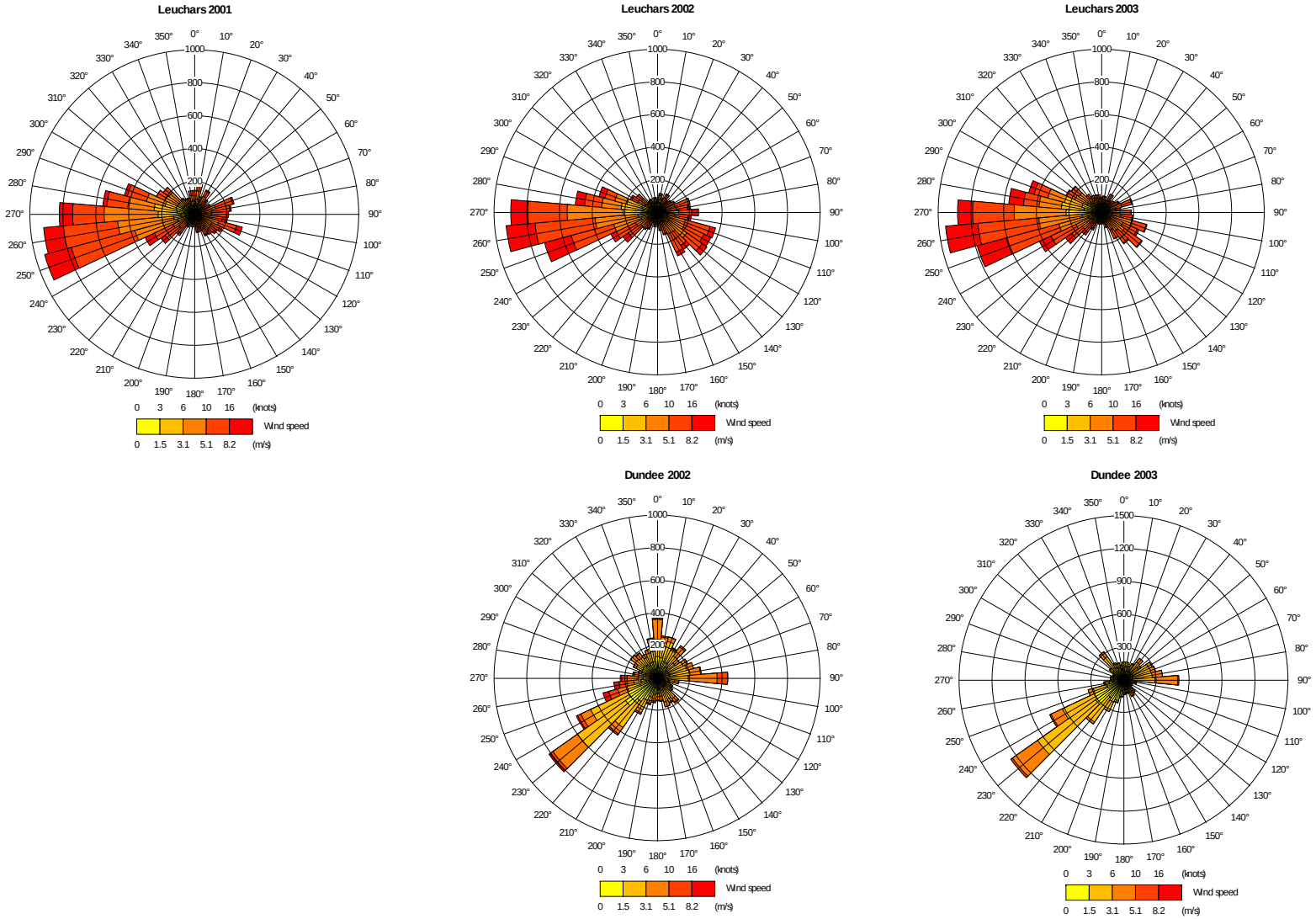
ADMS-Roads is the latest model in the ADMS family from Cambridge Environmental Research Consultants. Based on the ADMS-Urban system, it can model up to 150 road sources and 7 industrial sources at any one time. The model has been extensively used in local air quality management, and has formed the basis for many AQMA declarations. ADMS-Roads has integrated modules to take into account the effects of street canyons and plume chemistry. The predictions from dispersion models for road traffic should be

compared against local monitoring data in order to locally verify the model. This is described further in Section 3.5.

The most up-to-date and suitable emissions data for vehicles have been used for the assessment, in line with recent advice from the Department for Transport (DfT) regarding the use of emissions factors for road vehicles. The new DfT emission factors as described within the National Atmospheric Emissions Inventory (NAEI) are also used within the Design Manual for Roads and Bridges (DMRB) air quality screening model.

The use of ADMS-Roads allows any number of specific receptors to be identified for the prediction of air quality impacts. The link to a geographic information system (GIS) for mapping purposes provides the best method of analysing the pollution output. The model has been used to draw detailed concentrations contours of pollutant concentrations (via GIS tools) and allow areas of maximum impacts and any areas of exceedences to be identified.

Figure 3.7 Wind roses for Leuchars and Dundee Meteorological Data



3.5 Model Verification and Adjustment

3.5.1 NOx/NO_2

Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen, and are collectively referred to as nitrogen oxides (NO_X). The main source of NO_X emissions in the UK is vehicle exhausts, which are converted to NO_2, mainly as a result of reaction with ozone in the atmosphere. The ADMS-Roads dispersion model produces modelled results of the NO_X emissions from vehicles and these are then converted to NO_2 for comparison with the Air Quality Objective as outlined below.

Background concentrations, as described in Section 3.3, have been added to the modelled contributions of NO_X and conversion to NO_2 has been carried out using the NO_X: NO_2 ratio using the conversion method in LAQM.TG (03).

Verification has been undertaken using 2003 data from the Union Street continuous analyser and 36 diffusion tube sites in the assessment areas. These sites all have >9 months data capture; with the exception of 12 new sites started in September 2003 which have been annualised according to the methodology outlined in LAQM.TG(03).

As part of the local verification an adjustment factor for the predicted road traffic related NOx is derived when compared to local monitoring. The NO_X roads contribution factor used in this Detailed Assessment to correct modelled results are:

- 4.6 for the Dundee Central Assessment Area;
- 6.1 for the Logie Street and Lochee Road Assessment Areas; and
- 2.7 for the Strathmore Avenue Assessment Area.

The full verification process is shown in Appendix 3. Different verification factors have been derived based on model setup for the areas. The Dundee Central area mainly consists of narrow roads and street canyons in a city centre environment. While the Logie Street and Lochee Road areas are more open routes to the city centre. Strathmore Avenue is an isolated narrow street canyon.

Table 3.5 and Figure 3.8 to Figure 3.11 show the percentage difference (over and under-prediction) between the modelled and monitored results at diffusion tubes within the assessment areas following application of the relevant roads contribution verification factor.

During the verification process Casella Stanger aim to show that all final modelled NO_2 concentrations are within 25% of the monitored NO_2 concentrations. However, this is not possible at all locations and some outliers do exist. Modelled results may not compare well at some locations for a number of reasons including:

- Errors in traffic flow data estimates;
- Model setup (including street canyons, road widths, receptor locations);
- Model limitations (treatment of roughness and meteorological data); and
- Uncertainty in monitoring data (notably diffusion tubes, particularly with short-term data).

The difference between modelled and monitored final NO_2 concentrations were greater than 25% at four locations:

- 107 Whitehall Crescent 55%

The difference between modelled and monitored is the greatest at this location.

This location on the kerbside of the junction of Whitehall Crescent and Crichton Street and concentrations may have been overestimated due to the treatment of slow moving buses in this area towards the bus lane on Dock Street.

The predicted concentration for 2003 is 48 μg/m^3 compared to 30 μg/m^3 monitored and therefore the predictions at this location must be treated with caution. However concentrations measured elsewhere on Whitehall Street/Whitehall Crescent/Dock Street are 46 – 49 μg/m^3 and the diffusion tube concentration seems to be particularly low compared to these levels.

- 21 Commercial Street (Waterstones) 29%

This location is on the kerbside of Commercial Street and a very high proportion of buses has been modelled on this section road. Together with the assumption that the location is in a street canyon may have resulted in an over prediction at this location. This monitoring site was installed in September 2003 and therefore the period data for 2003 has been annualised, which may also add to the uncertainty at this location.

- 80/81/82 Seagate (Bond triplicate) 25%

This location is a street canyon and has a high proportion of slow moving buses. Over-prediction may be due to the combination of street canyon assumptions and emissions estimates as the tube is at the corner of Candle Lane and is less of a street canyon at this point. The predicted concentration at this location is 49 μg/m^3 compared to 39 μg/m^3 monitored. However, other monitoring on Seagate indicates levels of 42 – 48 μg/m^3.

- 58 Lochee Road (184) 28%

This location is to the north-west of the central area of Dundee and is one of the main routes into the city centre via West Marketgait. The modelled concentration is over-predicted at this location (47 μg/m^3 compared to 37 μg/m^3). However, monitoring results on the same road at a similar distance from the road are 50 – 54 μg/m^3 and the local modelled concentrations are in line with these annual mean concentrations. This monitoring site was installed in September 2003 and therefore the period data for 2003 has been annualised, which may also add to the uncertainty at this location.

Final predicted annual average NO_2 concentrations at all other locations are within 25% of the monitored concentrations.

Table 3.5 Comparison of Modelled and Monitored NO_2 Results at Diffusion Tube Sites

Site ID	Diffusion Tube Location	Monitored NO_2 (2003) in µg/m^3	Modelled NO_2 (2003) in µg/m^3	% Difference
107	Whitehall Crescent	30.9	47.9	**55**
11	Whitehall Street (BRJ)	36.3	38.1	5
26	Dock Street (14)	46.4	52.6	13
83	Seagate (Yates 7-9)	42.6	48.5	14
21	Commercial Street (Waterstones)	39.0	50.3	**29**
22	Commercial Street /Dock Street	48.2	41.4	-14
29	Dock Street (Unicorn)	39.3	37.1	-6
86	St Andrews Street DD	35.8	35.4	-1
87	St Andrews Street JAF	38.8	36.6	-6
80/81/82	Seagate (Bond triplicate)	39.3	49.0	**25**
78	Seagate	47.9	43.9	-8
105	Victoria Road/Hilltown	60.6	63.6	5
103	Victoria Road	40.5	36.2	-11
98/99/100	Union Street Rollalong	40.6	40.7	0
101	Union Street (Goodfellows)	38.7	39.9	3
102	Union Street (McIntyres)	37.2	41.7	12
72	Nethergate (Trades House)	42.4	40.2	-5
113	Whitehall Street (Deb A)	48.1	46.5	-3
112	Whitehall Street (BUS)	49.3	43.9	-11
115	Whitehall Street (TISO)	39.2	34.8	-11
108/109/110	Whitehall Street (BBBS triplicate)	39.6	35.1	-11
88	Nethergate B&B	43.7	40.5	-7
73	Nethergate/Marketgait	34.7	39.8	15
70	Nethergate (Charlie T)	47.7	43.9	-8
114	Whitehall Street (DEB E)	40.4	46.3	15
63	Loons Road	41.0	49.9	22
58	Lochee Road (184)	36.7	47.1	**28**
54/55/56	Lochee Road (164)	50.4	49.2	-2
51/52/53	Lochee Road (140)	54.3	46.1	-15
59	Lochee Road /Polepark Road	32.6	33.6	3
61	Logie Street (114)	53.6	43.5	-19
66	Muirton Road (6)	32.8	34.2	4
60	Logie Road (98)	38.9	43.1	11
94	Strathmore Avenue (337)	37.6	37.2	-1
95	Strathmore Avenue(353)	42.7	38.7	-10
96	Strathmore Avenue (Wellgate)	34.4	39.7	16

Figure 3.8 Under or Over-prediction of Annual Mean NO_2 concentrations at Central Diffusion Tube Monitoring Sites

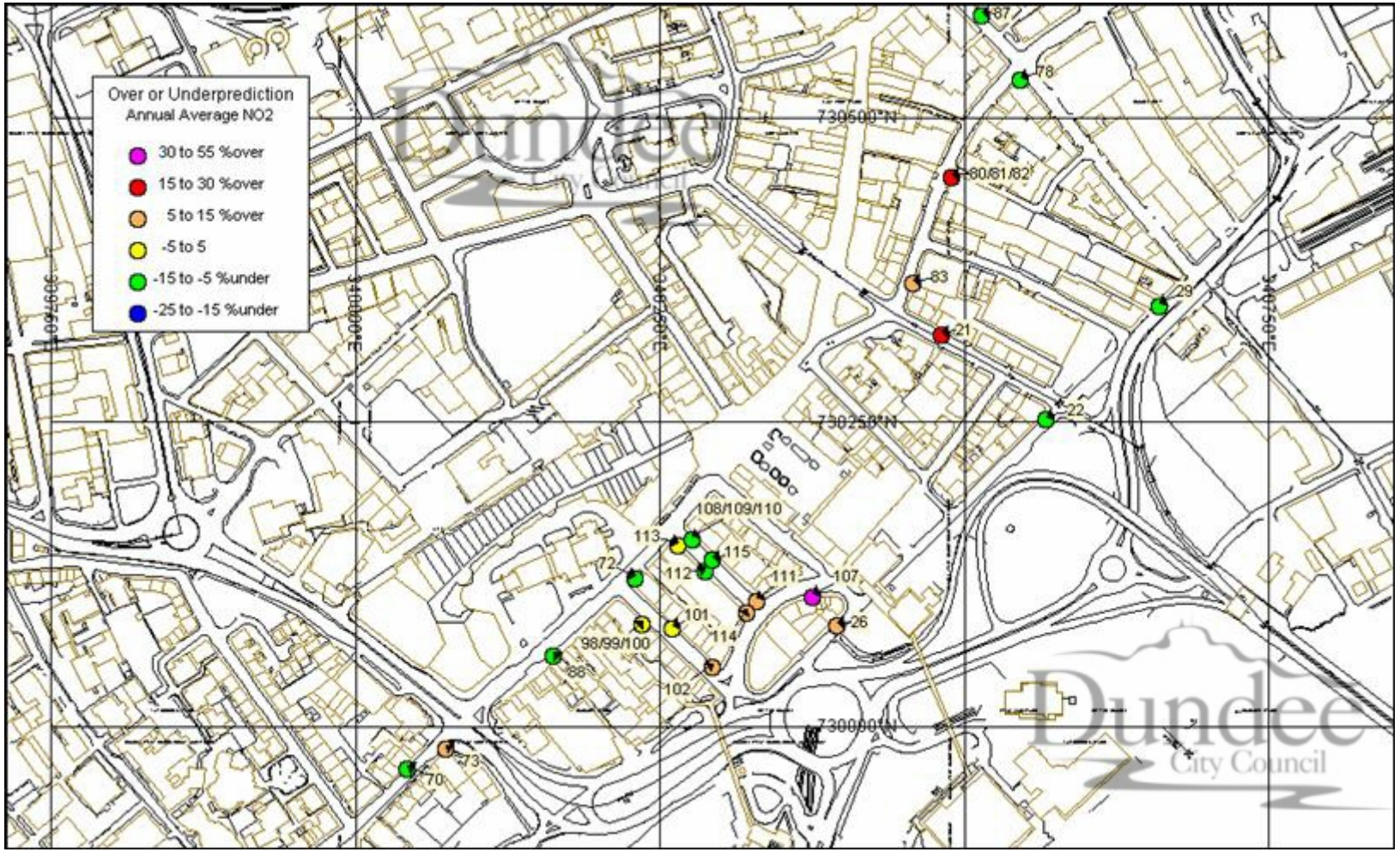


Figure 3.9 Under or Over-prediction of Annual Mean NO_2 concentrations at Lochee Road Diffusion Tube Monitoring Sites

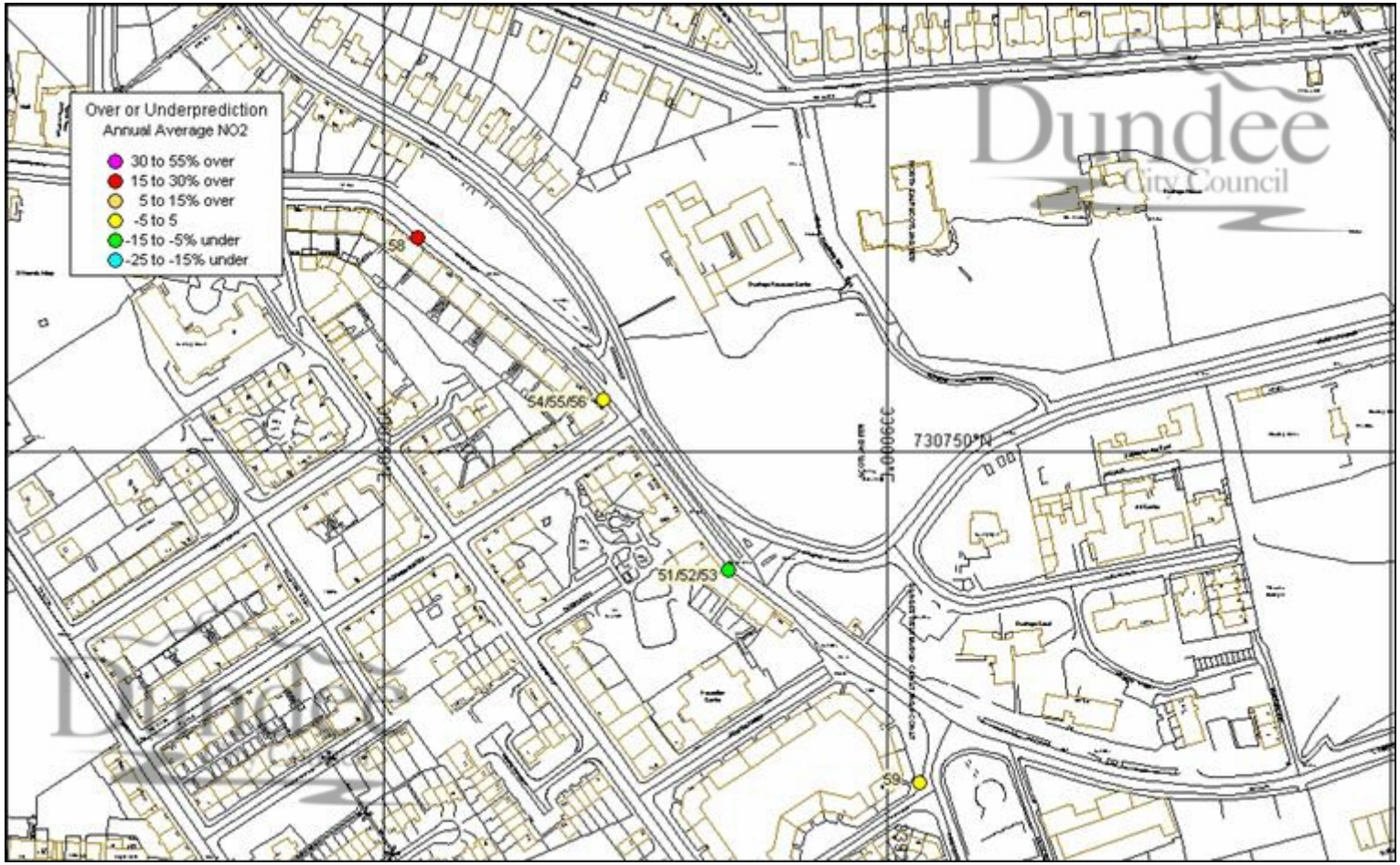


Figure 3.10 Under or Over-prediction of Annual Mean NO_2 concentrations at Logie Street Diffusion Tube Monitoring Sites

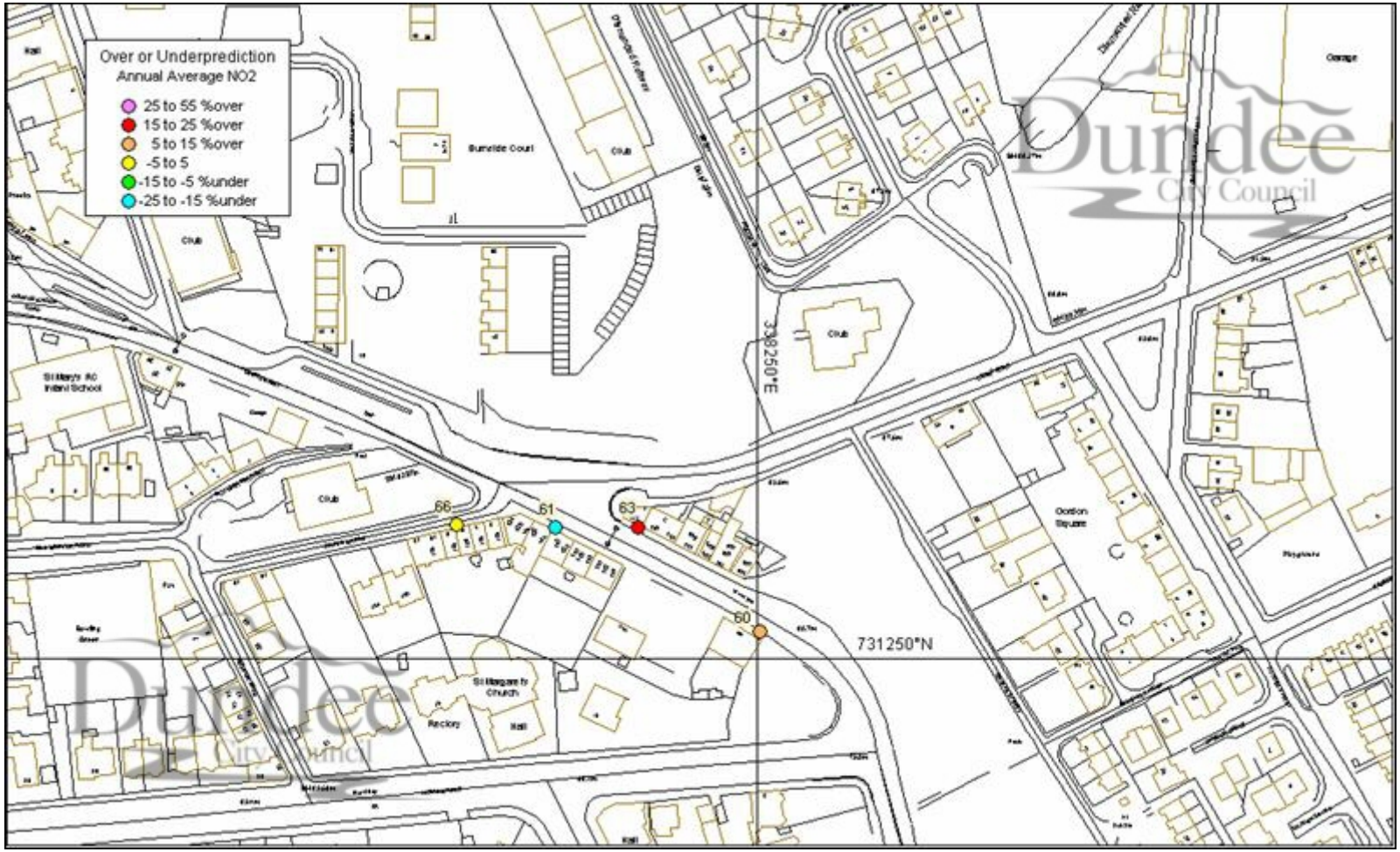
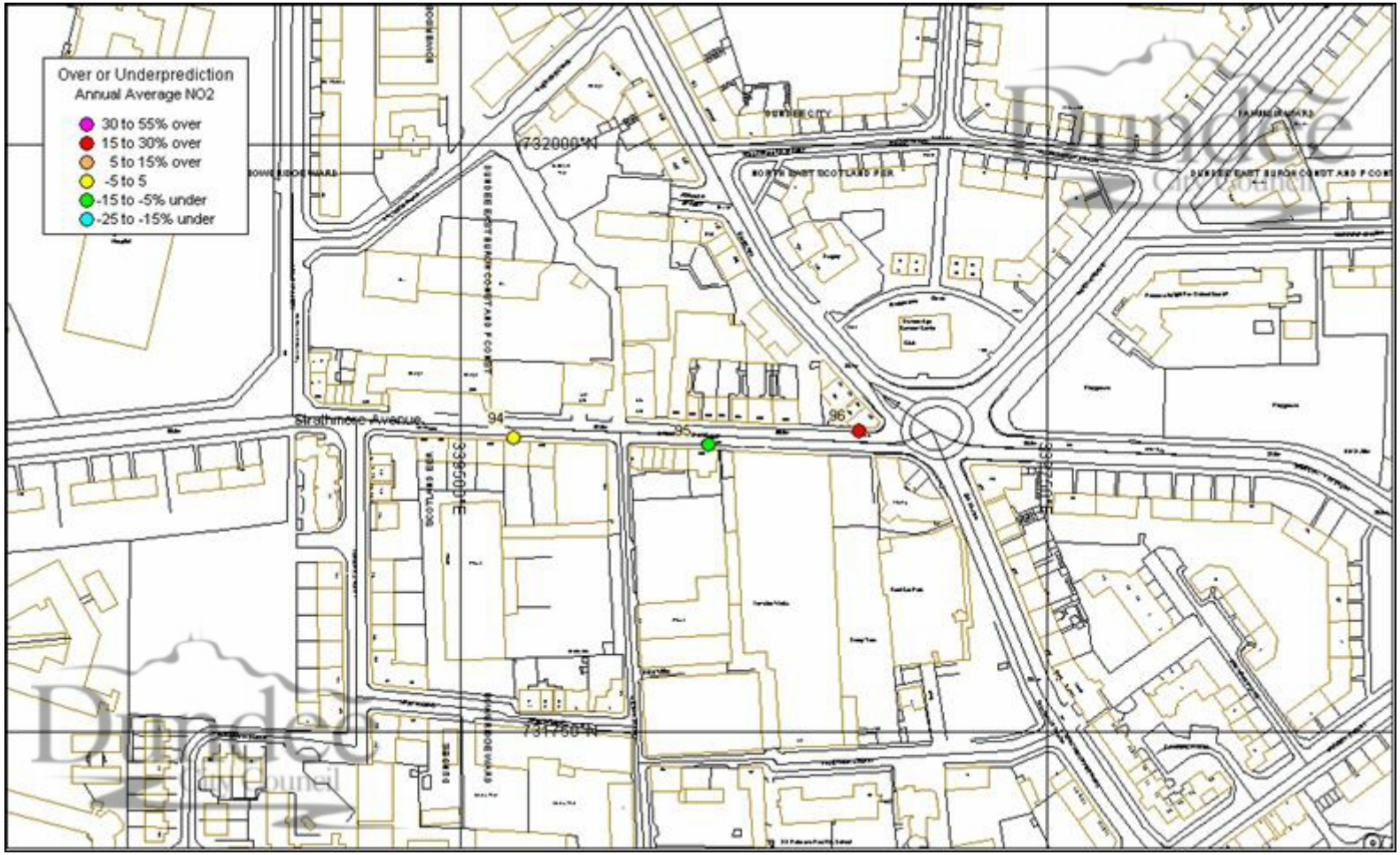


Figure 3.11 Under or Over-prediction of Annual Mean NO_2 concentrations at Strathmore Avenue Diffusion Tube Monitoring Sites



3.5.2 PM_{10}

ADMS-Roads model has been used to predict the contribution of the road network to annual mean PM_{10} at the automatic analyser site in Union Street in order to verify predicted modelled concentrations so they are in line with concentrations currently existing in the assessment area.

The road contribution correction factor from this site of 20.8 indicates that ADMS-Roads is greatly underestimating concentrations and performs poorly with regards to PM_{10}, notably when compared with modelled NO_X. The NO_X road contribution correction factors of 2.5-6.1 are within the range expected in an urban area, but the larger verification correction factor for PM_{10} results in great uncertainty in the modelled predictions.

Dispersion modelling of PM_{10} is difficult due to the number of different components of PM_{10}, and has been the subject of some review within the recent draft Air Quality Expert Group (AQEG) report. This has indicated that there is a 5-7 fold difference in model performance for open motorways compared to more urban roads, and in most cases dispersion models under-predict significantly in urban settings.

There are a number of potential reasons why models may under-predict PM_{10} concentrations from road traffic sources, including internal model parameters (such as surface roughness, street canyons, source height).

In addition, there may be considerable uncertainty in the following information:

- Traffic emissions of PM_{10};
- Background PM_{10} (secondary and course fractions);
- Re-suspended roadside component;

The AQEG report indicates that the annual average PM_{10} Objective for 2004 is likely to be met at most locations, including roadside, in the UK but that the 24-hour objective may not be achieved near major roads, particularly in London. Where prevailing meteorological conditions may lead to high background levels due to transport of particles from mainland Europe more areas may exceed the 24-hour Objective.

Modelling of future annual average PM_{10} concentrations is perhaps subject to more uncertainty as background concentrations, and high years due to transboundary effects, are likely to vary. Indications are that the annual average PM_{10} 2010 Objective will be exceeded at many urban and roadside sites. Estimates of the number of exceedences of the 24-hour Objective vary considerably and will also be subject to variations due to background concentrations and prevailing meteorological conditions.

The local verification factor has been used to correct the modelled PM_{10} results at identified critical receptors within the assessment areas to assess predicted concentrations of PM_{10}. However, concentration contours and areas of exceedence have not been predicted as the results of the PM_{10} modelling are considered uncertain. At specific receptors the predicted concentrations have been used to provide an estimate of the annual mean concentrations and number of exceedences of the 24-hour mean Objective.

Future predictions of PM_{10} (see Table 3.6) have taken account of forward projections of background PM_{10} levels, which forecast some reduction in concentrations. It is currently unclear if the annual mean objective for 2010 will be met, and it is recommended that

monitored data be reviewed on a regular basis, along with additional guidance from SEPA and the Scottish Executive with regards to longer-term concentrations. In addition, current monitoring (as described in Table 3.1 and 3.2) shows that in typical years, such as 2001 and 2002, the 24-hour mean Objectives for 2004 and 2010 are met in Dundee. However, high pollution years such as 2003 were heavily influenced by prevailing meteorological conditions and it is possible that these may occur again before 2010. The sources that result in the increase in the number of exceedences are therefore likely to be outside of local control. Monitoring over the coming years will provide some indication as to the risk of exceeding the 2010 objective.

3.6 Road Traffic Results

Annual average concentrations for NO_2 and PM_{10} were predicted for the baseline year 2003 and future years 2004/2005/2010 at critical receptor locations in each area undergoing Detailed Assessment, in addition to a 5m grid spacing across the assessment areas for the production of contour maps. The results are shown in Table 3.6 and Figures 3.12 – 3.12 of this report.

All predicted results have been produced using the verification methodology described in Section 3.5 of this report. To predict for future years, the same verification methodology has been applied, using relevant projected background concentrations.

The dispersion modelling has been undertaken for four areas to include all the identified potential exceedence areas:

- Dundee Central assessment area which includes Union Street/Nethergate, Nethergate/West Marketgait, Whitehall Street/High Street/Nethergate, Dock Street, Seagate and Victoria Road/Hilltown
- Lochee Road assessment area
- Logie Street assessment area
- Strathmore Avenue assessment area

3.6.1 Dundee Central Assessment Area

NO_X/NO_2 Concentrations

The verified modelled NO_2 annual mean concentrations in 2005 at critical receptors, as shown in Table 3.6 show predicted exceedences of the 2005 Objective at the nearest receptors to Seagate and Nethergate/Marketgait junction. The maximum predicted concentration in 2005 is 45.9µg/m^3 along Seagate (x=340533, y=730519). Figures 3.12 – 3.15, which show the NO_2 annual mean contours, indicate there are also likely to be exceedences at the lower part of Dock Street, Commercial Street (including the Commercial Street/Dock Street junction) and Victoria Road. It should however be noted, as shown in Figure 3.8, that the modelled results for Commercial Street significantly over-predict the monitored results (>30% at the Commercial Street (Waterstones) site), but as the monitoring is short-term, based on four months annualised 2003 data, it is recommended that monitoring be continued and 2004 results be assessed.

The verified modelled NO_2 annual mean concentrations in 2010, as shown in Table 3.6, indicate that the EU Limit is likely to be met at critical receptors in Dundee.

PM_{10} Concentrations

The verified modelled PM_{10} annual mean concentrations in 2004 at critical receptors, as shown in Table 3.6, indicate that the annual mean and 24 hour mean 2004 Objectives are likely to be met at all critical receptor locations.

The verified modelled PM_{10} annual mean concentrations in 2010, as shown in Table 3.6, indicate that there are potential exceedences of the 2010 annual mean Objective of 18µg/m^3 in Seagate, Victoria Road, Nethergait/Marketgait and Dock Street. The maximum predicted concentration in 2010 is 21µg/m^3 along Seagate (x=340533, y=730519).

3.6.2 Lochee Road Assessment Area

NO_X/NO_2 Concentrations

The verified modelled NO_2 annual mean concentration in 2005 at the critical receptor in the Lochee Road assessment area, as shown in Table 3.6, shows a predicted exceedence of the 2005 Objective. The predicted concentration in 2005 is 42.8µg/m^3 (x=338930, y=730682) i.e. above the 40µg/m^3 Objective level. Figures 3.16 and 3.17, which show the NO_2 annual mean contours, indicate there are likely to be exceedences at ground level at the façade of properties to the South of Lochee Road in close proximity to the Lochee Road/Rankine Street and Lochee Road/Dudhope Terrace junctions.

The verified modelled NO_2 annual mean concentrations in 2010, as shown in Table 3.6, indicate that the EU Limit is likely to be met within the Lochee Road assessment area.

PM_{10} Concentrations

The verified modelled PM_{10} annual mean concentrations in 2004 at the critical receptor in the Lochee Road assessment area, as shown in Table 3.6, indicate that the annual mean and 24 hour mean 2004 Objectives are likely to be met.

The verified modelled PM_{10} annual mean concentrations in 2010, as shown in Table 3.6, indicate that there is a potential exceedence of the 2010 annual mean Objective of 18µg/m^3. The predicted concentration in 2010 is 20.2µg/m^3 at the critical receptor (x=338930, y=730682).

3.6.3 Logie Street Assessment Area

NO_X/NO_2 Concentrations

The verified modelled NO_2 annual mean concentration in 2005 at the critical receptor in the Logie Street assessment area, as shown in Table 3.6, indicates the Objective is likely to be met at this first floor location. The predicted concentration in 2005 is 36.3µg/m^3 (x=338185, y=731292) i.e. below the 40µg/m^3 Objective level. Figures 3.18 and 3.19, which show the NO_2 annual mean contours, indicate there are likely to be exceedences at ground level at the façade of properties in close proximity to the Logie Street/Loons Road junction. The model predicts the highest concentrations at the façade of properties to the north-east of the junction due to the prevailing wind direction. Figure 3.10 indicates that the model is over-estimating at the Loons Road (Tube No. 63) diffusion

tube site to the north of Logie Street, but underestimating at the Logie Street 114 (Tube No. 61) diffusion tube site to the south of Logie Street. As the monitoring at these sites is short-term, based on four months annualised 2003 data, it is recommended that monitoring be continued and 2004 results be assessed with regard to compliance with the Objective.

The verified modelled NO_2 annual mean concentrations in 2010, as shown in Table 3.6, indicate that the EU Limit is likely to be met within the Logie Street assessment area.

PM_{10} Concentrations

The verified modelled PM_{10} annual mean concentrations in 2004 at the critical receptor in the Logie Street assessment area, as shown in Table 3.6 indicate that the annual mean and 24 hour mean 2004 Objectives are likely to be met.

The verified modelled PM_{10} annual mean concentrations in 2010, as shown in Table 3.6, indicate that there is a potential marginal exceedence of the 2010 annual mean Objective of 18µg/m^3.

3.6.4 Strathmore Avenue Assessment Area

NO_X/NO_2 Concentrations

The verified modelled NO_2 annual mean concentration in 2005 at the nearest receptors in the Strathmore Avenue assessment area, as shown in Figure 3.20 and (worst case critical receptor) in Table 3.6, indicates the Objective is likely to be met. The maximum predicted concentration in 2005 of all receptors modelled is 38µg/m^3 at the ground level façade (x=339604, y=731870) i.e. below the 40µg/m^3 Objective level.

The verified modelled NO_2 annual mean concentrations in 2010, as shown in Table 3.6, indicate that the EU Limit is likely to be met within the Strathmore Avenue assessment area.

PM_{10} Concentrations

The verified modelled PM_{10} annual mean concentrations in 2004 at the critical receptor in the Strathmore Avenue assessment area, as shown in Table 3.6, indicate that the annual mean and 24 hour mean 2004 Objectives are likely to be met. The verified modelled PM_{10} annual mean concentrations in 2010, as shown in Table 3.6, indicate that the 2010 Objectives are likely to be met at this location.

Table 3.6 Predicted Concentrations at Critical Receptor Locations – all in µg/m^3 (except No. exceedences)

X	Y	Location	Floor	Annual mean NO_2 (2003)	Annual mean PM_{10} (2003)	No. exceedences daily mean PM_{10} (2003)	Annual mean PM_{10} (2004)	No. exceedences daily mean PM_{10} (2004)	Annual mean NO_2 (2005)	Annual mean NO_2 (2010)	Annual mean PM_{10} (2010)	No. exceedences daily mean PM_{10} (2010)
340566	730261	Dock Street	First	37.9	22.8	8	22.0	6	35.6	29.0	17.7	1
340543	730235	Dock Street	Ground	39.7	23.4	9	22.5	7	37.2	30.4	18.0	1
340073	729978	Nethergate/Marketgait	First	32.7	20.5	4	19.9	3	30.5	25.0	16.7	1
340156	730047	Nethergate/Marketgait	First	33.2	20.3	4	19.7	3	31.1	25.4	16.5	1
340210	730100	Nethergate/Marketgait	First	33.9	20.5	4	19.9	3	31.8	26.0	16.5	1
340201	730091	Nethergate/Marketgait	First	35.0	21.0	5	20.2	4	32.9	26.8	16.8	1
340054	729983	Nethergate/Marketgait	First	43.7	26.7	17	25.5	14	40.7	33.3	19.9	3
340491	730450	Seagate	Ground	37.9	22.4	7	21.6	6	35.5	28.9	17.5	1
340499	730470	Seagate	Ground	38.3	22.6	7	21.8	6	35.9	29.3	17.6	1
340533	730519	Seagate	Ground	48.7	29.5	26	28.0	21	45.9	37.6	21.0	5
340236	730085	Union Street	First	31.7	19.6	3	19.0	2	29.7	24.4	16.1	0
340247	730698	Victoria Road/Hilltown	Ground	41.3	26.5	16	25.3	13	38.5	31.5	19.9	3
340299	730139	Whitehall Street (east side)	Roof	25.0	16.9	1	16.5	1	23.5	19.5	14.8	0
340289	730123	Whitehall Street (west side)	Roof	25.2	17.0	1	16.6	1	23.7	19.7	14.8	0
340299	730139	Whitehall Street (east side)	Third	26.4	17.4	1	17.0	1	24.8	20.5	15.1	0

340289	730123	Whitehall Street (west side)	Third	26.7	17.5	1	17.1	1	25.0	20.7	15.1	0
340289	730123	Whitehall Street (west side)	Second	28.5	18.2	2	17.8	1	26.7	22.0	15.5	0
340289	730123	Whitehall Street (west side)	First	31.0	19.3	3	18.7	2	29.0	23.8	16.0	0
338930	730682	Lochee Road	Ground	45.6	27.1	18	25.8	14	42.8	35.0	20.2	4
338185	731292	Logie Street	First	38.8	23.1	8	22.2	7	36.3	29.5	18.1	1
339604	731870	Strathmore Avenue	Ground	29.6	22.0	6	21.3	5	27.5	22.6	17.7	1

Figure 3.12 Predicted Annual Average NO_2 2005 Contours in Dundee Central Assessment Area – all in µg/m^3

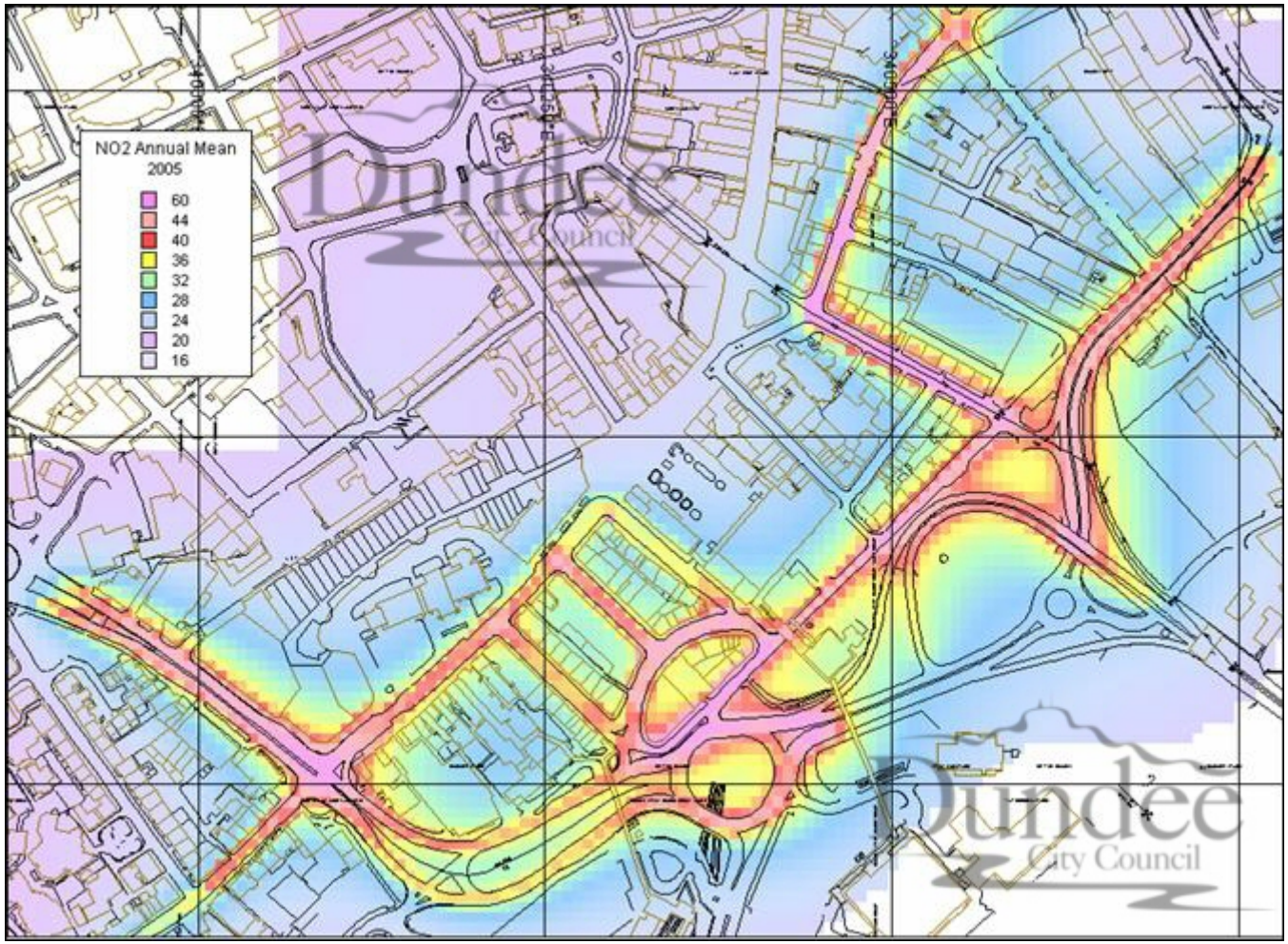


Figure 3.13 Predicted Annual Average NO_2 36 and 40µg/m^3 Contours in Dundee Central Assessment Area in 340500E

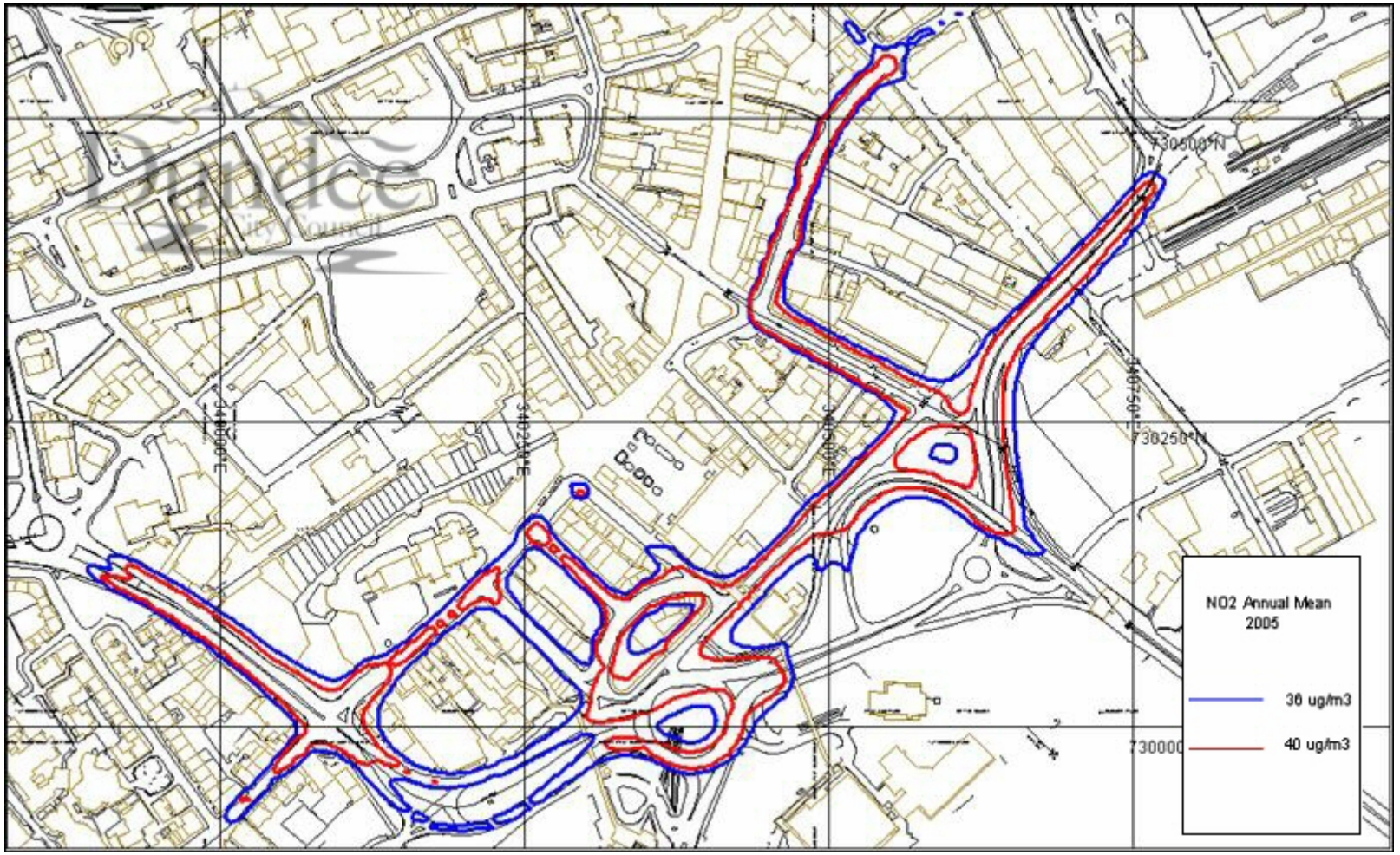


Figure 3.14 Predicted Annual Average NO_2 2005 Contours in the Hilltown/Victoria Road Assessment Area – all in µg/m^3

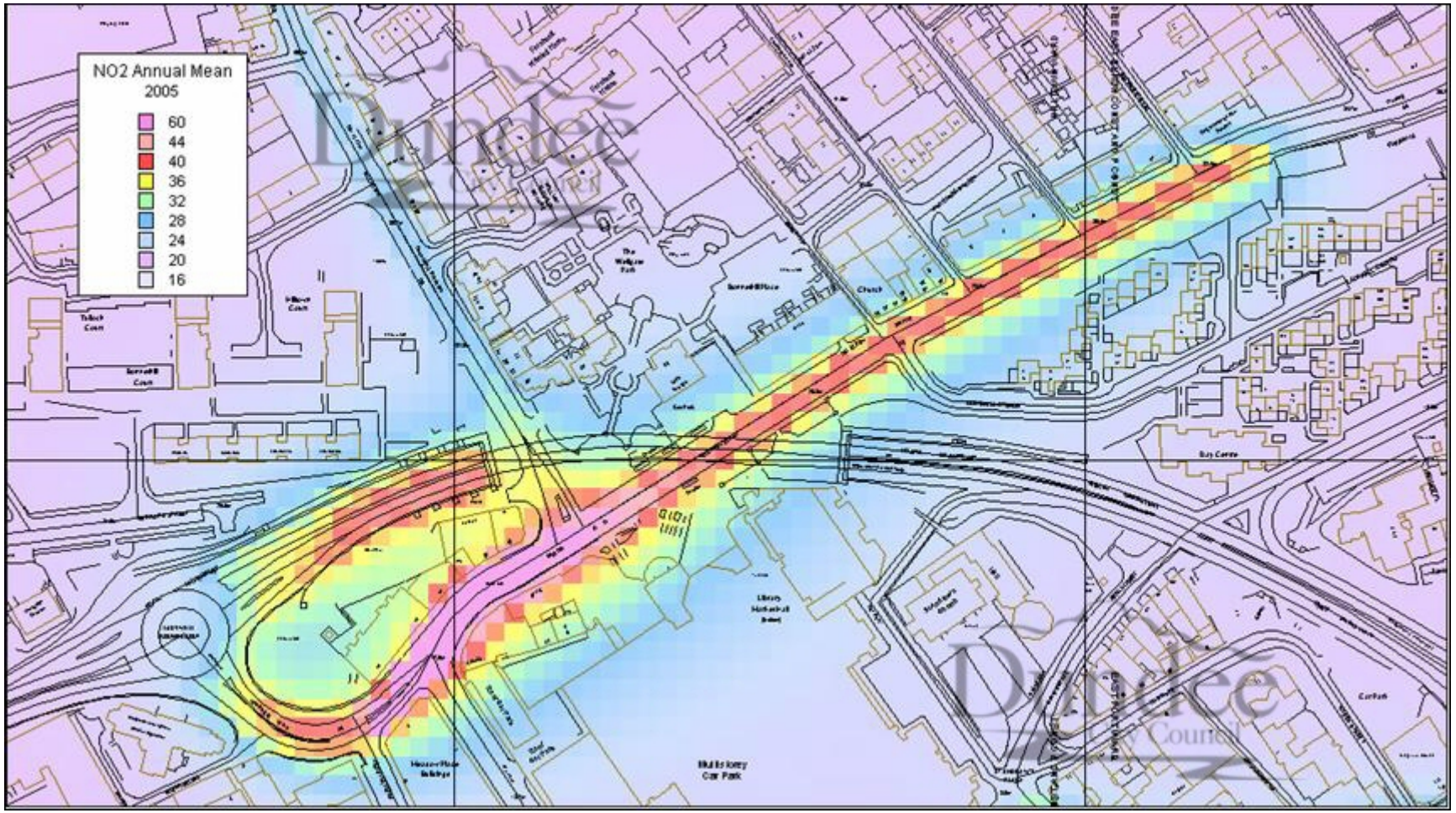


Figure 3.15 Predicted Annual Average NO_2 36 and 40µg/m^3 Contours in Hilltown/Victoria Road Assessment Area in 2005

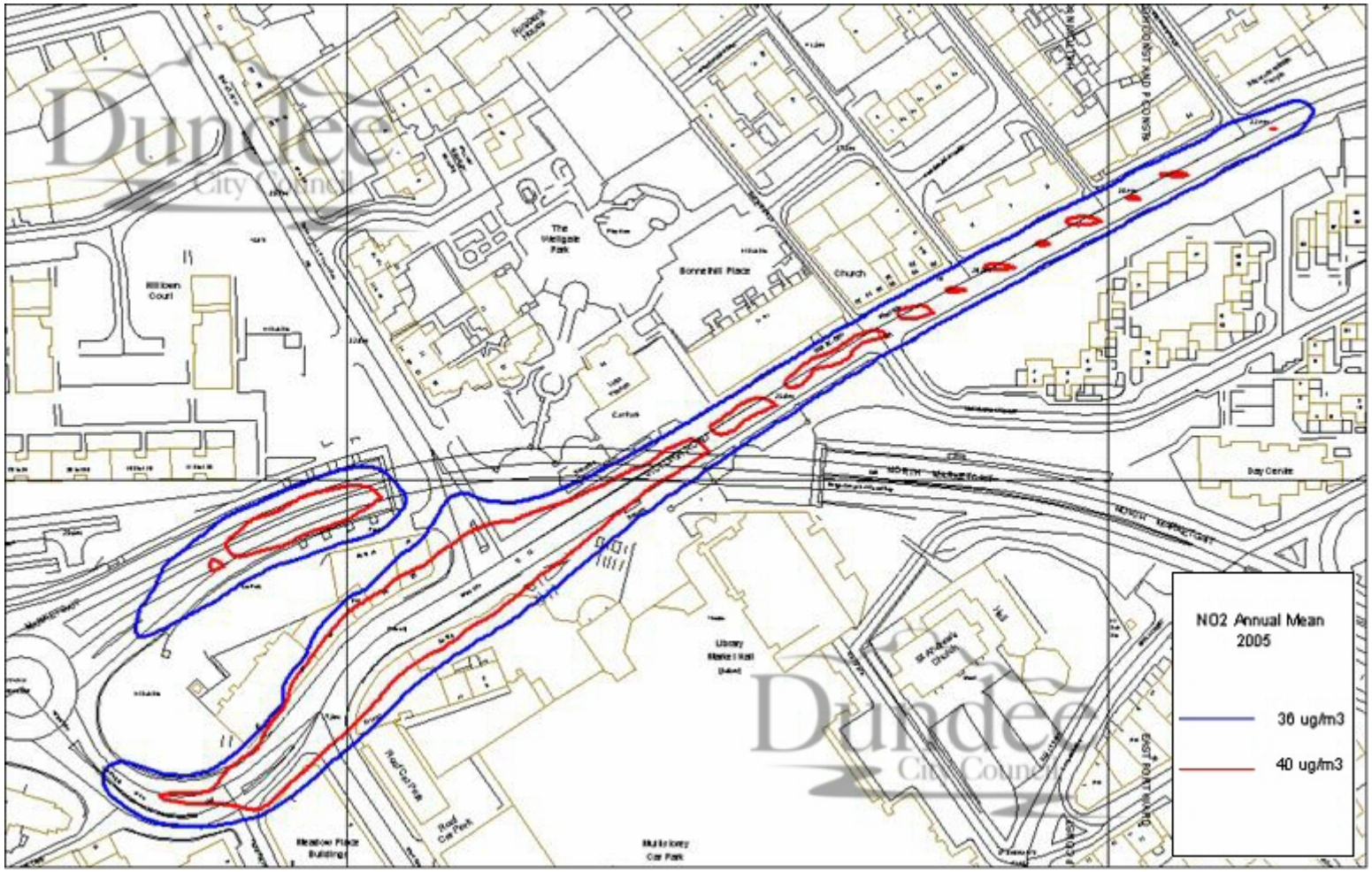


Figure 3.16 Predicted Annual Average NO_2 2005 Contours in the Lochee Road assessment area – all in µg/m^3

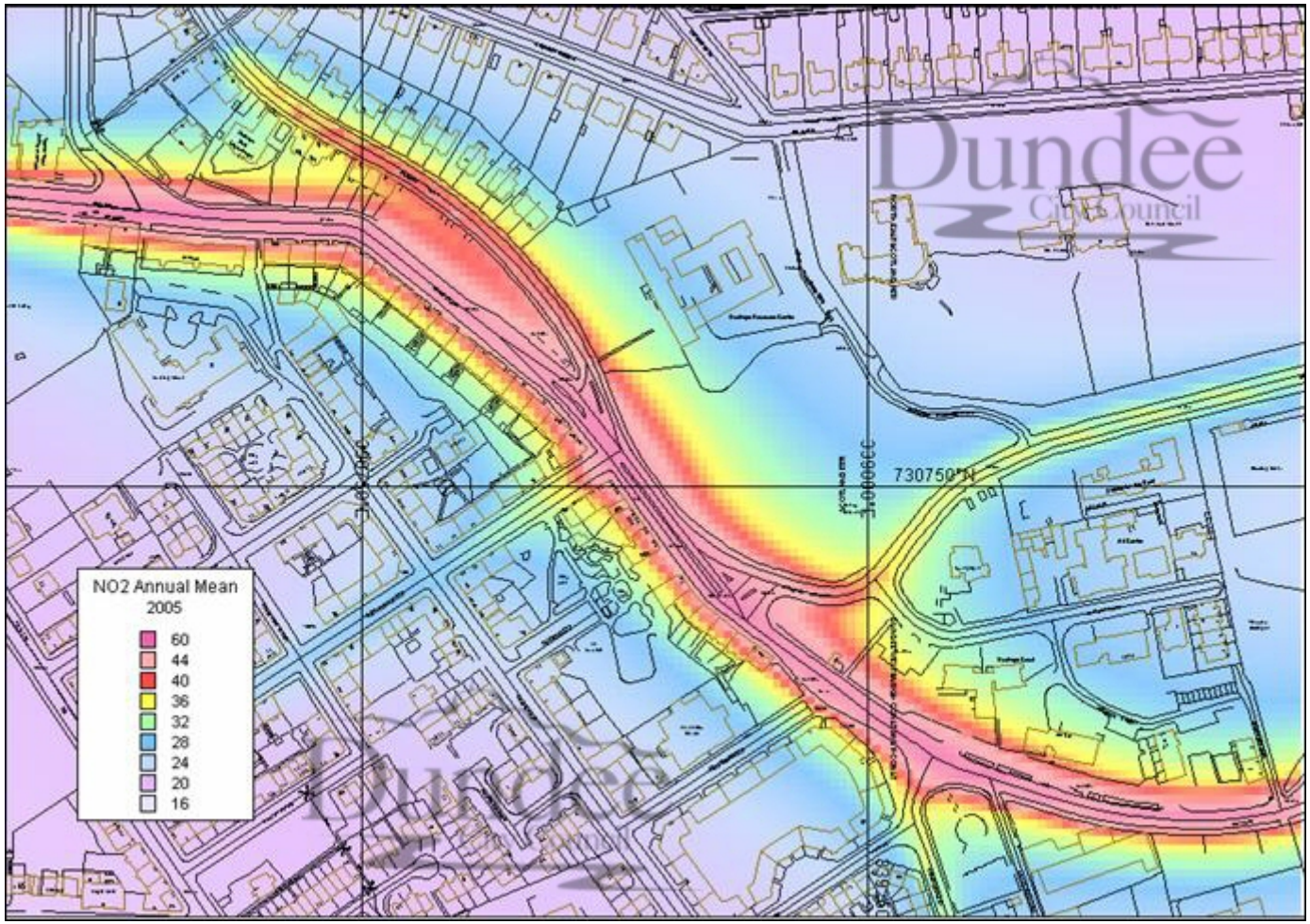


Figure 3.17 Predicted Annual Average NO_2 36 and 40µg/m^3 Contours in Lochee Road Assessment Area in 2005

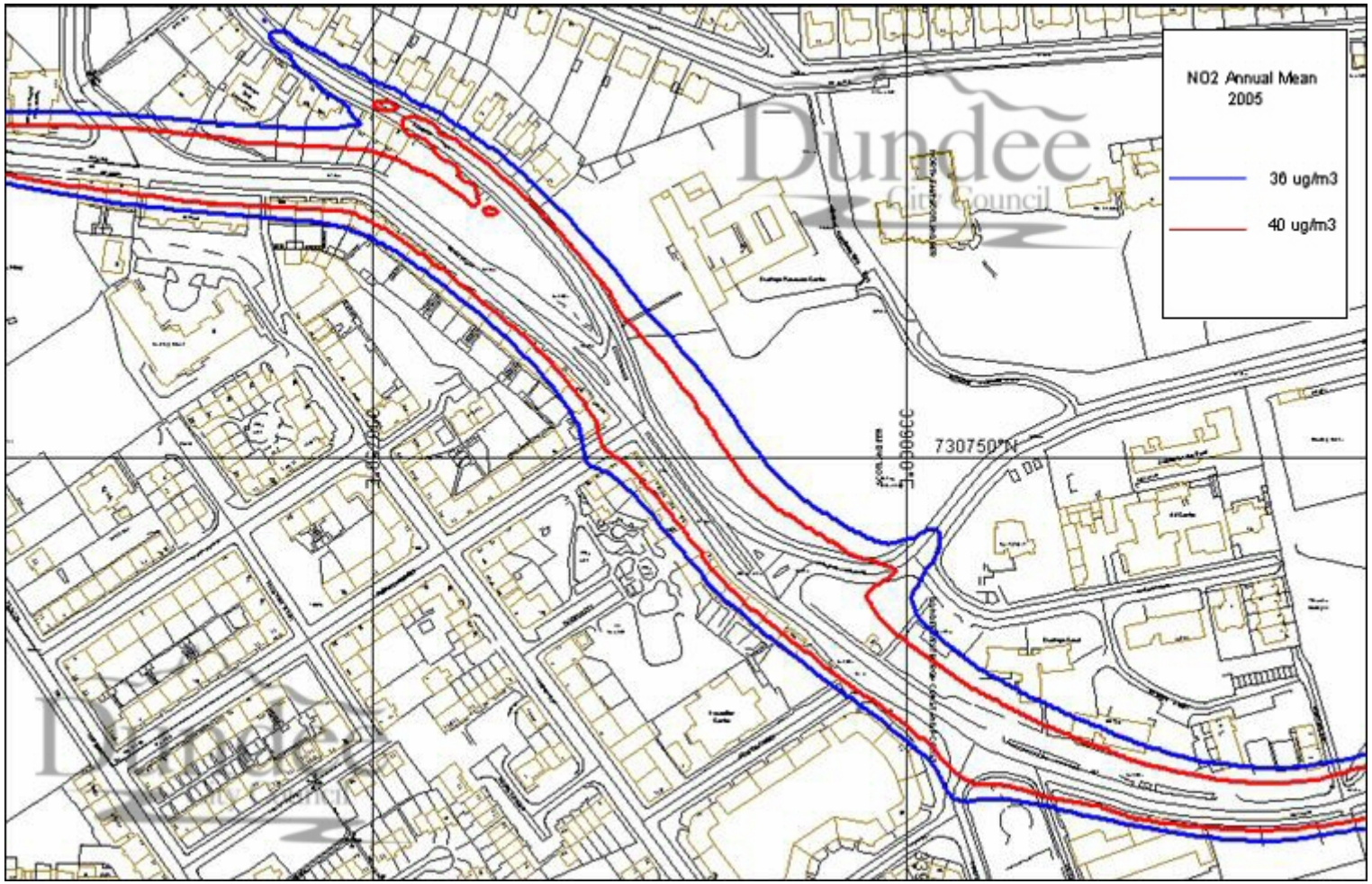


Figure 3.18 Predicted Annual Average NO_2 2005 Contours in the Logie Street assessment area – all in µg/m^3

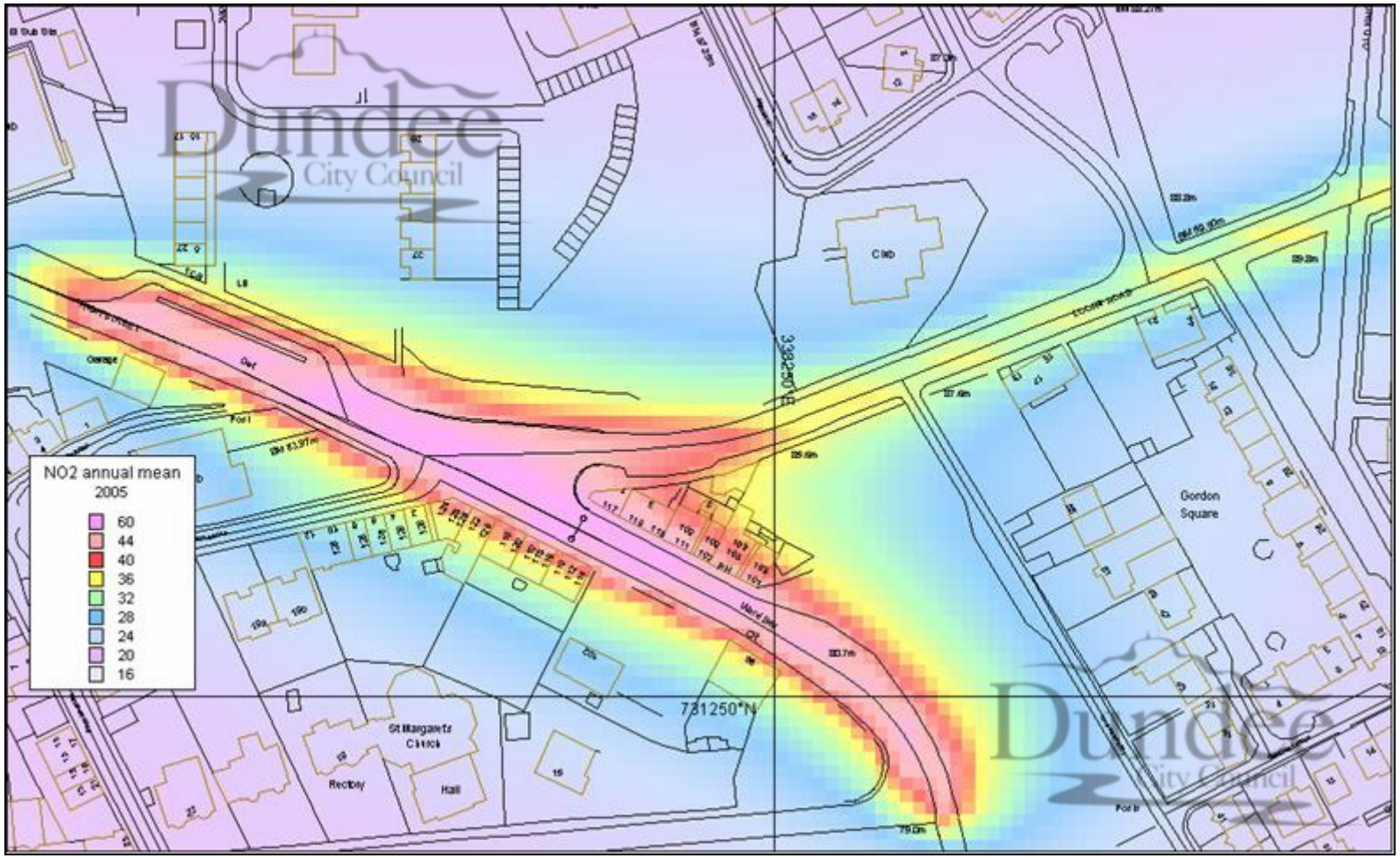


Figure 3.19 Predicted Annual Average NO_2 36 and 40µg/m^3 Contours in Logie Street Assessment Area in 2005

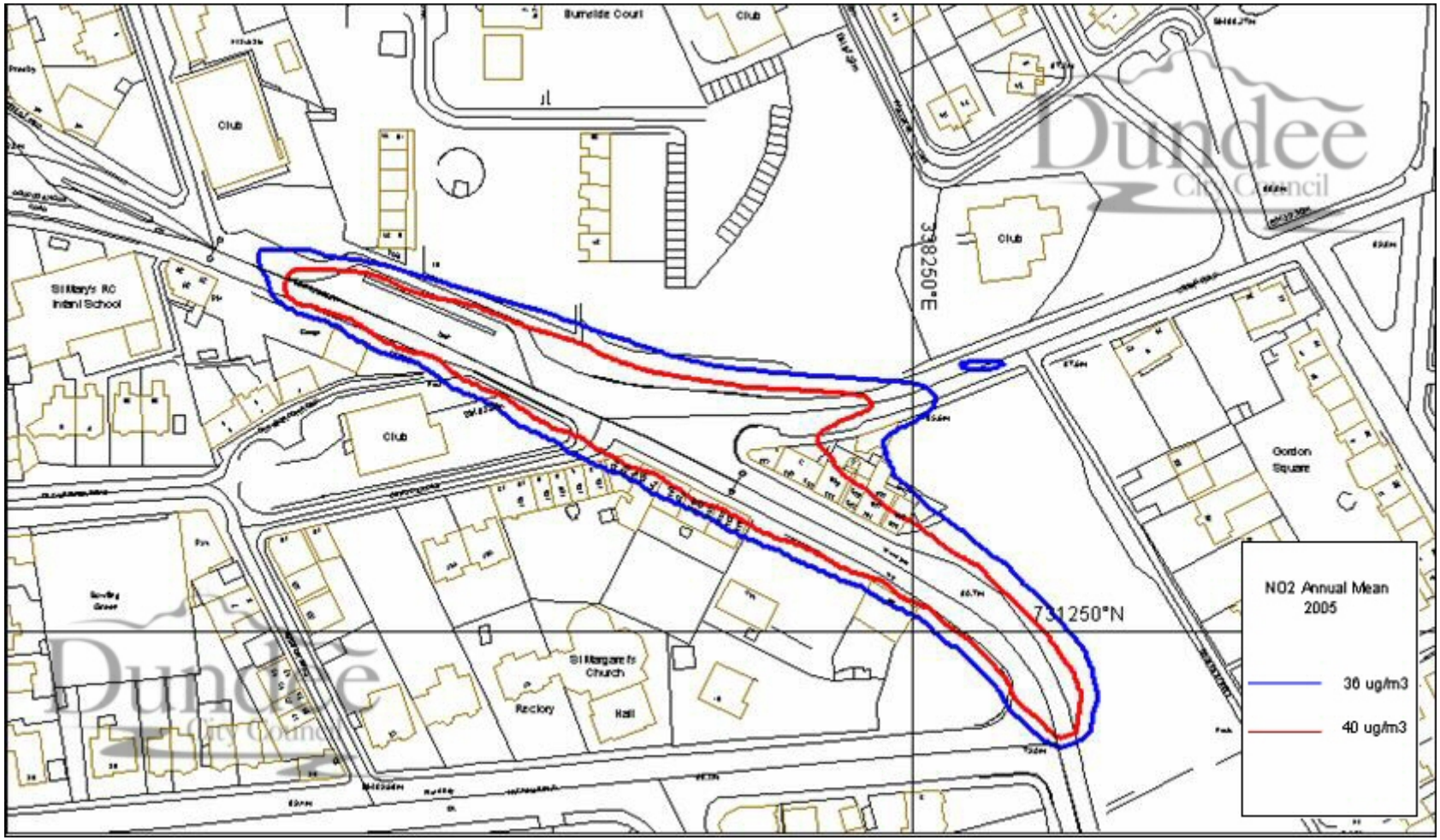
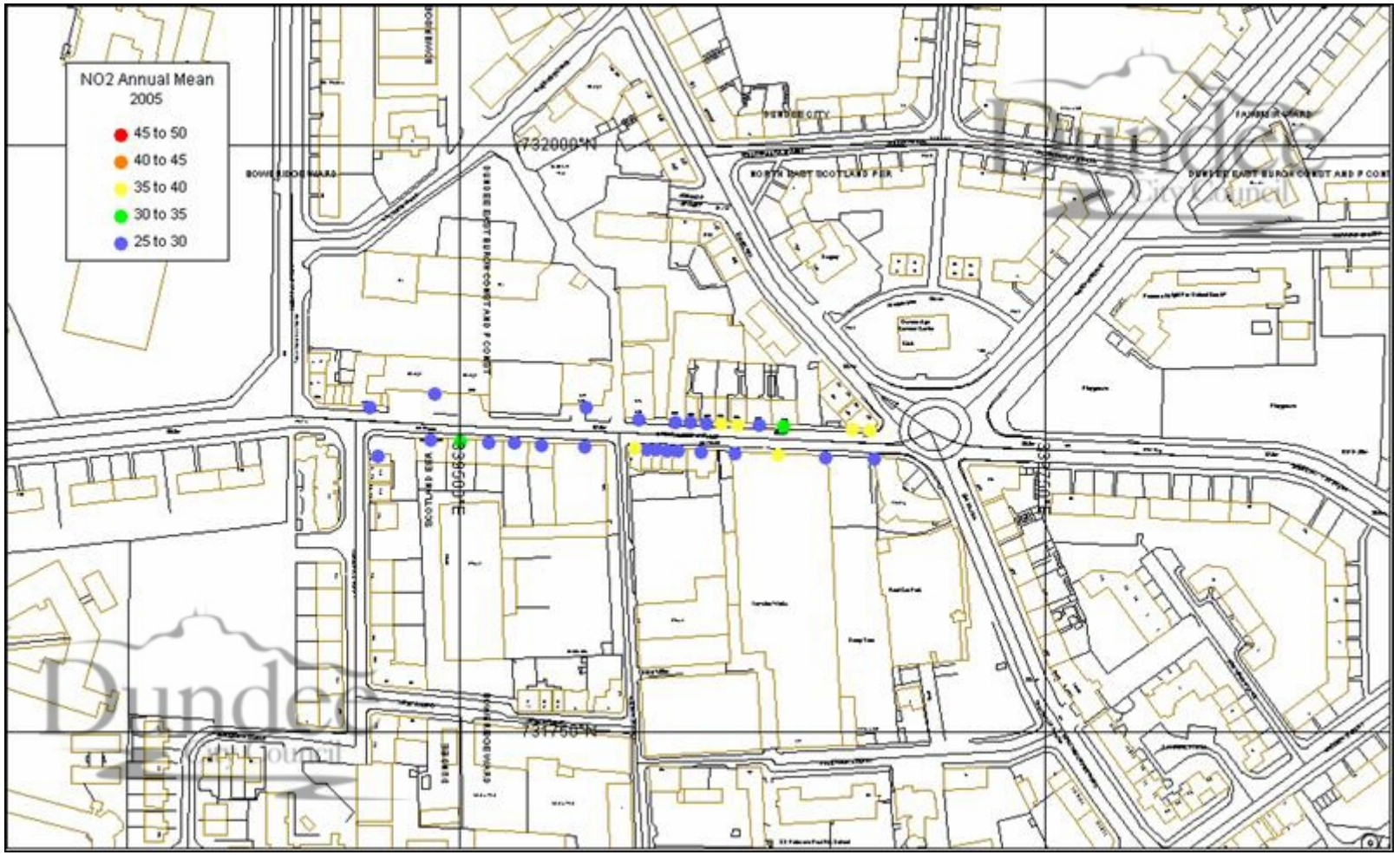


Figure 3.20 Predicted Annual Average NO_2 2005 in the Strathmore Avenue assessment area – all in µg/m^3



3.7 Conclusions of Detailed Assessment for Road Sources

The verified modelled annual mean NO_2 results for road traffic emissions in 2005 in the Dundee central assessment area along Seagate, Nethergate/Marketgait, Dock Street and Commercial Street, Victoria Road indicate annual mean nitrogen dioxide concentrations at relevant receptor locations will exceed the annual mean Objective of 40µg/m^3. It recommended that Dundee City Council consider declaration of an AQMA for NO_2 in these areas.

There are also predicted exceedences of the annual mean NO_2 Objective at relevant receptors in close proximity to the Lochee Road/Rankine Street and Lochee Road/Dudhope Terrace junctions. It recommended that Dundee City Council consider declaration of an AQMA for NO_2 in these areas.

Within the Logie Street and Loons Road assessment area, there are predicted exceedences of the annual mean Objective of 40µg/m^3 largely to the north-east of the junction which is not reflected in the current monitoring at the site. As model verification has been based on 2003 monitoring data and the relevant monitoring sites within the Logie Street assessment area were started in September 2003, there is a degree of uncertainty in the predictions within this area. It is therefore recommended that monitoring be continued at the Logie Street and Loons Road sites and 2004 monitoring results be assessed against the model predictions and annual mean Objective. The requirements for an AQMA in this area should be reassessed once 2004 monitoring has been reassessed.

The verified modelled annual mean NO_2 results in 2005 in the Strathmore Avenue assessment area predicted that the Objective would be met and no AQMA is required in this area.

The verified modelled PM_{10} results for road traffic emissions in 2004 indicate that both the annual mean and daily mean Objectives will be met. There are however predicted exceedences of the annual mean in 2010 with the maximum predicted concentration of 3µg/m^3 above the Objective at the critical receptor modelled in Seagate. It should be noted that ADMS-Roads has not performed as well for PM_{10}, when compared to the predictions of NO_X, which is reflected in the higher roads contribution verification factor and there is likely to be more uncertainty in modelled predictions. Predictions for 2010 are also currently reliant on estimated projected reductions in background concentrations which themselves are likely to have a degree of uncertainty. It is therefore recommended that PM_{10} monitoring be continued at the Union Street and Dock Street sites to monitor and assess changes in concentrations of PM_{10} in the light of the modelled predictions for 2010. In addition, background monitoring is now being collected within Dundee City which will provide a more local estimate of background concentrations, and information on trends over the coming years. Currently, declaration of an AQMA for PM_{10} is not required within the Dundee assessment areas.

To take account of uncertainty in the model, the Technical Guidance LAQM.TG(03) suggests that predicted concentrations above 36µg/m^3 may exceed the annual mean Objective (10% of the annual mean Objective) and the Council may wish to consider using the 36µg/m^3 concentration as the outer extent of the AQMA. Whilst systematic under or over-predictions can be taken into account through the model verification process, random errors will occur and uncertainty will exist in corrected data.

In order to facilitate the declaration of an AQMA, separate contour lines have been drawn representing the Objective and model uncertainty levels for NO_2. The Council will need to confirm that the exposure criteria with respect to the Objectives are fulfilled before defining the extent of any AQMA(s).

4 DETAILED ASSESSMENT FOR INDUSTRIAL SOURCES

4.1 Introduction

Atmospheric dispersion modelling has been undertaken as part of the Detailed Assessment for the Nynas site in Broughty Ferry Road/Dock Street area of Dundee. The pollutants of concern have been previously identified as SO_2 and NO_2.

SEPA provided Casella Stanger with the model input files for the site based on previous modelling undertaken by SEPA for Dundee City Council (DCC). However errors in the meteorological data were determined and remodelling was required.

From 1 January 2003 the site is only authorised to burn fuel oil with less than 1% mass sulphur in the combustion plant in order to comply with The Sulphur Content of Liquid Fuels (Scotland) Regulations 2002.

The modelling has been carried out for two emissions scenarios:

- Higher Sulphur Content (Pre-2003) – referred to as "HSF Scenario"
- Low Sulphur Content (Post-2003) – referred to as "LSF Scenario"

An investigation of the variation of predicted concentrations based on different meteorological data was also undertaken for SO_2 predicted concentrations. The meteorological data used was:

- 2002 Leuchars
- 2002 Dundee (Broughty Ferry Road/Dock Street site)
- 2003 Leuchars
- 2003 Dundee (Broughty Ferry Road/Dock Street site)

Predicted concentrations of SO_2 are compared to those monitored at the continuous monitoring site in Broughty Ferry Road/Dock Street – referred to as the Dock Street monitor.

4.2 Dispersion Modelling Methodology

4.2.1 The ADMS Dispersion Model

Casella Stanger has used the ADMS 3.2 dispersion model for the prediction of the ground level impacts as a result of emissions from two stacks (one being multi-flued) at the Nynas site.

A number of IPPC and LAPC applications using ADMS 3.2 have been accepted by the regulatory bodies in the UK and the model satisfies the requirements of the Environment Agency on choice of dispersion models[21].

4.2.2 Stack Parameters

The parameters shown in Table 4.1 have been used for the stacks as provided by SEPA in the original model input files.

[21] Environment Agency, Air Quality Modelling and Assessment Unit, "Air Dispersion Modelling Report Requirements (for detailed dispersion modelling)", EAS/2007/1/1

Table 4.1 Stack Parameters

	Units	Boiler 2	Beverley Hot Oil Heater	Combined Crude and Vacuum Heater
Stack Location	(xxxxxx,yyyyyy) grid reference	341650/730690	341650/730690	341728/730713
Stack height	m	43	43	50
Exit diameter	m	0.47	0.28	0.845
Exit temperature	C	200	310	313
Efflux velocity (actual)	m/sec	12.85	16.27	15.36

4.2.3 Emission Rates

A constant emission has been assumed for all pollutants and modelling has assumed emissions occur for all hours in a year. Table 4.2 provides the emission rates assumed for each pollutant for the pre and post abatement scenarios.

Table 4.2 Pollutant Emission Rates

Pollutant Emission Rates g/sec	Boiler 2	Beverley Hot Oil Heater	Combined Crude and Vacuum Heater
	HSF Scenario		
SO_2	2.932	1.542	7.692
NOx	0.402	0.193	0.640
	LSF Scenario		
SO_2	2.80	0.92	2.14
NOx	1.21	0.50	0.56

It is useful to note that there are considerable reductions in the emissions of SO_2 from both the Beverley Hot Oil Heater and the Combined Crude and Vacuum Heater. However there are large increases in the NOx emission rates with the Low-Sulphur Fuel scenario for the Boiler 2 and Beverley Hot Oil Heater.

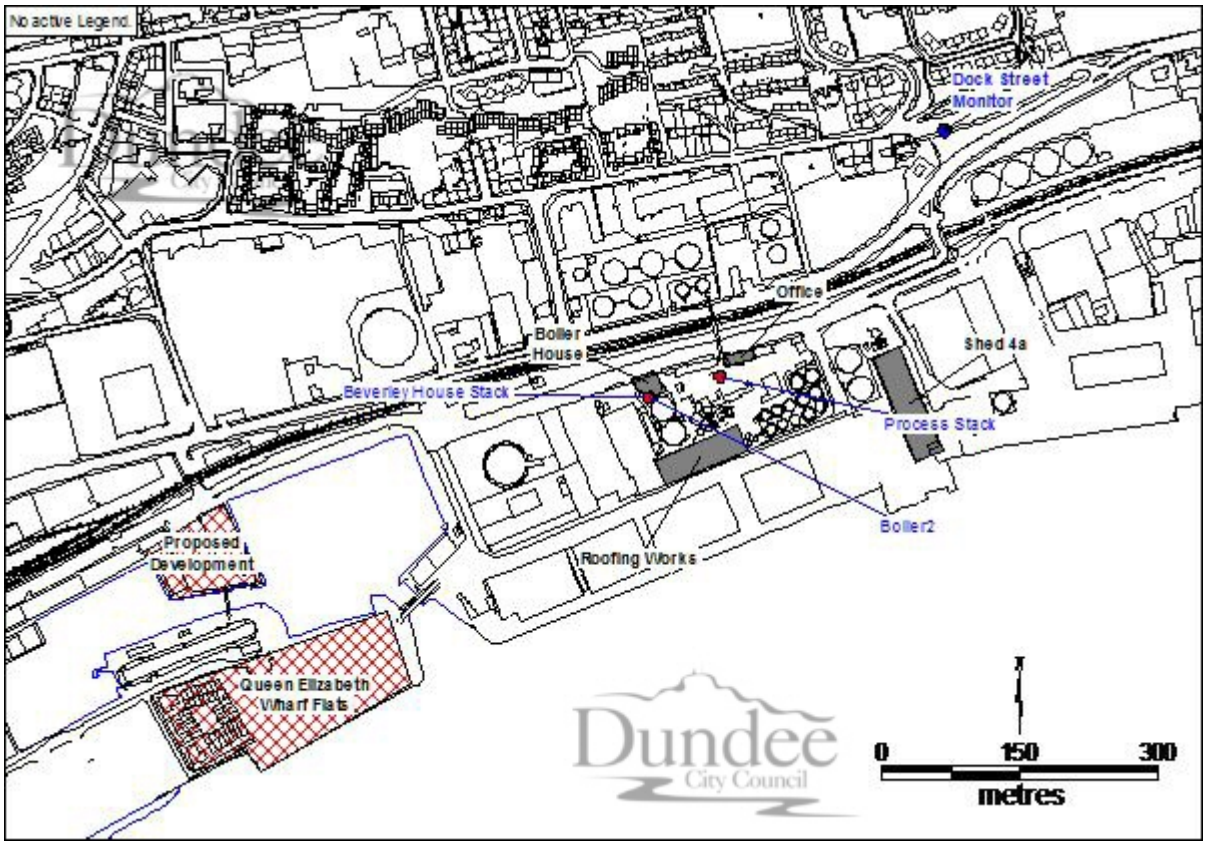
4.3 Building Parameters

Both nearby buildings and complex topography can have a significant effect on the dispersion characteristics of the plume; ADMS 3.2 has algorithms which attempt to take account of these effects. Buildings can cause the plume to come to ground much closer to the stack than otherwise expected, causing significantly higher pollutant concentrations. Plumes can also impact on hillsides under certain weather conditions, or a source within a basin or hollow may result in emissions being trapped during low level inversions.

For the HSF scenario the Boiler House (32.6m), Shed 4a (22.5m), the East Office Block (18.6m) and the Roofing Works (18.9m) have been included in the model. The roofing works are not included in the LSF scenario as these are now dismantled.

The location of stacks and buildings, along with Dock Street Monitor are shown in Figure 4.1.

Figure 4.1 Location of NYNAS stacks and buildings

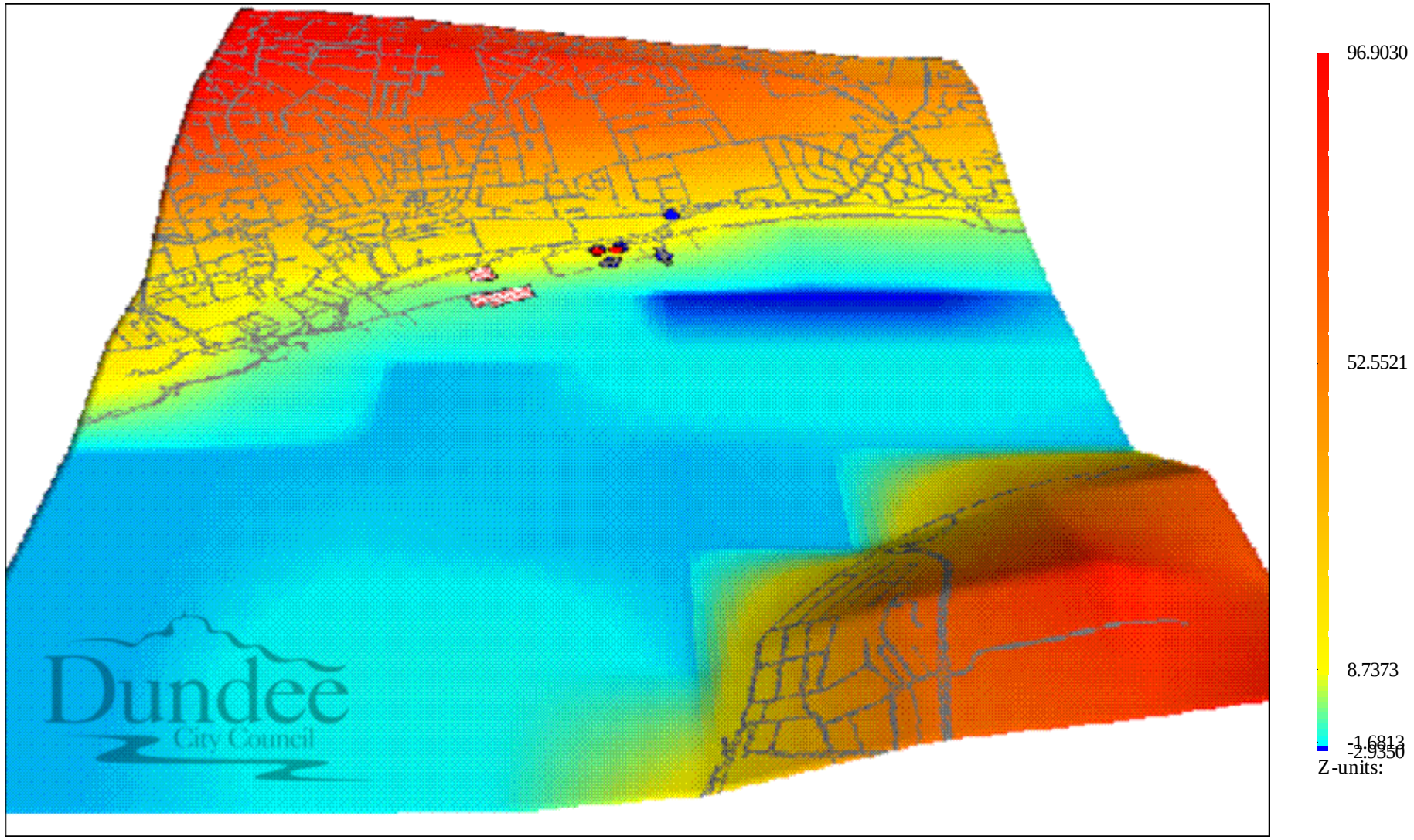


4.4 Terrain

Terrain data based on Ordnance Survey data was provided by SEPA for an area around the site covering approximately 20km^2.

A schematic of the terrain file used for this assessment is provided in Figure 4.2.

Figure 4.2 Terrain map for Nynas Assessment Area (Z units in metres)

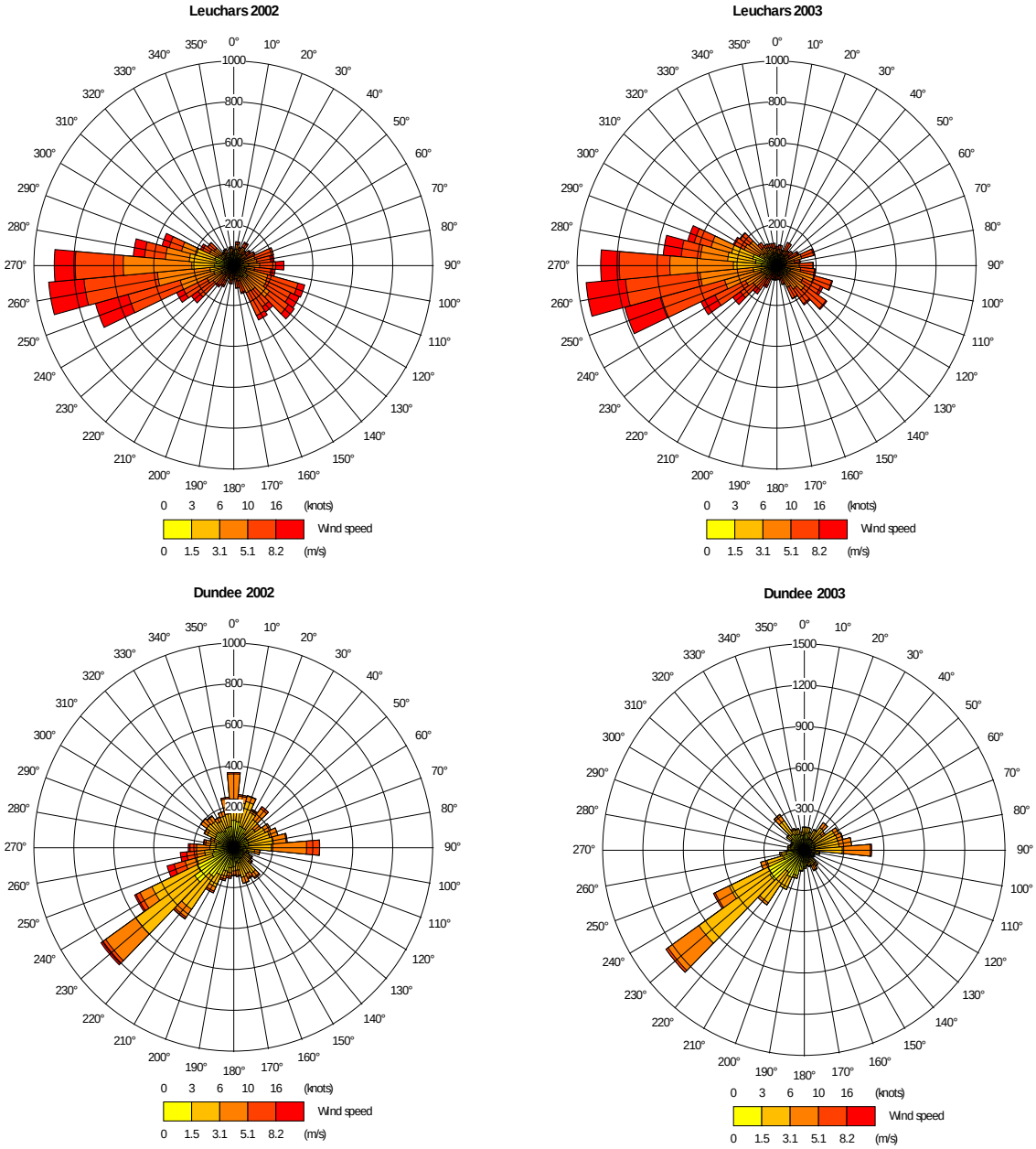


4.5 Meteorological Parameters

Wind roses for the different meteorological data used to determine variability (in particular for 15-minute mean SO_2 predictions) are shown in Figure 4.3.

Only wind speed and direction are collected at the Dock Street meteorological station, therefore other meteorological parameters (temperature and cloud cover) from the same year of data for Leuchars have been used.

Figure 4.3 Wind roses for Leuchars and Dundee Meteorological Data



4.6 Background Concentrations

The contribution of stacks on existing levels (background) must also be taken into account. Background estimates for NO_2 as described below have been used for this assessment. For the purposes of SO_2 predictions, annual average background concentrations have been included for the annual average predictions only but not for short term concentrations as estimates of short term background SO_2 are unreliable and stack sources are likely to be the only significant source in the local area.

The background concentrations used for industrial source assessment are shown in Table 4.3.

Table 4.3 Industrial Assessment Background Concentrations

Pollutant	Concentration ($\mu g/m^3$)	Averaging Period
NO_2	27.8	Annual
NOx	19.1	99.8th percentile 1-Hour Mean
SO_2	2	Annual
O_3	44.3	Annual
Total Oxidant (NO_2+ O_3)	151	99.8th percentile 1-Hour Mean

Ozone concentrations were derived from Eskdalemuir after comparison against Bush Estate and St Leonard's (both Edinburgh region), and Aberdeen. Eskdalemuir was used as it compared better with Aberdeen O_3 levels and had a data capture greater than 90% compared to 40% at Aberdeen.

Background concentrations have been added to predicted contributions from the stack in the following way as described in Defra Guidance LAQM.TG(03):

SO_2

- Annual average SO_2 background added to predicted 99.2nd percentile of 24-hour means

NO_2

- Annual average NO_2 added to predicted annual average NOx (assumed 100% NO_2)
- Twice annual average NO_2 background added to predicted 99.8th percentile of 1-hour means

4.7 Industrial Source Results

Concentrations have been predicted over a regular spaced grid of receptors (50m spacing). Predictions for nitrogen dioxide and sulphur dioxide have been made.

4.8 Nitrogen Oxide/Nitrogen Dioxide

Table 4.4 summarises the maximum predicted long and short-term NOx and NO_2 concentrations.

Table 4.4 Maximum Predicted NOx and NO_2 concentrations ($\mu g/m^3$)

Scenario	Met Data	Max Annual Average NOx	Max 99.8th percentile NOx	Max Annual Average NO_2	Max 99.8th percentile NO_2
	Objective	n/a	n/a	40	200
HSF	Leuchars 2002	0.3	3.6	28.1	59.2
HSF	Dundee 2002	0.2	5.4	28.0	61.0
HSF	Leuchars 2003	0.3	3.6	28.1	59.2
HSF	Dundee 2003	0.3	6.6	28.1	62.2
LSF	Leuchars 2003	0.3	3.5	28.1	59.1

The predictions indicate that the levels contributed from the stack are extremely low. For the 1-hour Objective for NO_2, the maximum predicted concentration predicted for all scenarios are well below the Objective and are only a small proportion of background levels in the area. For the annual mean NO_2, the contribution from the stack is very small (less than 1 $\mu g/m^3$) and are only a small proportion of existing background concentrations which are estimated at 19 $\mu g/m^3$.

While there was an increase in emission rates for the LSF scenario the predicted impacts do not show the same level of increase. An analysis of the grid of concentration contours shows that this is likely to be due to the removal of the roofing works building in the LSF scenario.

The stacks at Nynas contribute small levels of NOx and NO_2 in the area and are not considered to be a significant source and none of the NO_2 Objectives are predicted to be exceeded.

4.9 Sulphur Dioxide

Table 4.5 summarises the maximum predicted long and short-term SO_2 concentrations.

Table 4.5 Maximum Predicted SO_2 concentrations ($\mu g/m^3$)

Scenario	Met Data	Max Annual Average SO_2	Max 99.7th percentile 1-Hour SO_2	# Exceedences
	Objective	na	350	24
HSF	Leuchars 2002	13	262	11
HSF	Dundee 2002	14	298	19
HSF	Leuchars 2003	13	266	18
HSF	Dundee 2003	19	248	9
LSF	Leuchars 2003	8	125	0
Scenario	Met Data		Max 99.2nd percentile 24-Hour SO_2	# Exceedences
	Objective		125	3
HSF	Leuchars 2002		111	1
HSF	Dundee 2002		111	2
HSF	Leuchars 2003		87	1
HSF	Dundee 2003		100	0
LSF	Leuchars 2003		42	0
Scenario	Met Data		Max 99.9th 15-Minute Mean percentile SO_2	# Exceedences
	Objective		266	35
HSF	Leuchars 2002		1022	165
HSF	Dundee 2002		991	185
HSF	Leuchars 2003		1164	141
HSF	Dundee 2003		500	131
LSF	Leuchars 2003		435	45

The predictions indicate that SO_2 is a more significant emission sources from the stacks at Nynas. The maximum predicted concentrations for the 24-hour and 1-hour averaging periods are below the air quality Objectives. However, the predicted 15-minute mean concentrations are above the air quality Objective. However the maximum concentrations are all predicted to occur very close to or within the site and are not at relevant locations for exposure.

In addition, the LSF scenario which represents the current operating scenario at the site shows that predicted maximum concentrations for the site are considerably lower than for previous scenarios.

SO_2 monitoring is undertaken at the Dock Street monitor and data from the site can be compared to the model predictions in order to determine if the model predictions provide reasonable certainty for the conclusions that may be drawn from them.

Table 4.6 shows the monitored and modelled SO_2 concentrations at the Dock Street monitoring station based on difference scenarios. Monitored concentrations are also shown in Figure 4.4.

Table 4.6 Monitored and Modelled SO_2 Concentrations at Dock Street in µg/m^3

	Monitored			Modelled			
	2002	2003	2004	2003 Leuchars		2003 Leuchars	
SO2	HSF	LSF	LSF	HSF		LSF	
				Monitor	Similar Distance	Monitor	Similar Distance
Max 24-Hour	70	54	34				
3rd Highest 24-Hour	42	31	19				
99.18th percentile 24-Hour	39	28	19	19	10 - 66, mean 24	8	4 - 32, mean 10
# Exceedences 125	0	0	0				
Max 1-Hour	209	268	296				
24 Highest 1-Hour	102	62	39				
99.73rd percentile 1-Hour	106	62	41	66	47 - 200, mean 78	28	20 - 99, mean 36
# Exceedences 350	0	0	0				
Max 15-Minute	385	392	395				
35 Highest	160	117	59				
99.9th percentile 15-Min	166	117	64	83	62 - 505, mean 107	36	26 - 243, mean 50
# Exceedences 266	8	6	5				
Annual Average	8	6	4	5	2 - 10	3	2 - 5

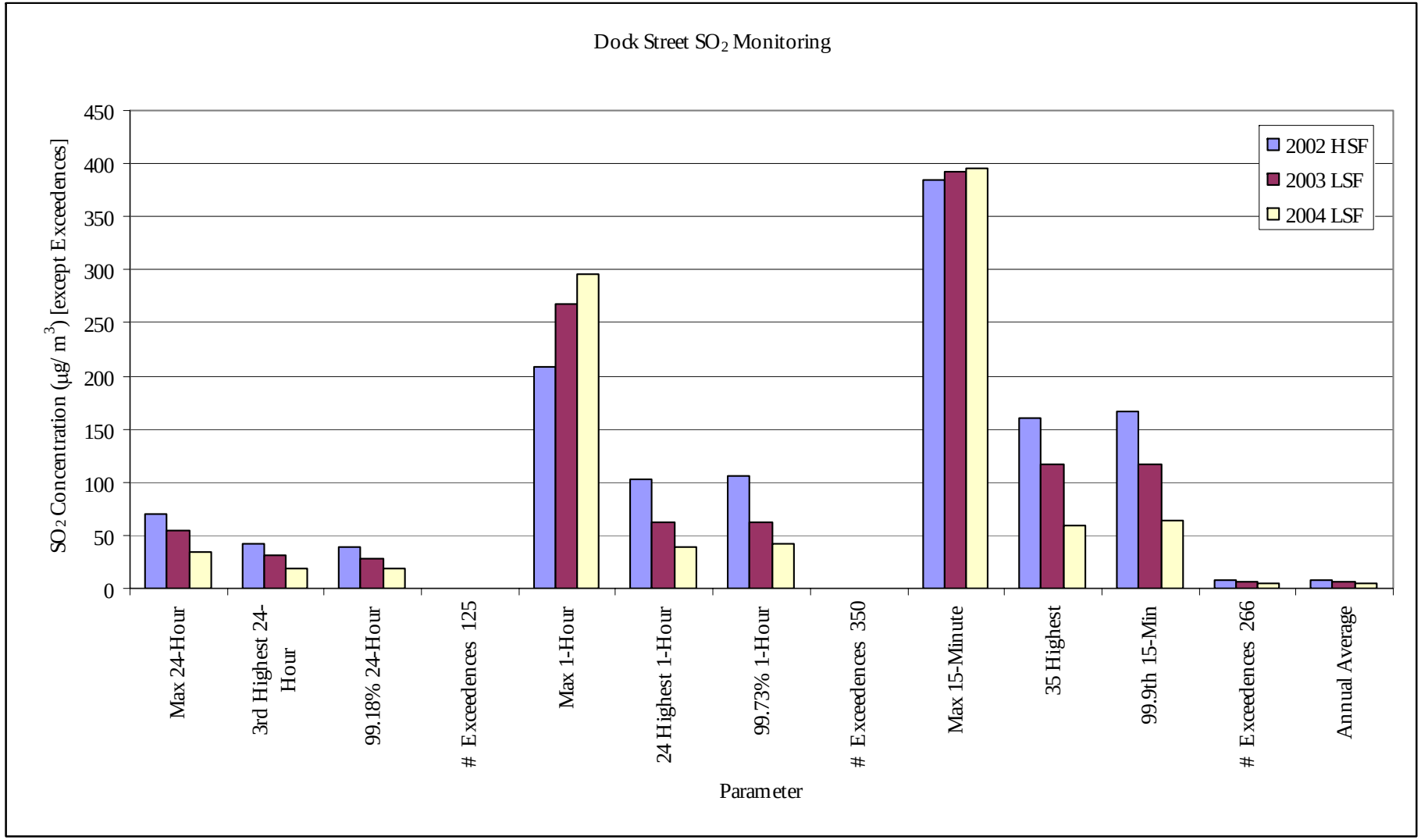
4.10 24-Hour and 1-Hour SO_2

The monitored concentrations indicate that the SO_2 Objectives for 24-hour, 1-hour and 15-minute averaging periods have not been breached in 2002, 2003 or 2004. There have been monitored reductions for all averaging periods each year and significant reductions between 2003 and 2004 (data to October 2004).

A comparison of predicted concentrations at the Dock Street monitor indicates that at this exact location the ADMS model is under-predicting SO_2 concentrations. For example, for the HSF scenario (using 2003 Leuchars meteorological data) the monitored 15-minute mean concentration (99.9th percentile) was 166 µg/m^3 in 2002

(this is when HSF was operational) while the model predicts a concentration of 83 $\mu g/m^3$ – a difference of a factor of 2 approximately.

Figure 4.4 Dock Street Monitored SO_2 Concentrations (µg/m^3)



There is likely to be some variation in the prediction due to emissions estimates and also meteorological data used which will result in variation in wind speed and direction. Therefore, it is useful to consider the predictions in the following way:

- At locations a similar distance to the monitor but in different directions (due to differences between actual onsite winds and those in the hourly sequential meteorological data) as shown in Figure 4.5; and
- Due to varied meteorological data (wind speed and directions)

Figure 4.5 Similar Distance Region for Analysis

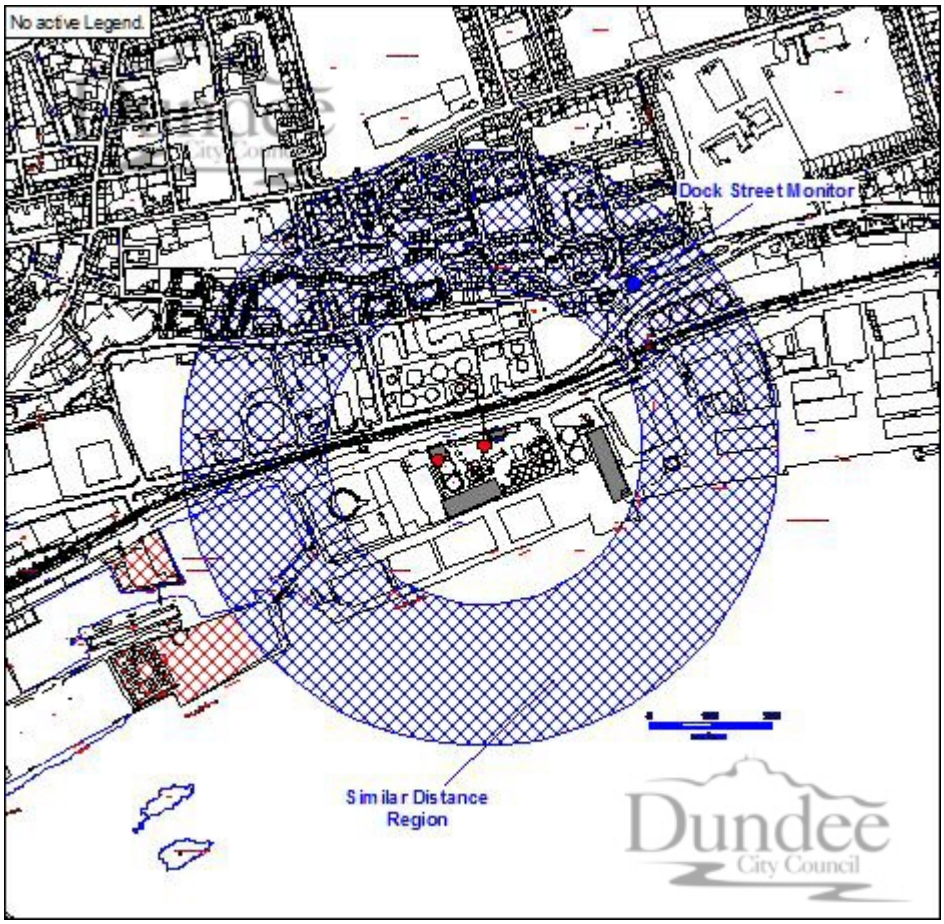
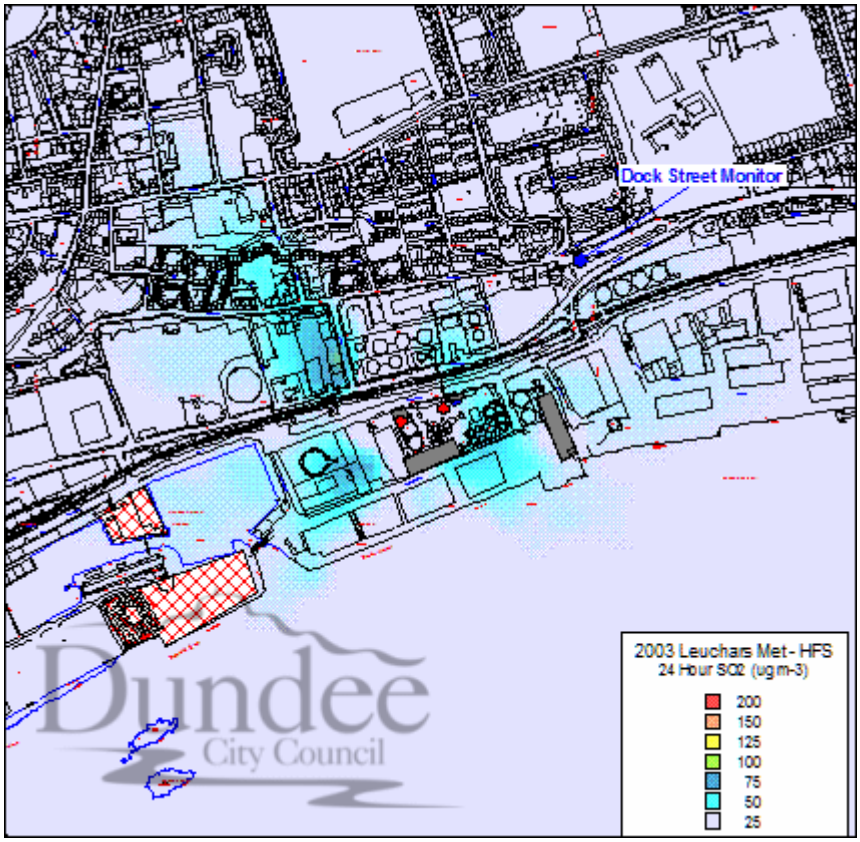


Table 4.6 shows that for the HSF and LSF scenarios with 2003 Leuchars meteorological data the range of predicted concentrations for the 24-hour and 1-hour objectives at a similar distance to the Dock Street monitor are similar to those monitored. In addition, the maximum predicted concentrations at a similar distance are below the objectives.

Figure 4.6 and Figure 4.7 show the predicted 24-hour and 1-hour mean concentrations respectively for the HSF and LSF scenarios using Leuchars meteorological for 2003. These show that no exceedences are predicted for either objective at any location, and that the maximum impacts are generally predicted to be within the docks area and Nynas site.

The figures also show that the predicted impact areas of highest impacts are significantly smaller for the LSF model scenario due the reductions in sulphur content of fuels.

Figure 4.6 Predicted 24-Hour Mean SO_2 Concentrations (99.2nd percentile)



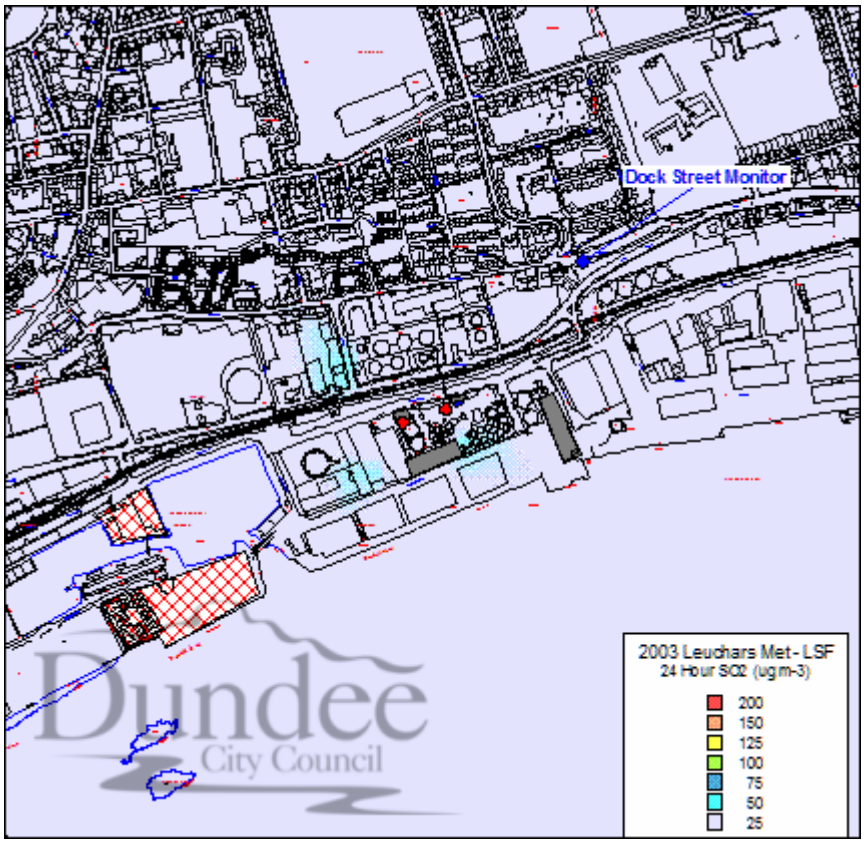
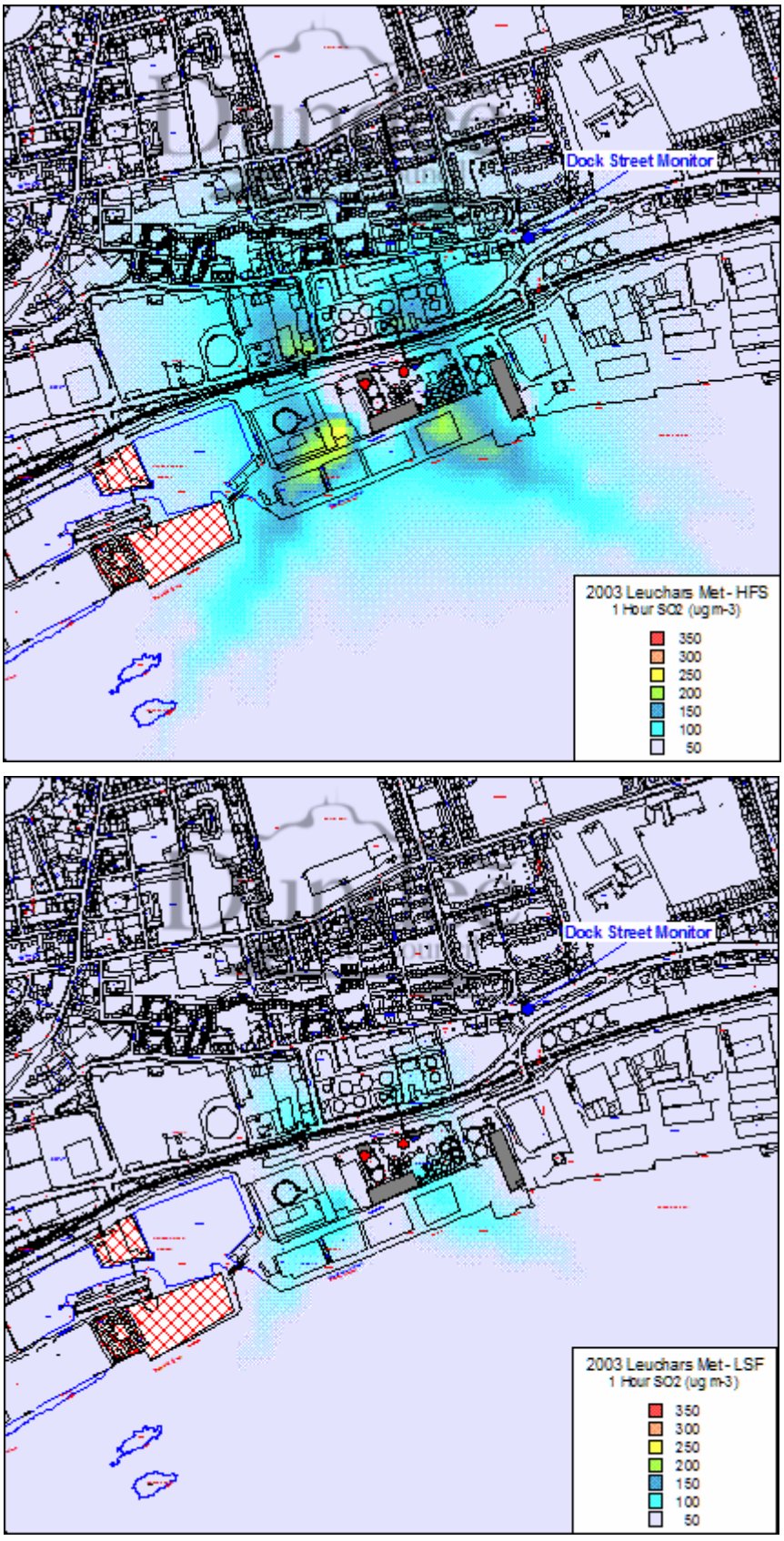


Figure 4.7 Predicted 1-Hour Mean SO_2 Concentrations (99.7th %ile)



4.11 15-Minute SO_2

The 15-minute mean objective for SO_2 is the most stringent for this pollutant and further analysis of modelling has been undertaken to determine the impacts.

The monitored concentrations (summarised for 15-minute mean in Table 4.7) indicate that the SO_2 Objectives for 15-minute averaging periods have not been breached in 2002, 2003 or 2004. Maximum monitored SO_2 concentrations for all years are similar, but the 99.9th percentile 15-minute concentrations have reduced considerably since 2002 and levels in 2004 are 39% of those in 2002.

Table 4.7 15-Minute Mean SO_2 Concentrations in µg/m^3– Leuchars 2003 Meteorological Data

	Monitored			Modelled			
	2002	2003	2004	2003 Leuchars		2003 Leuchars	
SO2	HSF	LSF	LSF	HSF		LSF	
Max 15-Minute	385	392	395				
35 Highest	160	117	59				
99.9th percentile 15-Min	166	117	64	83	62 - 505, mean 107	36	26 - 243, mean 50
# Exceedences 266	8	6	5				
Annual Average	8	6	4	5	2 - 10	3	2 - 5

The modelling of 15-minute mean concentrations is subject to more uncertainty than other averaging periods because input data are based on 1 hour inputs – both emissions and meteorological data. The fluctuations that may occur in emissions of the short term and those in wind speed and direction cannot easily be determined, and inevitably there will be differences between monitoring and modelling.

An initial comparison of the modelling of the HSF and LSF scenario using Leuchars 2003 meteorological data shown in Table 4.7 indicates that the model under-predicts by a factor of approximately 2 at the Dock Street monitor location. However, analysis of the wider area indicates that the concentrations predicted in different directions but similar distance to the monitor are more in line with those monitored – this effect may be due to the difference in wind data in close proximity to the site compared to that from Leuchars.

The maximum concentration at a similar distance for the HSF scenario is 505 µg/m^3, which is above the objective. This maximum is predicted within the site boundary towards the south-west. Predicted concentrations at the recently completed Queen Elizabeth Docks residential properties (also to the south-west) are approximately 120 µg/m^3. However, the introduction of low sulphur fuel use has reduced the emissions of SO_2 and the maximum predicted concentration for the LSF scenario at these properties is reduced to approximately 60 µg/m^3 .

As the model is generally under-predicting concentrations, local meteorological data for 2002 and 2003 has also be used, and the results for the 15-minute mean concentrations are shown in Table 4.8 and Table 4.9.

Table 4.8 15-Minute Mean SO_2 Concentrations - Dundee 2003 Meteorological Data

	Modelled					
	2003 Dundee Met			2003 Dundee Met		
	HSF			LSF		
SO2	Monitor	Similar Distance	High Region Near Monitor	Monitor	Similar Distance	High Region Near Monitor
99.9th 15-Min	105	65 - 451, mean 116	80 - 235, mean 131	47	25 - 179, mean 52	38 - 132, mean 63

Table 4.9 15-Minute Mean SO_2 Concentrations - 2002 Meteorological Data

	Modelled			
	2002 Leuchars		2002 Dundee	
	HSF		HSF	
SO2	Monitor	Similar Distance	Monitor	Similar Distance
99.9th 15-Min	82	60 - 499, mean 106	97	69 - 483, mean 119

The predicted concentrations with local meteorological data are higher at the monitor than those with Leuchars meteorological data. However, the monitoring concentrations in 2002 (HSF) are not represented (at the monitoring location) by modelling for the HSF for any of the meteorological data used in the assessment. It may be that the emissions for the HSF modelling scenario have been under-estimated.

The LSF is the current scenario and the modelled concentrations using Dundee 2003 meteorological data are very similar to those monitored (47 $\mu g/m^3$ modelled vs. 64 $\mu g/m^3$ monitored).

The comparison of modelled and monitored data, and the range of concentrations predicted within a similar distance to the monitoring data suggests that local wind data is more suitable for modelling of sources in the docks area.

The predicted concentrations of 99.9th percentile 15-minute means are shown in Figure 4.8 for the HSF scenario and Figure 4.9 for LSF scenarios with different sets of meteorological data.

Figure 4.8 Predicted 15-Minute Mean SO_2 Concentrations (99.9nd %ile) - HSF

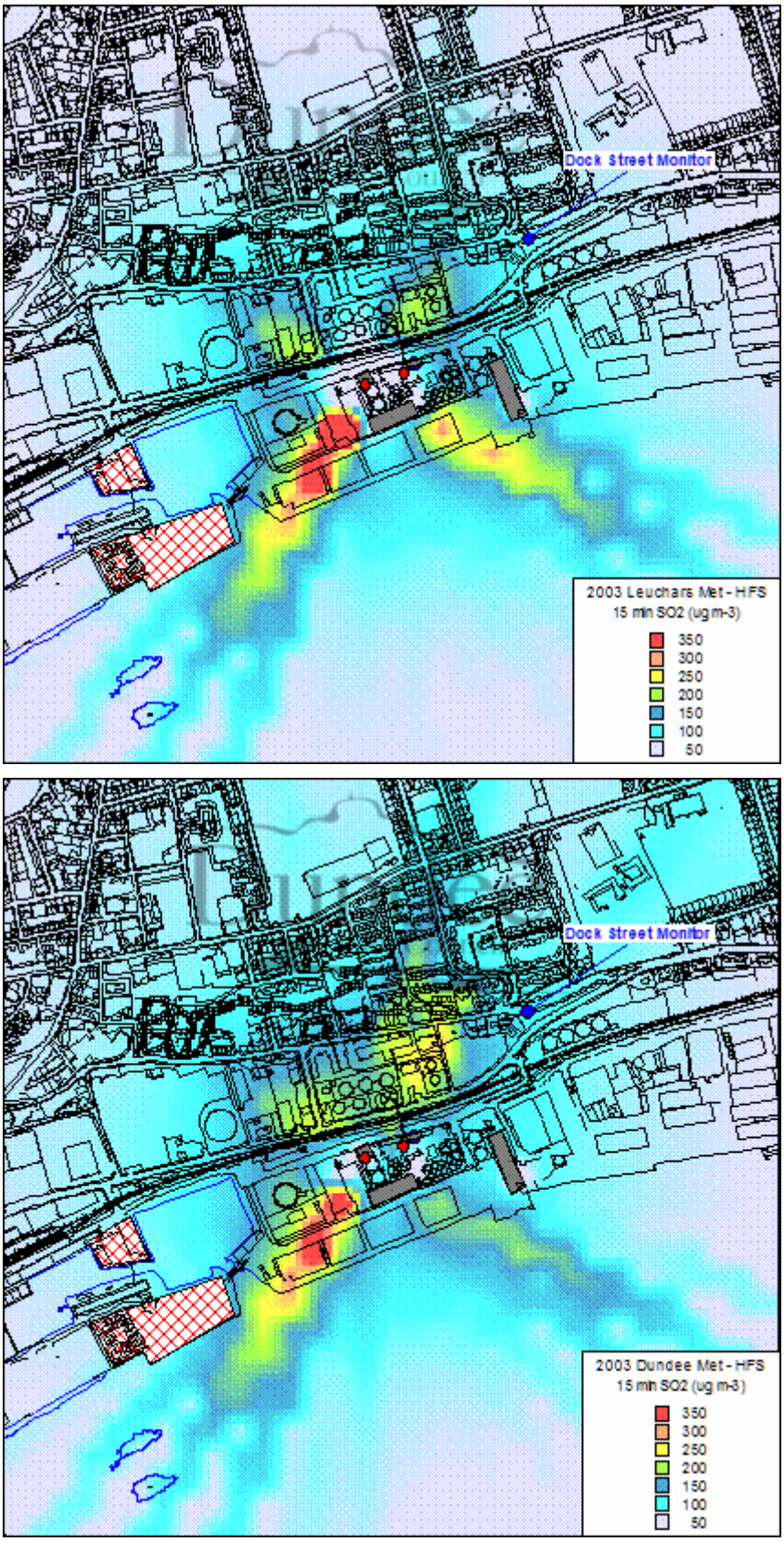
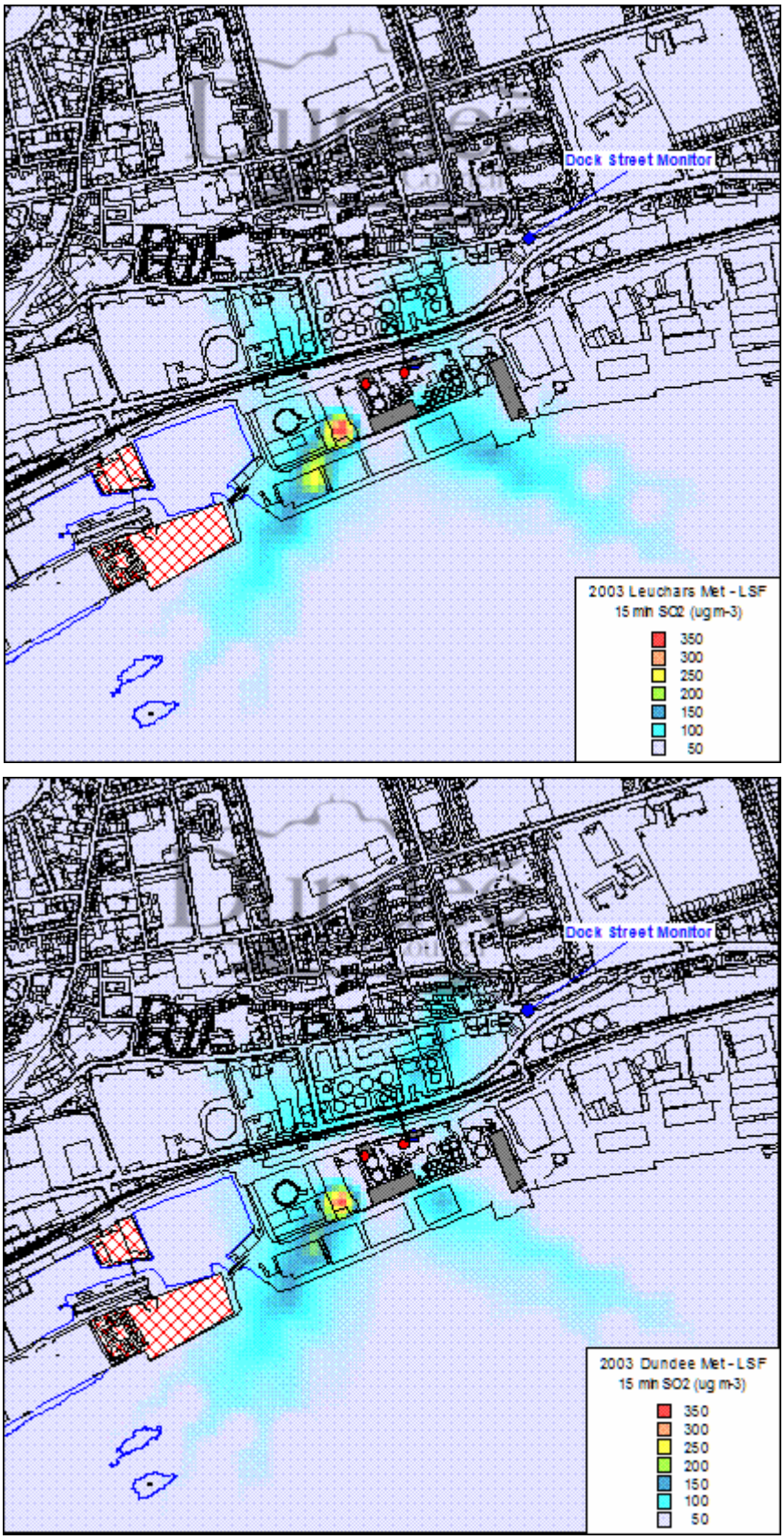


Figure 4.9 Predicted 15-Minute Mean SO_2 Concentrations (99.9nd %ile) - LSF



The predicted concentrations for HSF are higher than for the LSF scenario as would be expected. Predicted concentrations for either Leuchars 2003 or Dundee 2003 meteorological data are similar in range, but for the local Dundee meteorological data the pattern of predictions are slightly different and an area of higher impacts is predicted close to the monitor location. The results for this higher area have been drawn out in Table 4.8 and predicted concentrations are more similar to those monitored.

Predicted concentrations for the HSF scenario shown in Figure 4.9 are considerably lower than those for the HSF. Concentrations are predicted to be higher near the monitor with the local Dundee 2003 meteorological data as described above.

4.12 Conclusions for Industrial Source Detailed Assessment

The 15-minute mean objective is not predicted to be exceeded with the current LSF operating scenario in place. The monitoring data has also shown that there have been large reductions in SO_2 concentrations (as percentiles). However, it is interesting to note that some of the maximum hourly and 15-minute concentrations have not reduced significantly indicating that certain activities at the site are not related to operations where low sulphur fuels are now used.

The predicted concentrations at the recently completed Queen Elizabeth flats and proposed residential properties are not expected to be within areas where the SO_2 Objectives would be approached. However, both Leuchars and Dundee meteorological data indicate that the Queen Elizabeth Docks flats are close to one of the main impact areas to the south-west of the Nynas site.

5 RECOMMENDATIONS

5.1 Assessment of New Monitoring and Traffic Data

An assessment of additional monitoring and DMRB modelling for additional areas (not covered within the detailed assessment for road sources) has shown that no exceedence of the NO_2 or PM_{10} Objective are predicted. However, it is recognised that monitoring at some of these locations should continue in order to provide information on trends in pollutant concentrations in these areas for further reviews of air quality. In addition, monitoring will help identify significant changes in air quality should changes to traffic flows (e.g. vehicle numbers, classifications, speeds) occur in the areas.

5.2 Road Traffic Sources

The detailed assessment for road traffic sources has indicated that AQMA are required in the Dundee central assessment area, and at locations close to Lochee Road. It is recommended that monitoring continue in these areas.

An AQMA is not currently required for the Logie Street and Loons Road assessment area and some over-prediction of concentrations has been recognised compared to available monitoring. It is therefore recommended that monitoring be continued at the Logie Street and Loons Road sites and 2004 monitoring results be assessed against the model predictions and annual mean Objective. The requirements for an AQMA in this area should be reassessed once 2004 monitoring has been reassessed in line with the review and assessment timetable.

The verified modelled annual mean NO_2 results in 2005 in the Strathmore Avenue assessment area predicted that the Objective would be met and no AQMA is required in this area.

No AQMAs for PM_{10} are recommended at this stage of the review and assessment process. Predictions for 2010 are currently reliant on estimated projected reductions in background concentrations which themselves are likely to have a degree of uncertainty. It is therefore recommended that PM_{10} monitoring be continued at the Union Street and Dock Street sites to monitor and assess changes in concentrations of PM_{10} in the light of the modelled predictions for 2010. However, current monitoring shows that in typical years the 24-hour mean Objectives for 2004 and 2010 is met in Dundee. However, high pollution years such as 2003 were heavily influenced by prevailing meteorological conditions and it is possible that these may occur again before 2010. The sources that result in the increase in the number of exceedences are therefore likely to be outside of local control. Monitoring over the coming years will provide some indication as to the risk of exceeding the 2010 objective. In addition, future guidance from SEPA and the Scottish Executive on projections of PM_{10} and background PM_{10} concentrations should be used when reassessing requirements for an AQMA for PM_{10}.

5.3 Industrial Sources

No further assessment of the Nynas site is required for the purposes of review and assessment and an AQMA for SO_2 is not required. Dundee City Council should continue to assess monitored concentrations of SO_2 and PM_{10} on a regular basis. It may also be useful to determine if particular site activities are resulting in peaks in concentrations as additional improvements may be possible through on site practices.

APPENDIX 1 DMRB DATA INPUTS

Background pollutant concentrations for each relevant grid square are taken from the national database on www.airquality.co.uk/archive/laqm/tools.php

Annual average traffic speeds were selected in accordance with the default speeds given in the statutory guidance

Abbreviations: LGV are Light Goods Vehicle; OGV1 are rigid vehicles over 3.5 tonnes with 2 or 3 axles; OGV2 are rigid vehicles with >=4 axles and all articulated vehicles

Strathmore Avenue								
Link 1 - (distance from centre line to receptor 5.83m, tube 4.38m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	7657	999	126	60	255	9097	95.2	4.8
AADT24(2004)	8806	1149	145	69	293	10462	95.2	4.8
%	84.2%	11.0%	1.4%	0.7%	2.8%	100.0%		
AADT24(2005)	8921	1171	145	70	294	10598	95.2	4.8
%	84.2%	11.0%	1.4%	0.7%	2.8%	100.0%		
AADT24(2010)	9430	1280	150	78	298	11281	94.9	4.7
%	83.6%	11.3%	1.3%	0.7%	2.6%	100.0%		

Clepington Rd/Forfar Rd junction								
Link 1 - (distance from centre line to receptor 12.65m, tube 4.94m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	7961	961	258	120	348	9647	92.5	7.5
AADT24(2004)	9155	1105	297	138	400	11094	92.5	7.5
%	82.5%	10.0%	2.7%	1.2%	3.6%	100.0%		
AADT24(2005)	9275	1126	298	141	402	11239	92.5	7.5
%	82.5%	10.0%	2.7%	1.3%	3.6%	100.0%		
AADT24(2010)	9804	1231	306	156	407	11963	92.2	7.3
%	82.0%	10.3%	2.6%	1.3%	3.4%	100.0%		
Link 2 - (distance from centre line to receptor 6.59m, tube 15.29m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	7970	1080	322	47	71	9489	95.4	4.6
AADT24(2004)	9166	1242	370	54	82	10912	95.4	4.6
%	84.0%	11.4%	3.4%	0.5%	0.7%	100.0%		
AADT24(2005)	9285	1266	372	55	82	11055	95.4	4.6
%	84.0%	11.4%	3.4%	0.5%	0.7%	100.0%		
AADT24(2010)	9815	1384	382	61	83	11767	95.2	4.5
%	83.4%	11.8%	3.2%	0.5%	0.7%	100.0%		

Kingsway/Strathmartine Rd roundabout								
Link 1 - (distance from centre line to receptor 29.86m, tube 19.73m), (40kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	22150	3553	1565	2163	136	29566	86.9	13.1
AADT24(2004)	25473	4086	1800	2487	156	34001	86.9	13.1
%	74.9%	12.0%	5.3%	7.3%	0.5%	100.0%		
AADT24(2005)	25805	4164	1807	2539	157	34445	87	13.1
%	74.9%	12.1%	5.2%	7.4%	0.5%	100.0%		
AADT24(2010)	27278	4553	1858	2816	159	36665	86.8	13.2
%	74.4%	12.4%	5.1%	7.7%	0.4%	100.0%		
Link 2 - (distance from centre line to receptor 14.17m, tube 12.09m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	7304	913	198	29	269	8712	94.3	5.7
AADT24(2004)	8400	1050	228	33	309	10019	94.3	5.7
%	83.8%	10.5%	2.3%	0.3%	3.1%	100.0%		
AADT24(2005)	8509	1070	229	34	311	10150	94.4	5.6
%	83.8%	10.5%	2.3%	0.3%	3.1%	100.0%		
AADT24(2010)	8995	1170	235	38	314	10804	94.1	5.4
%	83.3%	10.8%	2.2%	0.3%	2.9%	100.0%		

Albert St/Arbroath Rd/Princes St/Victoria Street								
Link 1 - (distance from centre line to receptor 7.43m, tube 28.36m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	8483	978	202	111	451	10223	92.5	7.5
AADT24(2004)	9755	1125	232	128	519	11756	92.5	7.5
%	83.0%	9.6%	2.0%	1.1%	4.4%	100.0%		
AADT24(2005)	9883	1146	233	130	521	11910	92.6	7.4
%	83.0%	9.6%	2.0%	1.1%	4.4%	100.0%		
AADT24(2010)	10447	1253	240	144	527	12678	92.3	7.2
%	82.4%	9.9%	1.9%	1.1%	4.2%	100.0%		
Link 2 - (distance from centre line to receptor 7.72m, tube 5.45m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	5409	538	94	35	295	6369	93.4	6.7
AADT24(2004)	6220	619	108	40	339	7324	93.4	6.7
%	84.9%	8.4%	1.5%	0.5%	4.6%	100.0%		
AADT24(2005)	6302	630	109	41	341	7420	93.4	6.6
%	84.9%	8.5%	1.5%	0.6%	4.6%	100.0%		
AADT24(2010)	6661	689	112	46	345	7898	93.1	6.4
%	84.3%	8.7%	1.4%	0.6%	4.4%	100.0%		

Dens Rd/Victoria St/Victoria Rd/Cotton Rd								
Link 1 - (distance from centre line to receptor 9.39m, tube 14.43m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	10028	1112	236	53	1000	12429	89.6	10.4
AADT24(2004)	11532	1279	271	61	1150	14293	89.6	10.4
%	80.7%	8.9%	1.9%	0.4%	8.0%	100.0%		
AADT24(2005)	11683	1303	272	62	1155	14480	89.7	10.3
%	80.7%	9.0%	1.9%	0.4%	8.0%	100.0%		
AADT24(2010)	12350	1425	280	69	1169	15413	89.4	9.8
%	80.1%	9.2%	1.8%	0.4%	7.6%	100.0%		
Link 2 - (distance from centre line to receptor 22.59m, tube 21.29m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	2571	244	52	14	211	3092	91	9
AADT24(2004)	2957	281	60	16	243	3556	91	9
%	83.2%	7.9%	1.7%	0.5%	6.8%	100.0%		
AADT24(2005)	2995	286	60	16	244	3602	91.1	8.9
%	83.2%	7.9%	1.7%	0.5%	6.8%	100.0%		
AADT24(2010)	3166	313	62	18	247	3834	90.7	8.5
%	82.6%	8.2%	1.6%	0.5%	6.4%	100.0%		
Link 3 - (distance from centre line to receptor 4.31m, tube 6.57m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	99	8	0	0	0	107	100	0
AADT24(2004)	114	9	0	0	0	123	100	0
%	92.5%	7.5%	0.0%	0.0%	0.0%	100.0%		
AADT24(2005)	115	9	0	0	0	125	100	0
%	92.5%	7.5%	0.0%	0.0%	0.0%	100.0%		
AADT24(2010)	122	10	0	0	0	133	99.6	0
%	91.9%	7.7%	0.0%	0.0%	0.0%	100.0%		

Albert St/Dura St/Forfar Rd/Pitkerro Rd/Mains Loan								
Link 1 - (distance from centre line to receptor 88.29 m, tube 42.8m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	700	93	16	2	12	823	96.4	3.6
AADT24(2004)	805	107	18	2	14	946	96.4	3.6
%	85.1%	11.3%	1.9%	0.2%	1.5%	100.0%		
AADT24(2005)	816	109	18	2	14	959	96.4	3.6
%	85.1%	11.4%	1.9%	0.2%	1.4%	100.0%		
AADT24(2010)	862	119	19	3	14	1021	96.1	3.5
%	84.5%	11.7%	1.9%	0.3%	1.4%	100.0%		
Link 2 - (distance from centre line to receptor 4.8m, tube 4.13m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	7553	800	218	58	214	8842	94.5	5.5
AADT24(2004)	8686	920	251	67	246	10168	94.5	5.5
%	85.4%	9.0%	2.5%	0.7%	2.4%	100.0%		
AADT24(2005)	8799	938	252	68	247	10301	94.5	5.5
%	85.4%	9.1%	2.4%	0.7%	2.4%	100.0%		
AADT24(2010)	9302	1025	259	76	250	10965	94.2	5.3
%	84.8%	9.3%	2.4%	0.7%	2.3%	100.0%		
Link 3 - (distance from centre line to receptor 20m, tube 48.2m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	5251	551	139	40	303	6282	92.4	7.7
AADT24(2004)	6039	634	160	46	348	7224	92.4	7.7
%	83.6%	8.8%	2.2%	0.6%	4.8%	100.0%		
AADT24(2005)	6118	646	160	47	350	7319	92.4	7.6
%	83.6%	8.8%	2.2%	0.6%	4.8%	100.0%		
AADT24(2010)	6467	706	165	52	354	7790	92.1	7.3
%	83.0%	9.1%	2.1%	0.7%	4.5%	100.0%		

Eastport Roundabout								
Link 1 - (distance from centre line to receptor 13.79m, tube 15.51m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	11842	1184	213	110	183	13530	96.3	3.7
AADT24(2004)	13618	1362	245	127	210	15560	96.3	3.7
%	87.5%	8.8%	1.6%	0.8%	1.4%	100.0%		
AADT24(2005)	13796	1388	246	129	211	15763	96.3	3.7
%	87.5%	8.8%	1.6%	0.8%	1.3%	100.0%		
AADT24(2010)	14584	1517	253	143	214	16779	96	3.6
%	86.9%	9.0%	1.5%	0.9%	1.3%	100.0%		
Link 2 - (distance from centre line to receptor 7.66m, tube 6.1m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	5833	652	121	28	535	7169	90.5	9.5
AADT24(2004)	6708	750	139	32	615	8244	90.5	9.5
%	81.4%	9.1%	1.7%	0.4%	7.5%	100.0%		
AADT24(2005)	6796	764	140	33	618	8352	90.5	9.5
%	81.4%	9.1%	1.7%	0.4%	7.4%	100.0%		
AADT24(2010)	7184	835	144	36	625	8890	90.2	9.1
%	80.8%	9.4%	1.6%	0.4%	7.0%	100.0%		
Link 3 - (distance from centre line to receptor 61.61m, tube 63.16m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	13749	1309	286	105	432	15881	94.8	5.2
AADT24(2004)	15811	1505	329	121	497	18263	94.8	5.2
%	86.6%	8.2%	1.8%	0.7%	2.7%	100.0%		
AADT24(2005)	16018	1534	330	123	499	18502	94.9	5.1
%	86.6%	8.3%	1.8%	0.7%	2.7%	100.0%		
AADT24(2010)	16932	1677	340	137	505	19694	94.5	5
%	86.0%	8.5%	1.7%	0.7%	2.6%	100.0%		

Ladywell Roundabout								
Link 1 - (distance from centre line to receptor 56.07m, tube 78.86m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	13662	1469	337	34	97	15599	97	3
AADT24(2004)	15711	1689	388	39	112	17939	97	3
%	87.6%	9.4%	2.2%	0.2%	0.6%	100.0%		
AADT24(2005)	15916	1722	389	40	112	18173	97.1	3
%	87.6%	9.5%	2.1%	0.2%	0.6%	100.0%		
AADT24(2010)	16825	1882	400	44	113	19345	96.7	2.9
%	87.0%	9.7%	2.1%	0.2%	0.6%	100.0%		
Link 2 - (distance from centre line to receptor 13.88m, tube 12.65m), (30kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	16806	2058	433	32	73	19400	97.2	2.8
AADT24(2004)	19327	2367	498	37	84	22310	97.2	2.8
%	86.6%	10.6%	2.2%	0.2%	0.4%	100.0%		
AADT24(2005)	19579	2412	500	38	84	22601	97.3	2.8
%	86.6%	10.7%	2.2%	0.2%	0.4%	100.0%		
AADT24(2010)	20697	2637	514	42	85	24058	97	2.7
%	86.0%	11.0%	2.1%	0.2%	0.4%	100.0%		

King Street								
Link 1 - (distance from centre line to receptor 7.76m), (48kph)								
	CAR	LGV	OGV1	OGV2	BUS	TOTAL	%LDV	%HDV
2004(12HR)	349	54	10	2	439	854	47.2	52.8
AADT24(2004)	401	62	12	2	505	982	47.2	52.8
%	40.9%	6.3%	1.2%	0.2%	51.4%	100.0%		
AADT24(2005)	407	63	12	2	507	995	47.2	52.3
%	40.9%	6.4%	1.2%	0.2%	50.9%	100.0%		
AADT24(2010)	430	69	12	3	513	1059	47.1	49.8
%	40.6%	6.5%	1.1%	0.2%	48.4%	100.0%		

APPENDIX 2 ADMS-ROADS DETAILED ASSESSMENT TRAFFIC DATA

Road Name/ Direction	X	Y	%HDV	Year	AADT	AADT 2003	AADT 2004	AADT 2005	AADT 2010
Nethergate East - left to Union Street	340215	730118	0	2004	5	5	5	5	5
Nethergate East - west to Nethergate West	340215	730118	57.8	2004	973	966	973	981	1003
Union Street -left to Nethergate West	340215	730118	34.6	2004	1149	1141	1149	1158	1184
Union Street -right to Nethergate East	340215	730118	42.4	2004	368	366	368	371	379
Nethergate West - east to Nethergate East	340215	730118	29.4	2004	2042	2027	2042	2058	2103
Nethergate West - right to Union Street	340215	730118	9.4	2004	40	39	40	40	41
Marketgait - left to Nethergate East	340089	730006	14.7	2004	1833	1819	1833	1847	1888
Marketgait - south to South Marketgait	340089	730006	3.8	2004	10029	9953	10029	10107	10330
Nethergate East - left to South Marketgait	340089	730006	22.3	2004	322	320	322	325	332
Nethergate East - west to Nethergate West	340089	730006	44	2004	598	593	598	602	616
Nethergate East - right to Marketgait	340089	730006	38.7	2004	1591	1579	1591	1603	1639
South Marketgait - left to Nethergate west	340089	730006	2.4	2004	2668	2648	2668	2689	2748
South Marketgait - north to Margetgait	340089	730006	3.4	2004	8560	8495	8560	8626	8816
South Marketgait - right to Nethergate East	340089	730006	55.9	2004	169	167	169	170	174
Nethergate West - left to Marketgait	340089	730006	4.3	2004	2387	2369	2387	2405	2459
Nethergate West - east to Nethergate East	340089	730006	53.5	2004	520	516	520	524	535
Nethergate West - right to South Marketgait	340089	730006	4	2004	247	245	247	249	254
Hilltown - left to Victoria Road East	340297	730722		2004					
Hilltown - right to Victoria Road West	340297	730722	4	2004	2682	2662	2682	2703	2763
Victoria Road - West to Victoria Road West	340297	730722	8.2	2004	5359	5319	5359	5401	5520
Victoria Road - Right to Hilltown	340297	730722		2004	4	4	4	4	4
Victoria Road - left to Hilltown	340297	730722	3.7	2004	2530	2511	2530	2549	2605
Victoria Road - east to Victoria Road East	340297	730722	11.3	2004	10063	9987	10063	10140	10364
Seagate North - left to Gellatly Street	340464	730398		2004					
Seagate North - South to Seagate South	340464	730398	30.8	2004	3370	3345	3370	3396	3471
Gellatly Street - left to Seagate South	340464	730398	5.4	2004	161	160	161	162	166
Gellatly Street - right to Seagate North	340464	730398	2.2	2004	1438	1428	1438	1450	1482
Seagate South - north to Seagate North	340464	730398	16.1	2004	2039	2023	2039	2054	2100
Seagate South - right to Gellatly Street	340464	730398		2004					
St Andrews Street - left to Seagate	340547	730545	2.8	2004	1022	1014	1022	1030	1052
St Andrews Street - south to Trades Lane	340547	730545	27.7	2004	81	80	81	81	83

Road Name/ Direction	X	Y	%HDV	Year	AADT	AADT 2003	AADT 2004	AADT 2005	AADT 2010
St Andrews Street- right to Seagate	340547	730545	80.5	2004	673	668	673	679	694
Seagate - left to Trades Lane	340547	730545	21.1	2004	616	612	616	621	635
Seagate - west to Seagate	340547	730545	14.6	2004	2551	2531	2551	2570	2627
Seagate - right to St Andrews Street	340547	730545	5.9	2004	423	420	423	426	436
Trades Lane - left to Seagate	340547	730545	26.2	2004	208	207	208	210	215
Trades Lane - north to St Andrews Street	340547	730545	1.6	2004	227	225	227	229	234
Trades Lane - right to Seagate	340547	730545	1.8	2004	992	985	992	1000	1022
Seagate - left to St Andrews Street	340547	730545	9	2004	110	110	110	111	114
Seagate - east to Seagate	340547	730545	6.5	2004	3328	3303	3328	3354	3428
Seagate - right to Trades Lane	340547	730545	65.7	2004	126	126	126	127	130
East Marketgait - left to Seagate	340681	730642	1.4	2004	3782	3753	3782	3811	3895
East Marketgait - South to East Marketgait	340681	730642	2.5	2004	3205	3181	3205	3230	3301
East Marketgait - right to Seagate West	340681	730642	5.3	2004	1007	999	1007	1015	1037
Seagate - left to East Marketgait	340681	730642	4.9	2004	4090	4059	4090	4121	4212
Seagate - West to Seagate	340681	730642	11.6	2004	2507	2488	2507	2527	2582
Seagate - right to East Marketgait	340681	730642	4.2	2004	4941	4904	4941	4980	5090
East Marketgait - left to Seagate West	340681	730642	3.9	2004	510	506	510	514	525
East Marketgait -north to East Marketgait	340681	730642	2.7	2004	3432	3406	3432	3459	3535
East Marketgait -right to Seagate	340681	730642	3.3	2004	2368	2351	2368	2387	2439
Seagate - left to East Marketgait	340681	730642	3.2	2004	1884	1869	1884	1898	1940
Seagate - East to Seagate	340681	730642	11.6	2004	1644	1632	1644	1657	1694
Seagate - right to East Marketgait	340681	730642	17.3	2004	1342	1332	1342	1352	1382
Strathmore Avenue - Eastbound	339592	731877	5	2004	5684	5641	5684	5728	5855
Strathmore Avenue - Westbound	339592	731877	4.7	2004	5596	5554	5596	5639	5764
Ancrum Road - left to Loons Road	338167	731307	3.4	2004	1860	1846	1860	1874	1916
Ancrum Road - South to Logie Street	338167	731307	5.7	2004	6891	6839	6891	6944	7097
Ancrum Road - right to Muirton Road	338167	731307		2004					
Loons Road - left to Logie Street	338167	731307	10.5	2004	425	422	425	429	438
Loons Road - west to Muirton Road	338167	731307		2004					
Loons Road - right to Ancrum Road	338167	731307	8.4	2004	800	794	800	806	824
Logie Street - Left to Muirton Road	338167	731307		2004					
Logie Street - west to Ancrum Road	338167	731307	6.6	2004	6152	6105	6152	6199	6336

Road Name/ Direction	X	Y	%HDV	Year	AADT	AADT 2003	AADT 2004	AADT 2005	AADT 2010
Logie Street - right to Loons Road	338167	731307	3.5	2004	1817	1803	1817	1831	1871
Muirton Road- left to Ancrum Road	338167	731307	0.9	2004	289	287	289	291	298
Muirton Road - east to Loons Road	338167	731307	1.3	2004	1293	1284	1293	1303	1332
Muirton Road - right to Logie Street	338167	731307	0	2004	29	28	29	29	29
Marketgait East - Eastbound	340143	730679	4	2004	8060	7999	8060	8122	8302
Marketgait East - Westbound	340143	730679	3.3	2004	11407	11321	11407	11495	11749
Marketgait West - Eastbound	340143	730679	2.6	2004	14669	14559	14669	14783	15109
Marketgait West - Westbound	340143	730679	3	2004	10774	10693	10774	10858	11097
Marketgait East -left to Victoria Way	340143	730679	2.6	2004	7917	7858	7917	7979	8155
Marketgait East -West to Marketgait	340143	730679	4.9	2004	3461	3435	3461	3488	3565
Marketgait East - uturns	340143	730679	0	2004	29	28	29	29	29
Victoria Way - left to Marketgait West	340143	730679	2.5	2004	6236	6189	6236	6284	6423
Victoria Way - right to Marketgait East	340143	730679	3.4	2004	1329	1319	1329	1340	1369
Victoria Way -uturns	340143	730679	0	2004	172	171	172	174	178
Marketgait West - East to Marketgait East	340143	730679	2.4	2004	6578	6529	6578	6629	6775
Marketgait West - right to Victoria Way	340143	730679	3.1	2004	7013	6961	7013	7068	7224
Marketgait West - uturns	340143	730679	0	2004	1078	1069	1078	1086	1110
Castle Street - left to Dock Street	340489	730174		2004					
Castle Street - right to Dock Street	340489	730174		2004					
Dock Street - West to Dock Street	340489	730174	72.4	2004	1583	1572	1583	1596	1631
Dock Street - right to Castle Street	340489	730174	3.5	2004	734	729	734	740	756
Dock Street - left to Castle Street	340489	730174	0	2004	33	33	33	34	34
Dock Street - East to Dock Street	340489	730174	68	2004	1085	1077	1085	1093	1118
Whitehall Crescent -left to Dock Street	340413	730100	66	2004	1118	1110	1118	1127	1152
Whitehall Crescent -right to Dock Street	340413	730100	3.1	2004	3259	3234	3259	3284	3356
Dock Street - west to Dock Street	340413	730100	72.4	2004	1583	1572	1583	1596	1631
Dock Street - right to Whitehall Crescent	340413	730100		2004					
Dock Street - left to Whitehall Crescent	340413	730100		2004					
Dock Street - east to Dock Street	340413	730100		2004					
Commercial Street - left to Gellatly Street	340582	730264	2.5	2004	1096	1088	1096	1105	1129
Commercial Street - south to Commercial Street	340582	730264	5.9	2004	1296	1286	1296	1306	1335

Road Name/ Direction	X	Y	%HDV	Year	AADT	AADT 2003	AADT 2004	AADT 2005	AADT 2010
Commercial Street - right to Dock Street	340582	730264	63.7	2004	1815	1802	1815	1829	1870
Gellatly Street - left to Commercial Street	340582	730264	0.9	2004	291	289	291	294	300
Gellatly Street - west to Dock Street	340582	730264	0	2004	17	17	17	17	18
Gellatly Street - right to Commercial Street	340582	730264	0	2004	6	6	6	6	6
Commercial Street - Left to Dock Street	340582	730264	3	2004	492	489	492	496	507
Commercial Street - north to Commercial Street	340582	730264	9.7	2004	1319	1309	1319	1330	1359
Commercial Street - Right to Gellatly Street	340582	730264	3.7	2004	1240	1231	1240	1250	1277
Dock Street -left to Commercial Street	340582	730264	77.5	2004	750	745	750	756	773
Dock Street - east to Gellatly Street	340582	730264	9.5	2004	26	26	26	26	27
Dock Street - right to Commercial Street	340582	730264	49.8	2004	309	306	309	311	318
Lochee Road - both ways	338887	730795	7	2002	17650	17788	17784	18062	18460
Rankine Street - both ways	338887	730795	3.8	2002	8073	8136	8134	8261	8444
Cleghorn Street - both ways	338887	730795	2.5	2002	3556	3584	3583	3639	3719
Dudhope Terrace - both ways	338935	730698	1.8	2002	7098	7153	7152	7264	7424
Pole Park Road - both ways	339028	730610	3.5	2002	6079	6126	6125	6221	6358
Lochee Road - left to Rankine Street	338887	730795	7	2002	117	117	117	119	122
Lochee Road - right to Cleghorn Street	338887	730795	7	2002	55	55	55	56	57
Lochee Road - south to Lochee Road	338887	730795	7	2002	7191	7247	7245	7358	7521
Rankine Street - right to Lochee Road	338887	730795	3.8	2002	42	42	42	43	44
Rankine Street - left to Lochee Road	338887	730795	3.8	2002	3026	3049	3049	3096	3164
Rankine Street - west to Cleghorn Street	338887	730795	3.8	2002	889	896	896	910	930
Lochee Road S -right to Rankine Street	338887	730795	7	2002	3530	3558	3557	3613	3692
Lochee Road S - left to Cleghorn Street	338887	730795	7	2002	1326	1336	1336	1356	1386
Lochee Road S - north to Lochee Road	338887	730795	7	2002	6950	7004	7003	7112	7269
Cleghorn St - right to Lochee Road	338887	730795	2.5	2002	423	426	426	433	442
Cleghorn St - left to Lochee Road	338887	730795	2.5	2002	202	204	204	207	211
Cleghorn St - east to Rankine Street	338887	730795	2.5	2002	712	717	717	728	744
Lochee Road -left to Dudhope Terrace	338935	730698	7	2002	2354	2372	2371	2408	2462
Lochee Road - south to Lochee Road	338935	730698	7	2002	8267	8332	8330	8460	8646
Lochee Road - right to Dudhope Terrace	338935	730698	7	2002	1111	1120	1119	1137	1162
Lochee Road - north to Lochee Road	338935	730698	7	2002	9288	9360	9358	9504	9714

Road Name/ Direction	X	Y	%HDV	Year	AADT	AADT 2003	AADT 2004	AADT 2005	AADT 2010
Dudhope Terrace - right to Lochee Road	338935	730698	1.8	2002	2475	2494	2494	2533	2589
Dudhope Terrace - left to Lochee Road	338935	730698	1.8	2002	1269	1278	1278	1298	1327
Lochee Road - south to Lochee Road	339028	730610	7	2002	6896	6949	6948	7056	7212
Lochee Road - right to Pole Park Road	339028	730610	7	2002	2748	2769	2769	2812	2874
Lochee Road - north to Lochee Road	339028	730610	7	2002	8034	8097	8095	8221	8403
Lochee Road - left to Pole Park Road	339028	730610	7	2002	541	545	545	553	565
Pole Park Road - left to Lochee Road	339028	730610	3.5	2002	2396	2414	2414	2452	2506
Pole Park Road - right to Lochee Road	339028	730610	3.5	2002	527	531	531	539	551
Whitehall Street - one way	340297	730129	29.7	2002	2077	2093	2093	2125	2172
Taybridge northbound east ramp - one way	340484	730095	4	2003	6785	6785	6837	6889	7041
Taybridge northbound west ramp - one way	340514	730130	4	2003	8585	8585	8650	8717	8910
Taybridge southbound - one way			4	2003	11897	11897	11987	12080	12347
East Dock Street - both ways	340601	730334	3.7	2004	28068	27856	28281	28285	28909
S Marketgait After riverside rdbt to East Marketgait - eastward	340437	730047	3.4	2002	19301	19451	19447	19751	20186
S Marketgait After riverside rdbt to East Marketgait - westward	340435	730030	5	2002	18321	18464	18460	18748	19162

APPENDIX 3 VERIFICATION OF NO_X/NO_2

The ADMS-Roads model has been used to predict the contribution of the road network to annual mean NO_X at roadside diffusion tubes sites to verify predicted concentrations. The following information is required:

Calculation of Monitored and Modelled Roadside NOx Contributions

Annual Mean Concentrations ($\mu g/m^3$)	Total Monitored NOx (1)	Total Monitored NO_2 (2)	Background NOx (3)	Monitored Roadside NOx Contribution (1) – (3)	Modelled Roadside Contribution NOx (from ADMS-Roads)
Dundee Central Assessment Area					
Whitehall Crescent (Expresso)	78.5	30.9	27.8	50.7	36.4
Whitehall Street (BRJ)	109.5	36.3	27.8	81.7	20.2
Dock Street (14)	183.3	46.4	27.8	155.5	46.1
Seagate (Yates 7-9)	152.9	42.6	27.8	125.1	37.5
Commercial Street (Waterstones)	127.1	39.0	27.8	99.3	41.2
Commercial Street /Dock Street	199	48.2	27.8	171.2	25.1
Dock Street (Unicorn)	129.2	39.3	27.8	101.4	18.8
St Andrews Street DD	106.4	35.8	27.8	78.6	16.5
St Andrews Street JAF	125.8	38.8	27.8	98.0	18.1
Seagate (Bond triplicate)	129.2	39.3	27.8	101.4	38.7
Seagate	196.3	47.9	27.8	168.5	29.3
Victoria Road/Hilltown	337.1	60.6	27.8	309.3	76.7
Victoria Road	137.5	40.5	27.8	109.7	17.5
Union Street Rollalong	156	40.6	27.8	128.2	24.1
Union Street (Goodfellows)	125.1	38.7	27.8	97.3	22.8
Union Street (McIntyres)	115.2	37.2	27.8	87.4	25.5
Nethergate (Trades House)	151.4	42.4	27.8	123.6	23.2
Whitehall Street (Deb A)	198.1	48.1	27.8	170.3	33.8
Whitehall Street (BUS)	209	49.3	27.8	181.2	29.2
Whitehall Street (TISO)	128.5	39.2	27.8	100.7	15.7
Whitehall Street (BBB triplicate)	131.2	39.6	27.8	103.4	16.0
Nethergate B&B	161.4	43.7	27.8	133.6	23.8
Nethergate/Marketgait	99.8	34.7	27.8	72.0	22.6
Nethergate (Charlie T)	194.6	47.7	27.8	166.8	29.2
Whitehall Street (DEB E)	136.8	40.4	27.8	109.0	33.5
Lochee Road/Logie Street Assessment Area					
Loons Road	141.1	41.0	27.8	113.3	30.4
Lochee Road (184)	112.1	36.7	27.8	84.3	26.4
Lochee Road (164)	219.4	50.4	27.8	191.6	29.5
Lochee Road (140)	259.4	54.3	27.8	231.6	25.0
Lochee Road/Polepark Road	87.7	32.6	27.8	59.9	10.7
Logie Street (114)	251.9	53.6	27.8	224.1	21.5
Muirton Road (6)	88.8	32.8	27.8	61.0	11.3
Logie Road (98)	126.4	38.9	27.8	98.6	21.1
Strathmore Avenue Assessment Area					
Strathmore Avenue (337)	117.8	37.6	27.8	90.0	32.4
Strathmore (353)	153.7	42.7	27.8	125.9	35.8
Strathmore Avenue (Wellgate)	98	34.4	27.8	70.2	38.5

Calculation of the Average Modelled Roadside NOx Correction Factor

Annual Mean Concentrations (µg/m^3)	Monitored Roadside NOx / Modelled Roadside NOx Contribution	Average Correction Factor Modelled Roadside NOx
Dundee Central Assessment Area		
Whitehall Crescent (Expresso)	1.4	**4.6**
Whitehall Street (BRJ)	4.0	
Dock Street (14)	3.4	
Seagate (Yates 7-9)	3.3	
Commercial Street (Waterstones)	2.4	
Commercial Street /Dock Street	6.8	
Dock Street (Unicorn)	5.4	
St Andrews Street DD	4.8	
St Andrews Street JAF	5.4	
Seagate (Bond triplicate)	2.6	
Seagate	5.8	
Victoria Road/Hilltown	4.0	
Victoria Road	6.3	
Union Street Rollalong	5.3	
Union Street (Goodfellows)	4.3	
Union Street (McIntyres)	3.4	
Nethergate (Trades House)	5.3	
Whitehall Street (Deb A)	5.0	
Whitehall Street (BUS)	6.2	
Whitehall Street (TISO)	6.4	
Whitehall Street (BBB triplicate)	6.5	
Nethergate B&B	5.6	
Nethergate/Marketgait	3.2	
Nethergate (Charlie T)	5.7	
Whitehall Street (DEB E)	3.3	
Lochee Road/Logie Street Assessment Area		
Loons Road	3.7	**6.1**
Lochee Road (184)	3.2	
Lochee Road (164)	6.5	
Lochee Road (140)	9.3	
Lochee Road/Polepark Road	5.6	
Logie Street (114)	10.4	
Muirton Road (6)	5.4	
Logie Road (98)	4.7	
Strathmore Avenue Assessment Area		
Strathmore Avenue (337)	2.8	**2.7**
Strathmore (353)	3.5	
Strathmore Avenue (Wellgate)	1.8	

The average correction factor for modelled roadside NO_X is then applied to the original modelled roadside NO_X contribution and background NO_X is added back in to get the new total modelled NO_X concentration.

Calculation of Modelled Total Corrected NOx

Annual Mean Concentrations (µg/m^3)	Modelled Roadside NOx x Average Correction Factor + background NOx = Modelled Total NOx
Dundee Central Assessment Area	
Whitehall Crescent (Expresso)	195.9
Whitehall Street (BRJ)	121.1
Dock Street (14)	241.0
Seagate (Yates 7-9)	201.2
Commercial Street (Waterstones)	218.2
Commercial Street /Dock Street	143.9
Dock Street (Unicorn)	114.8
St Andrews Street DD	103.8
St Andrews Street JAF	111.4
Seagate (Bond triplicate)	206.5
Seagate	163.0
Victoria Road/Hilltown	382.2
Victoria Road	108.8
Union Street Rollalong	138.9
Union Street (Goodfellows)	133.1
Union Street (McIntyres)	145.8
Nethergate (Trades House)	135.0
Whitehall Street (Deb A)	184.0
Whitehall Street (BUS)	162.5
Whitehall Street (TISO)	100.4
Whitehall Street (BBB triplicate)	101.8
Nethergate B&B	137.6
Nethergate/Marketgait	132.4
Nethergate (Charlie T)	162.7
Whitehall Street (DEB E)	182.7
Lochee Road/Logie Street Assessment Area	
Loons Road	214.1
Lochee Road (184)	189.2
Lochee Road (164)	208.2
Lochee Road (140)	181.0
Lochee Road/Polepark Road	93.4
Logie Street (114)	159.4
Muirton Road (6)	96.8
Logie Road (98)	156.7
Strathmore Avenue Assessment Area	
Strathmore Avenue (337)	115.4
Strathmore (353)	124.7
Strathmore Avenue (Wellgate)	132.1

Calculation of the %Average Difference Between Modelled v Monitored NO_2

Annual Mean Concentrations ($\mu g/m^3$)	Conversion of Modelled Total NOx to NO_2 using TG(03)	[Modelled NO_2 – monitored NO_2]/monitored NO_2 x 100
Dundee Central Assessment Area		
Whitehall Crescent (Expresso)	47.9	54.9
Whitehall Street (BRJ)	38.1	5.0
Dock Street (14)	52.6	13.3
Seagate (Yates 7-9)	48.5	13.7
Commercial Street (Waterstones)	50.3	28.9
Commercial Street /Dock Street	41.4	-14.1
Dock Street (Unicorn)	37.1	-5.5
St Andrews Street DD	35.4	-1.1
St Andrews Street JAF	36.6	-5.6
Seagate (Bond triplicate)	49.0	24.8
Seagate	43.9	-8.3
Victoria Road/Hilltown	63.6	5.0
Victoria Road	36.2	-10.6
Union Street Rollalong	40.7	0.3
Union Street (Goodfellows)	39.9	3.1
Union Street (McIntyres)	41.7	12.0
Nethergate (Trades House)	40.2	-5.3
Whitehall Street (Deb A)	46.5	-3.3
Whitehall Street (BUS)	43.9	-11.0
Whitehall Street (TISO)	34.8	-11.2
Whitehall Street (BBB triplicate)	35.1	-11.5
Nethergate B&B	40.5	-7.3
Nethergate/Marketgait	39.8	14.7
Nethergate (Charlie T)	43.9	-8.0
Whitehall Street (DEB E)	46.3	14.7
Lochee Road/Logie Street Assessment Area		
Loons Road	49.9	21.6
Lochee Road (184)	47.1	28.3
Lochee Road (164)	49.2	-2.3
Lochee Road (140)	46.1	-15.0
Lochee Road/Polepark Road	33.6	3.1
Logie Street (114)	43.5	-18.9
Muirton Road (6)	34.2	4.3
Logie Road (98)	43.1	10.8
Strathmore Avenue Assessment Area		
Strathmore Avenue (33)	37.2	-0.9
Strathmore (353)	38.7	-9.5
Strathmore Avenue (Wellgate)	39.7	15.5

The method described above has been applied to all modelled concentrations of NOx at receptors in the study area to convert to NO_2.

APPENDIX 4 METEOROLOGICAL DATA ANALYSIS

The table below shows the verified modelled NO_2 results and roads NOx correction factors at Dundee central monitoring sites using three year's meteorological data from Leuchars meteorological station. The comparison shows that the model is not very sensitive to the year of meteorological data and the average roads NOx correction factor would be the same for all years.

		Modelled NO_2 2003 (including background NO_2)			**Roads NO_X Correction Factor**		
Location	**Monitored NO_2 2003**	**2001 Leuchars met data**	**2002 Leuchars met data**	**2003 Leuchars met data**	**2001 Leuchars met data**	**2002 Leuchars met data**	**2003 Leuchars met data**
Whitehall Crescent (Expresso)	30.9	47.8	48.1	47.9	1.4	1.4	1.4
Whitehall Street (BRJ)	36.3	37.7	38.7	38.1	4.1	3.9	4.0
Dock Street (14)	46.4	53.0	52.2	52.6	3.3	3.4	3.4
Seagate (Yates 7-9)	42.6	48.3	48.9	48.5	3.3	3.3	3.3
Commercial Street (Waterstones)	39.0	50.4	50.3	50.3	2.4	2.4	2.4
Commercial Street /Dock Street	48.2	41.1	41.5	41.4	6.9	6.8	6.8
Dock Street (Unicorn)	39.3	36.5	37.8	37.1	5.7	5.1	5.4
St Andrews Street DD	35.8	35.3	35.7	35.4	4.8	4.7	4.8
St Andrews Street JAF	38.8	36.5	36.9	36.6	5.4	5.3	5.4
Seagate (Bond triplicate)	39.3	49.0	49.3	49.0	2.6	2.6	2.6
Seagate	47.9	44.3	43.4	43.9	5.6	5.9	5.8
Victoria Road/Hilltown	60.6	64.0	63.2	63.6	4.0	4.1	4.0
Victoria Road	40.5	37.3	35.1	36.2	5.7	6.8	6.3
Union Street Rollalong	40.6	40.8	40.5	40.7	5.3	5.4	5.3
Union Street (Goodfellows)	38.7	39.8	40.2	39.9	4.3	4.2	4.3
Union Street (McIntyres)	37.2	41.6	42.1	41.7	3.4	3.3	3.4
Nethergate (Trades House)	42.4	40.5	39.7	40.2	5.2	5.5	5.3
Whitehall Street (Deb A)	48.1	46.4	46.5	46.5	5.0	5.0	5.0
Whitehall Street (BUS)	49.3	43.7	44.0	43.9	6.3	6.2	6.2
Whitehall Street (TISO)	39.2	34.7	35.0	34.8	6.5	6.3	6.4
Whitehall Street (BBB triplicate)	39.6	34.9	35.1	35.1	6.5	6.4	6.5
Nethergate B&B	43.7	41.2	39.7	40.5	5.4	5.9	5.6
Nethergate/Marketgait	34.7	40.7	38.9	39.8	3.0	3.4	3.2
Nethergate (Charlie T)	47.7	44.4	43.5	43.9	5.5	5.9	5.7
Whitehall Street (DEB E)	40.4	46.0	46.8	46.3	3.3	3.2	3.3
				Average	**4.6**	**4.6**	**4.6**

REPORT STATEMENT

Casella Stanger completed this report on the basis of a defined programme of works and within the terms and conditions agreed with the Client. This report was compiled with all reasonable skill and care, bearing in mind the project objectives, the agreed scope of works, prevailing site conditions and degree of manpower and resources allocated to the project as agreed.

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