

7 Glossary

If the term you are looking for is not included in this glossary, further terms can be found at the California Air Resources Board, Glossary of Air Pollution Terms web page (www.arb.ca.gov/html/gloss.htm).

Advection	Transport of pollutants by the wind
Airshed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Assessment of environmental effects	A piece of expert advice submitted to regulators to support a claim that adverse effects will or will not occur as a result of an action, and usually developed in accordance with section 88 of the Resource Management Act 1991
Atmospheric chemistry	The chemical changes that gases and particulates undergo after they are discharged from a source
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Building wakes	Strong turbulence and downward mixing caused by a negative pressure zone on the lee side of a building
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Complex terrain	Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows
Configuring a model	Setting the parameters within a model to perform the desired task
Convection	Vertical movement of air generated by surface heating
Convective boundary layer	The layer of the atmosphere containing convective air movements
Data assimilation	The use of observations to improve model results – commonly carried out in meteorological modelling
Default setting	The standard (sometimes recommended) operating value of a model parameter
Diagnostic wind model (DWM)	A model that extrapolates a limited amount of current wind data to a 3-D grid for the current time. It is the ‘now’ aspect, and makes the model ‘diagnostic’.
Diffusion	Clean air mixing with contaminated air through the process of molecular motion. Diffusion is a very slow process compared to turbulent mixing.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Dispersion coefficients	Variables that describe the lateral and vertical spread of a plume or a puff
Dry deposition	Removal of pollutants by deposition on the surface. Many different processes (including gravity) cause this effect.

Eddies	Small-scale turbulent disturbances contained within a larger air flow
Elevated receptors	Receptors that are on the ground but above the level at which the contaminants are released
Emission factors/models	A method used to calculate the amount of emissions that a particular source will release
Emission rates	The rate at which contaminants are discharged from a particular source
Emission temperature	The temperature of the gas stream that carries the contaminants from the source
Eulerian dispersion model	The pollution distribution is described by changing concentrations at discrete points on a fixed grid
Exit velocity	The velocity at which the exhaust gases leave a stack
Far field	Locations more than about 10 km from the source region
Flagpole receptors	Receptors that are located on structures above ground level
Fumigation	The process whereby pollutants held above an inversion layer are transferred back to ground level during the break-up of the inversion
Gaussian plume	A plume within which the pollutants are distributed vertically and horizontally in a Gaussian (or normal) manner about the plume centreline
Inversion	The situation where temperature increases with height; a highly stable condition in which vertical dispersion is suppressed and pollution is trapped
Katabatic flows	Downslope flow at night due to the air on the slope being cooler than the air at the same altitude away from the slope. The horizontal temperature gradient induces the downslope flow.
Lagrangian model	The pollution distribution is described by a set of discrete particles or puffs, which are labelled by their changing location (i.e. their trajectories are followed)
Macro-scale	Large spatial scale, 1000 km plus
Mechanical momentum	The upward (or otherwise) force a stream of gas exerts due to the velocity with which it leaves the point of discharge
Mesoscale	Medium spatial scale, 5 – 100 km
Micro-scale	Small spatial scale, less than 5 km
Mixing height	The height in the atmosphere to which pollutants released at the surface can be mixed by turbulent eddy motion
Model performance	A measure of a model's ability to reliably predict pollutant concentrations
Model sensitivity	The scale to which model predictions change when the value of a particular input parameter is changed
Model validation	The process used to demonstrate that a model produces reliable output
Modelling domain	The area over which the model is making predictions
Near field	The area close to the source, usually within a few km
Orographically driven flows	Winds driven by the relief of mountains and hills
Plume depletion	The removal of pollutants from a plume by gravity or chemical reaction
Plume rise	The height to which a plume rises above its release point due to its initial momentum and thermal buoyancy

Polar grid	A receptor grid defining a group of points located on a series of concentric circles, which are usually centred on the source
Prognostic model	A meteorological model which solves fully time-dependent equations, predicting the future from a known current state
Receptor	The location at which modelled concentrations need to be calculated
Radiosonde	Instruments suspended beneath a balloon to sense and relay temperature, humidity and pressure as the balloon ascends through the (whole) atmosphere
Screening	A model run that aims to calculate the highest concentration that might occur, but gives no information on the frequency or location of the event
Screening meteorological data	A synthetic data set that contains combinations of meteorological variables which include all possible atmospheric conditions (without saying how likely each would be to occur)
Sensitivity analysis	The process of establishing the effect of changing the value of an input variable on model output
Simple terrain	Terrain that will not influence larger-scale wind flows nor has receptors at a height greater than the release height of the pollutants
Slope flows	Air flows generated up or down hillsides by surface heating or cooling
Stability classification scheme	A simplified method of categorising the amount of turbulent mixing in the atmosphere
Stack-tip downwash	The small downward movement of a plume as it leaves a stack caused by a negative pressure zone on the lee side of the stack
Steady-state dispersion model	The Gaussian-plume; a mathematical solution to the dispersion equation, which is independent of time
Surface roughness length	A parameter needed in boundary calculations. Surface roughness increases the vertical mixing of an air stream due to enhanced mechanical turbulence generated as the air moves over surface features.
Thermal buoyancy	The buoyancy of a plume generated by the temperature difference between the exhaust gas and the ambient air
Turbulence	Small-scale (random) atmospheric motions that tend to mix pollutants through the air
Upper air data	Meteorological data that are collected above the height of a meteorological tower
Wet deposition	Removal of pollutants through scavenging by falling raindrops
Wind direction shear	A tendency for wind direction to turn with height
Wind field	The set of vectors that describe wind speed and direction conditions over a particular modelling domain at a particular hour
Wind speed profile	A measure of the rate at which wind speed increases with height above a surface

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Appendix A: Pasquill Turbulence Types

Table A1: Meteorological conditions defining Pasquill turbulence types*

Surface wind speed m/s	Daytime insolation			Night-time conditions**	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	≤ 3/8 cloudiness
< 2	A	A-B	B		
2-3	A-B	B	C	E	F
3-4	B	B-C	C	D	E
4-6	C	C-D	D	D	D
> 6	C	C	D	D	D

Key: A: Extremely unstable; B: Moderately unstable; C: Slightly unstable; D: Neutral[#]; E: Slightly stable; F: Moderately stable.

Notes :

* From FA Gifford, 1976, Turbulent diffusion-typing schemes: A review, *Nuc. Saf* 17(1): 71.

Applicable to heavy overcast day or night.

** The degree of cloudiness is defined as that fraction of the sky above the local apparent horizon that is covered by clouds.

Appendix B: Site-specific Meteorological Data Sets

Table B1 contains a list of site-specific meteorological data sets that have been generated for use in New Zealand. This list is not definitive and is intended only to be a guide to the number and type of data sets that have been developed in New Zealand.

As noted in section 6 of this guide, the meteorological data are a critical input into any dispersion modelling study. It is therefore very important that the modeller is satisfied that any particular meteorological data set contains good-quality information and has been produced using standard/recommended methods. For this reason the data sets listed here have been classified into one of two categories.

Classification A

Meteorological data sets that have been:

- produced using recommended methods outlined in section 6
- subjected to peer review
- employed in a relatively large number of studies and resource consent applications.

Class A meteorological data sets are generally considered appropriate and robust for most applications in the relevant site.

Classification B

Meteorological data sets that have been:

- produced using a variety of methods, some standard some non-standard
- subject to limited or no peer review
- used for a small number of specialised applications.

The limitations of Class B meteorological data sets should be carefully considered before using them in a particular study. It may be helpful to justify your selection of the data set in the study's methodology.

Table B1: Site Specific Meteorological Data Sets Available

Location	Year	Model application	Classification	Contact
Auckland	1978	AUSPLUME	A	NIWA
Auckland	1996	AUSPLUME	A	NIWA
Christchurch	1979	AUSPLUME	A	ECAN
Christchurch	1991	AUSPLUME	A	ECAN
Christchurch	1997–98	AUSPLUME ISC3	A	ECAN
Auckland	1997 and 1999	CALPUFF AUSPLUME TAPM	B	NIWA
Auckland (Henderson)	1996	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Auckland (North Shore)	1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Awatoto	1995	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Blenheim	1997	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Christchurch	1997 and 1998	CALPUFF TAPM	B	NIWA
Christchurch (Hornby)	1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Gisborne	1995	AUSPLUME	B	NIWA
Hamilton	1997-1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Invercargill	1998	AUSPLUME	B	NIWA
Invercargill	1998-1999	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Kaitaia	1988	AUSPLUME	B	NIWA
Kaitaia	1988-1999	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Kawerau	1996-1997	CALPUFF	B	NIWA
Keri-Keri	1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Levin	1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Lower Hutt	1994-95	AUSPLUME	B	NIWA
Marsden Point	1989	AUSPLUME/ CDTMPLUS	B	NIWA
Napier	1999	CALPUFF AUSPLUME	B	NIWA
Nelson	2000	AUSPLUME CALPUFF	B	NIWA
Palmerston North	1996	AUSPLUME	B	NIWA

Location	Year	Model application	Classification	Contact
Palmerston North	2000	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
New Plymouth	1996	AUSPLUME	B	NIWA
Paraparaumu	1997-1998	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Rotorua	1996	AUSPLUME	B	NIWA
Scott Base	1990	CALPUFF	B	NIWA
Stratford	2000	TAPM AUSPLUME	B	NIWA
Tauhara (Taupo)	1998	ASUPLUME	B	NIWA
Tauranga	1999	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Wanganui	2000	AUSPLUME ISC3	B	Terry Brady Consulting Ltd
Wellington	2000-2001	AUSPLUME CALPUFF	B	NIWA WRC
Wellington (Moa Point)	2000	CALPUFF AUSPLUME	B	NIWA
Westport	1998	AUSPLUME ISC3	B	Sinclair Knight Merz
Whitianga	1996	AUSPLUME ISC3	B	Terry Brady Consulting Ltd

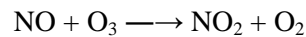
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Appendix C: Estimation of Nitrogen Dioxide Concentrations from Modelled NO_x

C1 Introduction

Nitrogen oxides are emitted mainly in the form of nitric oxide (NO), but once released into the atmosphere are oxidised to the more toxic nitrogen dioxide (NO₂). The predominant short-term transformation process is the reaction of nitric oxide with ambient ozone to form nitrogen dioxide:



Since the reaction is a 1 to 1 transformation that does not affect total NO_x concentrations, the maximum extent of conversion of NO to NO₂ that can be expected in the emission plume is directly related to the maximum ambient concentration of ozone. Photo-dissociation of NO₂ to re-form NO and ozone decreases the concentrations of NO₂ to some degree, but is ignored here.

Ozone concentrations in air coming off the ocean are quite reproducible and show a seasonal variation, with the highest concentrations occurring during winter, at about 35 ppb at the Baring Head site. Summer concentrations are about 20 ppb. The maximum ozone concentration is sufficient to produce 72 µg/m³ of nitrogen dioxide by oxidation of nitric oxide. This information provides the basis for a simple method for calculating generally conservative estimates of nitrogen dioxide concentrations from modelled NO_x concentrations.

C2 Relationship to the US EPA Ozone Limiting Method

This method of calculating nitrogen dioxide concentrations is related to the Ozone Limiting Method (OLM) available from the US EPA SCRAM website. The OLM describes only the modelling or calculation of annual average nitrogen dioxide concentrations, presumably because the US National Ambient Air Quality Standards include only an annual average standard of 100 µg/m³ for nitrogen dioxide. However, the most sophisticated approach described under the OLM does use one-hour average modelling, together with one-hour average meteorological, ozone and nitrogen dioxide data, to calculate annual averages.

The OLM model requires simultaneously recorded one-hour average meteorological data, ozone and nitrogen dioxide concentrations extending over at least one year, with at least 90% valid data. Apart from the expense of obtaining such information at a single location, there are significant problems in locating the monitoring site relative to existing emission sources and the proposed new emission source. The US EPA guidance recommends two or more monitoring sites because of the perceived difficulty of accounting for scavenging of ozone by nitric oxide.

The method described here avoids the difficulties perceived in the OLM, and the ozone and NO_x monitoring requirement, by recognising that for a small island country such as New Zealand, significant photochemical production of ozone is relatively rare at most locations and will seldom need to be taken into account when considering the local effects of NO_x emissions. The combination of this situation with the stable, but seasonally varying, concentrations of ozone in air moving onto New Zealand off the oceans means that realistic, but conservative, estimates of concentrations can be based on these ozone concentrations, the total NO_x

concentration at the site under consideration and the percentage of nitrogen dioxide in the NO_x in emissions affecting that site.

C3 The calculation methodology

For cumulative NO_x concentrations less than 80 µg/m³ (expressed as nitrogen dioxide) all of the NO_x is considered to be present as nitrogen dioxide. The 80 µg/m³ corresponds to 8 µg/m³ of nitrogen dioxide resulting from a default percentage of 10% of nitrogen dioxide in emitted NO_x plus 72 µg/m³ of nitrogen dioxide formed by oxidation of nitric oxide by ozone.

For cumulative NO_x concentrations above 80 µg/m³, the nitrogen dioxide concentrations are calculated as follows:

$$[\text{NO}_2]_{\text{cum max}} = 72 + [\text{NO}_x]_{\text{bkgrd tot}} \times \% \text{NO}_2 \text{ bkgrd} + [\text{NO}_x]_{\text{emiss}} \times \% \text{NO}_x \text{ emiss}$$

where:

- $[\text{NO}_2]_{\text{cum max}}$ is the maximum estimate of total cumulative NO₂ from both background NO_x and the additional emission under consideration
- $[\text{NO}_x]_{\text{bkgrd tot}}$ is the total background NO_x concentration in the receiving air
- $\% \text{NO}_2 \text{ bkgrd}$ is the percentage of nitrogen dioxide in the NO_x emitted from the sources contributing to the background levels of NO_x
- $[\text{NO}_x]_{\text{emiss}}$ is the concentration of NO_x at the receptor originating from the emission
- $\% \text{NO}_x \text{ emiss}$ is the percentage of nitrogen dioxide in the NO_x emitted from the source under consideration.

If either $\% \text{NO}_2 \text{ bkgrd}$ or $\% \text{NO}_x \text{ emiss}$ are not known, the default percentage of 10% used in the OLM is probably the best (although often highly conservative) choice.

If the percentages of nitrogen dioxide in the emissions are not known, or happen to be 10%, the expression above simplifies to:

$$[\text{NO}_2]_{\text{cum max}} = 72 + [\text{NO}_x]_{\text{cum tot}} \times 10\%$$

where:

- $[\text{NO}_x]_{\text{cum tot}}$ is the cumulative total NO_x concentration including both background NO_x and the NO_x concentration increment at the receptor resulting from the emission under consideration.

C4 Common situations resulting in conservative predictions

There are common situations where these calculations give substantial overestimates of nitrogen dioxide concentrations, including:

- during the day, when the photochemical equilibrium reverses the oxidation of nitric oxide by ozone to some degree
- during stable atmospheric conditions, particularly at night, when both nitrogen dioxide and ozone are removed by reaction with vegetation and other surfaces.

C5 Validation against monitoring data

Use of this method to calculate nitrogen dioxide concentrations from NO_x concentrations measured at several monitoring sites in both Auckland and Christchurch shows that taking the percentage of nitrogen dioxide in NO_x emissions contributing to the measured concentrations as 10% is highly conservative and that 5% still predicts nitrogen dioxide concentrations higher than any reliable measured concentrations. This may reflect the combined effect of the true percentage of nitrogen dioxide in NO_x emissions being less than 10%, together with scavenging of both nitrogen dioxide and ozone by vegetation, plus the photochemical equilibrium.

C6 Caution re application of the method to some types of locations

The Khyber Pass site in Auckland is unique among New Zealand NO_x monitoring sites in that nitrogen dioxide concentrations measured there quite frequently exceed the predictions using this method. After 7 pm and before 7 am, there are only a few hourly averages during the year when the measured nitrogen dioxide concentrations exceed those predicted using 10% as the percentage of nitrogen dioxide in NO_x emissions, and essentially no measured concentrations exceed those predicted using 15%. However, during the remainder of the day, there are a considerable number of measured concentrations that exceed those predicted using 15% as the percentage of nitrogen dioxide in NO_x emissions. This is in marked contrast to both the Penrose and Takapuna monitoring sites, both of which are dominated by traffic emissions, as is the Khyber Pass site, but which show few if any measured concentrations exceeding those calculated using 5% of nitrogen dioxide in NO_x emissions.

The frequent, unusually high nitrogen dioxide concentrations at the Khyber Pass site may be associated with some of the following features of the site:

- the kerbside location alongside an uphill queue for traffic lights, with uphill exits in all directions
- the absence of any vegetation between the location of the emissions and the monitoring intake
- the relatively confined nature of the location, which may mean that relatively high concentrations of both reactive organic compounds and NO_x from vehicle emissions may move away only slowly, so that there may be the possibility of photochemical reactions (this is consistent with most of the unexpectedly high nitrogen dioxide concentrations occurring during the day)
- the proximity of the site to the busiest section of the northern motorway, which may also contribute to relatively long residence times of high concentrations of reactive organic compounds and NO_x in the area
- the relatively high proportion of diesel vehicles among the traffic flow, which may emit high percentages of nitrogen dioxide in NO_x emissions at idle, immediately adjacent to the monitoring intake, while waiting for the traffic lights.

The calculation method described here should be used only with great caution at locations where NO_x concentrations originate predominantly from vehicle emissions and which share some of the other features described above for the Khyber Pass site. Ideally, some monitoring data should be obtained to determine whether unexpectedly high concentrations occur at these locations.

Appendix D: Sources of Helpful Information

Source	Provider or publisher	Material	Website or author
Technology Transfer Network TTNWeb	Office of Air Quality Planning and Standards (US EPA)	Collection of related Web sites containing information about many areas of air pollution science, technology, regulation, measurement and prevention.	http://www.epa.gov/ttn/direct.html To search the TNN Web: http://www.epa.gov/ttn/ttn_search.html
Clearinghouse for Inventories and Emission Factors (CHIEF)	US EPA	Emission factor and inventory information, tools and software, publications, conference proceedings, related sites	http://www.epa.gov/ttn/chief/
Support Centre for Regulatory Air Models (SCRAM)	US EPA	Modellers forums, FAQs, model code and support, conference proceedings, related sites	http://www.epa.gov/ttn/scram/
Modelling Helpdesk	Casella-Stanger and Department for Food Environmental and Rural Affairs (DEFRA) UK	FAQs, toolkits and reports	http://www.casellastanger.com/JointProjects/DEFRA-Home.asp?jointprojectid=7
Air Quality, Emissions, and Modelling	California Air Resources Board	Emissions inventories and air quality models, and glossary of terms	http://www.arb.ca.gov/html/aeq&m.htm Glossary of terms found at: http://www.arb.ca.gov/html/gloss.htm
Air Quality Modelling Forum	Western Region Air Partnership (WRAP) (US)	WRAP aims to develop data, tools, and policies needed to improve air quality	http://www.wrapair.org/forums/aqmf/index.html
Model Documentation System	European Topic Centre on Air and Climate Change	Aims to provide guidance to any model user in the selection of the most appropriate model for a specific application	http://air-climate.eionet.eu.int/databases/mds.html
TAPM	CSIRO	Description, documentation, availability and support for TAPM	http://www.dar.csiro.au/tapm/
CALMET-CALPUFF	Earthtech	Description, documentation, availability and support for CALMET and CALPUFF	http://www.src.com/calpuff/calpuff1.htm
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes	National Environmental Research Institute Denmark	Workshop and conference proceedings, model validation kit, tools for dispersion modelling	http://www.harmo.org/
Open Directory	Open Project Directory	Comprehensive and interesting list of air quality modelling resources	http://dmoz.org/Science/Environment/Air_Quality/Air_Dispersion_Modeling/Software/
National Climate Database	NIWA	New Zealand's national repository of high-quality climate data	http://www.niwa.co.nz/services/clidb
Terralink	Terralink International	Provider of land information	http://www.terralink.co.nz/

Source	Provider or publisher	Material	Website or author
Handbook on Atmospheric Diffusion	Technical Information Center, US Department of Energy	Textbook	Hanna SR, Briggs GA, Hosker RP, 1982. Prepared for the Office of Health and Environmental Research, Office of Energy Research, US Department of Energy Document number DOE/TIC-11223 (DE82002045)
Fundamentals of Atmospheric Modelling	Cambridge University Press, Cambridge UK.	Textbook	Jacobson MZ, 1999 ISBN 0521637171
Workbook of Atmospheric Dispersion Estimates	National Technical Information Service, Springfield VA, USA	Textbook	Turner DB, 1970
Fundamentals of Stack Gas Dispersion (Ed 3)	Milton R Beychock, 2233 Martin Street, Unit 205, Irvine, CA92612	Textbook	Beychock MR, 1994 ISBN 0-9644588-0-2
Turbulence and Diffusion in the Atmosphere, Lectures in Environmental Sciences	Springer	Textbook	Blackadar AK, 1996 ISBN 3-540-61406-0
Atmospheric Dispersion Modelling Compliance Guide	McGraw-Hill	Textbook	Schnelle KB, Dey PR, 2000 ISBN 0-07-058065-0
Modelling Special Interest Group (ModSIG)	Clean Air Society of Australia and New Zealand	The primary purpose of ModSIG is to bring together CASANZ members who have an interest in the development and/or application of air quality models	http://www.casanz.org.au/