

Guide to Air Pollution Modelling

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Air, Odour and Noise Sciences, Environmental Sciences Branch, Science Division

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| Guide to Air Pollution Modelling |



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Executive summary

The introduction of EPA’s General Environmental Duty (GED) on 1 July 2021 increased public awareness of issues pertaining to air quality. Air dispersion models are essential tools for assessing air pollution impacts resulting from industrial activities. Because of their complexity, dispersion models require proper use with carefully selected input data to obtain meaningful and accurate results.

**EPA Publication 1957 - Guide to Air Pollution Modelling** provides guidance for Air Pollution Impact Assessments (APIA) required by Victoria’s Environment Protection Authority (EPA) for licence approvals and other regulatory purposes within the state. The guidance provides best-practice guidelines for modelling practitioners who are involved in conducting air dispersion modelling of discharges to air in Victoria.

The guidance combines previous EPA Publications 1550 and 1551, provides updated guidance, and clarifies areas of uncertainty for practitioners submitting APIAs to EPA. It should be read in conjunction with the guideline for assessing and minimising air pollution in Victoria (EPA publication 1961) and Appendix W of USEPA Guideline on Air Quality Models (USEPA, 2017).

As AERMOD (American Meteorological Society and U.S. Environmental Protection Agency Regulatory Model) is EPA’s approved regulatory model in Victoria, this guideline is focused on the adoption of best-practices based on the United States Environment Protection Agency (USEPA) AERMOD model guidance. However, depending on the type of project and subject to prior permission granted by EPA, the information presented in this guideline can also be applied to other models. Information on the use of alternative models is provided in Section 8 of this document.

It is acknowledged that dispersion models are not perfect tools. They require proper use with carefully selected input data to obtain meaningful and accurate results. Therefore, the guideline presents practical advice on:

* choice of input parameters
* specification of emissions
* preparation of representative meteorological data
* preparation of terrain data
* choice of model options, and
* analysis of model results.

The guideline also provides information on sensitivity analysis and reporting.

Glossary of terms

**Albedo**: The ratio of light that is received by a body to that reflected by it.

**Algorithm**: A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer.

**Atmospheric dispersion model**: A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere.

**Background air concentration**: Concentration of air pollution at any one location which is not directly affected by local activities, or specific identified sources.

**Bowen ratio**: The ratio of heat that results in temperature change (sensible heat) to heat that does not result in temperature change (latent heat).

**Building downwash effects**: Strong turbulence and downward mixing caused by a negative pressure zone on the lee side of a building.

**Cartesian grid**: A coordinate system whose axes are straight lines intersecting at right angles.

**Complex terrain**: Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows.

**Cumulative impacts**: A quality impacts from total concentration of a pollutant in air (that is, resulting from all sources of the pollutant).

**Default setting**: The standard (sometimes recommended) operating value of a model parameter.

**Dispersion**: The spreading of concentration of pollutants over a larger area by the combined processes of advection and diffusion.

**Emission rates**: The rates at which contaminants are discharged from a particular source.

**Exit velocity**: The velocity at which the exhaust gases leave a stack.

**Incremental effects**: Air quality impacts from concentration of a pollutant in air resulting from the activity being assessed, ignoring any existing background concentrations.

**Mixing height**: The height in the atmosphere to which pollutants released at the surface can be mixed by turbulent.

**Model performance**: A measure of a model's ability to reliably predict pollutant concentrations.

**Modelling domain**: The area or receiving environment over which the model is making predictions.

**Polar grid**: A receptor grid defining a group of points located on a series of concentric circles, which are usually centred on the source.

**Pollutant**: A substance associated with pollution or waste that has the potential to cause harm to human health or the environment through physical, chemical, biological or other hazardous properties.

**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.

**Screening**: A model run that aims to calculate the highest concentration that might occur but provides no information on the frequency or location of the event.

**Sensitivity analysis**: The process of establishing the effect of changing the value of an input variable on model output.

**Sigma theta**: The standard deviation of horizontal wind direction fluctuation at the current level (degrees).

**Simple terrain**: A terrain (often flat) that will not influence larger-scale wind flows nor has receptors at a height greater than the release height of the pollutants.

**Steady-state plume model**: Often for a Gaussian-plume, this is a mathematical solution to the dispersion equation, which is independent of time.

**Surface roughness**: A characteristic of the ground surface associated with its efficiency as a momentum sink for turbulent flow. This is an important parameter for determining the rate of air pollution dispersion and is used in dispersion modelling.

**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.

**Wake effects**: Turbulence and downward mixing caused by a negative pressure zone on the lee side of an obstacle such as a building.

Acronyms and abbreviations

AEST Australian Eastern Standard Time

AQI Air quality index

AERMAP AMS/EPA Regulatory Model Terrain Pre-processor

AERMET AERMOD meteorological pre-processor

AERMODAmerican Meteorological Society/EPA Regulatory Model

APAC Air pollution assessment criteria

APIA Air pollution impact assessments

AUSPLUME Australian plume dispersion model

CALMET California Meteorological Model

CALPUFF California Puff model

DEM Digital Elevation Model

GED General environmental duty

NATA National association of testing authorities

NED National Elevation Dataset

PRIME Plume Rise Model Enhancements

SRTM Shuttle Radar Topography Mission

TAPM The Air Pollution Model

USGS US Geological Survey

WRF Weather Research and Forecasting Model

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# Introduction

Air dispersion models are essential tools for assessing air pollution impacts which can result from pollutant discharge to air from industrial activities. However, due to their complexity, dispersion models require proper use with carefully selected input data to obtain meaningful and accurate results.

The Guideline for assessing and minimising air pollution in Victoria (EPA publication 1961) sets out a framework for assessing risks to the environment and human health from air emissions. It also details new air quality assessment criteria, which replaces the design criteria in the State Environment Protection Policy for Air Quality Management (SEPP AQM). The determination of concentrations that are assessed against these criteria is to be carried out using the EPA’s approved AERMOD regulatory model.

## Purpose of the guide

The purpose of this guideline is to provide modelling guidance for Air Pollution Impact Assessments (APIA) required by EPA for license approvals and other regulatory purposes in Victoria. It is to be used in conjunction with EPA publication 1961.

## Intended audience

This guideline is primarily intended for technical specialists and air practitioners seeking to conduct or review air pollution impact assessments for EPA-approved projects in Victoria.

## Overview

An outline of this guideline is presented as follows:

*Section 1* presents the background information, purpose and intended audience.

*Section 2* presents a brief description of EPA’s approved regulatory model, AERMOD.

*Section 3* presents a description of the recommended preparation of emissions data.

*Section 4* presents a description of the recommended preparation of meteorological data.

*Section 5* presents a description of the recommended preparation of terrain data.

*Section 6* presents information on AERMOD setup options, including selection of domain size and resolution, modelling of area/volume sources and other options.

*Section 7* presents a description of the use of background data for assessing cumulative impacts.

*Section 8* presents information on the use of alternative models.

*Section 9* presents a discussion of sensitivity and risk control analyses.

*Section 10* presents reporting requirements.

*Appendix* presents a step-by-step guideline of how to prepare AERMOD model input data.

# About AERMOD: EPA’s approved regulatory model

AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts. This model includes treatment of both surface and elevated sources, and both simple and complex terrain (Cimorelli *et al*., 2003, Perry *et al.*, 2005).

Following its development in 1995, the model was declared by the United States Environment Protection Agency (USEPA) in 2000 as a replacement of the Industrial Source Complex model (ICS3). AERMOD became EPA Victoria’s approved regulatory model in October 2013, replacing the AUSPLUME gaussian dispersion model.

AERMOD is normally used as part of a modelling system comprising of three components:

* AERMOD (dispersion model)
* AERMET (meteorological pre-processor)
* AERMAP (terrain pre-processor).

The basic source and executable codes for the latest approved version of AERMOD (currently version 21112 as of September 2021) and its component pre-processors can be downloaded at no cost from the [USEPA web site](http://www.epa.gov/scram). There are also several commercial software packages with closed source code marketed by third-party vendors. These software packages include the following features:

* Proprietary Graphical User Interfaces (GUIs) designed to facilitate setting up the inputs for the model and/or analysing the model results, with often no changes to the AERMOD dispersion model kernel that is used by, or embedded within, the GUI.
* Proprietary software marketed as optimised versions of AERMOD that can provide the benefit of reduced runtimes from parallel processing using multiple processors.
* Integrated packages where AERMOD is one of a suite of models and tools.

EPA will approve the use of any of these packages, provided the basic AERMOD source code has not been modified. The USEPA memorandum [Clarification on Regulatory Status of Proprietary Versions of AERMOD](https://www.epa.gov/scram/air-quality-models-clarification-memos-dispersion-models) (addresses the regulatory status issues of these proprietary software packages, and includes the requirement to use test cases to demonstrate equivalency with the approved version.

AERMOD evolves to accommodate the best available science, therefore it is the responsibility of the user to ensure that the latest approved version is used. If in doubt, the user is encouraged to check with EPA.

# Preparation of emissions data

Once the appropriate emission sources have been identified as per Section 3.4.1 of EPA publication 1961 (EPA 2021), they need to be quantified and prepared so that they can be used by AERMOD. The following information is required to be provided, along with the final modelling results in a table:

* Identification of source release type (Section 3.1)
* Source release parameters (Section 3.2)
* Estimate of emission rate (Section 3.3)
* Quality of emission rate (Section 3.4)

## Identification of emission type

The emission source type can be one of the following (see Section 6.3):

* Point sources: Discharges from stacks and vents.
* Line sources: The main source in this category is roadways, but can include any source of discharges that is spread along a line of more than a few tens of metres.
* Area sources: Typically, areas of more than a few tens of metres in either direction, such as wastewater ponds, landfill gas, and dust from open areas.
* Volume sources: Less commonly used, and not frequently observed as industrial discharges, these are sources that create contaminants within a volume, rather than a point, area, or line. They are used for secondary pollution formulation or for specific buildings with multiple discharge points. The use of volume sources in Section 6.3, rather than area sources, is to be noted.
* Fugitive emissions: These are the combination of all other sources that are not individually identified. Because of this, fugitive emissions can be hard to measure and therefore difficult to assess. Often presenting as leaks or emissions through gaps and cracks in walls and containers, they can sometimes be the most significant source for a site. These are often represented as volume sources.

## Determination of source release parameters

Having identified the source type, the next step is to specify the source release parameters. These are typically obtained from site-specific data for existing premises, or from engineering drawings for new projects. The release parameters required depend on the emission type.

For point sources, the source parameters are measured in International Standard of Units (SI), and include:

* emission rate (g/s)
* gas exit temperature (K)
* stack diameter (m)
* stack height (m)
* exit velocity (m/s)
* location - X and Y coordinates (m).

For area sources, the source parameters include:

* emission rate (g/s)
* length of X, Y sides (m)
* orientation of angle from north (degrees)
* initial vertical dimension (m)
* location - X and Y coordinates (m).

For volume sources, the source parameters include:

* emission rate (g/s)
* length of side (m)
* initial lateral and vertical dimensions (m)
* X and Y coordinates (m).

## Estimation of emission rates

The emission rate of a pollutant — usually stated in g/s — and the source of the emission rate is to be clearly defined as part of the modelling report. There are several sources that can be used to estimate emissions data. These may include, but are not limited to, the following:

* Measurements from the project (or similar) source
* Manufacturer specifications or process information
* Published data, for example, USEPA’s Air Pollution compilation factors (AP-42) database
* Regulatory authority files and data (see Section 3.4.3)
* Emission models.

## Quality of emission rates

While it is reasonable to assume that a measurement from the project (or similar source) is likely to provide the best estimate of a pollutant emission rate, this may not always be the case. In addition to the source of the emission rate, modelling reports should include an assessment of the quality of the emission rate. A rating similar to the USEPA AP-42 scale is to be used as follows:

* A-rated emissions factors are calculated using highly rated source test data from many randomly chosen tests or facilities in the industry. The source category population is sufficiently specific (for example, regarding fuel type) to minimise variability. A-rated factors are considered excellent.
* B-rated emissions factors are calculated using highly rated source test data from a reasonable number of tests or facilities. It is not clear whether the tests or facilities tested represent a random sample of industry. As with A-rated factors, the source category is sufficiently specific to minimise variability. B-rate factors are considered above average.
* C-rated emission factors are calculated using source test data from a reasonable number of tests or facilities. It is not clear whether the tests or facilities tested represent a random sample of industry. As with A and B-rated factors, the source category is sufficiently specific to minimise variability. C-rated factors are considered average.
* D-rated emission factors are calculated using source test data from a small number of tests or facilities. There may be reason to suspect that the tests or facilities tested do not represent a random sample of industry. There may also be evidence of variability within the source population. D-rated factors are considered below average.
* E-rated emission factors are calculated using source test data that has been rated poor. There may be reason to suspect that the facilities tested do not represent a random sample of industry, and there may also be evidence of variability within the source population. An example of a E-rated emission factor is one that has been carried out using a method that is not National Association of Testing Authorities (NATA) accredited. E-rated factors are considered poor.

Due to the comparatively smaller number of facilities in Australia, a reasonable number of facilities may be considered a small number, so there may be little differentiation between C and D-rated emissions. In addition, these ratings do not preclude the use of emission factors rated as D or E. However, these factors need to be clearly articulated in the modelling report so that any uncertainty associated with them can be assessed along with the modelled outputs.

### Measurements from project

Emission rate data should ideally be sourced from measurements undertaken at either the site in question (for an existing site) or a similar site (if available)., Data may need to be adjusted depending on the differences in plant capacity, noting that scaling between different plant sizes is unlikely to be linear (Ellsworth, 2009).

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| **Emissions derived from stack emission tests**  If a facility uses a NATA accredited tester and laboratory to carry out emissions tests at another facility that they own, they should conduct three tests spaced out over several years. It is likely that this would constitute a reasonable number of tests even though they were carried out at a single facility. It is also likely that an emission factor derived from this test data would be considered B-rated. |

As part of demonstrating compliance with EPA licence conditions in Victoria and Australia, industry conducts periodic emissions tests. As a result, there is a substantial amount of local emissions data available and new projects can enquire from an existing project for data that can inform their assessment if the processes/projects are similar.

If the source characteristics are calculated or estimated values, the methodology used for estimating emissions is to be clearly stated. Detailed calculations with potential uncertainty are to be provided in an appendix to the main report.

For realistic representation of the source characteristics, the emissions diurnal profile should reflect the project operation, with continuous sources emitted continuously and intermittent sources emitted only during the operating hours of the project. Whatever emission values are used, it is important to include modelling for ‘worst case’ discharge conditions.

Where there are several sources of a pollutant on one industrial site, it is acceptable to model all the sources together by using an average emission rate. However, it is also useful to simulate each source individually using its worst-case maximum emission rate. This will determine its maximum potential effect when assessed against short-term APAC.

### Manufacturer’s specification and published data

Unless there is additional supporting information provided by the manufacturer, including test data from alternative manufacturers, emission rates from specifications are to be treated as D-rated factors.

### Regulatory emission data

For emission factors from sources where no rating is provided, the emission rate should be treated as D-rated. Examples of these include the [USEPA's AP-42 Emission Factors](http://www.epa.gov/ttn/chief/) or the UK [Emission Factors Database](http://www.naei.org.uk/emissions/) . The Department of Climate Change, Energy, the Environment and Water (DCCEEW) is responsible for administering the National Pollutant Inventory (NPI) program and has prepared a set of 82 emission estimation handbooks for the National Pollutant Inventory. These handbooks are based largely upon USEPA emission factors, and are available at the [National Pollutant Inventory webpage](http://www.npi.gov.au). .

### Emission models

Reactor models and mass flow rate models can be used to develop emission factors, and in most cases these should be treated as D-rated, unless they have been verified by stack testing, in which case they may be assigned a higher rating depending on the number of tests.

# Preparation of meteorological data

Meteorological data determines the transport and dispersion of pollutants from an emission source to the receiving environment. Errors in meteorological data are a major source of errors in dispersion models (for example, Turner, 1979). Therefore, preparation of meteorological data should follow recognised and accepted procedures.

AERMOD requires the input of two meteorological files: a ‘surface’ data file and a ‘profile’ data file. In the USA, these files are typically provided by the AERMET meteorological pre-processor. However, the use of AERMET is not suitable for standard use outside of that region in its current form due to the country-specific nature of its basic input requirements. This section provides a guide to the construction of files.

There are two types of sources of meteorological data that can be used to run AERMOD:

* Measured meteorological data.
* Prognostic meteorological data.

Which data to use is dependent on factors such as availability of data, as well as representativeness of the data — that is, how close to the site, how similar the local topography of the source site is to the project site, and other factors. However, the preference is to use measured data.

Appendix A contains a detailed step-by-step guide to the construction of AERMOD meteorological input data files for air pollution impact assessments in Victoria.

## Measured meteorological data

The use of measured meteorological data is preferred over modelled meteorological data. However, this is only if the meteorological data is site-specific (that is, measured on site) or is within 5 km of the site with no major topographical features between the project site and the measurement site. Special considerations may be arranged with EPA in cases where the distance is larger than 5 km and the surrounding terrain is relatively flat.

Meteorological data consisting of five consecutive years of hourly averaged scalar wind speed, wind direction and temperature. Measurement using Australian Standard AS2923, *Ambient Air Guide for Measurement of Horizontal Wind for Air Quality Applications*, by a NATA-accredited laboratory is preferred. However, in the absence of such data, local meteorological measurements by the Australian Bureau of Meteorology (BoM) may be used. Preference is given to BoM weather stations having 1 minute or 10-minute average wind and temperature data. Where possible, calculation of sigma theta should always be done from the shortest time interval.

It should be noted that one year of measured meteorological data may be used instead of the mandatory recent five sequential years of measurement data. However, this is only acceptable for on-site measured data.

The following mandatory data is required:

* Scalar wind speed (hourly average based on 1 or 10-minute average)
* Vector wind direction (hourly average based on 1 or 10-minute average)
* Screen temperature (last 10-minute average or instantaneous).

The following supplementary data can be used to derive parameters and convective mixing height:

* Surface pressure
* Dew point or relative humidity
* Total cloud cover (hourly preferred, 3 hour acceptable)
* Rainfall rate
* Twice-daily vertical temperature and moisture profiles.

If it is available for the application site, measured net radiation is preferred over cloud observations. When there is no representative cloud cover data, the net radiation can acceptably be derived by running a suitable prognostic model (see Section 4.2).

## Modelled meteorological data

For locations where there is no suitable measured data available, the mandatory data and supplementary data required may be generated by a prognostic model such as Weather Research Forecasting (WRF) or The Air Pollution Model (TAPM).

It should be noted that TAPM is no longer supported by CSIRO, therefore users are encouraged to use other prognostic models such as the WRF model. Output from WRF can be converted using the Mesoscale Model Interface Program (MMIF) to the parameters and format required for AERMET or AERMOD (USEPA, 2018).

Current guidance from USEPA is to first use MMIF for AERMET, and then use AERMET for subsequent conversion for AERMOD (USEPA, 2017b). More information on the use of MMIF software is found at the [USEPA SCRAM website](https://www3.epa.gov/ttn/scram/models/relat/mmif/MMIF_Guidance.pdf).

The CALMET diagnostic model may be used where there is Automatic Weather Station (AWS) data from several stations at distances greater than 25 km from the modelling site to generate winds and mixing heights at the modelling site. Preferably, this should be used in conjunction with upper air data from a prognostic model such as WRF. The use of such data requires justification, verification, and tests of representativeness (see section 4.3).

## Representativeness of meteorological data

It is the proponent’s responsibility to ensure that the meteorological data used in air impact assessments is representative of the proposed project site. An assessment of the representativeness of the data should be presented as part of the application, and may include the following details:

* Comparison of prognostic meteorological data with measurement meteorological data from another site within the prognostic model domain
* A description of the proximity of the project site to the measured meteorological data site
* A note on any significant — or lack of — terrain features between the project site and meteorological data site
* A note on any differences or similarities in surface parameters between the project site and meteorological data site.

# Preparation of terrain data

AERMOD is designed to calculate air pollutant concentrations in all types of terrain, ranging from flat to complex. The AERMAP pre-processor analyses several types of ‘standardised’ terrain data to produce terrain elevations for each receptor and source, as well as a receptor ‘hill height scale’ for use in complex terrain.

The AERMAP pre-processor has been developed in the USA. It therefore uses standard USA terrain data sources, with the current version supporting processing of US Geological Survey (USGS) Digital Elevation Model (DEM) data, as well as data from the National Elevation Dataset (NED) in the Geotiff format.

EPA recommends the use of local topographical data when using the pre-processor. This can then be gridded to create a representative terrain input file with a spatial resolution not greater than 90 m (or 3 arc-seconds in latitude and longitude).

One option is to convert this gridded data into a form that mimics the DEM data format before using AERMAP to generate terrain input information for AERMOD. The [USEPA Support Center for Regulatory Atmospheric Modelling (SCRAM) website](http://www.epa.gov/scram/) () provides information on how to undertake this process.

Terrain elevation data from the Shuttle Radar Topography Mission (SRTM) can also be processed by AERMAP, as they are available in the same Geotiff format as NED data from the USGS Seamless Data Server. This enables the applications to be used outside the USA.

SRTM elevations represent the height of the ‘reflective surface’ for the radar signal, including the heights of obstacles such as buildings and trees. There are data gaps in SRTM data due to the nature of radar reflectivity measurements.

The following points should also be noted:

* One-second (30 m resolution) DEM of Australia based on SRTM data can be downloaded from the [CSIRO website](https://epavictoria.sharepoint.com/sites/grpo365t170/Shared%20Documents/Applied%20Science%20Connect/AS%20Connect%20files/OCES%20docs/ASR0014403%20-%20Modelling%20Guidance%20for%20EPA%20Victoria's%20regulatory%20air%20pollution%20model%20AERMOD/data.csiro.au/dap)
* Gap-filled and filtered (vegetation and obstacles removed) topography data in high resolution is also available from Geo Science, Australia.
* AERMOD software products that enable conversion of global SRTM3 terrain data files from WebGIS into DEM format for input into AERMAP are commercially available.

# Approved use of AERMOD model options

To obtain accurate model results, careful consideration should be given as to which model options are suitable for the domain or area being modelled. This section details model options approved by EPA for air quality assessment projects in Victoria.

## Domain resolution and size

As detailed in Chapter 4 of EPA publication 1961, the choice of domain size and resolution should be guided by consideration of all relevant factors. The domain size should be large enough to cover all significant features in the receiving environment (such as emission sources and sensitive locations) without compromising accurate simulation of the dispersion. EPA recommends domains that are centred on emission sources and use the following maximum grid sizes:

* 10 km for non-complex and/or flat terrain
* 5 km for complex terrain.

For grid spacing, EPA recommends the use of Cartesian grids (see Section 6.2) with resolution chosen so that the maximum concentration is not significantly underestimated and not greater than 50m.

## Receptors

Receptors are points representing physical locations at which the model will predict pollutant concentrations in the receiving environment. Receptors are usually represented in two main ways:

* Gridded receptors
* Discrete receptors.

Gridded receptors can be represented as groups of Cartesian or Polar receptors. The choice of which type to use will depend on factors such as:

* type of modelling, whether screening (Level 1 type assessments) or more refined (Level 2 and above)
* consideration of site location and topography
* size and number of emissions.

EPA recommends the use of Cartesian grids for best coverage, as the receptor resolution of Polar grids diminishes as radial distance increases.

In addition to receptor grids, discrete receptors are usually needed to identify specific locations of interest. This includes sensitive receptors, such as schools, as well as residential dwellings, and others. Identification of sensitive receptors should be conducted as specified in Chapter 4 of EPA publication 1961.

## Modelling of area/volume sources

Concentration predictions for area sources in the current approved version of AERMOD are likely to be overestimated under very light wind conditions (that is for wind speeds less than 1 m/s). This issue is addressed in Section 6.2 of the [USEPA AERMOD Implementation Guide](https://www3.epa.gov/ttn/scram/models/aermod/aermod_implementation_guide.pdf) which recommends several options avoiding overestimates during such wind conditions.

EPA recommends that the current USEPA approach be adopted until further notice. This uses a volume source approximation to model area sources for cases when key receptors are sufficiently distant from the source.

Users of the volume source approach should carefully consider the technical discussion in the USEPA Implementation Guide. As selection of source options can affect the model output significantly, choosing this approach should be discussed and justified in any application to EPA.

## Rural vs urban mode

AERMOD includes an option for incorporating the effects of increased surface heating from an urban area on pollutant dispersion under stable atmospheric conditions. Previously, only the use of the ‘rural’ mode was approved by EPA. However, the use of this ‘urban’ mode is now allowed for urban sites.

To determine whether a site should be classified as rural or urban, EPA recommends utilising the Irwin land use category method (1978) outlined in paragraphs (c) to (f) of the Appendix W of USEPA Guideline on Air Quality Models (USEPA, 2017).

## Building downwash effects

Airflow around buildings can result in zones of strong turbulence with downward mixing on the building’s lee side. This effect is known as building downwash. As a result, the entrainment of exhaust gases released from short stacks or rooftop vents in the wake of a building can lead to much higher ground-level concentrations than the model would otherwise predict. It is important to note that the direct influence of buildings is only for point sources in AERMOD, although they can be indirectly included via the use of volume source(s).

It is generally accepted that building downwash is unlikely to occur if a stack is 2.5 times higher than any nearby building. Therefore, the good engineering practice guidance provided by USEPA (1985) should be consulted.to minimise or reduce building wake effects when designing new stacks.

The following guide may be of assistance accounting for potential building wake effects:

* Assess whether building wake effects influence the results by running the dispersion model with and without building wake effects
* For AERMOD, use the PRIME building downwash
* For other models, use the most conservative of the Schulman-Scire (S-S), Huber-Snyder (H-S) or hybrid (combination of S-S and H-S) algorithms if PRIME is not available (Schulman, 2000)
* When reporting building wake results, acknowledge the complex nature of plume/building interactions and the increased uncertainty contained in calculations of results within zones affected by building wakes
* Consider the additional uncertainty in ground-level concentrations predicted for receptors within the near wake (that is, within three building heights or widths)
* If model predictions among buildings and in the downwash areas are critical, then a computational fluid dynamics model should be considered (for example, Huber et al., 2004).

## Choice of other options

Caution should be exercised when using the following options, as they are not routine applications and will not be accepted by EPA unless with prior approval for specific circumstances.:

* Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM) option for modelling conversion of NOx to NO2
* Dry and wet particle deposition options
* Capped stacks and horizontal sources option
* Air toxics option
* Screening mode.

# Approved use of background data for cumulative impacts

This guideline provides information which can be used to inform a risk-based assessment under the new legislation. Proponents must include pollutant background concentrations in the model simulation, except where the proponent can demonstrate to the satisfaction of the EPA that background levels of the pollutant are not significant.

Background data informs the inherent (pre-control) and residual (post-control) risks of a project. Therefore, inclusion of background concentrations of pollutants in the assessment enables the total impact of the proposed project on existing air quality to be assessed.

Background data should take the form of temporally varying (hourly) background concentrations for each pollutant of concern for the modelling period and be considered representative of the proposed location as deemed appropriate by the EPA.

This data should be added to the model to predict the cumulative concentration for the modelling period. Previously, the EPA allowed the use of 70th percentile of background concentration data for cumulative impacts. However, the 70th percentile static concentration is not considered appropriate for cumulative assessments, as it is not representative of seasonal variations that are likely to occur during the modelling period and is therefore likely to underestimate the background contribution. The whole set of representative background data should be used in the cumulative assessment.

## Choice of background data

To ensure a rigorous process is undertaken and to ensure confidence in the assessment, it is important to ensure the background data set used is representative of the project site. The following should be considered when choosing background data for assessments:

* Currency – the default background concentrations should be obtained from recent measurements
* Proximity – for better representativeness or conservativeness, use data that is closest to the project site. If there is no data available in the vicinity of the site, data from a regional site may be used assuming the site is impacted by similar or adequately representative sources
* Weather – use data from similar weather regimes as the project site
* Land use – whether rural, urban or peri-urban, and proximity to industrial or population centres
* Terrain – note presence or absence of significant topographical features
* Data gaps –a combination of measurements from different sites may be used to fill data gaps, provided that proper justification and permission from EPA has been supplied.

For more information on selecting suitable background air quality data, consult Chapter 4 of EPA publication 1961.

# Use of alternative models

As AERMOD is the approved regulatory model, there is an expectation that all assessments will use it as part of the supporting information for any regulatory approval. This is intended to provide a consistent assessment of all regulatory approvals. However, it is recognised that, an alternative model may provide a better estimate of ground level concentrations in some circumstances. It may therefore be appropriate for an alternative model to be considered in addition to the regulatory model to support a regulatory approval decision.

The following are examples where alternative modelling approaches may be allowed:

1. Complex geographical locations whereby factors such as terrain, coastal and land-use influences — in combination with the spatial scale of the impact zone of the sources — require the use of fully 3-dimensional meteorological fields. Potential alternative models for such circumstances include:
   * the [CALPUFF modelling system](http://www.src.com/calpuff/calpuff1.htm)
   * the [TAPM prognostic model](http://www.dar.csiro.au/tapm).
2. Dispersion from source types not adequately modelled by the current version of AERMOD. As an example, aluminium refineries requiring the use of buoyant line sources algorithms given in the current CALPUFF model.

# Sensitivity and risk control analysis

Models are not perfect tools. Therefore, a good understanding of model uncertainty may assist in ascertaining whether a sensitivity analysis should be undertaken. This determines how much results may differ if inputs are incorrect.

Under the GED, the goal of an APIA is not just to meet a target pollutant concentration, but to also minimise concentrations as far as reasonably practicable. To this end, modelling has a key role in testing various risk control options to help identify those that minimise risks as far as reasonably practicable.

A sensitivity and risk controls analysis can be carried out by varying the following examples:

* Source parameters, such as emissions and stack heights
* Level of management control
* Efficiency of equipment that controls pollution levels, such as scrubbers
* Separation distances.

An outcome from this analysis can help ascertain the most cost-effective and environmentally-friendly strategy.

# Reporting

The following output options in AERMOD should be selected to assess the impact of emissions to air, as specified in EPA publication 1961:

* The ‘top 100 table’ of the model results
* 99.9 percentile concentration files (plot files) for pollutants having an averaging time of 1 hour. This may be the 9th highest concentration when the modelling period is one year.
* The highest (100 percentile) concentration files (plot files) for pollutants having an averaging time of greater than 1 hour.

The following electronic output files should be submitted to, or made available to, EPA:

* Model log file – aermod.out
* Rank file, including top 100 predicted values
* Plot files (.plt) containing the highest and 9th highest predicted values
* Exceedance files (frequency of exceedances)
* Time-series files for selected discrete receptors.

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# Appendix A– Construction of input meteorological files for AERMOD

Construction of met data files involves the following steps:

* 1. Compilation of all required representative meteorological data for the application site.
  2. Determination of surface characteristics for the application site.
  3. Estimation of scalar parameters.
  4. Estimation of hourly mixing heights (boundary layer heights - convective and stable)
  5. Formatting all data/information into AERMOD compatible file formats.

# A1 Content of meteorological files

AERMOD requires hourly values (preferably hourly averages) of the following meteorological parameters to be entered into the input files:

# A1.1 Surface Data file (.sfc)

* Scalar wind speed (m/s) at wind reference height (for example, 10m).
* Wind direction (degrees measured clockwise from true north) at wind reference height
* Ambient temperature (°K) at screen level height (for example, 2m).
* Surface characteristics of the application site.
  + Albedo
  + Bowen ratio
  + Surface roughness (m)
* Scalar parameters.
  + Friction velocity (m/s)
  + Convective velocity scale (m/s)
  + Monin-Obukhov length (m)
  + Sensible heat flux (W/ m2)
* Mixing heights.
  + Convective Boundary Layer height (CBL) (m)
  + Stable Boundary Layer Height (SBL) (m)
* Vertical gradient of potential temperature (°K/m).
* Precipitation code
* Precipitation rate (mm/hr)
* Relative humidity (%)
* Surface pressure (hPa)

Total cloud amounts (10ths)

The following information should be noted when constructing input meteorological files for AERMOD:

* Parameters (a) to (g) are mandatory, with the remaining parameters required to model deposition.
* Parameters (a), (b), (c), (h), (i), (j), (k) and (l) are based on direct measurements, although data from prognostic models may be acceptable in some situations (see Section A2).
* The remaining mandatory parameters are derived parameters determined using other relevant information and/or USEPA recommended algorithms in AERMET or AERMOD (see Section A2).
* Data coverage of a meteorological file should be 90% or better valid data.
* Yearly files for recent 5 years should be used for air impact assessments related to new work approvals, as well as for risk assessments. EPA may relax this requirement to 1 year of data, provided the worst-case model results are 50% or less of the assessment criterion in the EPA policy.
* The file may contain missing days, and the days need not be sequential. However, there cannot be any missing hours in a day.
* The directly measured parameters (a), (b) and (c) must be site-specific (within a 25 km radius of the application site) and the rest of the measured parameters should be site-representative.

# A1.2 Profile Data file (.pfl)

* Measurement height for each level (m).
* Wind directions at the current level (degrees measured clockwise from true north).
* Wind speed at the current level (m/s).
* Temperature at the current level (0C).
* Sigma-theta (standard deviation of horizontal wind direction fluctuation) at the current level (0).
* Sigma-w (standard deviation of vertical wind direction fluctuation) at the current level (m/s).

that the following points should also be noted:

* Parameters (a) to (d) are mandatory and based on direct measurements, although data from prognostic models may be acceptable in some situations (see Section A2).
* Parameters (e) and (f) should be based on direct measurements but are optional with AERMOD adopting default values or algorithms in their absence.
* In some cases, the profile file may only contain one level (surface).

# A2 Data format

AERMOD expects to read the input meteorological data files in a fixed format. The surface meteorological file should have one header line;

Latitude, Longitude, UA (Upper Air Station No.) identifier, SF (Surface Station No) identifier, OS (Onsite Station No.) identifier (optional), Version # (if using AERMET).

*Format :2(2X,A8),8X, ‘ UA\_ID :’,A8,’ SF\_ID :’,A8, ’ OS\_ID :’,A8,T85, ‘VERSION:’,A6*

The lines after the initial header line should each contain a single hour of data. Year, Month, Day, Julian Day, Hour then;

1. Sensible heat flux (SHF)
2. Surface friction velocity (Ustar)
3. Convective velocity scale (Wstar)
4. Vertical potential temperature gradient above PBL (VPTG)
5. Convective mixing height (PBL)
6. Mechanical mixing height (SBL)
7. Monin-Obukhov length (MOL)
8. Surface roughness(Z0)
9. Bowen ratio (BRatio)
10. Albedo (ALBD)
11. Wind speed (WS)
12. Wind direction (WD)
13. Reference height for winds (WRef=10m)
14. Surface temperature (KTEMP)
15. Reference height for surface temperature (TRef=2m)
16. Precipitation code
17. Precipitation rate (RPPTN)
18. Relative humidity (RH)
19. Pressure (PR)
20. Cloud cover (10ths) (CLD)

*Format: 3(I2,1X),I3,1X,I2,1X,F6.1,1X,3(F6.3,1X),2(F5.0,1X),F8.1,1X,F6.3,1X,2F(6.2,1X),F7.2,1X,F5*

*.0,3(1X,F6.1)*

The profile meteorological file has no header and the following data for each hour:

Year, Month, Day ,Hour, Height, Top, WDnn, WSnn, TTnn, SAnn, SWnn

Where:

1. Height = data measurement height (m)
2. Top = 1, if this is the last (highest) level for this hour, or = 0 otherwise
3. WDnn = wind direction at the current level (degrees)
4. WSnn = wind speed at the current level (m/s)
5. TTnn = temperature at the current level (°C)
6. SAnn = sigma-theta (degrees)
7. SWnn = sigma-w (m/s)

*Format: (4(I2,1X), F6.1,1X, I1,1X, F5.0,1X, F7.2,1X, F7.1, 1X,F6.1, 1X,F7.2)*

**Sample: AERMOD Surface data file (.sfc)**

|  |  |  |
| --- | --- | --- |
| 33.950N 83.317W UA\_ID: 99999 SF\_ID: 00001 OS\_ID: 0 | VERSION: 06341 |  |
| 8 1 1 1 1 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0 0.334 1.50 | 1.00 0.00 0. | 10.0 |
| 306.6 2.0 0 0.00 999. 1008. 7 |  |  |
| 8 1 1 1 2 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0 0.334 1.50 | 1.00 0.00 0. | 10.0 |
| 306.6 2.0 0 0.00 999. 1008. 7 |  |  |
| 8 1 1 1 3 -9.0 0.115 -9.000 -9.000 -999. 90. 15.2 0.001 1.50 | 1.00 3.60 354. | 10.0 |
| 305.6 2.0 0 0.00 999. 1008. 7 |  |  |
| 8 1 1 1 4 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0 0.334 1.50 | 1.00 0.00 0. | 10.0 |
| 304.8 2.0 0 0.00 999. 1008. 5 |  |  |
| 8 1 1 1 5 -9.4 0.103 -9.000 -9.000 -999. 76. 10.4 0.001 1.50 | 1.00 3.60 13. | 10.0 |
| 304.4 2.0 0 0.00 999. 1008. 5 |  |  |
| 8 1 1 1 6 -1.3 0.033 -9.000 -9.000 -999. 16. 2.4 0.001 1.50 | 1.00 1.50 342. | 10.0 |
| 303.6 2.0 0 0.00 999. 1008. 5 |  |  |
| 8 1 1 1 7 -0.5 0.022 -9.000 -9.000 -999. 7. 1.7 0.001 1.50 | 1.00 1.00 315. | 10.0 |
| 302.4 2.0 0 0.00 999. 1009. 7 |  |  |
| 8 1 1 1 8 -0.5 0.022 -9.000 -9.000 -999. 7. 1.7 0.001 1.50 | 1.00 1.00 313. | 10.0 |
| 300.6 2.0 0 0.00 999. 1009. 7 |  |  |

**Sample: AERMOD Profile data file (.pfl)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 8 | 1 | 1 | 1 | 10.0 1 | 0.0 | 0.00 | 33.50 | 99.00 | 99.00 |
| 8 | 1 | 1 | 2 | 10.0 1 | 0.0 | 0.00 | 33.50 | 99.00 | 99.00 |
| 8 | 1 | 1 | 3 | 10.0 1 | 350.0 | 3.60 | 32.50 | 99.00 | 99.00 |
| 8 | 1 | 1 | 4 | 10.0 1 | 0.0 | 0.00 | 31.60 | 99.00 | 99.00 |
| 8 | 1 | 1 | 5 | 10.0 1 | 10.0 | 3.60 | 31.30 | 99.00 | 99.00 |
| 8 | 1 | 1 | 6 | 10.0 1 | 340.0 | 1.50 | 30.50 | 99.00 | 99.00 |
| 8 | 1 | 1 | 7 | 10.0 1 | 310.0 | 1.00 | 29.30 | 99.00 | 99.00 |
| 8 | 1 | 1 | 8 | 10.0 1 | 310.0 | 1.00 | 27.50 | 99.00 | 99.00 |
| 8 | 1 | 1 | 9 | 10.0 1 | 20.0 | 2.60 | 29.40 | 99.00 | 99.00 |
| 8 | 1 | 1 | 10 | 10.0 1 | 0.0 | 0.00 | 32.40 | 99.00 | 99.00 |
| 8 | 1 | 1 | 11 | 10.0 1 | 360.0 | 4.60 | 35.10 | 99.00 | 99.00 |

In these data files missing data is represented by 999 or 99999 or 99.00.

# A3 Recommended surface characteristics

The recommended surface characteristics to be used in the meteorological data file for AERMOD are detailed in this section. These are consistent with values given in the AERMOD User Guide, with additional categories and revised values specific for Australia.

Surface Roughness (Z0) (m)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Use** | **Seasonal Surface Roughness** | | | |
|  | Summer | Autumn | Winter | Spring |
| Open water | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Low intensity residential | 0.40 | 0.40 | 0.30 | 0.40 |
| High intensity residential | 1.00 | 1.00 | 1.00 | 1.00 |
| Sites at Airports | 0.07 | 0.07 | 0.07 | 0.07 |
| Industrial/Commercial (no airports) | 0.70 | 0.70 | 0.70 | 0.70 |
| Quarries / Strip Mines / Gravel | 0.30 | 0.30 | 0.30 | 0.30 |
| Deciduous forest | 1.30 | 1.30 | 0.60 | 1.00 |
| Mixed forest | 1.30 | 1.30 | 0.90 | 1.10 |
| Shrub land (Arid region) | 0.15 | 0.15 | 0.15 | 0.15 |
| Shrub land (Non-arid region) | 0.30 | 0.30 | 0.30 | 0.30 |
| Grassland | 0.10 | 0.01 | 0.001 | 0.05 |

**Albedo**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Use** | **Seasonal Albedo** | | | |
|  | Summer | Autumn | Winter | Spring |
| Open water | 0.10 | 0.10 | 0.10 | 0.10 |
| Low intensity residential | 0.16 | 0.16 | 0.18 | 0.16 |
| High intensity residential | 0.18 | 0.18 | 0.18 | 0.18 |
| Sites at Airports | 0.18 | 0.18 | 0.18 | 0.18 |
| Industrial/Commercial (no airports) | 0.18 | 0.18 | 0.18 | 0.18 |
| Quarries / Strip Mines / Gravel | 0.20 | 0.20 | 0.20 | 0.20 |
| Deciduous forest | 0.16 | 0.16 | 0.17 | 0.16 |
| Mixed forest | 0.14 | 0.14 | 0.14 | 0.14 |
| Shrub land (Arid region) | 0.25 | 0.25 | 0.25 | 0.25 |
| Shrub land (Non-arid region) | 0.18 | 0.18 | 0.18 | 0.18 |
| Grassland | 0.18 | 0.18 | 0.20 | 0.18 |

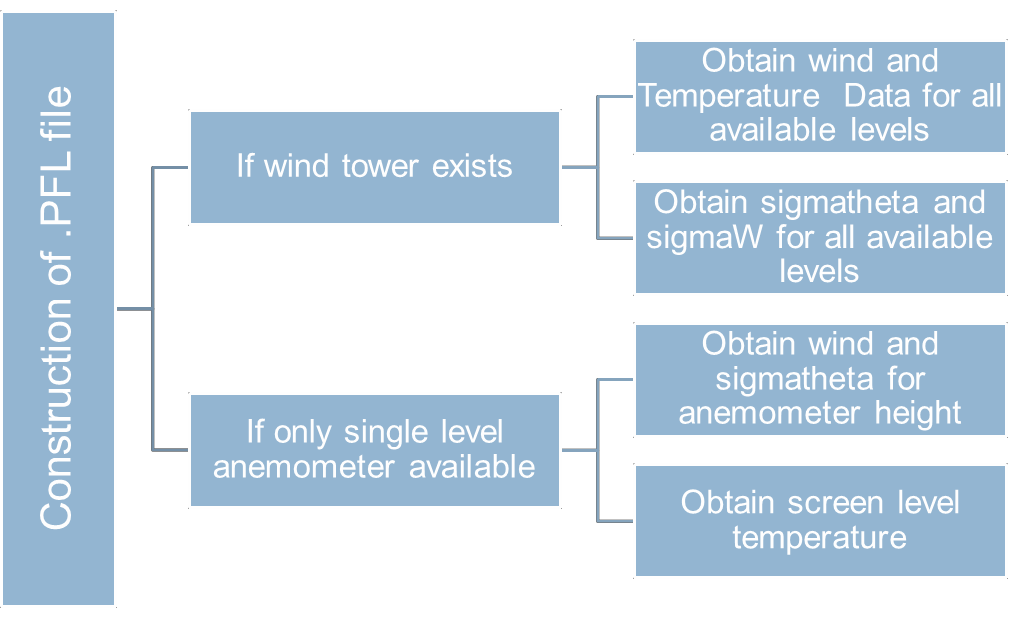
**Bowen Ratio (three options depending on moisture conditions)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Use** | **Seasonal Bowen Ratio - Average** | | | |
|  | Summer | Autumn | Winter | Spring |
| Open water | 0.10 | 0.10 | 0.10 | 0.10 |
| Low intensity residential | 0.80 | 1.00 | 1.00 | 0.80 |
| High intensity residential | 1.50 | 1.50 | 1.50 | 1.50 |
| Sites at Airports | 1.50 | 1.50 | 1.50 | 1.50 |
| Industrial/Commercial (no airports) | 1.50 | 1.50 | 1.50 | 1.50 |
| Quarries / Strip Mines / Gravel | 1.50 | 1.50 | 1.50 | 1.50 |
| Deciduous forest | 0.30 | 1.00 | 1.00 | 0.70 |
| Mixed forest | 0.30 | 0.90 | 0.90 | 0.70 |
| Shrub land (Arid region) | 4.00 | 6.00 | 6.00 | 3.00 |
| Shrub land (Non-arid region) | 1.00 | 1.50 | 1.50 | 1.00 |
| Grassland | 0.80 | 1.00 | 1.00 | 0.40 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Use** | **Seasonal Bowen Ratio - Wet** | | | |
|  | Summer | Autumn | Winter | Spring |
| Open water | 0.10 | 0.10 | 0.10 | 0.10 |
| Low intensity residential | 0.60 | 0.70 | 0.70 | 0.60 |
| High intensity residential | 1.00 | 1.00 | 1.00 | 1.00 |
| Sites at Airports | 1.00 | 1.00 | 1.00 | 1.00 |
| Industrial/Commercial (no airports) | 1.00 | 1.00 | 1.00 | 1.00 |
| Quarries / Strip Mines / Gravel | 1.00 | 1.00 | 1.00 | 1.00 |
| Deciduous forest | 0.20 | 0.40 | 0.40 | 0.30 |
| Mixed forest | 0.20 | 0.30 | 0.35 | 0.30 |
| Shrub land (Arid region) | 1.50 | 2.00 | 2.00 | 1.00 |
| Shrub land (Non-arid region) | 0.80 | 1.00 | 1.00 | 0.80 |
| Grassland | 0.40 | 0.50 | 0.50 | 0.30 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Land Use** | **Seasonal Bowen Ratio - Dry** | | | |
|  | Summer | Autumn | Winter | Spring |
| Open water | 0.10 | 0.10 | 0.10 | 0.10 |
| Low intensity residential | 0.80 | 1.00 | 1.00 | 0.80 |
| High intensity residential | 1.50 | 1.50 | 1.50 | 1.50 |
| Sites at Airports | 1.50 | 1.50 | 1.50 | 1.50 |
| Industrial/Commercial (no airports) | 1.50 | 1.50 | 1.50 | 1.50 |
| Quarries / Strip Mines / Gravel | 1.50 | 1.50 | 1.50 | 1.50 |
| Deciduous forest | 0.30 | 1.00 | 1.00 | 0.70 |
| Mixed forest | 0.30 | 0.90 | 0.90 | 0.70 |
| Shrub land (Arid region) | 4.00 | 6.00 | 6.00 | 3.00 |
| Shrub land (Non-arid region) | 1.00 | 1.50 | 1.50 | 1.00 |
| Grassland | 0.80 | 1.00 | 1.00 | 0.40 |

# A4 Flow charts – construction procedure

Graphical user interface

Description automatically generatedFLOW CHARTS - CONSTRUCTION PROCEDURE

Accessibility

Contact us if you need this information in an accessible format such as large print or audio.   
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