Local Government Air Quality Toolkit

Module 1: The science of air quality

Part 5: Predicting or modelling air pollution

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

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Air pollution concentrations can be predicted by computer modelling done by atmospheric dispersion modelling experts.

It should be noted that a practical knowledge of the factors affecting plume dispersion can address simple small-scale problems without the need to resort to expensive modelling.

Dispersion modelling is used to estimate pollutant concentrations at receptors, resulting from emission sources in the vicinity of those receptors. This modelling informs an air quality assessment. Depending on its sophistication, models typically take account of local meteorology, topography and the characteristics of the built environment or the area (land use).

A dispersion model is a mathematical representation of the physical atmospheric environment. The models are usually operated using a graphical user interface to help visualise the modelling set-up.

Pollutants have traditionally been assumed to disperse in the atmosphere in a Gaussian manner. This means that if a set of concentration samples were taken simultaneously across the direction of movement of a pollutant plume, a plot of concentration against crosswind distance would look like the characteristic bell-shaped curve of a normal statistical distribution; that is, a Gaussian curve. The peak concentration would be at the centre of the plume.

Gaussian mathematics are used to predict the concentration of a pollutant at any point in space downwind of the pollution source. A computer model then calculates the downwind pollutant concentrations for a source across the full range of situations corresponding to variations in weather conditions at the location; that is, wind speed, wind direction, temperature and atmospheric stability. It is usual to apply hourly data for a year; that is, all meteorological variations for each of the 8,760 hourly time-steps in the model.

When there are no site-specific meteorological datasets available, data typical for the region can be used. This data can be sourced from other local meteorological stations nearby, or by carrying out predictive meteorological modelling for the site using known local characteristics. This is referred to as prognostic meteorological data.

1.1 Contour plots

The modelling results are analysed to estimate ground level concentrations at various locations. The results are usually plotted as concentration contour plots (also known as isopleths) on a map around the source. A concentration contour is a line joining points of equal predicted concentration. Predictions can also be made at various heights above the ground (using so-called ‘flagpole’ receptors), with contours produced to represent that elevated surface above ground level.

Concentration contours are compiled for time periods corresponding to the averaging periods in different air quality criteria. For example, for nitrogen dioxide, figures could be drawn separately to show contours for both the maximum predicted 1-hour average and annual average concentrations. Figure 1 is an example of concentration contours across a modelled area (or domain). With the emission source at the centre, higher concentrations occur around the source and decrease with distance away from the source. The dispersion pattern is affected by the predominant wind conditions and local topography.

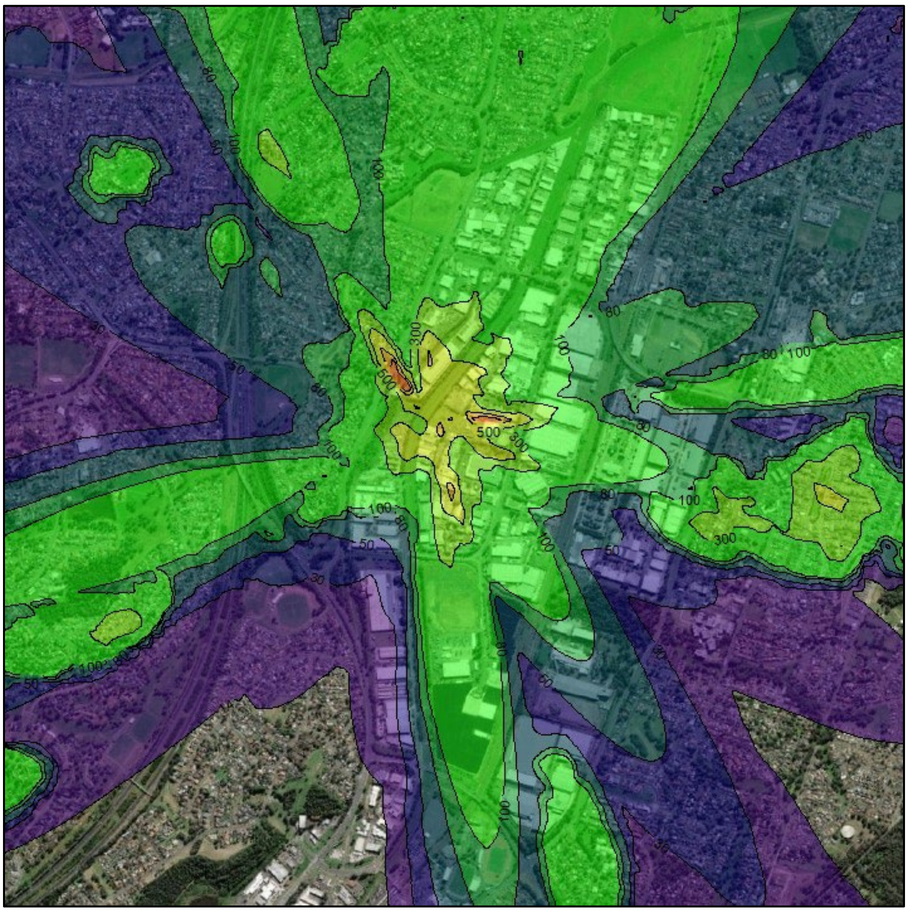

Figure 1 **Concentration contours across a modelled area/domain**
Source: Zephyr Environmental

1.2 Background air quality

When completing an air quality assessment, consideration must be given to the existing air quality of the region (the background concentrations). If data on existing air quality is not available then it must be estimated from nearby, or similar airsheds/areas. In areas with high background concentrations the addition of a new emission source may result in unacceptable predicted air quality impacts, requiring consideration of mitigating measures.

1.3 Dispersion models

Table 1 provides a summary of dispersion models either used in New South Wales or included in the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2022). The table provides the type of model, a summary of the model and its suitable application.

Table 1 **Summary of dispersion models in use in New South Wales**

Model	Type	Summary	Application
Weather Research and Forecasting model (WRF)	Meteorological	An open-source, community-developed 3-dimensional numerical meteorological model. WRF (sometimes pronounced 'Warf') is also used to generate 3-dimensional gridded meteorological data (such as hourly wind and temperature fields) where local observations are not available. Provides surface level and vertical profiles of parameters that can be used within air dispersion modelling to generate suitable meteorological files for CALMET or AERMET respectively.	Increasingly used as an alternative for The Air Pollution Model (TAPM) in New South Wales Meteorology
Ausplume	Plume	Currently included as an accepted model in the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2022). This model has not been supported or updated for over a decade.	Historically used for air emissions from mines, quarries and industrial facilities The use of Ausplume for any new assessment should be queried
CALPUFF	Puff	Assumes the pollutant behaves like a set of discrete 'puffs' of pollutant in the atmosphere. Can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. Contains algorithms for near source effects such as building downwash and long-range effects such as coastal interactions. Includes the meteorological pre-processor CALMET that generates a 3-dimensional wind field. Currently included in the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2022) as an appropriate alternative to Ausplume in some situations.	Commonly used in New South Wales Air emissions from large mines Odour emissions from activities such as composting Coastal locations Locations with significant terrain features

Model	Type	Summary	Application
AERMOD	Plume	US Environmental Protection Agency's recommended steady-state plume dispersion model for near-field regulatory purposes. Uses Monin-Obukhov length scale to account for the effects of atmospheric turbulence-based dispersion. Includes AERMET (used for preparation of meteorological input files) and AERMAP, which is used for the preparation of terrain data.	Commonly used in New South Wales Air emissions from mining and quarries Air emissions from industrial facilities Air emissions from airports
The Air Pollution Model (TAPM)	Meteorological and Lagrangian	Prognostic meteorological model that generates gridded 3-dimensional meteorological data for each hour of the model run period. Predicts the 3-dimensional flows important to local-scale air pollution, such as sea breezes and terrain induced flows. The air pollution component uses the predicted meteorology and turbulence from the meteorological component, while the Plume Rise Module is used to account for plume momentum and buoyancy effects for point sources. Both the meteorological and pollution components have not been actively supported / updated for a number of years. Currently included in the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2022) as an appropriate alternative to Ausplume in some situations.	Commonly used in New South Wales Plume rise Meteorological data
GRAL	Lagrangian	Ground-level pollutant concentrations are predicted by simulating the movement of individual 'particles' of a pollutant emitted from an emission source in a 3-dimensional wind field. The trajectory of each of the particles is determined by a mean velocity component and a fluctuating (random) velocity component.	Air emissions from complex road networks at a regional or city-wide resolution involving multiple pollutant sources (including tunnel portals, road sources and stacks)

Model	Type	Summary	Application
CALINE and CAL3QHCR	Plume	The CAL3QHCR dispersion model is an enhanced version of the CALINE Gaussian dispersion model. CALINE has been validated for Australian conditions. CAL3QHCR determines pollutant concentrations at receptors downwind of roads located in relatively uncomplicated terrain. The model is applicable for any wind direction, road orientation and receptor location, and the model can process up to a year of meteorological data.	Air emissions from roads, typically for sensitive land uses near major roads
Roadside Air Quality Screening Tool (RAQST)	Vehicle fleet emissions estimation	The RAQST helps to assess air quality impacts from surface roads using a simple, screening model. RAQST reflects recent model developments in New South Wales and other jurisdictions. It is also designed to be consistent with the requirements of the *Clean Air Society of Australia and New Zealand Good practice guide for the assessment and management of air pollution from road transport projects* (the CASANZ Guide; CASANZ 2023). RAQST is the model used in New South Wales for screening assessments as specified in the CASANZ Guide.	Air emissions from roads, typically for sensitive land uses near major roads

1.4 Air modelling in the local government context

Local government officers need to be able to make sensible judgements as to when modelling is called for in the context of an air quality issue and the comparative cost of mitigation measures. For example, there may be little benefit in using modelling to understand the impacts of stack emissions from a fast-food restaurant on an adjacent residential apartment block less than 20 m away. Most of the conventional models discussed above are not designed to make predictions at such a fine spatial resolution. In this case, the better option may be to ensure the business owner is using best-practice mitigation measures to reduce emissions at the source.

On the other hand, for a case such as a proposed new cattle feedlot operation with a small rural town nearby, modelling may be the appropriate course of action to understand the dispersion pattern of odour, and how feedlot design might be optimised to mitigate odour appropriately. In the case of an existing feedlot, odour diaries and / or odour surveys may be more appropriate to establish the level of odour impact.

If modelling is used, it is important that council officers understand which model is best for the type of operation and local setting. Guidelines for specifying and interpreting the reports from this type of specialist consulting service are available in Chapter 9 of the Local Government Air Quality Toolkit – Module 4, *Practical regulation of air pollution*, and Chapter 6 of the *Resource pack*.

Figure 2 provides an overview of a typical modelling methodology from meteorological data through to dispersion modelling and post-processing of modelling outputs (results).

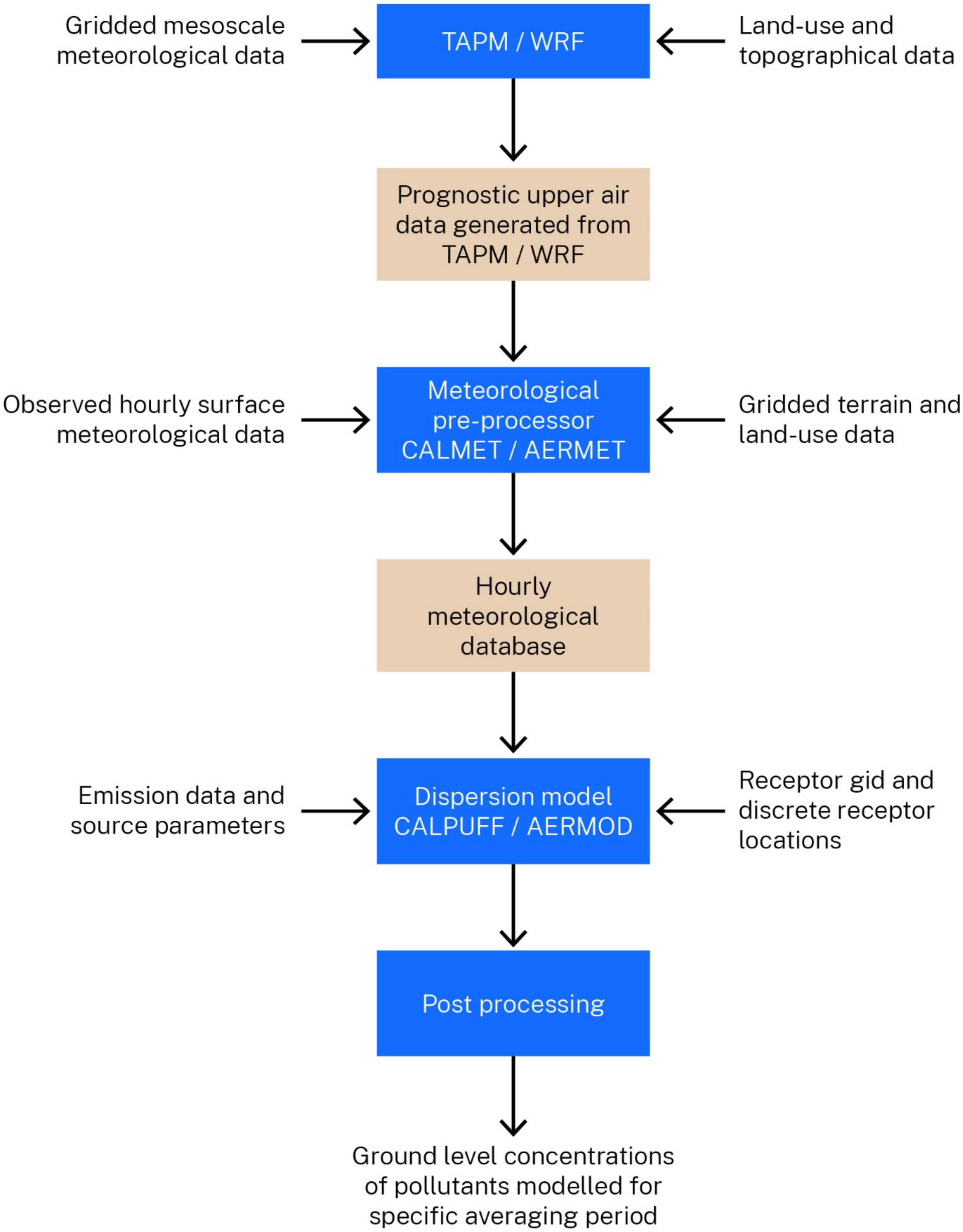

Figure 2 **Typical modelling methodology**

2. References and other resources

All documents and webpages that are part of the Local Government Air Quality Toolkit are available from the EPA website.

CASANZ (Clean Air Society of Australia and New Zealand) (2023) *Good practice guide for the assessment and management of air pollution from road transport projects*, Clean Air Society of Australia and New Zealand, Mooroolbark VIC, www.casanz.org.au/resources/the-good-practice-guide.

EPA (2022) *Approved methods for the modelling and assessment of air pollutants in NSW*, NSW Environment Protection Authority, Parramatta NSW, www.epa.nsw.gov.au/your-environment/air/industrial-emissions/approved-methods-for-the-modelling-and-assessment-of-air-pollutants.