National Environment Protection Council (Ambient Air Quality) Measure

Technical Paper No. 4
Revision 1 – January 2007

SCREENING PROCEDURES

Preamble

The National Environment Protection Measure (NEPM) for Ambient Air Quality was made in June 1998 with the desired environmental outcome of "ambient air quality that allows for the adequate protection of human health and well-being" across Australia. The NEPM sets national standards against which ambient air quality can be assessed. The NEPM includes a monitoring protocol to determine whether these standards are being met. Each jurisdiction is required to submit to the National Environment Protection Council (NEPC) a monitoring plan consistent with the protocol.

The Peer Review Committee (PRC) was established to assist NEPC in its task of assessing and reporting on the implementation and effectiveness of the NEPM by participating jurisdictions. The PRC includes government experts from all participating jurisdictions, in addition to representatives from industry and community groups. A significant activity of the PRC is the provision of advice to NEPC on the adequacy of jurisdictional monitoring arrangements, to ensure as far as possible that a nationally consistent data set is obtained.

To assure the consistency and transparency of its advisory function, the PRC has developed a set of guidance papers that clarify a number of technical issues in interpretation of the NEPM protocol. These Technical Papers provide the basis for PRC assessment of jurisdictional plans, aimed at assuring the quality and national consistency of NEPM monitoring.

The PRC Technical Papers are advisory for jurisdictions, and they will evolve with time as the science of air quality monitoring and assessment develops and as practical experience with monitoring increases. A particular issue for the PRC has been the development of practical guidelines for screening procedures, which allow monitoring to be reduced below the nominal number of sites specified in the NEPM. Technical Paper No. 4 has been revised to incorporate updated modelling results from a CSIRO study on expected levels of nitrogen dioxide and ozone in regional centres.

M J Manton
Chair
Peer Review Committee

1. Purpose

The purpose of this paper is to provide screening criteria against which jurisdictions can assess the monitoring needs of their regions where reduced or no direct monitoring is justified.

2. Introduction

According to Clause 14 (3) of the Ambient Air Quality – National Environment Protection Measure (AAQ NEPM):

> "*Fewer performance monitoring stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure.*"

In order to provide transparent and reasonable criteria by which jurisdictions may evaluate whether "*pollutant levels are reasonably expected to be consistently lower than the standards mentioned in this Measure*", the Peer Review Committee (PRC) has considered and documented a range of analyses that could be used. These analyses are called "screening procedures".

Screening procedures may be used to:

- Reduce the number of performance monitoring sites for a given pollutant below that proposed by the AAQ NEPM formula of Clause 14(1); or
- Justify not monitoring a pollutant in regions with a population over 25,000.

It is important to note that the use of screening procedures is limited to the purpose described in Clause 14(3) of the AAQ NEPM. Clause 11(b) is very different in context from Clause 14(3). Clause 11(b) provides for the possible use of alternatives to performance monitoring stations in situations where performance monitoring would otherwise occur. In any situation where a jurisdiction employs Clause 11(b), it is obliged to report and employ the data generated by the Clause 11(b) assessment method in exactly the same way as if a performance monitoring station had been used (see Clause 17(2)). For instance, if the Clause 11(b) method is modelling, then results of the model (for example 1-hour time series predictions) must be used under Clauses 17 and 18 (evaluation and reporting) in the same way that monitoring data would.

As noted above, screening may result in monitoring not taking place in areas where it can be demonstrated that pollutant levels can be reasonably expected to be consistently lower than the AAQ NEPM Standards. Depending on the methodology employed to evaluate population exposures in unmonitored areas, there is potential for computational bias to be introduced in exposure assessments. To counter or minimise such potential bias, it would be appropriate for jurisdictions to identify the area and populations to which the screening applies and the screening level concentration below which concentrations are expected to lie. This information should be documented in monitoring plans and when reporting.

It is expected that the information in this Technical Paper will evolve as more information on pollutant levels becomes available as the outcome of activities such as campaign monitoring and detailed modelling studies. The results of relevant activities will be summarized in appendices to the Paper and the relevant Tables will be updated. The first revision of the Paper has risen from a CSIRO modelling study on the screening of NO_2 and O_3, and the results are summarised in Appendix 1.

3. Generic Types of Screening Procedures

When considering any particular region, it may not be possible to make a determination under Clause 14(3) based on a single screening procedure applied to all pollutants. For example, a region with a population of say 30,000 might clearly have low levels of O_3, NO_2, SO_2 and Pb, but might experience events which exceed the AAQ NEPM standard for PM_{10} due to domestic solid fuel heating or fuel reduction burns.

Nevertheless, it is possible to describe generic types of screening procedures for individual pollutants and to rank these in terms of the confidence which can be attached to the respective screening determinations. It is then reasonable to formalise the use of screening procedures by setting acceptance limits, generally expressed as percentages of the AAQ NEPM standards. These acceptance limits would take account of the confidence attached to the associated screening procedures. Screening would be considered acceptable only if the procedure yielded a prediction of maximum pollutant concentration which was below the acceptance limit for that procedure. If a procedure with low confidence (large uncertainty) did not predict a maximum concentration below the acceptance limit, a different procedure with higher confidence and higher acceptance limit could be used. This is best explained by examining the generic procedures in Tables 1 to 3 for the various pollutants.

The screening procedure should allow for trends in projected emissions over five to ten years. This is consistent with the possible schedule for reviewing AAQ NEPM monitoring plans.

The hierarchy of procedures in Tables 1 to 3 can be applied to each pollutant in each region within a jurisdiction. Consider, for example, CO in a particular region which, according to Clause 14(1), requires 3 monitoring stations. Full performance monitoring at 3 stations is the default. However, the jurisdiction is permitted to apply any screening procedure in Table 1 as long as the concentration of CO predicted by that procedure is less than the concentration set by the acceptance limit.

In using the screening procedures presented in Tables 1 to 3, the following notes apply:

- The maximum acceptance limit for any screening procedure, no matter how reliable, has been set at 75%, although adjustments have been made to account for background ozone, as detailed in Section 4.3. In other words, the PRC considers that if concentrations in excess of 75% of the standard for a pollutant are probable within a region, performance monitoring (or an approved alternative under Clause 11(b)) should occur. This is in accord with the intent of Clause 14(3);

- To maintain a conservative approach, except for PM_{10}, the maximum predicted or measured concentration in the period specified should be used for comparison with

acceptance limits, even though the AAQ NEPM goal may specify a number of exceedences; and

- For pollutants which have standards for more than one averaging period, the acceptance limit to be used is that of the standard which is most difficult to meet in any given region. In many cases, this may involve the shortest averaging period.

3.1 Periodic Review of Screening Determinations

The AAQ NEPM does not specify the need for periodical review of determinations under Clause 14(3). The PRC recommends that a jurisdiction which has employed a screening procedure to demonstrate that performance monitoring is not required in part or the whole of a region, should formally review whether the determination is reasonable at five-yearly intervals thereafter, or sooner if there are indications of a significant upward trend in emissions or concentrations.

4. Screening for Particular Pollutants

The PRC has determined screening criteria based on the best professional judgement with information available at the time. It is recognised that these criteria may need to be updated to reflect experience with their application.

4.1 Carbon Monoxide

- Jurisdictions may wish to continue to measure CO at a peak Central Business District (CBD) site, representing a maximum for traffic-generated CO.
- High CO may be associated with wood fires. CO monitors may be required in centres which have wood smoke problems.
- Since jurisdictions are likely to have performance monitoring station data from a number of centres, most of which will show CO levels well below the AAQ NEPM Standard, conclusions based on the lower emissions of smaller centres should be quite reliable, without the need to model. Modelling would be complicated by the difficulty in quantifying wood fire emissions. A check should nevertheless be made on the relative frequencies of stable meteorological conditions.

4.2 Nitrogen Dioxide

- Wherever ozone is monitored, it is recommended that NO_X also be monitored irrespective of the likely NO_2 concentrations. Ozone distributions cannot be interpreted without NO_X data.
- Emissions of NO_X within a region can be fairly readily estimated. The time dependent conversion of NO_X to NO_2 and loss of NO_2 via surface deposition and chemical reaction are factors which complicate modelling.
- A full 3D meteorology / dispersion / chemistry modelling study relevant to regional towns has been carried out by CSIRO. Appendix 1 allows the results of this study to be applied to screening of regional towns.

- A conservative screening modelling approach would be to assume all (or say 50% of) NO_X is NO_2, ignoring reactions and losses, and simply modelling NO_2 dispersion (as a conserved tracer) for a few selected days with adverse meteorological conditions. The model would handle area and point sources (surface and elevated releases). It may be possible to avoid running a model in some cases where a worst case desktop calculation yields an NO_2 maximum well under the AAQ NEPM Standard.
- Passive samplers can be used to measure 24-hour averages of NO_2. For general urban emissions there may be a reasonably consistent relationship between 24-hour average and 1-hour maximum across population centres of varying sizes. A combination of passive sampler measurement coincident with continuous monitor measurements in the capital city and a few smaller centres may provide a reliable method of screening via passive sampler alone in yet smaller centres. At the very least, passive sampling would be a useful component of ongoing assessment of a population centre which has been screened out (i.e. by providing long-term trend information).

4.3 Photochemical Oxidants (as Ozone)

- The PRC recognises that determining appropriate screening levels for photochemical oxidants (as ozone) is more difficult because in Australia there is often a substantial background level of ozone. This is formed from the interaction of naturally emitted substances: reactive organic compounds from trees, plants and grasses; and oxides of nitrogen from soil and the sea. The PRC has determined that a concentration of 0.03 ppm is a reasonable background ozone level for Australia. On this basis it was decided to generate screening percentages for photochemical oxidant by the following procedure. The percentages of Table 1 for the gaseous pollutants which have negligible backgrounds are applied to the *anthropogenic* component of the ozone standard. Thus the percentages of Table 1 are applied to the 0.07 ppm of the one-hour AAQ NEPM standard that is assumed to come from human activities. The results are then added to the natural background and expressed as percentages of the AAQ NEPM standard. The same calculations are applied to the 4-hour standard, resulting in values that are about 1 to 4 per cent higher. The results are rounded to the nearest 0, 2, 5 or 8 with preference given to 0 and 5 reflecting the inherent accuracy of the method (see below).

  For example, in row F of Table 1 the percentage is 40%. For row F in Table 2 the value has been determined by:
  - Using the 1-hour Standard (0.10 ppm)
    40/100 x (0.10-0.03) + 0.03 ppm expressed as a percentage of 0.10 ppm. The result is 58%.
  - Using the 4-hour Standard (0.08 ppm)
    40/100 x (0.08-0.03) + 0.03 ppm expressed as a percentage of 0.08 ppm. The result is 62%.

  Thus the value found in Table 2 is 60% - the average in this case.

- It should be noted that even though the results are expressed to two significant figures, this does not imply that the screening process has this level of accuracy. The PRC recognises that screening is an imprecise tool which should be used as a guide not a prescription. Where measured or inferred levels are close to the screening levels presented in the tables, jurisdictions need to be careful in the application so as not to screen out situations which, with a less literal application of the guidelines, should either

require monitoring or a stronger justification for its exclusion. This is particularly the case for one-hour ozone levels and Table 2 where more lenient screening criteria have been established to recognise the impact of background levels on 4-hour average results.

- In the case of criterion A in Table 2, an adjustment has been made to the durations of monitoring to account for the higher inter-annual variability of ozone. In order to cover the case of one-year campaign monitoring, a more stringent screening has been applied. This has been set at 60% of the AAQ NEPM Standard.

- Appendix 1 provides guidance on how the results of the modelling study by CSIRO can be applied to screening in regional towns.

4.4 Sulfur Dioxide

- SO_2 is relatively easy to assess, since it is almost entirely an industrial emission and reacts only slowly.
- Kwinana in the Perth region is a useful example of where procedure C from Table 1 might be applied. Kwinana and surrounds might be considered a sub-region containing all of the region's SO_2 emissions and the upper bound site(s). There will be a performance monitoring station downwind of Kwinana which will demonstrate AAQ NEPM compliance. The fact that concentrations reduce further downwind will be readily demonstrated by reference to the concentration gradients measured by the existing network of six "source management" stations and by previously validated Gaussian plume modelling. Lack of SO_2 emissions elsewhere in Perth will preclude the need for more than the single Kwinana station. SO_2 has been previously monitored at another site in the metropolitan area to confirm that concentrations are very low. These data could be used to support a Clause 14(3) assessment.
- Passive SO_2 samplers provide a useful means of confirming the reduction in SO_2 concentration with distance from sources. Data from these samplers is directly applicable to the 24-hour standard but can also be used to confirm the results of a model which produces estimates of both 1-hour and 24-hour concentrations.

4.5 Lead

- Jurisdictions are likely to want their CBD lead monitoring station to be a performance monitoring station and trend station for the purpose of the AAQ NEPM. This is possible under the wording of Clause 13(2), given that lead concentrations at peak sites are well below the AAQ NEPM and reducing. Lead levels in suburban areas are likely to be insignificant, a fact which could be confirmed by a brief campaign of monitoring. The strategy for monitoring lead in ambient air is covered in the National Environment Protection Council (Ambient Air Quality) Measure Technical Paper No.9.
- Modelling of near-roadside lead could be verified in a few instances by campaign monitoring and thereafter be used as a screening tool. Furthermore, it should be possible to develop simple conservative screening rules based on VKT per square kilometre and petrol lead content.

4.6 Particles (as PM_{10})

- Screening in centres subject to wood fire or prescribed burning smoke is not easy. High wood fire smoke concentrations occur locally under near calm conditions so total population is not a key determinant. Large prescribed burn plumes impact small and large centres alike over hundreds of kilometres. The values in Table 3 will apply to the 5th highest daily reading, where the higher readings can be shown to be due to bushfires or controlled burning.
- Hi-Vol samplers are relatively easy to install and operate on a six-day cycle for a year to provide data to support a screening assessment.
- If TSP data exist for an area, it can be used to assess the likelihood of PM_{10} exceedences by applying a conservative TSP/PM_{10} ratio.
- There are doubts about the use of particle counters and nephelometers for general AAQ NEPM measurements. However, they may have a place in providing measurements for use in screening. Their use in this role would need to be verified against PM_{10} (say TEOM) measurements but would not require such a rigorous demonstration of equivalence as for NEPM measurements.

Table 1. Acceptance limits by screening procedure for carbon monoxide, nitrogen dioxide, sulfur dioxide and lead.

Screening Procedure	Acceptance Limit (% of AAQ NEPM Standard)
A. Campaign monitoring at a Generally Representative Upper Bound (GRUB) monitoring location (with no significant deterioration expected over 5-10 years).	55% for 1 year of data 60% for 2 or more years of data
B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.	65% for 2 - 4 years of data 75% for 5 or more years of data
C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.	55%
D. In a region with no performance monitoring, use of validated[(1)] modelling with detailed and reliable estimates of emissions and meteorological data. As above in combination with F.	45% 50%
E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, "worst case" meteorology estimates and other conservative assumptions. Appendix 1 establishes corresponding population limits of 150,000 for coastal towns and 58,000 for inland towns. As above in combination with F. Appendix 1 establishes corresponding population limits of 250,000 for coastal and inland towns.	35% 45%
F. In a region with no performance monitoring, comparison with a AAQ NEPM compliant region with greater population, emissions and pollution potential[(2)].	40%
G. Use of non-standard monitoring methods, including passive samplers, which have been "calibrated" against data from performance monitoring stations.	This procedure should only be used in support of C, D, E or F, adding say 5% to the respective acceptance limits

[(1)] Validation means demonstrated satisfactory correlations between observations and predictions in the same or similar airshed.
[(2)] Pollution potential must take into account meteorology and topography.

Table 2. Acceptance limits by screening procedure for photochemical oxidants (as ozone), accounting for a natural background level of ozone and its high inter-annual variability.

Screening Procedure	Acceptance Limit (% of AAQ NEPM Standard)
A. Campaign monitoring at a Generally Representative Upper Bound (GRUB) monitoring location (with no significant deterioration expected over 5-10 years).	60% for one year of data 70% for 2 – 4 years of data 75% for 5 or more years of data
B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.	78% for 2 – 4 years of data 82% for 5 or more years
C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.	70%
D. In a region with no performance monitoring, use of validated[(1)] modelling with detailed and reliable estimates of emissions and meteorological data. Appendix 1 establishes corresponding population limits of 62,000 for coastal towns and 25,000 for inland towns. As above in combination with F. Appendix 1 establishes corresponding population limits of 95,000 for coastal towns and 75,000 for inland towns.	65% 68%
E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, "worst case" meteorology estimates and other conservative assumptions. As above in combination with F.	62% 65%
F. In a region with no performance monitoring, comparison with a AAQ NEPM compliant region with greater population, emissions and pollution potential[(2)].	60%
G. Use of non-standard monitoring methods, which have been "calibrated" against data from performance monitoring stations.	This procedure should only be used in support of C, D, E or F, adding say 5% to the respective acceptance limits

[(1)] Validation means demonstrated satisfactory correlations between observations and predictions in the same or similar airshed.
[(2)] Pollution potential must take into account meteorology and topography.

Table 3. Acceptance limits by screening procedure for PM_{10}.

Screening Procedure	Acceptance Limit (% of AAQ NEPM Standard)
A. Campaign monitoring at a Generally Representative Upper Bound (GRUB) monitoring location (with no significant deterioration expected over 5-10 years).	55% for 1 year of data 60% for 2 or more years of data
B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations (according to 14(1)) is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.	65% for 2 – 4 years of data 75% for 5 or more years of data
C. As in B above but using TSP and a conservative assumption about PM_{10}:TSP ratios.	60% for 2 - 4 years of data 70% for 5 or more years of data
D. In a region with no performance monitoring, comparison with a AAQ NEPM compliant region with greater population, emissions and pollution potential[(1)].	40%
E. Use of non-standard monitoring methods, which have been "calibrated" against data from performance monitoring stations.	This procedure should only be used in support of C or D, adding say 5% to the respective acceptance limits

[(1)] Pollution potential must take into account meteorology and topography.

Appendix 1 - SCREENING FOR NO_2 AND O_3 USING THE TAPM MODEL

BACKGROUND

The National Environment Protection (Ambient Air Quality) Measure Technical Paper No. 4 *Screening Procedures* was published in May 2001. This formalised procedures to be followed by jurisdictions when establishing that fewer than the nominal number[1] of monitoring stations are needed where pollutant levels are reasonably expected to be consistently lower than the standards. For NO_2 and O_3 the screening procedure involving "generic modelling" posed special challenges and CSIRO was commissioned to apply the TAPM model to assist in refining the procedure for these pollutants. This appendix has been developed to address the question of how the TAPM modelling studies by CSIRO[2] can be integrated into the screening procedures in Technical Paper 4. In particular, Procedure E for NO_2 and O_3 (in Tables 1 and 2) is affected:

E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, "worst case" meteorology estimates and other conservative assumptions.

In using the screening procedures presented in the Technical Paper, a number of notes apply. These include the following:

- To maintain a conservative approach, except for PM_{10}, the maximum predicted or measured concentration in the period specified should be used for comparison with acceptance limits, even though the AAQ NEPM goal may specify a number of exceedences; and
- For pollutants which have standards for more than one averaging period, the acceptance limit to be used is that of the standard which is most difficult to meet in any given region.

It should be noted that the CSIRO Phase II Report assumes that one exceedence of the acceptance limit is compliant with the screening criteria. However, the Technical Paper clearly considers one exceedence as being non-compliant with the criteria.

NITROGEN DIOXIDE

According to Table 1, procedure E specifies that in a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, "worst case" meteorology

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1 Under NEPM Clause 14.

2 Physick, B and Cope, M 2001, *A screening procedure for monitoring ozone and nitrogen dioxide in "small- to medium-sized" cities, Phase I – Validation of the procedure*, CSIRO Atmospheric Research.

Physick, B, Edwards, M and Cope, M 2002, *A screening procedure for monitoring ozone and nitrogen dioxide in "small- to medium-sized" cities, Phase II – Application of the procedure*, CSIRO Atmospheric Research.

estimates and other conservative assumptions, an acceptance limit of 35% of the AAQ NEPM standard applies for NO_2 (i.e. 35% of 120 = 42 ppb for the 1-hour standard and 35% of 30 = 10.5 ppb for the 1-year standard).

Results of CSIRO's Phase II study (see CSIRO Table 5.1) indicate that for a 1-hour averaging period, coastal towns with populations above approximately 100,000 and all inland towns requiring monitoring under the NEPM (i.e. with population greater than 25,000) would be non-compliant with the 35% acceptance limit for NO_2.

CSIRO Table 5.1. Maximum modelled hourly-averaged glcs of NO_2 (ppb) within the town boundaries for different population sizes. The number of days on which the acceptance limit is exceeded is shown in parentheses.

	Coastal	Inland
250,000	51 (3)	55 (7)
150,000	47 (1)	51 (3)
100,000	42 (-)	52 (2)
50,000	34 (-)	46 (1)
25,000	31 (-)	46 (1)

Reproduced from CSIRO Phase II study.

The implication of the results in CSIRO Table 5.1 for jurisdictional monitoring plans is that the Phase II study results can not be used to screen out the need for NO_2 monitoring in a large number of specified monitoring regions (for example see Table 2 of Technical Paper No. 2 – *Selection of Regions*, which is updated with 2001 census data here, as Table A-1).

However, in hindsight it is apparent that CSIRO took an overly conservative estimation of smog formation, which is represented by the parameter R_{smog} in the TAPM model. Thus, an alternative approach[3] is to subtract 5 ppb from the model calculations to compensate for the over-conservative estimate of R_{smog} (0.75) used. The acceptance limit remains at 42 ppb but in looking up the population limit from CSIRO Table 5.1 we use 47 ppb (this is equivalent to subtracting 5 ppb from all concentrations). This makes coastal towns up to 150,000 and inland towns up to 58,000 compliant (see Table A-2), which illustrates the sensitivity of the modelling to the value of R_{smog} used. The CSIRO report presents an analysis of sensitivity to R_{smog} showing that the sensitivity is greater for towns of 250,000 than towns of 25,000 population. Most of the towns for which screening is sought under Procedure E are expected to lie nearer to 25,000 (see Table A-1).

[3] Suggested in Section 5.4 of the Phase II report.

Table A-1. Urban centres and localities with population ≥ 25,000 (rounded to the nearest thousand) ranked by population (x1000) by State/Territory**

NSW	Pop
Sydney	3,502
Newcastle	280
Central Coast	255
Wollongong	229
Maitland	53
Wagga Wagga	44
Albury-Wodonga*	42
Gold Coast-Tweed Heads*	45
Port Macquarie	38
Tamworth	33
Orange	32
Dubbo	31
Canberra.-Queanbeyan*	30
Lismore	27
Bathurst	27

SA	Pop
Adelaide	1,002

Vic	Pop
Melbourne	3,160
Geelong	130
Ballarat	73
Bendigo	69
Shepparton-Mooroopna	36
Melton	32
Mildura	28
Albury-Wodonga*	28
Warrnambool	27

WA	Pop
Perth	1,177
Rockingham	61
Mandurah	47
Kalgoorlie-Boulder	28
Geraldton	25

Tas	Pop
Hobart	126
Launceston	68

Qld	Pop
Brisbane	1,508
Gold Coast-Tweed Heads*	377
Sunshine Coast	170
Townsville-Thuringowa	120
Cairns	99
Toowoomba	89
Rockhampton	59
Mackay	58
Bundaberg	45
Hervey Bay	36
Gladstone	27

ACT	Pop
Canberra-Queanbeyan*	310

NT	Pop
Darwin	71
Alice Springs	25

* Component within jurisdiction.
** 2001 census data updating Table 2 of Technical Paper No. 2.

Table A-2. NO_2 screening criteria

Model Assumption	Compliant Population	
	Coastal	Inland
R_{smog} = 0.75	100k	<25k
5 ppb R_{smog} correction	150k	58k

Figure A-1 shows the maximum NO_2 concentration as modelled by TAPM with the R_{smog} correction, compared with the acceptance limit (42 ppb). The concentration varies slowly with population, making the population limits sensitive to model assumptions.

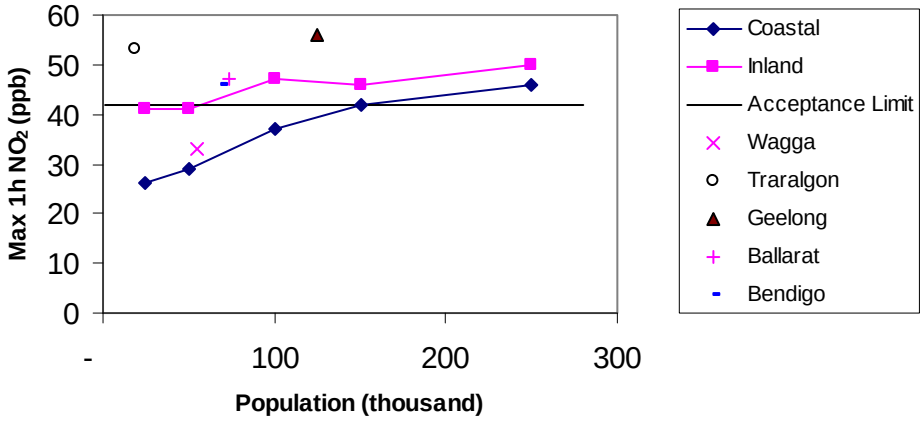

Figure A-1. Worst case NO_2 and population limits

Monitored 1-hour maxima have also been plotted in Figure A-1 for Wagga Wagga, Traralgon, Geelong, Ballarat and Bendigo. Some of these data points can be criticised:

- Wagga Wagga data were obtained from outside the town boundary.
- Traralgon and, to a lesser extent, Geelong are influenced by significant sources of NOx and are not suitable for generic modelling.
- Traralgon is influenced by sea breezes and valley recirculations in spite of being about 150 km from the sea.

For Ballarat and Bendigo, the inland modelled line is above the limit, in good agreement with monitored data. More suitable campaign monitoring results should be included as they become available. This will allow comparison with the model results, and indicate the stringency of the acceptance limit compared with actual concentrations. For example, if all data points fall well below the line, the model's predicted maxima would be unrealistically high.

There are two AAQ NEPM standards for NO_2, namely for 1 hour and 1 year. The 1-hour standard is expected to be the more difficult of the two to comply with in regions with small to medium population. For this reason, compliance with the acceptance limit for a 1-hour period may be considered sufficient for screening purposes (as noted in the second dot point in Background, above).

PHOTOCHEMICAL OXIDANTS (AS OZONE)

According to Section 4.3, screening acceptance limits, as percentages of the standards for photochemical oxidant are calculated from a consideration of percentages for gaseous pollutants which have negligible backgrounds (as found in Table 1) and the natural background for ozone:

$$L_2 = \text{ROUNDOFF}\{ [\{L_1/100 \times (O_{std\ 1h} - b) + b\} \times 100/O_{std\ 1h} + \{L_1/100 \times (O_{std\ 4h} - b) + b\} \times 100/O_{std\ 4h}] /2 \}$$

where L_2 is acceptance limit for oxidant (as %);
ROUNDOFF is rounding to nearest 0, 2, 5 or 8;

L_1 is acceptance limit (as %) for pollutants with negligible backgrounds (see Table 1);
$O_{std\ 1h}$ is NEPM standard for oxidant – 1 hour averaging period (ppm);
b is background concentration of ozone, which is assumed to be 0.03 ppm; and
$O_{std\ 4h}$ is NEPM standard for oxidant – 4 hour averaging period (ppm).

The round off and averaging procedure reflect the inherent uncertainty of the method.

It should be noted that the CSIRO Phase II report calculates L_2 without round-off or averaging the two time periods. The modelling results are quoted in CSIRO Tables 5.2 and 5.3, which are reproduced below. In deriving population limits CSIRO did not interpolate between the population levels shown. More significantly, CSIRO used a background O_3 concentration of 20 ppb. The population acceptance limits derived by CSIRO were:

- coastal towns less than 100,000 and inland towns less than 150,000 do not exceed the acceptance limit of 48 ppb for 1-hour O_3;
- coastal towns greater than 150,000 and inland towns of 100,000 or greater exceed the acceptance limit of 41 ppb for 4-hour O_3.

CSIRO Table 5.2. Maximum modelled hourly-averaged glcs of O_3 (ppb) within the town boundaries for different population sizes. Assumed background concentration is 20 ppb.

	Coastal	Inland
250,000	58	54
150,000	56	44
100,000	51	42
50,000	40	39
25,000	36	39

Reproduced from CSIRO Phase II study.

CSIRO Table 5.3. Maximum modelled 4-hourly-averaged glcs of O_3 (ppb) within the town boundaries for different population sizes. Assumed background concentration is 20 ppb.

	Coastal	Inland
250,000	45	48
150,000	39	42
100,000	36	40
50,000	30	34
25,000	27	34

Reproduced from CSIRO Phase II study.

The background level of O_3 enters the calculation in two ways: in calculating the acceptance limit L_2, and in the O_3 modelling. The L_2 calculation assumes b = 0.03 ppm for all the acceptance limits in Table 2. For consistency between the different screening procedures this should not be changed. A background of 0.03 ppm is

consistent with preliminary work on ozone for the current review of the NEPM[4]. However, it may be desirable to change the background used in the generic modelling.

The CSIRO Phase II report compares monitored ambient concentrations of O_3 in Wagga Wagga with model cumulative frequency distribution results for an inland town of comparable population, concluding that a background of 45 ppb (in the middle of the day and on very warm and perhaps smoky days) may be more appropriate than 20 ppb. According to the CSIRO report, if a background O_3 value of 45 ppb (instead of 20 ppb) were to be used, a close approximation to the maximum values would be the addition of 25 ppb to those values in CSIRO Tables 5.2 and 5.3.

If the correction for R_{smog} is assumed, as for NO_2, predicted concentrations may be decreased by 10 ppb.[5] The combined effect of these two changes is to increase the calculated concentrations by 15 ppb. Population limits can be interpolated from CSIRO Tables 5.2 and 5.3 by subtracting 15 ppb from the concentrations in these tables. The population limits according to Technical Paper 4 procedures are:

- for a one hour averaging period, coastal towns with populations over 64,000 and inland towns over 125,000 would exceed the acceptance limit of 58 ppb;
- for a four hour averaging period, coastal towns with populations over 62,000 and inland towns over 25,000 would exceed the acceptance limit of 46 ppb.

Choosing the standard more difficult to meet, coastal towns smaller than 62,000 and inland towns smaller than 25,000 then become compliant (see Table A-3). (We note that the population limits derived by CSIRO do not fully comply with the guidelines of this Technical Paper.)

Table A-3. O_3 screening criteria

Model Assumptions	Compliant Population	
	Coastal	Inland
20 ppb background, R_{smog} = 0.75, as derived by CSIRO	≤100k	≤100k
20 ppb background, R_{smog} = 0.75, according to Technical Paper 4 procedures	≤250k	≤223k
45 ppb background, R_{smog} correction	≤62k	<25k

The CSIRO report presents an analysis of sensitivity to R_{smog} showing, as for NO_2, that its effect is greater at towns of 250,000 than at lower populations where Procedure E is expected to be used most often.

Ozone results can also be plotted like the NO_2 results, with separate graphs of the 1-hour and 4-hour averages (see Figures A-2 and A-3). As for NO_2, the coastal and inland curves are very flat against population. Horizontal lines have been drawn for

[4] The issues paper prepared in preparation for the review of the AAQ NEPM (available at http://www.ephc.gov.au/pdf/Air_Ozone_Review/O3IssuesPaper_13_May_05.pdf) includes a discussion of background ozone (Section 4.3) and lists it as one of the key issues on which comment is sought. It says: "Estimates of background ozone in urban centres in Australia are usually between 0.02 and 0.034ppm, and occasionally up to 0.04ppm."

[5] According to the Summary of the CSIRO Phase II report.

the acceptance limits of 58 ppb (1h) and 46 ppb (4h) calculated assuming a 45 ppb background and concentrations incorporating the R_{smog} correction. Monitoring data for some towns have been added. The data for Traralgon, Wagga Wagga and Geelong are subject to the criticisms noted above for NO_2; in addition, Bathurst may be influenced by large sources of NOx. The points Bendigo and Ballarat lie reasonably close to the TAPM predictions for an inland town.

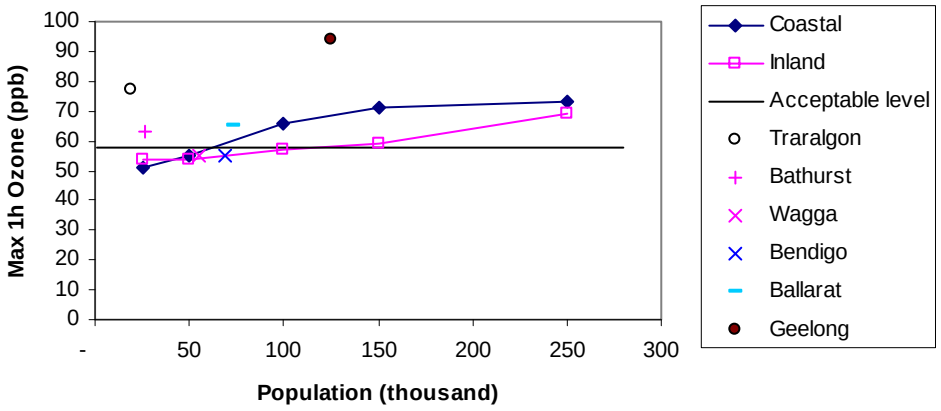

Figure A-2. Worst case 1-hour O_3 and population limits (45 ppb background and R_{smog} correction)

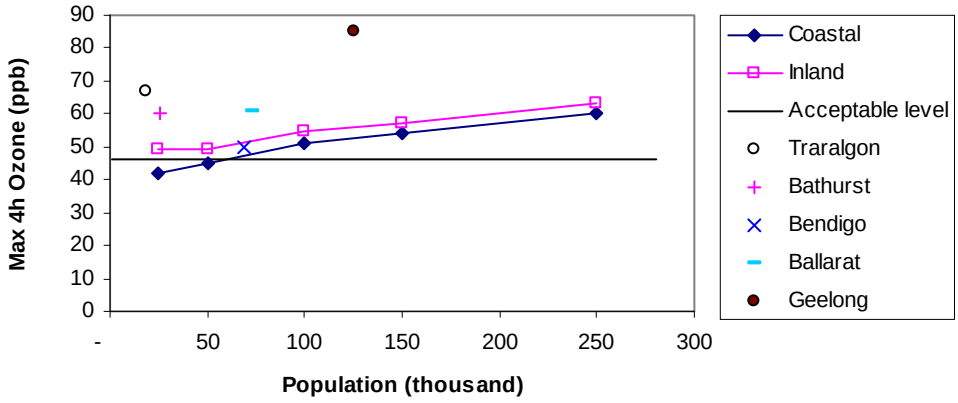

Figure A-3. Worst case 4-hour O_3 and population limits (45 ppb background and R_{smog} correction)

CAN THE OZONE ACCEPTANCE LIMIT BE RELAXED?

Procedure E is for "A region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic modelling results based on gross emissions estimates, 'worst case' meteorology estimates and other conservative assumptions." Since the TAPM method has had a degree of validation, it is appropriate to consider the possibility of relaxing the acceptance limit in Table 2 from 58% towards that used in Procedure D for 'validated modelling with detailed and reliable estimates of emissions and meteorological data' (65%). The population limits for a 65% ozone acceptance limit are:

- Coastal towns 95k, Inland towns 75k

In contrast to monitoring, which varies from year to year, modelling simulates the worst case. The acceptance limit for Procedure A (campaign monitoring for one year) is similar to that for Procedure E (60% and 58%, respectively), indicating that the uncertainty inherent in generic modelling of the annual maximum is expected to be similar to the uncertainty associated with the year-to-year variation of the monitored annual maximum (about 30 ppb). The acceptance limits in Table 2 allow for an increase in uncertainty going from Procedure D (validated modelling) to Procedure E (generic modelling) of 7% of the standard, corresponding to 7 ppb(1h) and 6 ppb(4h). The effect of relaxing the acceptance limit from E towards D in steps of 1% in L_2 is shown in Table A-4. L_2 has to move at least half way from E to D before any inland towns can be screened out. The question remains whether such a large relaxation of the limit can be justified on the basis of partial validation of the TAPM method.

Table A-4. Comparison of acceptance limits

Procedure	L2	Acceptance Limit (ppb)		Compliant population	
		1 h	4 h	Coastal	Inland
D	65%	65	52	95k	75k
	64%	64	51	91k	68k
	63%	63	50	86k	62k
	62%	62	50	82k	55k
	61%	61	49	77k	<25k
	60%	60	48	73k	<25k
	59%	59	47	68k	<25k
E	58%	58	46	62k	<25k

To assess the accuracy of the TAPM generic method, modelling results can be compared with monitoring in appropriate coastal and inland towns. There are few rural centres where ozone has been monitored for several years. Results for Moe, Traralgon, Geelong and Bathurst have been used for this purpose, although these locations are not ideal because in each case there are significant industrial emissions nearby. The annual maxima for several years are shown in Figure A-4 and indicate that the year-to-year variation is much larger than the differences between acceptance limits of different screening procedures.

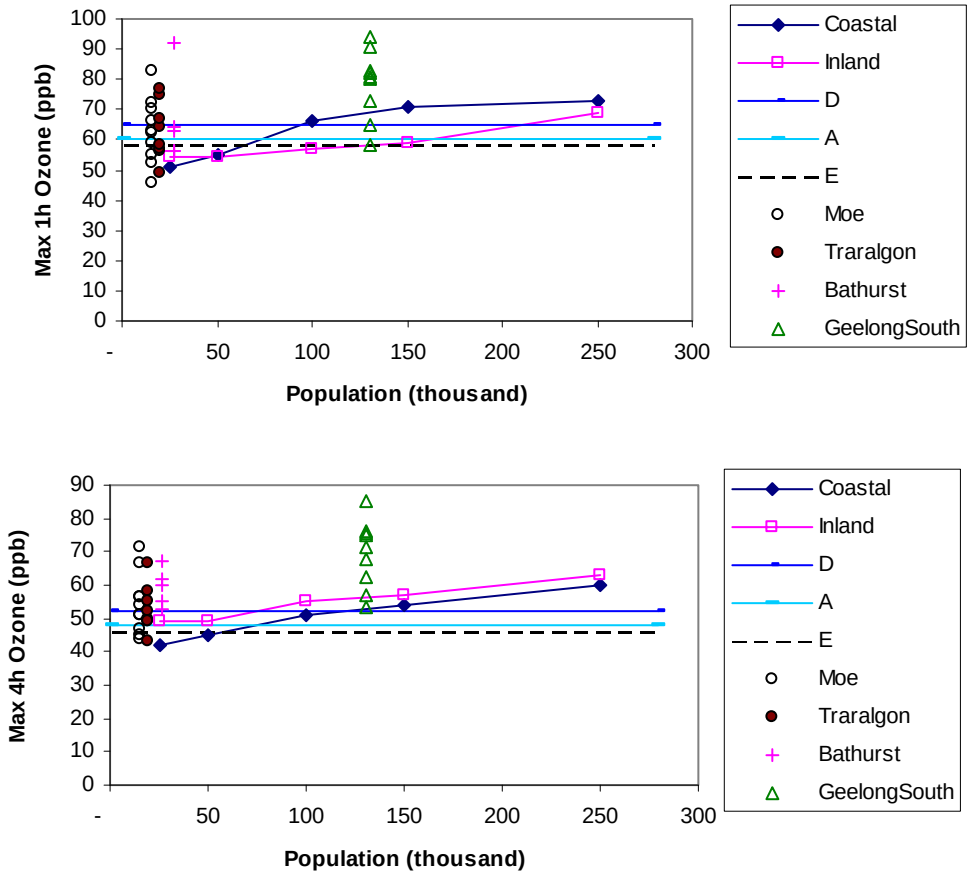

Figure A-4: Monitored data compared with TAPM generic modelling, also showing acceptance limits for screening procedures

For the four towns considered, the annual maxima calculated by the TAPM method lie towards the lower end of the range of monitored annual maxima. For good prediction, they should be in the middle of the range, and with 'conservative assumptions' they should be at the higher end. Therefore the results from these four towns do not support a relaxation of the screening procedure on the basis of partial validation of the TAPM method. As the four locations are not ideal for validation (they each have large NOx emissions which could affect ozone), further comparisons with data from other towns are desirable.

VALIDATION OF PROCEDURE A ACCEPTANCE LIMIT

Although not directly relevant to screening by generic modelling, the monitoring data in Figure A-4 allow a comparison with the acceptance limit in Procedure A. The 60% limit that has been used here is for one year's monitoring and is more stringent for ozone than for other pollutants, recognising the greater variability from year to year.[6] (The 55% limit for other pollutants corresponds to L_2 = 70% after allowing for the ozone background of 30 ppb.) Higher maximum readings are allowed under Procedure A for monitoring over longer periods than one year. Therefore, if the

[6] Section 4.3, penultimate paragraph.

screening criterion is met in any single year, the region can be screened out even if it is not met in other years.

Annual maxima in Figure A-4 show that Geelong would not be screened out on the basis of Procedure A. This is in agreement with the fact that Geelong has exceeded the four-hour standard.

Points for Moe and Traralgon lie below the Procedure A acceptance limit in several years, allowing screening by Procedure A. This is in agreement with the fact that they actually comply with the standards.

Bathurst does not meet the criterion for screening by Procedure A as all years lie above the acceptance limit (however, only five years were available, which may not be sufficient to cover the full year to year variability). The ozone standards were not exceeded in these years.

To within expected tolerances, monitoring data support the stringency of the acceptance limits for Procedure A, in particular the allowance for increased year-to-year variability that is inherent in the choice of L_2 = 60% for ozone.

SCREENING IN CONJUNCTION WITH PROCEDURE F

Tables 1 and 2 allow the use of Procedure E in combination with Procedure F (comparison with an AAQ NEPM compliant region with greater population, emissions and pollution potential). If such a region is known to be compliant, the acceptance limit for generic modelling (L_1 = 45%) is higher than that for Procedure E (35%) or procedure F (40%). Using the two procedures in combination allows larger towns to be screened.

The NO_2 limit in this case is 54 ppb. With calculations incorporating the R_{smog} correction all coastal and inland towns up to 250,000 population may be screened out provided an appropriate region with higher pollution potential is known to comply with the NO_2 standards. Due to the low slope of the modelling results (Figure A-1) the population limits would be considerably above 250,000. Extrapolation of the results suggests limits of 450,000 for coastal towns and 350,000 for inland towns.

Similarly, for ozone screening in conjunction with Procedure F, the acceptance limits are L_1 = 45%, L_2 = 65%, 65 ppb(1h) and 52 ppb(4h) (the same as for Procedure D). With modelling assuming a background of 45 ppb and incorporating the R_{smog} correction, coastal towns below 95,000 and inland towns below 75,000 are compliant provided an appropriate region with higher pollution potential is known to comply with the O_3 standards.

CONCLUSION

In developing acceptance limits in terms of population for use under Screening Procedure E, the following factors have been taken into account:

- The CSIRO TAPM modelling;
- Supplementary advice on the modelling provided by Dr Bill Physick;

- The analysis in this Appendix;
- The degrees of sensitivity of the model results to population size, acceptance limits and other adjustable parameters;
- The improved understanding of photochemistry in smaller urban centres that has been gained as a result of the above;
- The need for screening criteria to be as consistent as possible between the various pollutants;
- The conservative choice of $R_{smog} = 0.75$ for most of the TAPM modelling;
- Preliminary work on ozone for the review of the AAQ NEPM commencing in 2005.

The options adopted do not depart from the assumptions used for other screening procedures in Technical Paper 4, i.e.:

- the acceptance limit for generic modelling is 35% of the NEPM standard;
- for O_3, the 35% is applied above a background level.

However, a higher background O_3 of 45 ppb is used in the generic modelling, as in the CSIRO report. In addition, the model results have been adjusted in line with the less conservative assumption of $R_{smog} = 0.5$, as discussed in the last paragraph of Section 5.4 "Summary" of the CSIRO Phase II report.

The population acceptance limits for coastal and inland towns are those in Table A-5. If the requirements of Procedure F are also met, the population thresholds increase to those in Table A-6.

Table A-5. Population limits derived from Procedure E

	Compliant population	
	Coastal	Inland
NO_2	150k	58k
O_3	62k	<25k

Table A-6. Population limits derived from Procedure E coupled with Procedure F

	Compliant population	
	Coastal	Inland
NO_2	250k	250k
O_3	95k	75k

The distinction between 'coastal' and 'inland' centres may not be clear-cut in all cases. A jurisdiction wishing to apply the above screening methods with the more lenient 'coastal' population limits should justify the coastal designation by reference to the expected conditions leading to worst-case smog.

Any increase to the acceptance limit for TAPM modelling on the basis that the method has been partially validated would have to cover at least half the difference between Procedure E and Procedure D before any inland towns could be screened. Limited monitoring data do not support such an increase.

Limited monitoring data also suggest that the acceptance limit of 60 per cent for ozone in Procedure A is at an appropriate level to account for year-to-year variations in the monitored annual maxima.