National Environment Protection (Ambient Air Quality) Measure Review

Review Report

Prepared for the National Environment Protection Council

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1 EXECUTIVE SUMMARY

1.1 The National Environment Protection (Ambient Air Quality) Measure as varied 2003

A national environment protection measure (NEPM) is legislation designed to protect particular aspects of the environment in a consistent way across state, territory and Commonwealth jurisdictions in Australia.

The National Environment Protection (Ambient Air Quality) Measure as varied 2003 (the NEPM) and its five schedules provide a framework and guidelines about standards and methods for monitoring ambient air quality. The NEPM is supported by a Peer Review Committee (PRC) which has produced a set of advisory technical papers and provides guidance and advice to support quality and national consistency of monitoring.

1.2 Review of the National Environment Protection (Ambient Air Quality) Measure

This review is the first since the NEPM was made in 1998, providing an opportunity to assess whether it is achieving its desired environmental outcome, which is 'ambient air quality that allows for the adequate protection of human health and wellbeing'. The review process also provided an opportunity to obtain feedback from interested parties regarding the efficacy of the current framework of the NEPM.

At numerous stages in the review, stakeholders and any other interested parties were invited to provide feedback and comment regarding the NEPM and potential variations to its structure and/or content. All submissions favoured some form of change, with the option most supported by stakeholders being to:

> *Vary the monitoring and reporting protocols which address specific issues, vary the existing policy framework to include an exposure reduction overlay with any targets or goals and required monitoring and reporting protocols, and vary the existing policy framework to include the monitoring and reporting protocols for air toxics found in the National Environment Protection (Air Toxics) NEPM.*

The review looked at the technical issues involved in moving towards an integrated air quality management paradigm that addresses criteria pollutants and multiple sources, considers overall risk reduction as a principal decision metric, and uses retrospective analysis as a tool for assessing and improving air quality management.

1.3 Review findings and strategic directions

The National Environment Protection (Ambient Air Quality) Measure (NEPM) was made in 1998 and implemented with a focus on monitoring and reporting on air quality and assessing compliance with the NEPM standards. This allowed us to gain an understanding of air quality in Australian cities and to carry out management activities. However, the NEPM also required assessing and reporting on population exposure which has not occurred.

Implementing the NEPM has led to a greater understanding of air quality in Australia which has, in turn, led to an improved understanding about the health impacts of air pollution on the community. There has also been a marked reduction in emissions of some pollutants since the NEPM was made. Therefore, governments now have the opportunity to act more strategically to manage and further improve air quality in Australia, moving beyond strict compliance with the standards to a focus on reducing population risk.
This approach is consistent with international air quality policy direction and has been supported by the majority of the submissions from all stakeholder groups to this review.

Australia faces significant challenges from climate change and from population growth, which are predicted to have significant impacts on air quality. This will mean that all jurisdictions will have difficulty in achieving air quality improvements.

The frequency and severity of bushfires and dust storms are predicted to increase. These events are known to significantly increase particle levels across both urban and rural areas of Australia. Rural communities in many parts of Australia are already feeling the impact of increased dust levels due to prolonged periods of drought. This is likely to increase as the effects of climate change become more apparent across Australia.

The predicted population growth in Australian cities will put pressure on sustaining air quality improvements due to increased transport demands, domestic emissions and energy use.

The opportunity now exists to adapt the NEPM framework to meet these challenges.

1.4 List of recommendations

The overall finding of the review was that there are advantages to an integrated, risk-based approach; however, achieving it will be an evolutionary process. This evolution will require improvements in exposure assessment and changes in monitoring approaches to support these assessments. It will also require considerable advance planning in order to select appropriate accountability metrics and obtain the information needed to evaluate them.

Even if disagreement remains as to the absolute level of protection that the NEPM should ensure, it would be difficult to contest the notion that the desired environmental outcome should reflect the desire to continuously improve air quality to minimise risk to the health of the Australian population. The extent to which health risk can be minimised will be dependent on a range of factors, including economic, social and environmental considerations that will be determined through a variation process.

The recommendations support a shift in the focus of the NEPM and if adopted should assist in minimising risk to population health from air pollution. In determining health risk, it needs to be acknowledged that many pollutants do not have a recognised threshold for adverse health effects. Further detail and discussion about the recommendations can be found in the next section and throughout this report.

The 23 recommendations arising from the review are listed here in the order they appear in this report.

Recommendation 1
Revise the desired environmental outcome of the NEPM to 'minimise the risk from adverse health impacts from exposure to air pollution for all people wherever they may live'.

Recommendation 2
Revise the desired environmental goal to make reference to the air quality standards and incorporation of exposure reduction targets for priority pollutants.

Recommendation 3
Remove lead from the Ambient Air Quality NEPM and include in the Air Toxics NEPM during the scheduled Air Toxics NEPM review of 2012.

Recommendation 4
Revise the standards for all air pollutants in Schedule 1 of the NEPM to take into account new evidence around the health effects of air pollution.

Recommendation 5
Introduce compliance standards for $PM_{2.5}$.

Recommendation 6
Introduce an 8-hour standard for ozone.

Recommendation 7
Introduce an annual average standard for PM_{10}.

Recommendation 8
Introduce an exposure reduction framework and targets for priority pollutants.

Recommendation 9
Remove allowable exceedances from Schedule 2 and introduce a natural events rule.

Recommendation 10
Redesign monitoring networks to represent population exposure on a pollutant-by-pollutant basis without compromising data collection for long-term trend analysis. A procedure to determine the location and number of sites similar to EU and/or US EPA is recommended.

Recommendation 11
Remove the population threshold and formula to enable monitoring on potential population risk rather than on population size.

Recommendation 12
Amend requirements of monitoring methods (clause 16 and Schedule 3) to allow appropriate Australian Standards methods; or methods determined by the EU and/or US EPA as Reference or Equivalence Methods.

Recommendation 13
Remove Schedule 5 of the NEPM.

Recommendation 14
Develop nationally consistent approaches to assess population exposure, including appropriate modelling and emissions inventories.

Recommendation 15
Revise the assessment (clause 17) and reporting (clause 18) protocol to include additional performance assessment indicators and expanded reporting requirements to enable inclusion of population exposure determinations, severity of exceedance and effectiveness of management actions undertaken.

Recommendation 16
Revise guidance documents and templates associated with assessment and reporting to accommodate presentation of clear messages, to allow for better communication and more accessible air quality reports.

Recommendation 17
Amend the NEPM protocol (part 4) to incorporate natural event rule including definition of these events and criteria for assessment and reporting.

Recommendation 18
Require timely reporting of all exceedances, with jurisdictions publicly releasing the analysis of these events on their respective websites within 3 months of the event.

Recommendation 19

Disband the existing PRC and replace with a specialist working group or groups with a broader range of expertise to assist with scientific and technical matters. This working group would report to the Air Quality Working Group.

The following recommendations relate to future research and emerging issues. These recommendations should be considered and prioritised by the EPHC Air Quality Working Group.

Recommendation 20

Evaluate the options to assess ozone and secondary particle precursors.

Recommendation 21

Initiate research into the composition of particles in Australia and associated health impacts.

Recommendation 22

Initiate health research on the impact of air pollution (in particular, particles) in regional areas.

Recommendation 23

Monitor and report coarse particle fraction.

2 BACKGROUND TO THE REVIEW

2.1 The National Environment Protection (Ambient Air Quality) Measure

The Environment Protection and Heritage Council (EPHC) is concerned with broad national policy issues relating to environmental protection, particularly in regard to air, water and waste matters. The EPHC incorporates the National Environment Protection Council (NEPC) which is a statutory body under relevant Acts of the Commonwealth, states and territories. The NEPC meets simultaneously with the EPHC.

A National Environment Protection Measure (NEPM) is legislation designed to protect and manage particular aspects of the environment. NEPMs are similar to environmental protection policies. A NEPM may consist of any combination of goals, standards, protocols, and guidelines. The objectives of a NEPM are to ensure:

- that people enjoy the benefit of equivalent protection from air, water and soil pollution, wherever they live
- that decisions by businesses are not distorted and markets not fragmented by variations between jurisdictions in relation to the adoption or implementation of the NEPMs.

In 1998, the NEPC made the National Environment Protection (Ambient Air Quality) Measure (the NEPM) which set ambient air quality standards to apply in all states and territories and over land controlled by the Commonwealth. This was the first time that national air quality standards had been set in Australia. These standards covered six common pollutants—particles (PM_{10}), ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead. The NEPM provided a nationally consistent framework for the monitoring and reporting of these six pollutants.

A number of 'future actions' were initiated at the time the NEPM was made. Intended to facilitate a later review, these future actions, and associated work, included preliminary reviews of particular pollutant standards and a number of research studies.

The NEPM was varied in 2003 to incorporate advisory reporting standards for fine particles ($PM_{2.5}$). Preliminary work for a review of the ozone standards and the standard for sulfur dioxide was completed in 2005. The Time Activity Study was completed in 2004, and the Multi-city Mortality and Morbidity Study completed in 2006. The Children's Health and Air Pollution Study is currently being conducted and it is anticipated that the results will be available for consideration if it is decided to vary the NEPM.

Although the NEPM deals only with ambient air quality, it is acknowledged that indoor air quality is also an important factor in the exposure of individuals to air pollution.

The NEPM focuses on ambient air pollution whereby monitoring can be undertaken and management actions implemented by jurisdictions. Given the infiltration of outdoor air into the indoor environment, reductions in ambient air pollution levels should also lead to reductions in indoor air pollution.

2.2 *Key features of the NEPM*

The key parts of the NEPM are as follows:

National environment protection goal (Part 2)
The NEPM sets out a goal that:

(a) relates to the desired environmental outcome of ambient air quality that allows for the adequate protection of human health and well-being
(b) guides the formulation of strategies for the management of human activities that may affect the environment.

National environment protection standards (Part 3)
The NEPM sets standards that consist of quantifiable characteristics of the air against which ambient air quality can be assessed.

National environment protection protocol (Part 4)
The NEPM sets out the processes to be followed in measuring the concentration of pollutants in the air to determine:

(a) whether the standards of the NEPM are being met
or
(b) the extent of the difference between the measured concentration of pollutants in the air and the standards.

Accompanying schedules
The NEPM contains five schedules that establish air quality standards and methods for monitoring air quality. They include:

Schedule 1: Pollutants
Schedule 2: Standards and goal
Schedule 3: Australian standards methods for pollutant monitoring
Schedule 4: Protocol for monitoring $PM_{2.5}$
Schedule 5: $PM_{2.5}$ equivalence program

Additional guidance
As part of the initial decision to make the NEPM, the NEPC agreed to establish a Peer Review Committee (PRC) comprising nominees from industry and the environment movement, as well as from each jurisdiction, and supported by the NEPC Service Corporation.

The PRC was established to assist jurisdictions to develop monitoring plans to meet the requirements of the NEPM, and to provide NEPC with advice on the adequacy of those plans. The PRC produced a set of technical papers to guide the development of jurisdictional monitoring plans, with the aim of assuring quality and national consistency (see Bibliography for a list of the PRC's technical papers).

2.3 *Approach to the review*

When the NEPM was made, there was a commitment to initiate a full review of the NEPM in 2005. The overall purpose of the review was to evaluate the performance of the current NEPM in achieving the desired environmental outcome, and to recommend to the NEPC any required changes to the NEPM.

A Review Team was established by the NEPC to undertake the review. The Review Team was chaired by Victoria and comprised representatives from the Australian Government, Victoria, Western Australia, South Australia and enHealth. The Review Team was supported by a Project Manager from the NEPC Service Corporation.

The following advisory groups were established to assist with the review:

- Non-government Organisations Advisory Group
- Jurisdictional Reference Network
- Health Advisory Group
- Technical Advisory Group

These groups had input into the development of discussion papers, and provided policy, technical and operational advice and information throughout the review process.

In addition, the EPHC established the Standards Setting Working Group to develop a nationally agreed approach to setting air quality standards in Australia. The draft standard-setting methodology developed by this group was used to guide the review of the health literature in assessing the need to revise the current standards.

Stakeholder input was sought through the development and circulation of an issue scoping paper and two discussion papers, and through a series of public consultations. Comment was invited about the information presented, the issues raised and the options proposed. Feedback received during this process has been taken into account in formulating the recommendations contained in this report.

2.4 Terms of reference for the review

This review of the NEPM considered:

- the effectiveness of the NEPM in achieving its desired environmental outcome, which is 'ambient air quality that allows for the adequate protection of human health and wellbeing'
- the effectiveness of the NEPM in generating comparable, reliable information on the levels of air pollutants
- the environmental, economic and social impact of the NEPM, including unintended consequences
- the simplicity, efficiency and effectiveness of the administration of the NEPM, including the adequacy of its support mechanisms
- any regional environmental differences in Australia and the implications for the NEPM
- the links between the NEPM and other government policies (including other NEPMs) and the potential for integration
- the need, if any, for variation of the NEPM (in accordance with the Act), including:
    - whether any changes should be made to the Schedules
    - whether any changes should be made to improve the effectiveness of the NEPM in achieving the desired environmental outcome set out within it
    - the potential costs and benefits of any proposed changes.

2.5 The review process

Below is a summary of the work that has been undertaken since 2005 as part of the review of the NEPM.

Development and distribution of an issue scoping paper
An Issue Scoping Paper (ISP) was developed in 2005 and stakeholder views sought to assist with developing the scope of the NEPM review. Submissions to the ISP identified areas of concerns and suggested issues to be investigated in the review. A review proposal was subsequently presented to the NEPC in 2006 and the review was initiated that same year.

To assist and inform the review, two discussion papers were developed (in 2007 and in 2010) to gain stakeholder and public views on improving the effectiveness of the NEPM and formulating recommendations regarding potential variations.

The 2007 discussion paper on framework, monitoring and reporting
The first discussion paper focused on the current framework of the NEPM, and its monitoring and reporting protocols. Respondents were invited to comment on six broad options put forward to address issues that had been raised in the ISP.

The options are summarised below.

Option A
Make no changes to the current NEPM policy framework or protocols.

Option B
Vary only the monitoring and reporting protocols that would address specific issues raised with the existing policy framework.

Option C
Include an exposure reduction overlay in the current policy framework or protocols.

Option D
Vary the monitoring and reporting protocols that would address specific issues, and vary the existing policy framework to include an exposure reduction overlay incorporating procedures to determine reduction targets or goals and required monitoring and reporting protocols.

Option E
Vary the monitoring and reporting protocols that would address specific issues, and vary the existing policy framework to include monitoring and reporting protocols found in the National Environment Protection (Air Toxics) Measure.

Option F
Vary the monitoring and reporting protocols which address specific issues, vary the existing policy framework to include an exposure reduction overlay with any targets or goals and required monitoring and reporting protocols, and vary the existing policy framework to include the monitoring and reporting protocols for air toxics found in the National Environment Protection (Air Toxics) Measure.

The 2010 discussion paper on air quality standards
The second discussion paper reviewed health research related to the pollutants currently included in the NEPM and pollutants being considered for inclusion. International trends in air quality policy and the rationale for the current standards were also discussed. Respondents were invited to comment on whether existing standards were appropriate in light of any new evidence regarding the effect of air pollution on human health.

Cost-benefit analysis
A preliminary cost-benefit analysis of possible changes to the NEPM has been conducted, and will inform the NEPC's decision on whether to proceed to a variation. If the decision is made to proceed with a variation, a more detailed and comprehensive cost-benefit analysis and impact assessment will be conducted to identify and assess economic and social impacts on the community.

Costs of air pollution are typically estimated on the basis of health impacts, while net benefits of changing standards are estimated as health costs avoided, less abatement costs.

The rationale for a cost-benefit approach is that community resources for health and the environment should be used effectively. A cost-benefit analysis will support outcomes when there is a net benefit to communities. Each airshed is likely to require somewhat different policy responses, so incremental abatement costs may vary from city to city.

Emission reduction actions
Closely linked to the review process, jurisdictions are working together through the EPHC to develop a set of national emission reduction actions that will improve air quality and help meet the existing NEPM and any potential variation to the NEPM. These will complement the air quality management strategies of individual jurisdictions. The feasibility of additional emission reduction actions at state and national level to meet the NEPM will also be undertaken to inform NEPC's decision on whether to proceed to a variation of the NEPM.

Review report
This review report draws on information received and analysed from the range of sources described above. It includes a number of recommendations and will be presented to the NEPC in early 2011.

If a decision is made to vary aspects of the NEPM, a draft varied NEPM and an impact statement will be prepared. The impact statement will include an assessment of environmental, economic and social impacts. In accordance with the *National Environment Protection Council Act 1994* (the NEPC Act), and the NEPC consultation protocol, both the draft variation and the impact statement will be made available for public consultation. The NEPC will then consider the impact statement and submissions received during that consultation period and decide whether to adopt the proposed variation to the NEPM.

3 REVIEW OUTCOMES

This review has extensively examined all aspects of the NEPM. The terms of reference of the review focused attention on the strategic direction of the NEPM as well as on a range of technical issues with respect to monitoring and reporting. This report assesses and documents the outcomes of the review in a logical way, in line with the current structure of the NEPM; that is, under the headings of national environment protection goal, standards, and protocols.

The review concludes that the NEPM has been successful in developing a national approach to the monitoring and assessment of air quality in Australia. However, the review process has revealed some issues in the implementation of the NEPM that will, if addressed, improve efficiency and consistency in addition to meeting jurisdictional and stakeholder expectations. These are discussed in detail in the discussion papers (found at www.ephc.gov.au/airquality/aaq_nepm) and throughout this report.

3.1 National environment protection goal

As explained earlier in this report, the national environment protection goal is found within part 2 of the NEPM and relates to the desired outcome which is the protection of human health and well-being. It also guides the development of strategies for the management of human activities that may affect the environment, in this case ambient air quality.

The national environment protection goal establishes the policy framework of the NEPM. As a result, the issues, findings and recommendations of the review relating to part 2 of the NEPM also have implications for air quality standards (part 3) and monitoring and reporting (part 4). Given this, there is some overlap of discussion in the different sections of this report. As much as possible, this has been kept to a minimum.

3.1.1 Issues

In reviewing progress towards achieving the desired environmental outcome, the Review Team considered:

- air quality monitoring data
- risk to population health
- complexity surrounding cost-benefit analysis
- vulnerable subgroups in the population
- expanding the intent of the NEPM to include ecological considerations (secondary standards).

The simplicity, efficiency and effectiveness of implementing and administering the NEPM all have an impact on a jurisdiction's ability to achieve the desired environmental outcome and formulate management strategies. To enable the Review Team to consider this impact, jurisdictions were asked to provide a range of information including cost estimates for developing and preparing monitoring plans and establishing the monitoring networks.

3.1.1.1 Progress in meeting the desired environmental outcome

The intent of the NEPM was to provide a framework to monitor and assess air quality to ensure 'adequate protection of human health and well-being'. The review process established that there is no shared understanding among stakeholders as to the meaning of 'adequate protection'. The concept of adequate protection implies a range of issues such as the appropriate balance between population health, economics, social equity and lifestyle. Implicit in the NEPM was the inference that meeting the compliance standards would ensure

the achievement of the desired environmental outcome of the NEPM in providing adequate protection of human health and well-being.

The review concludes that, even if disagreement remains as to the absolute level of protection that the NEPM should ensure, it would be difficult to contest the notion that the desired environmental outcome should reflect the desire to continuously improve air quality to minimise risk to the health of the Australian population. The extent to which health risk can be minimised will be dependent on a range of factors, including economic, social and environmental considerations that will be determined through a variation process.

One method of determining how effective the NEPM has been in driving improvements in air quality is assessment of the air quality data from monitoring stations. However, linking air quality improvement directly to the implementation of the NEPM is difficult because of the range of reasons that may be behind specific management actions. Furthermore, there are often extended lag periods between implementing management action (such as new design emission standards for a particular source) and observing ambient air quality improvements. In addition, a number of other factors such as population growth, economic development and increased motor vehicle use (just to name a few) counteract emission reduction resulting from implementing management actions.

It does appear that, in general, air quality in Australian cities is good by international standards. The data show that nitrogen dioxide, carbon monoxide, sulfur dioxide and lead concentrations are consistently below the NEPM standards in all jurisdictions. Most jurisdictions still experience exceedances of the standards for particles (both PM_{10} and $PM_{2.5}$) and ozone on occasions. These exceedances often appear to be associated with bushfires and/or management burns. An analysis of the monitoring data (undertaken during preparation of the first discussion paper on the NEPM policy framework, reporting and monitoring protocols) did not present any clear trends, with the exception of two cases: one being the reduction in ambient lead due to its removal from motor vehicle petrol, and the other being reductions in particle levels in Launceston through domestic wood heater incentive and education campaigns.

The review of the potential population health risk resulting from ambient air quality exposure across Australia considered a range of factors. Stakeholder comment was sought on whether additional pollutants such as benzene and benzo(a)pyrene should be incorporated into the NEPM.

Determining potential population health risk resulting from ambient air quality exposure has been complicated by the fact that epidemiology studies are now indicating there is no clear threshold for effect for the current NEPM pollutants, with exposures below the standards still representing a statistically significant and measurable health risk to the Australian population. This is a shift in thinking, given that when the NEPM was made it was thought sulfur dioxide and carbon monoxide had an identified threshold of effect, and nitrogen dioxide and lead had an apparent threshold of effect. In light of this new evidence, compliance with the standards alone may not achieve the desired environmental outcome of 'adequate protection'.

Jurisdictions also acknowledged that it is difficult to assess whether the population is adequately protected based on the NEPM monitoring data as networks have been established to assess compliance at GRUB sites, rather than measure the potential range of concentrations across an airshed.

3.1.1.2 Resources for, and administration of, NEPM implementation

The perceived cost to implement the NEPM varies considerably between jurisdictions. The total direct cost attributed to implementation is estimated to be approximately $4 million over 8 years. These costs are lower than those predicted at the time of making the NEPM (NEPC 1998) which estimated a total of $5 million over the same time period. Jurisdictions did identify the provision of insufficient resources as a key issue in the implementation of the NEPM. Some jurisdictions reported they were unable to fully implement monitoring as approved through the monitoring plans due to resource constraints and competing priorities.

Although there has been no significant increase in the coverage of the air quality monitoring networks in urban areas (i.e. more stations), one key improvement identified as a direct result of NEPM implementation has been increased monitoring in regional areas, particularly in Victoria and NSW. Implementation of the NEPM has also ensured that equipment upgrades have occurred and new instrumentation incorporated into existing stations to increase the number of pollutants assessed, as in additional particle monitoring (for both PM_{10} and $PM_{2.5}$).

Most jurisdictions reported that they had not experienced any difficulties in administering the NEPM. Western Australia, however, did observe that implementation had resulted in political and community concern when standards were exceeded. These exceedances were often perceived to pose a significant risk to individual and population health, whilst any value below the NEPM standard (no matter how close to the standard) was perceived to be 'safe'. This issue is important when considering the desired environmental outcome of the NEPM, the form of the standards, and the monitoring and reporting processes in place.

3.1.1.3 Consideration of environmental, economic and social impacts

As mentioned previously, the current desired environmental outcome of the NEPM focuses on human health and well-being. It does not give consideration to other parts of the environment, including ecosystems, which may include economic and ecological values of crops, forests, natural areas, animals, property, and aesthetic values such as visible distance. Internationally, some jurisdictions have introduced secondary air quality standards to assist management of these issues. With the exception of standards to protect local visual distance, most secondary standards are designed to protect agricultural or natural ecosystems. These standards have been introduced where there is evidence that the ecosystem is more sensitive than human health to specific air pollutants, and are based on high quality data and assessments.

While there is considerable scientific knowledge about the impacts of air pollution on the agricultural crops and some plantation trees, there is much less knowledge about impacts of air pollution on the natural vegetation and natural ecosystems of Australia.

The 2007 discussion paper inferred that an extensive review of the available literature would be required prior to any determination regarding the need for secondary standards in the Australian context. In addition to this, modelling would need to occur to predict regional impacts so a cost-benefit analysis could be performed. The desired environmental outcome would also need to be revised to accurately reflect the intent of the NEPM.

Any variation to the NEPM will require the preparation of an impact statement, involving a comprehensive cost-benefit analysis, to identify and assess the economic and social impact on the community. This analysis is made difficult by the following factors:

- many pollution abatement policies are implemented at a jurisdiction level
- some intervention programs will pre-date any variation and should not be fully attributed to any variation
- there are often long delays between the intervention activity and widespread market penetration
- current monitoring networks do not provide an adequate representation of population exposure.

Background or non-anthropogenic pollution would need to be accounted for in the cost-benefit analysis, as air pollution levels can be dominated by natural events like bushfires and dust storms. Anthropogenic sources should be separated from background sources so that the cost of management strategies to reduce the anthropogenic contribution can be assessed. Both ozone and particles occur naturally and their presence can contribute substantially to measured levels and exceedances.

The 2007 discussion paper proposed consideration of an exposure reduction approach to achieve the desired environmental outcome, given the lack of identified thresholds for health effects from exposure to these pollutants. Therefore any reduction in exposure will provide health benefits that will need to be factored into any cost-benefit analysis. The exposure reduction approach is discussed further in this report and in detail in the discussion papers of both 2007 and 2010. Information on the way this approach is being taken in the EU and the UK is widely available on the internet.

An exposure reduction approach moves away from a strict standards-based approach and places more focus on reducing population exposure. This assessment and any resulting management strategies are based on the premises that:

- there is no clear threshold for effect, so any reduction in exposure (either above or below a compliance standard) will result in health benefits
- it may be more cost efficient to implement management actions which reduce exposure to a large segment of the population, rather than peak exposures to a small proportion of the population.

The 2007 discussion paper raised another important issue with respect to the desired environmental outcome, that being the experiences of sensitive subgroups within the community. It is well documented that exposure to air pollution causes a range of responses across the population. Known sensitive subgroups within the community include people with existing respiratory and cardiovascular disease, children, and the elderly. In addition, there is increasing evidence that air pollution may have a disproportionate impact on people in lower socio-economic groups.

This review has considered current monitoring and reporting procedures for these sections of the population, as well as potential inconsistencies in the use of the term 'adequate protection' as it relates to the desired environmental outcome and these sensitive subgroups. What is adequate for one person or population subgroup may not be for another.

3.1.2 Comments and discussion

All of the submissions received proposed some form of change to the NEPM. As expected, there were divergent views on some issues and general support for others. Of the six broad options presented in the 2007 discussion paper (detailed earlier in this report), the NEPM variation most supported by stakeholders was Option F which proposed to:

> *Vary the monitoring and reporting protocols which address specific issues, vary the existing policy framework to include an exposure reduction overlay with any targets or goals and required monitoring and reporting protocols, and vary the existing policy framework to include the monitoring and reporting protocols for air toxics found in the National Environment Protection (Air Toxics) NEPM.*

Option D was the next preferred variation, featuring the same elements as Option F without proposing the incorporation of the air toxics NEPM into the NEPM. A number of submissions separately discussed the perceived benefits and issues with amalgamating the two air quality-related NEPMs at this time.

3.1.2.1 Adequate protection

The review process established that there is no agreement on what the term 'adequate protection' means or should mean.

The health sector considered it important to clarify the definition of 'adequate protection' particularly as it relates to sensitive subgroups, suggesting that definitions should not be left to the interpretation of individual agencies. The sector was also concerned that the review determine to what extent the community should or will accept risks. Representatives from the health sector indicated that their experiences and discussions highlight assumptions within the community that full protection is achieved when air quality standards are met, and that exceedances are major health issues.

There was an expectation, raised primarily by the community submissions, that sensitive subgroups would be considered and provided 'adequate' protection when implementing the NEPM to achieve the desired environmental outcome.

A similar interpretation was observed by the Western Australian environment agency. Other submissions received were also consistent with the views of the health sector.

There is overwhelming support to have the term 'adequate protection' defined.

3.1.2.2 Exposure reduction

There was support for the adoption of an exposure reduction approach. The most-preferred variations, options F and D, both included exposure reduction as a key addition to the current NEPM. Several review participants voiced their support for the introduction of an exposure reduction overlay separate to identifying a preferred variation from a predetermined list.

Although support was given by Clean Air Society of Australia & New Zealand (CASANZ) for exposure reduction targets, caution was suggested, with the society recommending that an approximate exposure assessment be undertaken prior to a commitment to this approach. It was suggested that it would be difficult to undertake a cost-benefit analysis of various reduction targets without this assessment.

It appears from the submissions that clarification is required as to how an exposure reduction framework may apply. One submission indicated that it would be preferable for exposure reduction to focus on the most exposed populations. It was not clear whether the submission was referring to elevated concentrations of a particular pollutant, or where large segments of the population may be exposed. Other submissions supported a broader application across whole populations.

3.1.2.3 Resourcing and implementation

Several commentators raised concerns that jurisdictions did not appear to be adequately resourced to implement the NEPM. It was suggested many of the issues raised in the review regarding the location of monitoring stations were, in fact, linked to resource constraints and will not be remedied by simply varying the NEPM. Another submission (by a community group) argued that where there are limited resources, there is a need to take a precautionary approach to station siting, as exemplified by the Generally Representative Upper Bound, or 'GRUB' concept. This submission went on to suggest that detailed emissions inventories and airshed modelling could be used to assist in determining population exposure. A number of commentators noted it was essential that any variations to improve the NEPM be realistically costed and resourced to build upon the core achievements of the NEPM to date. This should include any resource implications of implementing an exposure reduction approach.

3.1.2.4 Secondary standards

There was support to investigate the option of secondary standards when the ISP was released for comment. However, only one submission specifically mentioned the potential of ecological standards in response to information provided in the 2007 discussion paper. This submission, from industry, suggested tighter standards for ecological reasons are unlikely to show further improvement without major technological and behavioural changes to population mechanisms, particularly when management action to date has shown little if any improvement based on human health protection principles.

3.1.2.5 Industrial emissions

The NEPM standards were established as ambient standards; that is, pertaining to broad air quality within airsheds. They were not generally aimed at assessing air quality at localised point sources, such as those from industrial plants. However, many jurisdictional authorities (perhaps most) have used them as a basis for licence conditions or other instruments for protecting local communities from ground level impacts of pollutants in residential areas outside industrial activity boundaries.

Several industry commentators raised concerns about the use of NEPM standards for managing industrial emissions, arguing that the original intent of the NEPM was to avoid monitoring near localised point sources of pollution and at peak sites as these would not represent general population exposure. In contrast, elements of the health sector expressed the view that areas impacted by industrial emissions should be included as part of a population exposure monitoring regime as the general population also includes these sub-populations.

In relation to applying standards for industrial limits, this is a matter of choice by jurisdictions in implementing their own respective legislation and does not, therefore, fall within the purview of this review.

3.1.3 Review findings

The issues identified and examined in the 2007 and 2010 discussion papers suggest there is justification for amendments to the NEPM policy framework, standards and protocols. Some of these changes are linked to unanswered questions (e.g. what is adequate protection?), whereas others are supported by an increase in knowledge (e.g. no health effect threshold). Support for amendments to the NEPM is reiterated through the comments received and the breadth of views expressed.

It is clear that the desired environmental outcome of the NEPM requires alteration. There is a large proportion of the community that expects that absolute protection should be provided. This is not compatible with the concept of adequate protection given the findings of epidemiology studies that there is no evidence of a clear threshold for effect.

Studies in Australia and overseas (see Discussion Paper www.ephc.gov.au/airquality/aaq_nepm) show that exposures below the current NEPM standards still represents a statistically significant and measurable health risk to the Australian population, and on this basis the Review Team suggests it would be difficult to reach consensus on a tightly defined definition for 'adequate protection'. The Review Team considers that the desired environmental outcome should be revised to acknowledge the health risks associated with air pollutant exposure and that implementation of the NEPM will aim to minimise these risks as much as possible.

To ensure that the requirement of the NEPC Act provide equivalent protection for all Australians is met, consideration should be given to considering patterns of exposure and reducing risks to the whole population arising from these exposures. The Review Team considers that the desired environmental outcome should be amended to focus on minimising risk for all people wherever they may live. In a later section of this report, changes are also proposed to reporting protocols to ensure that NEPM information is more easily accessible to all parts of the community.

There appears to be significant merit and across-the-board stakeholder support for an exposure reduction framework. Its implementation should improve the effectiveness of the NEPM by targeting management strategies to reduce population exposure rather than complying with a standard. It will also highlight the fact that the air quality standards do not provide absolute protection and any reduction in exposure will have a net positive health benefit. The introduction of an exposure reduction approach will align Australian air quality management policy with international best practice approaches.

The issue of jurisdictional resourcing will be explicitly considered within the impact statement as part of a variation process. There does not appear to be sufficient information or impetus at this time to develop and incorporate national ecological air quality standards. The Review Team anticipates research and policy responses will progress at a jurisdictional level as localised issues arise. This work should be investigated as part of any future review of the NEPM.

3.1.4 *Recommendations relating to national environment protection goals*

Recommendation 1
Revise the desired environmental outcome of the NEPM to 'minimise the risk from adverse health impacts from exposure to air pollution for all people wherever they may live'.

Recommendation 2
Revise the desired environmental goal to make reference to the air quality standards and incorporation of exposure reduction targets for priority pollutants.

3.2 National environment protection standards

The purpose of part 3 of the NEPM is to set standards that consist of quantifiable characteristics of the air against which ambient air can be assessed.

3.2.1 *Issues*

When the NEPM was made in 1998, it set standards for carbon monoxide, nitrogen dioxide, sulfur dioxide, particles (as PM_{10}), ozone, and lead. In 2003, the NEPM was varied to include advisory reporting standards for $PM_{2.5}$. At the time of making the NEPM, there were no studies conducted in Australia linking adverse health effects with exposure to air pollution. Consequently, the standards were based on evidence from studies conducted overseas, particularly in the US.

Studies that have since been conducted in Australia support the findings of studies overseas. These studies provide evidence of adverse health effects attributable to air pollution in the Australian population at pollution levels currently experienced in Australian cities. The current air pollution levels are largely below the current air quality standards in the NEPM although exceedances of the particle and ozone standards are experienced at times.

The key policy-relevant questions which provided a framework for review of the scientific evidence were:

1. Has new information altered scientific support for the occurrence of health effects following short- and/or long-term exposure to levels of air pollutants found in the ambient air in Australian cities?
2. What do recent studies focused on the near-source environments tell us about health effects of air pollutants?
3. At what levels of exposure to air pollutants do health effects occur?
4. Has new information altered conclusions when the NEPM was made regarding the plausibility of adverse health effects caused by exposure to air pollutants?
5. To what extent have important uncertainties been identified and addressed?
6. What are the relationships between short- and long-term exposures to air pollutants and adverse health effects?

The main aim of setting NEPM standards is the prevention of adverse health impacts from air pollution and to provide adequate protection for all Australians. For the purpose of setting air quality standards, the risk characterisation applies to population risk not individual risk. Population risk refers to an assessment of the extent of harm for the population as a whole.

In determining the risk of adverse health effects in the population from exposure to air pollution, evidence of causality is largely drawn from estimates of how the risk changes in response to exposure. Generally, the response is evaluated within the typical range of air pollutant concentrations experienced by a defined population.

Extensive human data are available to inform risk assessments for all criteria pollutants. An important consideration in characterising the public health impacts associated with exposure to a pollutant is whether the exposure-response relationship is linear across the full concentration range or whether there is a threshold for effect.

Another factor that must be taken into account when setting air quality standards is the existence of vulnerable subgroups within the population. The sensitivity of individuals to air pollution arises from a number of factors including:

- age
- gender
- respiratory diseases, e.g. asthma, chronic obstructive pulmonary disease (COPD)
- cardiovascular diseases
- pre-existing disease, e.g. diabetes
- adverse birth outcomes: e.g. pre-term birth, low birth weight, growth restriction, birth defects
- race/ethnicity
- genetic factors
- obesity
- socio-economic status.

These factors may affect an individual's response to exposure to air pollution, and air quality standards must contain an adequate margin of safety to protect these individuals as far as practicable.

3.2.2 Comments, discussion and review findings

All of the submissions received proposed changes to the standards in the NEPM. The majority of submissions supported the removal of allowable exceedances and the inclusion of a natural events rule to account for events such as bushfires and dust storms. Caution about the natural events rule was noted in some submissions, and many submissions expressed the need to include strict guidelines about what would be excluded. There was strong support to include an exposure-reduction overlay together with compliance standards to minimise risk to the health of the Australian population.

3.2.2.1 Right pollutants

There were many specific comments received regarding the need to consider the form of the standards and whether they should be located in the ambient air quality NEPM, the air toxics NEPM, or a combined NEPM. These comments are considered in detail later in the report, where national environment protection standards (part 3 of the NEPM) are discussed.

One submission recommended the development of agreed criteria for the inclusion of 'common' pollutants in the NEPM. This could provide a logical procedure for determining the appropriateness or otherwise of air pollutants proposed for inclusion in the NEPM.

One of the questions raised through the review process was whether the right pollutants are included in the NEPM. In particular, since lead is no longer widely spread in the environment and is linked primarily to industrial sources, the Review Team considered whether it should be included in the ambient air quality NEPM or moved to the air toxics NEPM. The consultation process identified a consensus that lead no longer meets the definition of a 'criteria' pollutant and therefore does not belong in the ambient air quality NEPM. There was, however, a desire to have a national air quality standard that could be used in communities such as Port Pirie and Mt Isa that are impacted by industrial sources. There was strong support to move lead to the air toxics NEPM where monitoring is focused on hot spots.

Feedback on the Issues Scoping Paper supported benzene and PAHs be considered for inclusion in the ambient air quality NEPM, as they arise from multiple sources and are widely spread in the environment. These pollutants are currently included in the air toxics NEPM. The mixed views on whether these pollutants should be included in the ambient air quality NEPM were mainly due to the limited amount of data that is available. The mid-term review of the air toxics NEPM has shown that, although there is more data available than when that NEPM was made, it is still limited. The Review Team considers that, at this stage, benzene and PAHs should remain in the air toxics NEPM until further data are collected. The question of their removal to the ambient air quality NEPM should be considered as part of the full review of the air toxics NEPM scheduled to commence in 2012.

Particles were also the subject of comment in submissions to the review. Currently, the indicators are PM_{10} and $PM_{2.5}$ and questions were raised as to whether standards should be set for ultrafine particles (<0.1 μm), coarse particles ($PM_{2.5-10}$) or specific components (e.g. metals, black carbon), as well as the existing indicators. Issues to be considered include:

- whether we have sufficient evidence to show that there are health effects of the pollutants separate to those associated with PM_{10} and $PM_{2.5}$
- whether there is monitoring data available in Australia that would enable the setting of standards for these pollutants.

The health reviews conducted as part of this review have shown that, although there is some evidence for health effects linked to ultrafine particles, there is not sufficient evidence to support the setting of standards at this time. This finding is supported by the recent reviews conducted by WHO and the US EPA (US EPA 20090; WHO 2006). In addition, as ultrafine particles are not routinely monitored, there is no monitoring data available in Australia that would enable the setting of standards.

Although there is stronger evidence for independent health effects associated with the coarse fraction of $PM_{2.5-10}$, this information is limited and there are no Australian health studies for this size fraction. The health effects associated with this size fraction are similar to those attributed to PM_{10}. There is very limited monitoring data available in Australia for $PM_{2.5-10}$ and what is available is not sufficient to support the setting of standards at this time. However, given that this size fraction is significant in Australia due to the significant contribution from windblown dust to PM_{10}, further monitoring of the coarse fraction and studies into the associated health effects may be prudent to inform the setting of standards for $PM_{2.5-10}$ in the future.

Current research has not been able to conclude precisely what property of PM (size, mass, composition) is directly responsible for the observed health effects. There are very limited data available internationally about the health effects of individual components of particles. There is some evidence that metals and black carbon may have independent health effects from the particle mass indicators PM_{10} and $PM_{2.5}$; however, it is insufficient at this time to enable the setting of standards. In addition, there is very little monitoring data available in Australia to support the setting of standards for individual components.

In summary, the findings of the Review Team are that:

- lead is no longer widely spread in the environment and should be removed from the ambient air quality NEPM; although it is an issue at point sources, it is more appropriately placed within the Air Toxics NEPM
- a national standard is desirable for lead and should be included in the air toxics NEPM
- there are not sufficient data at this time to support the inclusion of benzene and PAHs in the ambient air quality NEPM. This should be considered as part of the full review of the air toxics NEPM commencing in 2012
- PM_{10} and $PM_{2.5}$ remain the relevant indicators for particles. There are not sufficient data at this time to support the development of standards for ultrafine particles, $PM_{2.5\text{-}10,}$ or individual components of particles.

3.2.2.2 Do we have the right standards?

Many submissions supported the need to revise air quality standards, using the most recent heath information.

The health reviews conducted as part of this NEPM review have shown that there is significant new evidence on the health effects of air pollution both in Australia and internationally. A full discussion on the health effects can be found in the Discussion Paper (www.ephc.gov.au/airquality/aaq_nepm). The results of epidemiological studies worldwide are showing health effects at lower pollution levels which, in many cases, are well within existing standards. One important finding of this review is that there appears to be no threshold below which no health effects are observed. This means that wherever the standards are set, there will be some level of risk associated with that exposure. The results of epidemiological studies are supported by the results of controlled human exposure studies and animal toxicological studies.

The findings of local studies show that health effects of air pollution in Australia are similar to those observed in studies conducted overseas. For nitrogen dioxide and particles, the effects appear to be greater than those observed in the US and Europe but similar to those observed in Canada. This means that the health effects are observed at lower levels of pollution and indicates that actions are required to minimise the exposure of the population to air pollution.

The overall body of evidence drawn from studies conducted in Australia and overseas indicates that the groups most vulnerable to the effects of air pollution are:

- people with existing heart and lung disease
- elderly people
- children
- foetuses.

A summary of the findings of the health reviews is presented below.

Carbon monoxide

Australian and international studies have found associations between carbon monoxide (CO) and increases in hospital admissions, emergency department attendances, and premature death from cardiovascular disease.

Associations have also been found with adverse birth outcomes such as low birth weights and reduced foetal growth. These effects can have an impact on childhood development.

Studies of hospital admissions and emergency department attendances for heart disease and congestive heart failure provide the strongest evidence of ambient CO being linked with adverse cardiovascular disease impacts. The results of studies conducted in Australia are consistent with those in the US and Europe.

Some studies have found it difficult to separate specific CO-related health effects; overall, however, the evidence indicates that associations between CO and adverse health outcomes remain strong even when the effects of other pollutants are accounted for. There is clear evidence from Australian studies that there are health effects linked to CO below the current Australian standards in the NEPM. The effects are greatest in elderly people with existing cardiovascular disease.

The results of animal toxicological studies show similar effects to those found in human epidemiological studies that find associations between exposure to CO and cardiovascular outcomes. The observed effects are consistent with the known mechanism for CO impacting on the cardiovascular system.

The findings of the CO review indicate that health effects are observed at current levels of CO in Australian cities which are well below the NEPM standard. The effects are greatest in people with existing cardiovascular disease. The Review Team considers that the CO standards should be revised and consideration should be given to this sensitive group.

Nitrogen dioxide

Epidemiological studies worldwide show consistent associations between short-term exposure to nitrogen dioxide (NO_2) and hospital admissions and emergency department attendances, particularly for children with asthma. Studies also show increases in asthma symptoms and medication usage linked to short-term exposures to NO_2. Clinical studies show that people with asthma are more susceptible to exposure to NO_2, and that short-term exposure to NO_2 is associated with airway reactivity and enhanced inflammatory response in people with asthma. Animal toxicology studies support the findings of epidemiological and controlled exposure studies.

Effects observed for exposure to NO_2 are greatest for respiratory outcomes. There is no strong evidence from international studies for an association between short-term NO_2 exposures and cardiovascular outcomes.

Australian multi-city studies have shown that ambient NO_2 is associated with increases in mortality and hospital admissions for all cause, respiratory and cardiovascular causes. The effects are greater than those observed in Europe and US but are similar to Canada (refer Discussion Paper at www.ephc.gov.au/airquality/aaq_nepm).

The effect estimates in Australia range from 0.11 to 0.9% increase in mortality per 1 ppb increase in NO_2 compared with 0.03 to 0.04% increase in the US. This indicates that health effects are observed at lower levels in Australia.

Infants, children, and elderly people are more susceptible to the effects of NO_2, and people with asthma and other chronic respiratory and cardiovascular disease are particularly vulnerable. Observed effects are independent of other pollutants and occur at current ambient levels of NO_2 which are well below current standards. Long-term exposures are linked to changes in lung growth in children and respiratory symptoms in asthmatic children. Effects are observed at levels between 0.03 and 0.04 ppm.

The findings of the review of the NO_2 health evidence indicate that health effects are observed at current levels of NO_2 in Australian cities which are well below the NEPM standard. The effects appear to be greater in Australia than those observed in the US and Europe and are greatest in children, the elderly and people with asthma and other chronic respiratory diseases. The Review Team considers that the NO_2 standards should be revised and consideration should be given to these sensitive groups.

Ozone

In 2005, the NEPC completed preliminary work for the review of the ozone standards. This work found that standards should be based on 1-hour, 4-hour and 8-hour averaging periods to account for exposure in Australian cities. The findings of the current review support these findings.

The health reviews found that short-term (1-4 hour) exposures are linked to increases in mortality, hospital admissions and emergency department attendances mainly for respiratory causes. The effects are greatest in the warm season and in elderly people. Studies show increases in emergency department attendances for asthma linked to both 1-hour and 8-hour exposures to ozone. Evidence for cardiovascular effects is not as strong as for respiratory effects and the US EPA concluded evidence for cardiovascular effect inconclusive.

Studies from Europe, US and Australia show similar associations. European studies show a 1.8% increase in all cause mortality, a 2.7% increase in cardiovascular mortality and a 6.8% increase in respiratory mortality per 30ppb increase in 8-hour ozone exposures. There is no evidence for threshold for effect.

Exposure to ozone is also linked to range of respiratory outcomes including:

- decreases in lung function
- increases in respiratory symptoms
- increased respiratory inflammation
- increased airway responsiveness.

Long-term exposure to ozone is not associated with increases in mortality but there is some evidence of increase in lung cancer in non-smoking populations in high ozone areas. Long-term exposures are linked to changes in lung function in both healthy adults and people with asthma. The results of the epidemiological studies are supported by results of animal toxicological studies.

Australian epidemiological studies show increases in hospital admissions for respiratory causes and ozone in the warm season. Studies also show ozone associated with risk of pre-term birth in Sydney and Brisbane. Associations are found for 1-hour, 4-hour and 8-hour ozone levels for all outcomes.

The findings of the review of the O_3 health evidence indicate that health effects are observed at current levels of CO in Australian cities which at times exceed the NEPM standards. The effects are greatest in the elderly and people with existing respiratory disease. The Review Team considers that the 1 and 4 hour standards should be revised and an 8-hour standard introduced and consideration should be given to these sensitive groups.

Sulfur dioxide

Exposure to sulfur dioxide (SO_2) creates an acute irritant response that leads to coughing, wheezing, sputum production, increased incidence of respiratory infections, aggravation of asthma, and COPD. People with asthma are particularly sensitive to SO_2 and respond very quickly (within minutes). Epidemiological studies show an association between short-term exposures and increases in daily mortality from respiratory and cardiovascular effects. The effects are stronger for respiratory outcomes. Hospital admissions and emergency department attendances for respiratory disease are linked with exposure to SO_2.

Epidemiological evidence is supported by controlled human exposure studies and animal toxicological studies conducted near ambient concentrations that show links between SO_2 and NEPMs of respiratory health such as respiratory symptoms, inflammation, and airway hyper-responsiveness. Effects are more pronounced in children with asthma and elderly people.

Exposure duration is not critical to the observed effects. Response is rapid and continuing exposure does not increase effect. Effects are observed at current levels of SO_2 which are well within existing standards in cities without industrial sources.

The findings of the review of the SO_2 health evidence indicate that health effects are observed at current levels of SO_2 in Australian cities which are well below the NEPM standard. The effects are greatest in people with asthma. The Review Team considers that the SO_2 standards should be revised and consideration should be given to these sensitive groups.

Lead

The lead (Pb) standards are based on blood lead levels not exceeding 10 µg/dL. Foetuses, infants and children are most susceptible to the effects of Pb. Strong evidence exists for a causal relationship between lead and increased blood pressure and hypertension in adults. There is some evidence from epidemiological studies of links between Pb and increases in mortality and morbidity for cardiovascular causes.

Epidemiological studies show decreases in cognitive function, in particular IQ, in children at blood lead levels below 10 µg/dL, and there appears to be a non-linear dose-response between blood lead and neurodevelopmental effects. There are a number of large studies that consistently show that Pb is associated with various neurodevelopmental effects at blood lead levels between 5 and 10 µg/dL. Epidemiological studies have also reported associations between Pb and indicators of renal function impairment. These effects are observed at mean blood Pb levels between 3.3 and 4.2 µg/dL. Results of toxicological studies support the findings of epidemiological studies.

The findings of the Pb review indicate that health effects are observed below the blood Pb target of 10 µg/dL. The Review Team considers that the standard should be revised to reduce risk to the affected populations, even if moved to the Air Toxics NEPM.

Particles

The health reviews found that there is substantial new evidence from time series studies and cohort studies on both short-term and long-term effects for particles. PM_{10} and $PM_{2.5}$ are associated with increases in mortality and morbidity, with much stronger evidence now for cardiovascular outcomes. Studies in Australia show similar effects to overseas studies; however, the effects appear to be similar to Canada but greater than in US and Europe.

The health effects of both PM_{10} and $PM_{2.5}$ include:

- increases in daily mortality
  - estimates of 0.12-0.8% increase per 10ug/m^3 of PM_{10} for all causes of mortality
  - Australian studies show 0.2 % increase per 10ug/m^3 of PM_{10} for all cause of mortality
- much stronger evidence now for particles causing cardiovascular disease
- some heterogeneity in effects.

Stronger effects have been found for cardiovascular causes than respiratory causes for particles in general. The effect estimates from multi-city studies range from 0.47 to 0.85% increase per 10 ug/m^3 $PM_{2.5.}$ Associations have also been found for coarse particles and cardiovascular mortality.

Increases in hospital admissions and emergency department attendances have been found with exposures to $PM_{10,}$ $PM_{2.5,}$ and $PM_{10\text{-}2.5.}$ There is evidence for links with both cardiovascular and respiratory effects, particularly respiratory disease, asthma and COPD, while there are strong associations with ischemic heart disease and congestive heart failure.

There is evidence that supports biological plausibility for cardiovascular effects. Epidemiological studies have shown that particles interfere with electrical signals in the heart disrupting heart function. These findings are supported by the results of toxicological studies.

Associations have also been found between particles and increases in respiratory symptoms and medication use in children with asthma. These are linked to reduction in lung function and increased lung inflammation.

There are several new studies that show links between long-term exposure to particles and increases in mortality respiratory and cardiovascular causes. The US EPA concluded that a causal relationship is likely to exist between long-term exposure to $PM_{2.5}$ and mortality, and that a causal relationship exists between long-term exposure to $PM_{2.5}$ and cardiovascular outcomes including mortality. Long-term exposure is also linked to decrements in lung growth, increased respiratory symptoms and asthma development. It appears that children are at greater risk from long-term exposures than adults.

There is not sufficient evidence at this time to show any independent effect of ultrafine particles, while there is only limited evidence for coarse particles and an independent role of particle composition.

Overall findings – right standards?
Overall, the results of the health reviews show that there are significant health effects at current levels of air pollution in Australian cities. These findings indicate that the current standards are not meeting the requirement for adequate protection of human health. There is evidence that these standards should be revised to minimise the impact of air pollution on the health of the Australian population. This finding was strongly supported by all stakeholders throughout the consultation process.

Another outcome from the consultation process was strong support to have a $PM_{2.5}$ compliance standard in place of the current advisory reporting standard. This support is based on the understanding of the health effects of $PM_{2.5}$. The initial introduction of advisory reporting standards rather than compliance standards was due to a lack of monitoring data. All jurisdictions have since been monitoring $PM_{2.5}$ and there are now sufficient data to develop compliance standards. The Review Team considers that compliance standards should be introduced for $PM_{2.5}$.

Averaging periods
The health effects of air pollution are linked with the exposure period. The averaging periods for standards reflect the health effects associated with the different exposures.

For NO_2, Pb, CO, SO_2 and $PM_{2.5}$, the health reviews indicate that the current averaging periods for the standards are appropriate and should be retained.
For ozone, the health evidence indicates that health effects are observed for 1-hour, 4-hour and 8-hour averaging periods. In addition, the formation of ozone in Australian cities, in particular Sydney, indicates that ozone peaks exist for longer periods. The findings of the preliminary work were also supported throughout the consultation process. The Review Team considers that an 8-hour ozone standard should be included in the NEPM.
The health reviews have shown that there is a larger body evidence for long-term health effects for particles. The current PM_{10} standards are based on short-term effects. Based on the new health evidence, the Review Team has concluded that an annual average standard for PM_{10} should be included in the NEPM. This was a strong view put forward by stakeholders during the consultation process.

3.2.2.3 Exposure reduction
The health reviews show a current understanding that there is no threshold for the health effects of air pollution. This means that wherever the standards are set there will be some residual risk associated with them. There is therefore a question as to how the desired environmental outcome of the NEPM can be achieved when there are health effects observed below the current standards.

The achievement of the desired environmental outcome requires driving improvements in air quality even if the standards are met in order to minimise the risk to the population arising from exposure to air pollution. One approach that is being implemented internationally and which was considered during this review is to add an exposure reduction overlay to the standards.

The exposure reduction approach is based on the principle that for pollutants with a low or zero threshold for adverse effects, it will generally be more beneficial to public health, and potentially more cost-effective, to reduce pollutant levels across the whole population of an urban area or region rather than in a specific localised area for compliance purposes.

The EU has set an exposure reduction target of 20% by 2020 based on 2010 levels for $PM_{2.5}$. The directive obliges member states to bring exposure levels below 20 µg/m^3 by 2015. Throughout their territory, member states will need to respect the $PM_{2.5}$ limit value set at 25 µg/m^3. This value must be achieved by 2015 or, where possible, by 2010. The exposure is to be determined using an average exposure indicator (AEI). The AEI is assessed as a 3-calendar-year-running annual mean concentration averaged over all urban background sampling sites of a member state. The AEI for the reference year (2010) shall be the mean concentration of the years 2008, 2009 and 2010. Similarly, the AEI for the year 2020 shall be the 3-calendar-year-running mean concentration averaged over all sampling points for the years 2018, 2019 and 2020.

The exposure reduction framework focuses policy on improving air quality in the places where the greatest number of people are likely to be exposed, rather than reducing high concentrations of pollution in small localised areas. This exposure reduction framework takes into account the fact that no lower threshold for effect has been identified and that any reduction in exposure is likely to result in a health benefit to the population.

The concept of an exposure reduction in the NEPM was supported through the consultative process although some stakeholders stated that there would need to be clear guidelines on defining the monitoring and assessment procedures. There was recognition that this approach would drive improvements in air quality that would assist in achieving the desired environmental outcome of the NEPM and address some environmental equity issues currently not addressed in that NEPM. Under the current monitoring protocol in the NEPM, people who live near major sources of pollution such as roads do not have air quality monitoring data and are likely to be exposed to higher levels of air pollution than that measured at performance monitoring stations. The exposure reduction approach would drive improvements in air quality across the whole population and not focus on meeting standards at the designated monitoring stations.

The health reviews indicate that there is a statistically significant and measurable health risk posed to the Australian population from NO_2, O_3, PM_{10} and $PM_{2.5}$. These pollutants arise from similar sources to CO; therefore, driving improvements in these pollutants will also drive reduction in CO levels and the associated health risks. Based on the understanding of the health risk posed by air pollution in Australia, the finding of the review is that an exposure reduction overlay should be incorporated into the NEPM for pollutants prioritised on the basis of risk to the health of the Australian population (priority pollutants), in addition to the standards. It is the view of the Review Team, supported by the outcomes of consultation, that the combination of standards and the exposure reduction overlay will reduce the impact of air pollution on the health of the Australian population and help meet the NEPM desired environmental outcome. Exposure reduction targets should be set for priority pollutants. The EU approach provides an appropriate model as a basis for an exposure reduction framework for inclusion in the NEPM.

3.2.2.4 Exceedances

As described earlier in this report, the NEPM includes standards which are quantifiable characteristics of the environment against which environmental quality can be assessed. It also incorporates protocols which are the procedures to be followed to determine whether the standard is being met and whether there is progress in meeting the NEPM goal. This goal is to meet the standards to a specified degree within 10 years.

It is important to consider the implication of allowing or not allowing exceedances of a specified numerical value. Exceedances may be permitted to allow for events that are known to occur, but which cannot be managed; for example, emissions from bushfires or dust storms. Alternatively, a stringent numerical value may be chosen for a particular pollutant due to the risk it poses, but allow a relatively larger number of exceedances to reflect current ambient concentrations, allowing for a tightening over time to drive improvements in air quality. However, the greater the number of allowable exceedances, the higher the overall average concentration can be, leading to greater risk to the community. These risks will, in part, be dependent on the magnitude of the exceedances.

This issue was raised throughout this review's consultation process and a number of alternatives were presented, including:

- allowing a certain number of exceedances
- reporting the data as a percentile form that allows exceedances but does not specify a specific number
- not allowing exceedances—introducing not-to-be-exceeded standards
- introducing a natural events rule to account for events such as bushfires and dust storms.

The exceedances in the current NEPM are arbitrary. The 5 exceedances for the PM_{10} standard were introduced to account for the impact of bushfires, dust storms and fuel reduction burning for fire management purposes. These exceedances are often misused and have been applied to urban air pollution and, in some cases, individual sources. Given greater understanding of the health effects of air pollution, it is clear that allowing exceedances increases the risk to the population and reduces the level of protection offered by the standard. There was strong support throughout the consultation process for the removal of the exceedances and the introduction of not-to-be-exceeded standards.

There was also support for the introduction of a natural events rule that would exclude the assessment of the impacts from bushfires and major dust storms from the compliance assessment (although data would be reported). This would focus compliance on sources of air pollution that can be managed. Tight guidelines would need to be developed for the natural events rule as discussed in the section on reporting within this report.

The Review Team considers that allowable exceedances should be removed from the NEPM and a natural events rule be introduced to account for major natural events. Together with the introduction of an exposure reduction overlay, it is believed that this will provide a stronger framework for the protection of population health.

3.2.3 *Recommendations relating to national environment protection standards*

Recommendation 3
Remove lead from the Ambient Air Quality NEPM and include in the Air Toxics NEPM during the scheduled Air Toxics NEPM review of 2012.

Recommendation 4
Revise the standards for all air pollutants in Schedule 1 of the NEPM to take into account new evidence around the health effects of air pollution.

Recommendation 5
Introduce compliance standards for $PM_{2.5}$.

Recommendation 6
Introduce an 8-hour standard for ozone.

Recommendation 7
Introduce an annual average standard for PM_{10}.

Recommendation 8
Introduce an exposure reduction framework and targets for priority pollutants.

Recommendation 9
Remove allowable exceedances from Schedule 2 and introduce a natural events rule.

3.3 National environment protection protocol

The national environment protection protocol sets out the processes and procedures to be followed in measuring the concentrations of pollutants, including preparation of monitoring plans, methods of measurement and monitoring, assessing performance against the air quality standards, and reporting the results of monitoring.

3.3.1 *Issues*

A range of issues in relation to monitoring, assessment and reporting were raised in both the 2007 and 2010 discussion papers and by commentators in public submissions to these papers, and these are dealt with below under relevant subheadings. There is, however, significant overlap of issues and readers are referred to relevant sections as appropriate, where the same theme is discussed from a different perspective.

3.3.2 Comments, discussion and review findings

The following discussion of the national environment protection protocol is divided into three main sections to reflect the themes covered by the respective clauses in the protocol. These are:

- monitoring
- performance assessment
- reporting.

Monitoring

Clauses 10—16 of the NEPM set out methods and procedures related to monitoring air pollution. They include clauses related to the preparation of jurisdictional monitoring plans; measurement and monitoring methods, including the location, number and type of monitoring stations; and accreditation, quality assurance and validation procedures.

Comments from stakeholders focused on the adequacy of current monitoring networks, particularly the number and location of monitoring stations, and how representative the networks are of exposure of the population. There were also a number of comments on the Australian standard measurement methods.

Location and number of performance monitoring stations

Clauses 13(1) and 13(2) of the NEPM provide guidance on the location of performance monitoring stations, in accordance with the Australian standard AS 2922-1987: *Ambient air – guide for siting of sampling units.* The stations must be located in a manner that contributes to obtaining a representative measure of the air quality likely to be experienced by the general population in a region.

The concept of GRUB stations was developed by the PRC as an additional category of station to those cited in AS 2922-1987. The intent was to provide some sense of population exposure by focusing on the higher levels to which a regional population was likely to be exposed, without direct influence of local sources such as major traffic areas; that is, where large portions of the population experience similar average air quality. Its effectiveness was predicated on sufficient preliminary work to ascertain the representativeness of the chosen sites. In some instances, this was based on good background information from monitoring or modelling programs, so the term was well justified. In areas where resources were limited, and particularly where single stations were installed to represent large urban areas, it was not always clear that such sites were chosen on the basis of rigorous science, so their 'representativeness' of upper bound exposure may not have been well established. The question for several commentators was whether the GRUB concept adds any value to understanding impacts of air quality.

Strong representations were made by several commentators that, while the GRUB concept was useful as an initial approach, a broader mix of station types would better reflect the exposure of the population. Health sector and community organisations, in particular, advocated a mix of industrial, major roads, low impact suburban, etc., to provide a picture of potential exposure to air pollutants. This is not to say that those stations currently designated as GRUB stations should necessarily be deleted; more, that they should continue to inform trends but as part of a wider approach to population monitoring that seeks to understand patterns of pollution and exposure.

Some commentators pointed to the lack of clear definitions surrounding the GRUB concept as described in the PRC's 'Technical paper no. 3: Monitoring strategy' (2001). Examples include '…a substantial area and fraction of the population', and '…large portions of the populated area'. The commentators saw these terms as being open to fairly broad interpretation. Some industry comment also did not support the use of GRUB sites and recommended removal of the term.
In particular, a significant industry group put forward the view that there are several problems with GRUB sites including that:

- their application appears to be incongruous with existing NEPM monitoring station definitions
- there is a lack of scientific and other stakeholder consensus as to the application of GRUB sites
- the use of GRUB sites will not yield data that are representative of the average population exposure or trends in overall ambient air quality.

Instead, industry favours the approach taken internationally to determine population exposure; however, it cautions against the implementation of this approach without due consideration to providing adequate direction and guidance to achieve a nationally consistent application.

Internationally, there has been a move to establish air monitoring networks to allow population exposure to be determined; for example, the EU, the US EPA, and the WHO. The air monitoring networks are based on consideration of population density, sources, distribution of pollutants within an airshed, and the concentration of a pollutant relative to air quality standards. A range of sites is recommended, including background (urban and rural), peak, rural, urban and suburban. Air quality modelling is a tool that is used to assist in the siting of air monitoring stations to ensure that an appropriate mix of air monitoring stations is achieved to enable population exposure to be determined.

Comment received on behalf of the PRC itself advocates retention of GRUB stations and disagrees with the concept of the NEPM providing information on population exposure beyond evaluating compliance with standards at these sites of 'upper bound' exposure.

The population formula in clause 14(1) of the NEPM provides guidance for jurisdictions to determine the number of performance monitoring stations within a given region. The formula embodies a lower population limit of 25,000, below which no monitoring is required. However, the formula is qualified in clauses 14(2) and 14(3) to allow for more or fewer stations according to specific regional or local characteristics.

A considerable number of commentators focused on the 25,000 population threshold. Respondents generally considered this limit to be an impediment to effective monitoring and therefore to adequate protection of populations, particularly those in small regional centres that characterise populations in several jurisdictions. One commentator pointed to specific issues in small mining towns where pollution levels are high.

The population formula was seen by some to be a product of a 'compliance mentality', which was in conflict with the original intent of the NEPM and an international trend towards population exposure monitoring.

Most of the issues with jurisdictional monitoring programs were seen to be more the result of resource issues than concepts embodied in the formula. One commentator suggested that some jurisdictions interpreted guidance from the PRC in a way that allowed them to establish fewer stations than would have been required under clause 14 of the NEPM.

Comment from the PRC was that the population formula does not limit the number of stations, based on the wording of clause 14 which allows for additional or fewer stations according to specific needs and circumstances. However, as noted above, other commentators suggested that in practice, jurisdictions generally interpreted clause 14 to limit the number of stations.

Review findings — location and number of monitoring stations

The Review Team concluded that the GRUB concept does not fit well with current population exposure approaches, and the station categories cited within AS 2922-1987 provide sufficient capacity to monitor the range of air environments required. The GRUB concept is not part of the NEPM. There has been confusion around some of the terms used to define GRUB stations and the factors used for their establishment, and this has led to inconsistencies between jurisdictions. For these reasons, the Review Team considers that the use of the GRUB concept should be discontinued and that careful consideration should be given to the optimal range and configuration of station types to provide a coherent picture of population exposure for the selected indicators for each population centre.

The Review Team also considers that the population formula and population threshold should be removed and a more risk-based approach to monitoring be adopted across regional populations rather than population centres. The population formula is seen as an impediment to effective monitoring and therefore to adequate protection of populations, particularly those in small regional centres that characterise populations in several jurisdictions.

Measurement methods, equivalency, consistency and flexibility

To evaluate and ascertain the status of air quality, uniform analytical methods are used to ensure consistency and accuracy in the data generated. Clause 16 of the NEPM requires Australian standard monitoring methods to be conducted for each specific pollutant, with the relevant Australian standard methods being listed in Schedule 3 of the NEPM.

The development of Australian standards for monitoring air pollution takes several years, and while this is not considered to be a major concern for the monitoring of the gaseous pollutants, new instrumentation for the measurement of particles (both PM_{10} and $PM_{2.5}$) is continually evolving. The requirement for an Australian standard monitoring method results in significant time lag in terms of the introduction of new and potentially superior methods for measuring particles.

The 2007 discussion paper considered the issue of whether more flexibility in the NEPM monitoring protocols is needed to enable newer technologies for particle measurement to be adopted without the formal process of introducing an Australian standard for the method. Comments indicate general support for a level of flexibility in methodologies for pollutant monitoring to be used in implementing the NEPM, as long as there is attention to their robustness and comparability with the Schedule 3 methods. It was noted that considerable care would be needed to ensure consistency and comparability is maintained.

Many commentators argued that it would be undesirable to relax the requirements for use of Australian standard methods, as to do so would result in much less comparable and consistent data and could create real problems in time series data.

The PRC is of the view that a major achievement of the NEPM has been the establishment of consistent instrumentation across jurisdictions, and moves away from this would inevitably weaken the degree of national consistency in the collected data at NEPM sites because of the uncertainties and inherent inadequacies of 'equivalence' for measurement of some pollutants, notably particles.

Clause 10 of the NEPM allows for appropriate internationally recognised measurement methods or standards to be used where an Australian standard has not been developed, provided that the method is comparable to the relevant Australian standard methods. This approach to measuring particles was seen as having some merit and worthy of further analysis; however, commentators point to a risk that jurisdictions may adopt such methods at different rates, which would result in a mish-mash of methods within and between jurisdictions, with no certainty of improvements in particle representations.

As noted above, alternative methods need to be comparable to the relevant Australian standard methods; therefore, the equivalence of the method would need to be established before being widely adopted. There is no formal equivalence program in the NEPM on how to establish the comparability of alternative PM_{10} measurement methods with the existing reference methods.

In the US and Europe, equivalence programs are well prescribed; for example, in the US, the comparability of alternative particle monitoring methods, called 'equivalent' methods, is measured relative to the reference method using high-volume samplers, and a set of criteria is prescribed for determining equivalence. An assessment of the accuracy and precision of the monitoring equipment forms part of the equivalency programs in both the US and Europe.

Because operation of high-volume samplers—a NEPM reference method— is labour-intensive and there are advantages of obtaining continuous measurements, Tapered Element Oscillating Microbalance (TEOM) samplers have almost universally been adopted by jurisdictions to measure PM_{10}. The PRC's 'Technical paper no. 10: Collection and reporting of TEOM PM_{10} data' (2001) provides guidance on the handling of TEOM PM_{10} data by way of an adjustment factor to generate equivalent information to the NEPM reference methods. These recommendations have not been implemented consistently by all jurisdictions and, according to commentators, equivalence remains an area of concern for PM_{10} data.

The NEPM was varied in 2003 to include advisory reporting standards and a monitoring protocol for $PM_{2.5}$. Schedule 5 of the NEPM establishes a program to assess whether the TEOM could be considered to generate data equivalent to the $PM_{2.5}$ reference method—the manual gravimetric method. An equivalence program has been implemented to determine the comparability of data generated by the two methods. Jurisdictions have been monitoring for several years with collocated instruments and this data will inform any variation process.

The 2007 discussion paper suggested that one of the difficulties arising from this equivalence program was the lack of shared understanding about what equivalency is trying to achieve; whether equivalency means generating the same number on both instruments, or whether it means that the instrumentation measures the same physical characteristics of the particles. The latter is referring to the fact that as instruments used to monitor particles (e.g. gravimetric versus optical and light scattering instruments) measure particles differently, determining equivalency is not straightforward and may be impossible for some instruments.

A major industry group acknowledged the difficulties in defining 'equivalency' in regard to monitoring methods, particularly in regard to adopting new technology, which may not meet the NEPM definition but may be of superior performance. Industry comments support a science-based approach, incorporating statistical analysis, to provide a resolution that can lead to a nationally consistent, if not uniform, approach to ambient air monitoring. They suggest such an approach would need to be flexible, including the potential for a variation of the NEPM to assist in resolving discrepancies in appropriate monitoring methods. Their comments go further in agreeing that greater flexibility needs to be provided to the monitoring of particulates, given that technology improvements can move faster than approvals for equivalency.

Industry commentators also noted that some clarification of equivalency is required, adding that, given that some jurisdictions are already using instruments that are not part of the approved NEPM methods but are understood to be 'best practice', there is a need to ensure that methods used are robust, accurate, precise and reproducible. They argue that it is vital that this matter is resolved because, until it is clarified, the values being generated by some jurisdictions can't be used with confidence to determine population exposure.

Review findings — equivalency, consistency and flexibility of monitoring

The Review Team considers that some flexibility needs to be built into the NEPM framework to allow for adoption of alternative methods to enable a faster response to technological advances in instrumentation. A review of methods for both gaseous pollutants and particles in the NEPM monitoring protocol would be beneficial to ensure they are reflective of international best practice for air quality monitoring and to resolve discrepancies in current monitoring methods, especially for particles.

Extensive work has been carried out internationally to determine equivalency between approved methods used for monitoring particles in ambient air. The Review Team considers that the NEPM should allow the use of any methods that have been tested and approved by the US EPA or the EU as reference or equivalence methods for monitoring ambient air quality. The findings of the $PM_{2.5}$ equivalence program, implemented after the NEPM was varied in 2003, should also be taken into account.

3.3.2.1 Performance assessment and evaluation

Clause 17 of the NEPM sets out the criteria for evaluating performance against the standards and goals set out in Schedule 2 of the NEPM. Jurisdictions are required to assess their annual performance against the NEPM standards and goals at each monitoring station. Performance is assessed as MET, NOT MET, or NOT DEMONSTRATED ('not demonstrated' relates to whether there were sufficient data available for a pollutant at the monitoring station to enable an assessment).

Five of the standards in Schedule 2 have associated goals to be achieved within 10 years of commencement of the NEPM. The goals describe the number of allowable exceedances of the standard in an assessment year. One exceedance day each is allowed for carbon monoxide, nitrogen dioxide, sulfur dioxide and ozone, and 5 exceedance days are allowed for PM_{10}. The 5 days allowed for PM_{10} was adopted to take account of unmanageable pollution events such as bushfires and dust storms and to allow for essential prescribed burning to be carried out.

Several commentators to the 2007 and 2010 discussion papers expressed concern about the practice of assessing performance against 'not-to-be exceeded' standards and the practice of having an allowable number of exceedances of the standard. There were two primary concerns:

- that not-to-be exceeded standards imply a threshold, and once concentrations are below this threshold, there is no need to do more
- that having an allowable number of exceedance days, especially for particulates, was not providing adequate protection of populations.

A common argument put forward by commentators was that assessing compliance against not-to-be exceeded standards encouraged the perception that compliance with a standard implies 'no risk'. However, given the lack of identified thresholds for health effects of the NEPM pollutants, there is still a risk to communities, and a more risk-based approach to evaluate impacts across regional populations was advocated.

Many commentators, including representatives from the health sector, said that air quality needs to be assessed in terms of population exposure and risk, rather than whether the standards have been exceeded or not. They argued that exceedances of the standard are often biased by single acute (natural) events and values consistently near but below the standard may have a greater influence on population exposure than a single event in an otherwise well-below-threshold data set. In any case, commentators argued that allowing a prescribed number of exceedance days for extreme events ignores their potential health impacts. Commentators further argued that, irrespective of the source of the episode, an exceedance contributes to community exposure and risk, and so should be assessed and reported on this basis.

The current reporting of exceedances on a station-by- station basis has in some cases led to a distorted picture of air quality (e.g. 15 station exceedances on one day is reported as 15 separate exceedances). Changes to the reporting protocols to report on days of exceedances and perhaps secondary reporting of the stations at which the exceedances occurred may overcome some of this misunderstanding of the data. The inclusion of an exposure reduction overlay may also assist in the reporting and understanding of the risk posed by exceedances of air quality standards.

The Review Team considers that the protocols for evaluating and reporting performance should be tightened. Clause 17 of the NEPM provides information on how jurisdictions should evaluate performance as MET, NOT MET and NOT DEMONSTRATED, but is silent on what factors need to be considered. The general approach to date has been to report performance in terms of the number of exceedances of the standards, referenced against the goals for the respective pollutants; that is, the number of allowed exceedances.

In the light of research evidence and comments received, the Review Team considers that the number of exceedances alone is of little real value. This number may incorporate events where concentrations just over the numerical standard are recorded, or where concentrations considerably larger than the standard are recorded, so says little about the impacts on communities, or about the effectiveness of air quality management programs. The Review Team therefore considers that some measure of 'severity of exceedance' should be incorporated into evaluation and reporting of performance rather than, or in addition to, simple statements about whether the standard has been met or not.

The Review Team further notes that this is consistent with clause 18(2)(b) of the NEPM which requires 'an analysis of the *extent* to which the standards of this Measure are, or are not, met in the jurisdiction'.

Review findings — Performance assessment and evaluation

The Review Team considers that clause 17 of the NEPM should be modified to incorporate a measure of 'severity of exceedance' into the evaluation and reporting of performance against the standards. The Review Team also considers that the requirement to express performance as MET, NOT MET and NOT DEMONSTRATED should be removed from the NEPM.

Exposure reduction

As discussed previously in this report, a strong and consistent element of comment from both the health and industry sectors was the need to consider risk-based approaches, such as exposure reduction in air quality management strategies, in line with international trends, underpinned by compliance standards against which air quality can be assessed.

In implementing population risk-based approaches to air quality management, a suite of tools would provide optimal use of resources; that is, a combination of monitoring, inventories and modelling working together in an iterative way. Clause 11 of the NEPM already includes modelling and inventories as examples of alternative methods for assessing pollutant concentrations; this could be expanded upon. Protocols will be required for applying exposure reduction targets and assessing and reporting on progress toward meeting them, including what should happen if targets are not met. In order to assess and report progress on meeting targets, nationally consistent methods will be needed to estimate population exposure. This topic is discussed in more detail below.

Population exposure estimation

Population exposure refers to the exposure of the population as a whole to ambient air pollution. It is not a measure of personal exposure of individuals. Population exposure estimation is foreshadowed under clause 17(2)(a) of the NEPM, but for various practical reasons the focus of monitoring and assessment to date has not been on population exposure. Instead, it has largely been directed towards evaluating compliance with the air quality standards and goals.

Recognising the difficulty in estimating the exposed population, and after considering the feasibility of alternative approaches, the PRC, in its 'Technical paper 08: Annual reports' (2002, revised 2010) advised that the requirements of clause 17(2)(a) of the NEPM can be met through a qualitative statement of the exposed population represented by each site.

In practice, determining population exposure estimates requires information on the average distribution of air pollution and the population density in the area or region of interest, along with other information. The tools to develop such a system would include comprehensive airshed models with detailed source inventories, as well as high-quality consistent data from the existing NEPM monitoring networks. As intimated in the monitoring section of this report, the current NEPM monitoring networks alone cannot give sufficient spatial coverage of all urban airsheds to provide detailed information on the exposure of all the population. Rather, they can only provide an indication of the exposure in the area represented by each performance monitoring site.

Accurate estimation of population exposure requires a significant investment, not only in monitoring and airshed modelling and data assimilation, but also in the development of comprehensive inventories of sources across each airshed. Airshed modelling requires the development of emission inventories at a relatively fine grid to enable predictions of air pollution levels across an entire airshed, including the variability in air pollution levels encountered across the population.

Review findings — population exposure

The Review Team considers that the NEPM monitoring protocols should be changed to enable an assessment of population exposure to be estimated. A range of tools for assessing population exposure and risk will need to be developed and evaluated. The Review Team considers that the role of modelling should be strengthened and appropriate modelling approaches to generate reports on population exposure patterns be incorporated into the clause dealing with evaluation of performance against standards and goals (clause 17).

3.3.2.2 Reporting

Under the NEPC Act, jurisdictions must submit an annual report on the implementation and effectiveness of the NEPM to the NEPC by 30 June in the year following the reporting year (ending 31 December). Reports are tabled in parliaments and made public on the EPHC website at < www.ephc.gov.au>.

Clause 18 of the NEPM establishes the reporting requirements for annual performance reports. The report must include:

- the evaluation and assessment mentioned in clause 17
- an analysis of the extent to which the standards are or are not met, and a statement of the progress made towards achieving the goal (this pertains to the desired outcome)
- a description of the circumstances that led to any exceedances of the standards, including the influence of natural events and fire management.

A number of issues were raised in submissions in relation to the effectiveness of the annual reports in communicating information about air quality to the public, including:

- whether they are pitched appropriately for the intended audience
- the effectiveness of the reporting format and content
- the degree of accountability offered by the reporting protocol.

Other reporting issues in relation to monitoring and assessment (clause 17) have been discussed in previous sections of this report.

Communicating air quality information

The PRC's 'Technical paper 08: Annual reports' (2002, revised 2010) provides guidance to jurisdictions to assist them in preparing their annual monitoring reports to the NEPC and to ensure a nationally consistent approach to reporting. The technical paper requires reporting in a scientific format for the purposes of compliance assessment.

There was a general feeling in submissions that current compliance reporting is largely technical and difficult for the broader community to interpret and understand, and therefore not an effective tool for communicating with the general community about air quality. Most commentators, including industry, highlighted the need for reports to use plain and accessible language.

However, some submissions also emphasised the need for reports to maintain scientific rigour and technical quality, and to retain the detailed tabulation of the monitoring data for the purposes of scientific analysis. It was argued that there is a risk that information in the reports may be simplified to the extent that scientific credibility is lost.

In a comment received from the Chair of the PRC, it was suggested that the formal requirement of the NEPM to ensure the technical quality of data collected under the NEPM protocol was being confused with the need for individual jurisdictions to communicate with the community, and that this was being done through other channels. However, in the view of the Review Team, there is an important role for the NEPM in the reporting of high quality data, explained in plain English, to a broader community.

Commentators suggested that a regular national summary of data would be useful to assist the community to understand air quality in regions throughout Australia. This type of reporting would enable comparison across jurisdictions and could also provide an external review function to ensure that the data was being interpreted and reported correctly.

Review findings — communicating air quality information
The Review Team considers that more explicit requirements need to be incorporated in the reporting protocols to make assessment and reporting on air quality more transparent to the wider community, while preserving the rigour needed to apply comparative methods for trend analysis across the country.

Content of reports
Many commentators indicated that they would like to see the content of annual reports expanded to include additional descriptors such as averages, trend analysis, pollutant distributions, and more contextual information to describe air quality beyond the current compliance approach. It is noted that, as reporting against the NEPM has evolved over its first decade, such descriptors have increasingly been incorporated into annual jurisdictional reports to the NEPC and many are now a standard part of those reports. However, the contextual information is still required, including interpretation of what this information means in terms of impacts on population health.

Review findings — content of reports
The review found that the current NEPM reporting protocols focus too much on reporting compliance with the standard and do not go far enough in interpreting information and communicating what the air quality data means to the community. The Review Team considers that the reporting protocols should be expanded to include more specific reporting criterion that considers:

- summary statistics (e.g. percentiles, averages, and uncertainties)
- the style of data presentation (e.g. graphs, tables, discussion)
- analyses and contextual information (e.g. air quality trends and population exposure and risk)
- interpretation and implications of particular exposure levels in relation to risks to human health and wellbeing
- actions implemented to improve air quality.

Accountability in reporting

The implementation of the NEPM and compliance with the air quality standards is the responsibility of each individual jurisdiction. Under the NEPC Act, accountability for meeting the standards lies in the public reporting; that is, there are no penalties associated with non-compliance. Jurisdictions are only required to evaluate their performance at each monitoring station against the NEPM standards and goals and report the results to the NEPC each year.

The issue was raised during this review as to whether jurisdictions should be made more accountable for implementation and compliance with the standards. Most commentators were of the view that increased accountability and transparency could be achieved by jurisdictions through improvements in the reporting protocol. Two issues in relation to accountability in reporting were highlighted:

- attributing exceedances
- management actions to deal with exceedances

The existing reporting protocol requires jurisdictions to report all exceedances of the standards and provide a description of the circumstances that led to the exceedances; however it does not require jurisdictions to provide information in annual reports on management actions being implemented to deal with non-compliances with the standards. If the data from performance monitoring stations show that some areas in a particular jurisdiction are above the standard, then it is at the discretion of that jurisdiction to decide what action should be taken to manage the problem.

Several commentators asserted that jurisdictions were in some cases misusing the PM_{10} goal (which allows 5 exceedances for natural events) by reporting only the sixth highest statistic, without any indication of whether the 5 top events were natural or anthropogenic. It was argued that appropriate attribution to sources was not being undertaken and that the reporting requirements should be strengthened in this area. Detailed reasons for all exceedances are needed to determine if a pollution event was beyond the normal management capabilities of the jurisdiction. And, irrespective of the source of the pollution episode, an exceedance contributes to community exposure and risk and so should be assessed and reported on this basis.

A number of submissions emphasised that jurisdictions should also be required to report on what actions have been taken to improve air quality if the standards have been exceeded and on actions being undertaken to reduce pollution generally. There was also strong support for reports to demonstrate through trend analysis whether improvements have been made over time and, accordingly, whether there is lower risk associated with population exposures with respect to air pollution.

Submissions noted that most jurisdictions already have active air quality management programs and implement strategies to reduce pollution, and these could be reported on in more detail. It was generally agreed that the accountability for implementation and compliance with the NEPM should remain a matter for individual jurisdictions, subject to their own policy and political processes and specific air quality concerns and priorities.

In assessing and reporting compliance, the US EPA has both an exceptional events and a natural events policy that enables the removal of unusual events from the data set when determining whether an area is or is not in compliance with the standard. The natural events rule applies to severe events such as volcanic or seismic activity, bushfires and dust storms.

In addition to these events, the exceptional events rule also includes events such as high winds, sandblasting, structural fires, chemical spills and industrial accidents, high pollen counts, construction and demolition, highway construction, agricultural tilling, unusual traffic congestion, prescribed burning, clean-up activities after a major disaster, plus several others. There are strict guidelines for the identification, flagging and reporting of the data and the rules only apply in the assessment of whether an area is in violation of the air quality standards.

There was support in submissions for a natural events rule rather than allowing exceedances of standards. This would enable assessment of the air quality management strategies in improving air quality as it focuses on the manageable sources of pollution. All data would need to be reported; however, when assessing compliance with standards, the natural events data would not be included. There was also a strong view that there would need to be strict guidelines about what defined a natural event.

Review findings – accountability in reporting

The Review Team concluded that increased accountability and transparency could be achieved by jurisdictions through improvements in the reporting protocol. Reports should attribute all exceedances and provide information on management actions being undertaken to deal with non-compliance with the standards. The latter should include trend analysis to demonstrate the effectiveness of management strategies over time. Exceedances are only of limited utility in describing impacts of air pollution on population health, so further descriptors of the underlying distribution of air quality data need to be developed and included in reports.

The Review Team considers that inclusion of a natural events rule would enable identification of issues that impact on air quality to be separated into 'natural' events that are not easily managed and 'anthropogenic' impacts that are manageable through the implementation of air quality management strategies. Strict guidance would need to be provided to identify what constitutes a 'natural' event (similar to the guidance developed by the US EPA). The justification and analysis would need to be included in the annual reporting to NEPC.

Timeliness of reporting

A number of submissions argued that reporting should be more frequent to provide timely information to the public when air quality is unhealthy. It was suggested that exceedances of the standards should be reported in real time as current reports take too long to be made public. Some commentators favoured reporting of daily air quality results. It was argued that immediate reporting and clear justification regarding the source of exceedances would benefit public health and increase public confidence in air quality monitoring.

Review findings — timeliness of reporting

The Review Team considers that reporting could be improved, and satisfy the community's right to know, if reporting on poor air quality was more timely. The Review Team is of the view that an investigation is warranted into ways to attribute reason for all exceedances in a timely manner; say, within 3 months, with jurisdictions publicly releasing the findings of the event on their respective websites. Several jurisdictions have already taken significant steps to publish information on air quality more frequently, in some cases in real time, on their respective websites, and this should be recognised (e.g. real-time web reporting using the health-related Air Quality Index, to assess and communicate air quality to the community).

3.3.3 Recommendations relating to national environment protection protocol

Recommendation 10
Redesign monitoring networks to represent population exposure on a pollutant-by-pollutant basis without compromising data collection for long-term trend analysis. A procedure to determine the location and number of sites similar to EU and/or US EPA is recommended.

Recommendation 11
Remove the population threshold and formula to enable monitoring on potential population risk rather than on population size.

Recommendation 12
Amend requirements of monitoring methods (clause 16 and Schedule 3) to allow appropriate Australian Standards methods; or methods determined by the EU and/or US EPA as Reference or Equivalence Methods.

Recommendation 13
Remove Schedule 5 of the NEPM.

Recommendation 14
Develop nationally consistent approaches to assess population exposure, including appropriate modelling and emissions inventories.

Recommendation 15
Revise the assessment (clause 17) and reporting (clause 18) protocol to include additional performance assessment indicators and expanded reporting requirements to enable inclusion of population exposure determinations, severity of exceedance and effectiveness of management actions undertaken.

Recommendation 16
Revise guidance documents and templates associated with assessment and reporting to accommodate presentation of clear messages, to allow for better communication and more accessible air quality reports.

Recommendation 17
Amend the NEPM protocol (part 4) to incorporate natural event rule including definition of these events and criteria for assessment and reporting.

Recommendation 18
Require timely reporting of all exceedances, with jurisdictions publicly releasing the analysis of these events on their respective websites within 3 months of the event.

3.4 The Peer Review Committee

The PRC was formed by Ministerial Agreement as an unfunded body to provide advice to jurisdictions, through the NEPC, on the implementation of the NEPM. Under its current terms of reference, the PRC has two complementary roles. First, it advises the NEPC on the adequacy of monitoring plans and compliance reports submitted by jurisdictions. Second, it provides ongoing advice on technical issues related to the consistent implementation of the NEPM protocol. Over time, the PRC has developed a series of technical guidance papers to assist with implementation (see bibliography for a list of the PRC's technical papers).

3.4.1 Issues

NEPM implementation has now 'matured' and while there is clearly still a need for a support group to assist jurisdictions in implementing the NEPM, the role and function of the support group will need to change if there is a move, through a NEPM variation, to focus on population exposure and exposure reduction approaches. It is important to ensure that any support body has the appropriate set of skills to provide the support to jurisdictions that will be required.

It would seem that the approaches being used internationally might provide a stronger basis for the design of monitoring networks in Australia to provide a measure of population exposure. Adoption of these approaches with amendments to account for differences in population density and sources is an option for consideration if the focus of the NEPM monitoring changes from strict compliance monitoring to a network that will deliver the original intent of the NEPM — a measure of population exposure. Such an approach may also assist jurisdictions to overcome some of the barriers they have experienced in implementing the NEPM because of the population formula and threshold.

Change to a population exposure approach will require changes to the current monitoring protocols and guidance documents. Air quality modelling will play a much greater role. Such a change may provide smaller jurisdictions with an approach that will overcome some of the problems that they have identified with the population threshold and formula for establishing monitoring stations. An agreed approach to modelling for population exposure will provide a mechanism whereby air pollution levels and associated health risk can be estimated even in centres where populations are small.

3.4.2 Comments, discussion, and findings

The PRC is comprised of government experts from all participating jurisdictions, in addition to representatives from industry and community groups. Some commentators called for an expansion of membership and a broadening of its brief from a purely technical focus on data collection, quality, methods and compliance reporting, to consideration of the whole system, to ensure that it meets the objectives of the NEPMs.

As an example, the concept of population exposure as articulated in the NEPM has not yet been appropriately addressed and an expanded PRC could consider how best to produce a report on air quality for evaluation of population impacts. This may well include integration of modelling and monitoring approaches.

There was general support from commentators to maintain a body with a broader scope of scientific and technical expertise to support implementation of the NEPM. It was argued that clear guidance will be needed on a range of issues, including monitoring, modelling, reporting, exposure assessment and health expertise, arising from this review and any variation to the NEPM, in order to ensure national consistency. This could be a fixed body or working groups convened to deal with specific issues related to the NEPM implementation and the model should be explored through a variation process. Whatever model is adopted, the working groups should report through the Air Quality Working Group to NEPC Committee and Council.

A major industry group suggested that the objectives of the NEPM may be better served through the participation of health professionals to assist in providing advice on monitoring plans and their adequacy in assessing population exposures. Comment from the Chair of the PRC did not support any significant changes to roles or structures, on the basis that the PRC is effective in its role and '…has independent members who are able to make comment without implications, as is the inferred case for jurisdictional representatives'. Whatever arrangements are adopted, it was acknowledged that an appropriate level of funding and support needs to be made available to the PRC or other expert body.

The Review Team considers that the PRC should be disbanded and replaced with a specialist working group or groups with a broader range of expertise to assist with scientific and technical matters, such as nationally consistent methodologies and guidance on population exposure assessment and health risk assessment, modelling, inventories and reporting/communication, in supporting the implementation of the NEPM. This working group would report to the Air Quality Working Group.

3.4.3 Recommendations relating to the Peer Review Committee

Recommendation 19
Disband the existing PRC and replace with a specialist working group or groups with a broader range of expertise to assist with scientific and technical matters. This working group would report to the Air Quality Working Group.

3.5 Research and emerging issues for future consideration

During the consultation process a number of issues were raised that require further investigation and data collection to assess whether they need to be addressed through the NEPM.

3.5.1 Issues and review findings

Regional environmental differences

There is a need to consider regional environmental differences. In making any NEPM or variation to an existing NEPM, the National Environment Protection Council must have regard to, *inter alia*, 'any regional environmental differences in Australia' (Section 15(g) of the NEPC Acts). In addition, Section 17(b)(v) of the Act requires that the impact statement to be prepared with the draft variation include 'a statement of the manner in which any regional environmental differences in Australia have been addressed in the development of the proposed Measure'.

The term 'regional environmental differences' recognises that fundamental environmental characteristics of individual regions may be very different, and that to apply uniform standards would not necessarily further the desired outcome of protection espoused in the legislation.

For ambient air quality, there are no clear-cut differences in the natural state of the atmosphere that could meaningfully be reflected in different ambient air quality standards for the protection of human health. While atmospheric conditions can change rapidly and dramatically across Australia, this provides a challenge for air quality management strategies but cannot, in any practical sense, be reflected in standards. In determining appropriate standards for the protection of human health, available evidence suggests that the variation in physiological response to pollutants within any population is likely to be significantly greater than any potential variation in impact due to meteorological or other differences across Australia.

Air quality standards relate to the protection of human health. It is difficult to argue air quality standards in the NEPM should differ for individual jurisdictions given that physiological response to exposure to air pollution will be the same. Although there may be some differences in the frequency of pollution episodes in some jurisdictions, for example, the duration of ozone events, the same standards should apply uniformly across Australia and these differences should be taken into account in the exposure assessment as part of the derivation of the national standards.

Arguments have been put forward to suggest that the composition of particles may differ in rural areas dominated by windblown dust compared to urban areas in Australia and that different standards for particles could be considered. This was a view put forward in some industry submissions. The evidence from epidemiological studies indicates that there are health effects associated with crustal particles as well as combustion particles. However, at this time there is not sufficient evidence to set separate standards based on particle composition.

Collection of air pollution data in regional areas together with research into the health effects associated with air pollution in these areas would inform any future review of the NEPM and assessment as to whether standards for sub-regions are appropriate. In some situations this could be reflected as a stricter standard that would drive air quality management strategies to improve air quality in these regions.

Links between the NEPM and other policy objectives

Consideration of sustainability issues is fundamental to the approaches that governments are taking to environmental management, including the management of air quality and associated health impacts. Sustainability issues were not explicitly addressed at the time of developing and making the NEPM, perhaps because consideration of sustainability may best be viewed as imperative at a jurisdictional level when developing implementation strategies.

Incorporation of sustainability considerations in the NEPM review requires discussion of what is meant by sustainability in this context. Many definitions of sustainable development have been proposed. Most definitions embody two central ideas. Firstly, development is not sustainable unless it takes a long-term perspective that aims to get the best possible quality of life for both present and future generations. Secondly, economic and social development and environmental quality are interconnected objectives, requiring the integration of economic, social and environmental policies and decision making.

For the purpose of this review, it was agreed by the NEPC that the NEPM's contribution to sustainability objectives would be assessed by consideration of the following:

- a framework that will lead to cleaner air and reductions in health risk
- natural resource issues (e.g. fuel, wood) and their subsequent impact on air quality
- social and economic factors.

The NEPM provides a framework for monitoring and reporting air quality and standards against which air quality is assessed. Air quality management strategies are developed and implemented by individual jurisdictions in accordance with legislation in the respective state or territory. Therefore, it is reasonable to suggest that actions taken to improve air quality contribute to sustainability objectives. They do this through reductions in human health risk and reduced impacts of the use and management of resources, contributing to the attainment of intergenerational equity.

Natural resource use can have significant impacts on air quality. The use of wood for domestic heating has a significant effect on air quality in many parts of Australia and can also impact on our forests. Although the use of firewood may have marginal greenhouse benefits, these are outweighed by the significant negative impact wood heating can have on air quality. Emissions from mining and extractive industries can also have a significant impact on air quality yet the extraction of these resources is important for economic growth and development. The use of water to control dust emissions from these industries is becoming an issue of concern due to prolonged drought conditions in many areas of Australia. However, uncontrolled emissions can lead to high particle levels and potential health issues in local communities.

The use of coal for electricity generation and fossil fuels for motor vehicles also has a significant impact on air quality, the latter on a regional scale. In examining options for alternative fuels the impacts on air quality (and ultimately the health of the Australian population) from these alternatives need to be considered and balanced against natural resource and economic considerations.

An effective response to climate change is emerging as a key area for sustainability. The impact of climate change may affect air quality. Increases in temperature are predicted to lead to an increase in ozone levels in Australian cities.

Drought conditions have increased particle levels in most parts of Australia and have led to an increase in the frequency and severity of bushfires that also impact on air quality. Hazard reduction burning is a critical practice to reduce the risk of bushfires but can in itself impact on air quality. It is important, when considering sustainability in the context of the NEPM, that air quality issues be considered in the context of these other programs. Some air pollutants also contribute to global warming although in the Australian context this is not well understood.

It is the view of the Review Team that further research needs to be undertaken into the links between climate change and air quality to ensure that any future standards address any impacts that arise. In particular, increasing temperatures may increase the vulnerability of the population to air pollution which would lead to health effects being observed at lower pollution levels.

The links between the NEPM and other policy objectives, for example, climate policy actions, should be explored to ensure that actions taken to address climate change do not impact negatively on air quality. The integration of air quality considerations into climate policy should be actively pursued and is consistent with international practice.

Strong views were expressed in submissions about the impact of fire management practices on air quality. Although it was generally accepted that fuel reduction burning for reducing bushfire risk was required, the extent of the burning and the use of fire for other purposes was questioned. In particular, the use of fire for regeneration burns and waste burning without consideration of the impact on air quality and the health of surrounding populations was a significant concern for many stakeholders. This is an issue that requires further work with fire authorities to integrate air quality considerations into fire management practices.

Evaluate the options to assess ozone and secondary particle precursors

Ozone and some particle components are secondary pollutants and to reduce ambient levels there needs to be an understanding of the precursors so that management action can be taken. In the EU and the US, air quality policies require the monitoring of ozone and secondary particle precursors in addition to monitoring ozone and particles per se. It is the view of the Review Team that options to assess ozone and secondary particle precursors need to be explored and consideration should be given to including similar requirements to the US and the EU in future reviews of the NEPM or in jurisdictional monitoring programs.

Initiate research into the composition of particles in Australia and associated health impacts.

The review of the health effects of particles has shown that there is some evidence that composition of particles may play a role in the observed health impacts attributed to total particle mass. At this stage, there is not sufficient health evidence to set standards for individual components. In addition, there is limited monitoring data available in Australia to enable development of standards even if the health data were available. Internationally, this is an area where a significant amount of work is under way. The Review Team considers that research should be initiated in Australia into the composition of particles to enable the setting of air quality standards in the future for specific components, for example, black carbon or metals.

Initiate health research on the impact of air pollution (in particular particles) in regional areas.
The NEPM applies to all people in Australia wherever they live. People in regional areas are significantly impacted by smoke from fires and dust which can impact on their health. The issues around regional environmental differences relate to potential differences in health impacts due to differences in air pollution and, in particular, the types of particles that people living in regional areas are exposed to. The Review Team considers that research should be initiated in Australia into the health effects of air pollution (in particular, particles) to gain an understanding of the impact in regional areas. This would enable an assessment as to whether the standards in the NEPM are adequate to ensure the protection of the health of these communities.

Monitor and report coarse particle fraction ($PM_{2.5}$ to PM_{10}) to inform the future development of air quality standards for this fraction.
There is growing evidence that the coarse fraction of particles, $PM_{2.5-10}$, has health effects independent of $PM_{2.5}$. This size fraction makes a significant contribution to total PM_{10} in Australian cities. Internationally, there are moves to set a separate standard for this size fraction and remove the standard for PM_{10}. As identified in the health reviews, there is not sufficient monitoring data in Australia on this size fraction to enable the setting of a standard. The Review Team considers that monitoring should be undertaken of this size fraction so that health research can be undertaken and data is available to set standards in the future should they be required.

3.5.2 Recommendations relating to research and emerging issues

The following recommendations relate to future research and emerging issues. These recommendations should be considered and prioritised by the EPHC Air Quality Working Group.

Recommendation 20
Evaluate the options to assess ozone and secondary particle precursors.

Recommendation 21
Initiate research into the composition of particles in Australia and associated health impacts.

Recommendation 22
Initiate health research on the impact of air pollution (in particular, particles) in regional areas.

Recommendation 23
Monitor and report coarse particle fraction.

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5 SHORTENED FORMS

AEI	average exposure indicator
CASANZ	Clean Air Society of Australia and New Zealand
COPD	chronic obstructive pulmonary disease
EPHC	Environment Protection and Heritage Council
GRUB	Generally representative upper bound
JRN	Jurisdictional Reference Network
NEPC	National Environment Protection Council
NEPM	national environment protection measure
NGO	non-government organisation
NHMRC	National Health and Medical Research Council
NPI	national pollutant inventory
PAH	polycyclic aromatic hydrocarbon
PRC	Peer Review Committee
SSWG	Standards Setting Working Group
TEOM sampler	tapered element oscillating microbalance sampler
US EPA	United States Environment Protection Agency
WHO	World Health Organisation

6 GLOSSARY

advisory reporting standard	(Pm2.5)
airshed	a body of air bounded by topography and meteorology in which a substance, once emitted, is contained
compliance standard	(Pm2.5)
enHealth Council	a subcommittee of the National Public Health Partnership, advising on environmental health matters
GRUB	Generally representative upper bound—the upper bound of pollution levels likely to be experienced by the general population in a specified region while avoiding the direct impacts of localised pollutant sources
hot spot	see peak site
jurisdiction	the Commonwealth, a state or a territory
National Public Health Partnership	a subcommittee of the Australian Health Ministers Advisory Council, advising on public health matters
peak site	a location where emissions from one or a number of cumulative sources give rise to elevated levels of particular pollutants
performance monitoring station	a monitoring station used to measure achievement against the NEPM goal. The station is located to measure air quality likely to be experienced by the general population in a region or sub-region
PM_{10}	refers to particulate matter with an equivalent aerodynamic diameter less than or equal to 10 micrometres
$PM_{2.5}$	refers to particulate matter with an equivalent aerodynamic diameter less than or equal to 2.5 micrometres
population formula	the number of performance monitoring stations for a region with a population of 25,000 people or more must be the next whole number above the number calculated in accordance with the formula: $1.5P + 0.5$ where P is the population of the region (in millions)
priority pollutants	Pollutants prioritised on the basis of risk to the health of the Australian population.