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Facilitator's Report

International Workshop on Tunnel Ventilation

7 to 9 June 2000 - Sydney, Australia

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EXECUTIVE SUMMARY

The Workshop provided a forum for a detailed discussion of international and local trends and factors with respect to tunnel ventilation design.

An examination of alternative technologies occurred and an assessment of a number of air quality treatment systems was undertaken.

The Workshop focussed on the example of the M5 East project while also discussing the Cross City and Lane Cove tunnel projects generally and the underlying philosophes of tunnel ventilation design in Sydney, Melbourne, Western Europe, Asia and America.

Discussions focussed on international and local experience with tunnel ventilation technologies, the relationship between air quality and health, local and international trends in air pollution management, air pollution initiatives, the costs and effectiveness of technologies, and the importance of the relationship between communities and government.

FINDINGS

- Emissions from motor vehicles can cause adverse health effects.

- In all urban areas, including Sydney – people suffer adverse health effects as a result of breathing polluted air.

- Technologies exist which can alter the composition of polluted air from tunnels.

- A holistic approach to addressing polluted air is required when assessing tunnel air cleaning technologies. Prudent use of financial resources demands that the use of technology to alter the composition of tunnel air has to be compared with other methods of improving air quality.

- Information on the effectiveness of electrostatic precipitators at changing the air quality around tunnels, their cost and operational performance should be obtained from countries such as Norway, Japan and South Korea which use them.

- The suite of air quality objectives for tunnel emissions in New South Wales are comparatively strict compared with many other countries.

- The M5 East design is expected to meet all Sydney's comparatively strict environmental performance requirements, however in engineering terms, location is not optimal due to the remote stack location in a shallow valley.

- Analysis of the ventilation systems designed for the M5 East tunnel indicates that Sydney's comparatively strict standards are expected to be met outside tunnel portals and in areas surrounding the stack.

- The M5 East ventilation design is an example of a system, which has been designed by considering, factors in addition to engineering.

- Conditions of approval substantially control the designs of Sydney tunnels.

- Holistic tunnel design includes consideration of more than engineering issues.

- The energy consumption of a ventilation system is a relevant factor in tunnel system design.

- Immediate consideration should be given to the most effective ways of improving air quality in areas identified as receiving the least benefit from the operation of the M5 East tunnel ventilation system.

- The benefits of cleaning tunnel air with various technologies – as they emerge – must be compared with the benefits of other measures to improve air quality.

- If measures to improve air quality are not implemented rapidly the opportunity afforded by the tunnel environment to manage motor vehicle emissions will become increasingly attractive.

I have not recommended air cleaning technologies be employed in the M5 East project. Nor have I recommended that works stop on the construction of the ventilation system. I have not made such recommendations on the basis that:

a) Such a conclusion was not reached at the workshop; nor could it be reasonably reached on the basis of material presented at the workshop;

b) My recommendations for further data collection, policy review, and air quality improvement measures will be responded to promptly;

c) The M5 East system has been designed in a way that can accommodate both particulate and gas cleaning technologies should it be determined they are necessary and effective in the future.

Given the acknowledged adverse health effects of motor vehicle emissions it is appropriate that tangible programs for air quality improvement are introduced as a priority.

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INTRODUCTION

1.1 Tunnels & Pollution

The construction of vehicle tunnels has focussed both government and community attention on the potential adverse health effects of polluted air.

I have not recommended air cleaning technologies be employed in the M5 East project. Nor have I recommended that works stop on the construction of the ventilation system. I have not made such recommendations on the basis that:

a) My recommendations will be addressed promptly;

b) The M5 East system has been designed in a way it can accommodate both particulate and gas cleaning technologies.

The tunnel environment provides an opportunity which can, and in at least some instances, has, been used to install technology to either extract or modify some of the pollutants emitted from motor cars.

However as noted by Giselle Mawer of the M5 East RAPS:

> *"we need to look at cost effectiveness in the holistic way. It is effective for the short term as well as the long term, is it effective in terms of the total cost not just the financial cost from the RTA budget, what about the health costs, what about the*

aesthetic costs, what about the amenity costs, the environment cost, the equity cost, and the cost for generations to come?"

It is for these reasons that factors such as effectiveness, the magnitude of any health risks posed, the comparative cost of achieving the environmental improvement must be carefully considered between different strategies to improve air quality.

In Western Europe programs designed to address motor vehicle emissions have resulted in such significant air quality improvements that in some instances it is not expected stacks will be needed on some tunnel projects in the future.

There was insufficient material presented at the workshop to decide on the practical effectiveness of electrostatic precipitators or other technologies such as gas cleaning.

Such information should be readily available – and should form the basis of any discussions made about their use. This material should be requested on at least on agency level.

1.2 The Nature of this Report

This report is an overview of themes, discussion, debate and conclusions which arose from the international workshop into tunnel ventilation held in Sydney from 7 to 9 June 2000.

I have revisited my draft report following both written and oral communications from participants at the Workshop. Material forwarded to me in response to my draft report is included on the resource CD.

This report should be read in the context of reference material contained on the International Workshop and Tunnel Ventilation Workshop CD. The transcript and overheads that were presented during the course of the 3 days of the proceedings are contained on that CD.

This report places more emphasis upon non-scientific and non-engineering matters, which were raised, at the workshop than my draft report.

The initial transcript was of such a poor quality that it required correction. The uncorrected transcripts together with the corrected version are contained on the CD. There remain errors in the transcript. These should be corrected in a co-operative arrangement between the RTA and RAPS whom have indicated they have a copy of the proceedings on a separate tape.

As the corrected version of the proceedings was not available while compiling this report, no detailed references to the quotations extracted have been included.

This report does not attempt to detail every matter canvassed, argument raised or conclusion reached at the workshop.

To obtain a detailed appreciation of all matters, argument and recommendations of the workshop the transcript, briefing material and overheads should be examined in their entirety.

Importantly an overview of community expectations of the Workshop were noted in a series of questions presented to the Workshop participants on Day 1 of the Workshop. They are reproduced in full:

"

1. What technology exists to treat the harmful pollutants (especially particulates and Nitrogen Dioxide) of vehicle emissions from tunnels?

2. Why and in what context have other countries used air cleaning and filtration technologies? To what extent have environmental issues played a part in these decisions? With what effect?

3. Would their use make stacks in urban areas redundant? What is the cost benefit analysis of comparative ventilation systems?

4. How would the available technology apply to Australian conditions? How would this technology apply specifically to the M5 East?

5. What are the implications of the latest research on the health effects of air pollution for current air quality goals? How appropriate are they for:
   a) Point source emissions?

b) Sustained levels of exposure?
c) Local as compared with regional impacts?
d) Sensitive sectors of the population?

6. How adequate are the current DUAP approval conditions for tunnel ventilation systems and monitoring processes in light of emerging standards and latest research on air pollution and its health effects? Are they actually applicable to a point source such as a stack?

7. What are the realistic predictions, time frames for implementation and impacts of improved air quality and health outcomes from proposed changes to the vehicle fleet and fuel standards?

8. What will happen as a result if this workshop? How will the findings from this workshop be recorded? How will recommendations be made? How will the public get access to this information? Who will write the draft report? Who will have input into it? What review/appeal mechanisms are available?

9. What are the implementation strategies and implementation timeframes?

10. How can the lessons learnt from the M5 East be applied to ensure more effective planning and consultation processes and better community acceptance of infrastructure projects?"

1.3 The Workshop

The RTA requested the facilitation of an international workshop to promote a detailed discussion of international experience local conditions and alternative technologies with a view to assessing the appropriateness of the treatment systems for road tunnels in New South Wales.

To achieve this tunnel ventilation experts from around the world and proponents of technology were brought together (for the first time) in a forum encouraging open discussion on tunnel air management strategies for Sydney.

1.4 Aims

In order to promote a full and frank dialogue about issues arising from past, current and future projects there were a number of essential elements of the workshop format implemented including:

A. The attendance of internationally recognised experts in tunnel ventilation.

B. The attendance of nominated tunnel advocates of tunnel air cleaning technology.

C. An appropriate venue for the discussions.

D. Representatives from Government Agencies, RTA, EPA Victorian and EPA New South Wales, Health, DUAP and CSIRO.

E. Recording of the proceedings coupled with publication of the transcript.

F. Limited numbers of participants.

G. The maintenance of a neither adversarial nor inquisitional environment.

To best ensure a fair and informed debate, a library of key documents in relation to the past, existing and future tunnel projects in Sydney, pertinent Web-sites and other resources with respect to Australia and the Sydney context was compiled on a briefing CD.

The briefing CD was delivered to each of the international delegates and the installation of the data on their computer systems overseen. This ensured that all overseas guests were able to appraise themselves of the peculiarities of the Sydney tunnelling environment. In this way each speaker had the opportunity to consider all relevant information prior to the commencement of the workshop.

In each instance, the speakers were advised that any further information they required would be available by request. Several requests were made, and further information was provided, where it was available.

1.5 Workshop Dynamics

Approximately 60 people were invited to attend the workshop. At least several hundred other people wished to attend. Numbers were limited to purposely create an environment that encouraged dialogue and debate. If the proceedings had not been recorded or the transcript made public, attendances would not have been limited.

All sessions ran overtime. All participants appeared to place considerable importance upon the issues being discussed. There was active open and frank discussion on important issues during the workshop.

The workshop did not, nor in hindsight could it reasonably be expected to have resolved all philosophical and factual issues associated with ventilation options for Sydney's road tunnels.

However it has served as a mechanism for focussing attention on relevant issues and resolving some factual matters which were in contention prior to the Workshop.

As a result of the complexity of issues raised during the workshop, the recommendations of this report have been consolidated. The reasoning for these recommendations is briefly described in the body of this report.

1.6 Community Concerns

A recurring theme from community representatives at the Workshop was that the RTA has not engaged in meaningful consultation. This was experienced by one observer in the following terms:

> *'[There was "disastrous community consultation around the M5 East Stack"] (Lalita Lakshmi & John Hutchinson)"*

The community representatives were critical of many matters. There was general:

- Dissatisfaction with environmental standards;
- Dissatisfaction with process;

- Suggestions of unfairness;
- That the proposals were bad for health;
- That there was a conspiracy and incompetence;
- That the RTA had adopted a "design and defend" mentality;
- That it caused devaluation of land;
- Was visually unacceptable;

to name just some issues.

It was within this context that the Workshop proceeded.

1.7 Material Provided Following the Workshop

Matsushita Electric Industrial Co, Ltd of Japan provided material on electrostatic precipitator use in Japan. A short discussion of that material, and revised recommendations arising from it appear in this report.

The comments on my draft report and the draft report are also contained also on the CD.

DISCUSSION OF WORKSHOP

2.1 Tunnel Ventilation Philosophy - General

All presenters agreed that each tunnel ventilation system must be considered on a tunnel-by-tunnel basis. On no other subject was such a unanimous view expressed.

Once accepted that each tunnel required individual examination, the technical problem - which remains unresolved - is how to balance competing factors in designing a tunnel ventilation system?

Dr Zumsteg, from Switzerland, proposed a simplified model for tunnel ventilation decision-making. At its most basic level, he observed:

> *"At the very least a balance had to be reached between the air quality sought to be achieved, the energy which was used to achieve it and the amount of money that has to be spent."*

On day 2, he noted:

> *"We have to apply certain limits to be able to dimension what we want to build so that if we don't know any limit for example for the air quality, we cannot say how much air we should put into this tunnel or take out of this tunnel. If we have no limit of money available then problem is not too big, we can afford everything, but usually there is quite a strict limit where the costs have to be and what the maximum cost can be…. "*

This basic model of decision-making was generally consistent with views expressed by a range of participants.

Throughout the Workshop there was a recurring theme that factors such as health, visual impact, process and equity should be considered as well as more fundamental engineering performance measures.

An insight into the task of dimensioning and general design of a tunnel ventilation system was provided by Charles MacDonald, formerly the General Manager, Engineering, on Melbourne's City Link project.

He explained that the form of the Australian ventilation system is driven by the current air quality requirement of minimal or no emissions at portals and applying comparatively strict environmental standards immediately outside the tunnel portals. On day 2, he said:

> *" … not having emissions at portals … applying the standards literally everywhere and not adjusting them in the circumstances of the portal …… gives us …… very tight constraints in which to work. …".*

The tunnel ventilation design engineers pointed out that there was a relationship between the strict environmental performance requirements of the M5 East tunnel ventilation system conditions of approval and the actual ventilation design.

Given this fact, the workshop explored the origin of the regulatory environment via extensive discussion, submission and debate.

A second non-technical and perhaps even more difficult issue arose: how are conflicting community expectations about ventilation design is accommodated?

There was a range of outcomes sought by the community, which were to varying extents non reconcilable. For example taller stacks for enhanced pollution dispersion as compared with no stacks and full portal emissions.

The importance of balancing a number of important considerations underlined much of the debate at the workshop.

Complex equity issues arose at the workshop in relation to the allocation of resources to improve the environment. It was beyond the scope of the workshop to consider a methodology for the assessment of the health implications of placing road infrastructure in tunnels in comparison with other public health initiatives to improve health.

Awareness of the relationship between exposure to air pollution and adverse health effects for people, in the context of a large city, raises complex equity issues on how limited resources should be allocated.

Another important implication of the dynamics of tunnel ventilation systems is their ability to respond to changes in pollution levels and/or environmental requirements with time. The demands may become more onerous – (such as in the Ten-nohzan Tunnel (Japan) in which precipitators have been retrospectively installed) or less demanding (such as in the Oslo Tunnel (Norway) where the precipitators were turned off.)

No detailed information was presented on the ability of competing tunnel ventilation designs to respond to decreased tunnel ventilation demands with time. The ability to retrospectively

fit technology simply is an example of a design that can respond to an increase in demands upon the system.

Currently portal emissions are effectively not permitted for the Melbourne City Link or Sydney's M5 East tunnels. Over the operational lifetime of a project it is conceivable that portal emissions may occur. Indeed, it is conceivable they may even be encouraged. In such circumstances, monitoring of air quality outside portals should be implemented, whether the current design anticipates portal emissions or not.

- **Serious consideration should be given to monitoring air quality outside portals, whether the ventilation design anticipates portal emissions or not.**

Air quality monitoring outside portals would allow informed management of the tunnel ventilation system with respect to outside tunnel air quality no matter what variations occur in the tunnels operational regime during its lifetime.

Of course it is conceivable that within our lifetime, improvements in vehicle emissions may render stacks redundant requiring them to be decommissioned.

Analysing the implications of variations in air quality - including regional, local, near surface road and local - were discussed, but there was insufficient information at the workshop to properly consider this matter.

Ultimately, there may be no correct way to balance competing issues, other than to observe that a process involving consultation and mutual respect between a community and its public servants is a critical factor in arriving at an acceptable solution. Like all relationships that between the community and government authorities is in a state of evolution.

2.2 Interdepartmental Regulatory Responsibility for Tunnels

The importance of meeting comparatively strict environmental goals immediately outside the M5 East tunnel was confirmed by Mark Hather of the Department of Urban Affairs and Planning (DUAP). He confirmed that the goals were part of , "*conditions of approval which need to be met*".

It was explained that these goals were the numerical equivalents to the environment protection goals, at the time the project was going through the approval process. The New South Wales Environment Protection Authority confirmed the applicability of these goals to the projects.

It became clear that the design philosophy of the tunnels, - as reflected in conditions of approval - are a result of a combination of environmental expertise from many regulatory arms of government including, the RTA, Department of Health (DoH), Environmental Protection Authority (NSWEPA) and the Department of Urban Affairs and Planning (DUAP).

The design of the Sydney tunnels is in substantial part a function of the criteria imposed on the tunnel designers by a number of departments, it is not solely the RTA's responsibility.

Changes in tunnel ventilation design philosophy would require changes in the regulatory environment.

2.3 How do New South Wales Environmental Performance Design Criteria Compare with the Overseas Experience?

During the course of the workshop, no other country was identified that required the maintenance of such high standards of environmental air quality immediately outside tunnel portals.

During the workshop, representatives from the RTA, EPA, DoH and DUAP all made comments based upon the fundamental design philosophy that their strict environmental standards must be met.

Several overseas presenters observed that in achieving these strict environmental objectives, there might be other undesirable environmental outcomes.

For example, large amounts of energy are required to run the ventilation systems to ensure that the strict environmental standards can be met outside the tunnels portals. European

countries consider it highly undesirable to use large amounts of energy to achieve these otherwise desirable environmental outcomes.

It was argued that such high-energy consumption should be considered as an undesirable consequence of insisting on strict environmental standards, particularly as it was generated by burning coal, which of itself creates other undesirable atmospheric discharges at another location.

This was one of the environmental "equity" arguments that were debated during the workshop.

Also of note in this regard are Australia's Kyoto obligations to the international community on reducing greenhouse gas emissions.

It was suggested that, at the very least, the strict environmental design philosophies in relation to environmental standards outside the tunnel should be reviewed in the context of these observations.

- **It is recommended that the regulatory authorities review the strict environmental performance requirements of tunnel ventilation systems in the context of other environmental outcomes that such requirements may cause.**

It is noteworthy that in Europe where energy is valued highly and environmental controls are comparatively strict, regulators have generally chosen to promote ambient air quality improvement - such as through emission standards and pollution taxation in preference to in tunnel air treatment.

2.4 Standards

At the workshop the environmental regulators, who were attending as observers, were unable to satisfactorily explain the rationale for the environmental standards when called upon to do so without notice. These standards are amongst the most stringent in the world. The standards and an explanation for them can be found at http://www.nepc.gov.au.

- **It is recommended that an explanation of the health risks implications of the standards in the context of tunnel emissions be prepared and made available to the public.**

HEALTH

3.1 General Health Issues

Discussions about health risk were of fundamental importance during the workshop. Without health issues, the tunnel ventilation system would only be needed to maintain the required air quality within the tunnel to enable drivers to safely pass through the tunnel; there would be no need for it to also disperse the tunnel exhaust air outside the tunnel. Other important issues such as fire and smoke control, visibility and CO are also health issues managed with ventilation systems.

Importantly, there was no dispute that internal combustion engine motor vehicle emissions can cause adverse health effects.

Specifically the importance of fine particles was discussed at some length. Dr Kearney, referred to a recent medical journal article which pointed out that the:

> *"..ultra-fine particles below .005 (0.05m m) have a relatively short life condensing into larger but still very small ones…[although] far from enough to overload the alveolar macrophages, it does provide a formidably large surface area for transport of adsorbed toxic substances to the alveoli membrane and therefore the potential for toxic effects.."*
> *(A Seaton, Journal Royal Society of Medicine, Volume 89(11). November 1996 P604-607)*

The health professionals generally agreed that the ultra-fine component of motor vehicle particulate emissions may be the most important component of particulate emissions from a health perspective – however they also noted that there are a very large number of other

components of the tunnel air which may also have health effects such as NOx, Volatile Hydrocarbons, CO and other compounds and gasses.

However, there was no resolution of the more important issue of the extent to which the "potential for toxic effects" would result in *actual* adverse health outcomes.

Other points which were made and may be relevant to health risk analysis included the:

- cumulative effects of exposure to pollution;
- role of adsorbed toxins;
- impact of respiratory irritants on health effects.

The likely impact on health of significantly changed vehicle emissions as a result of improved traffic flow were also left unresolved.

One of the international presenters suggested that an examination of the difference between current pollution exposure and predicted future exposure should be undertaken, so that substantive comparative analysis can be conducted.

3.2 Heath Risk Perspective

The difficulty that became immediately apparent during the health debates was how to put comparative health risk issues into a perspective. Some health professionals focussed on the likely "causes" of adverse health, while others focussed upon the significance to health of exposure to various identified risk factors.

As Dr Corbett, from the New South Wales Health Department, noted regarding the significance of a change in exposure to a specific pollutant:

> *"[It was] only significant if other source[s] [do not] …. dwarf that increase and for many of these substances, other opportunities for exposure dwarf that increase. It is*

just a question of looking at the increase in the context of the exposure we encounter going about in our daily life. That is the only point I would make because otherwise we are looking at it in isolation."

Dr Corbett has conducted research in Sydney, as pointed out by Dr Kearney in his response to the Draft Report – (but in the context of criticising Dr Corbett's opinion):

"Dr Corbett has examined the actual association between pollution and hospital admissions in Sydney and identified – amongst other things – that an increase in PM_{10} of 50mg/m^3 is associated with a 4% increase in admissions for chronic pulmonary disease".

Accordingly Dr Corbett's observations about the significance to health of exposure to substances were made within the context of actual analysis of health outcomes. Dr Kearney's important observations appeared to be made from the perspective of a doctor identifying the causes of particular illnesses.

Dr Vicky Sheppeard, from the Department of Health, also commented in the context of a discussion in relation to the health effects of NO2 on the importance of the significance to health of the gas:

" … those kinds of levels would not have an appreciable health effect."

On the other hand, some other participants considered such an approach to the health analysis was unacceptable. This was summed up when a community representative said:

" … the fact is, we don't care how small the increase is. Sure if we had an unflued gas heater or someone smokes in our house that is our choice. But if you put this out onto our roads and into our backyard, that is not our choice. If we choose to pollute our own atmosphere where we live then you cannot do anything about it but we don't want you to pollute it for us. So we don't care whether it's observable or not observable, what we want is [you to] stop it. So lets forget all of this and sit down and say, do you think this stuff works? [The air cleaning technologies] What do you

think of the technology? And how do you think we can adapt it to improve our environment."

Conflicts over health risk methodology were a common cause for conflicts of opinion at the workshop. The issue of health risk assessment must be further examined.

- **Methodologies for calculating and communicating comparative health risk assessment information should be established to better enable the assessment of the implications of tunnel ventilation systems.**

3.3 Presentation of Health Risk Data

Information generated about the performance of a tunnel ventilation system should be presented in a way that is useful for lay people as well as health professionals for conducting comparative health risk analysis.

Both acute and chronic health predictions are appropriate when trying to determine the impact of tunnel ventilation systems.

- **The use of both worst-case emissions predictions as well as cumulative and long term predictions for health risk assessment should be considered.**

TUNNEL AIR MANAGEMENT OPTIONS

4.1 Dispersion

It was apparent from discussions that all tunnels in Australia and most of the world have, to date, relied upon dispersion techniques to achieve the prescribed environmental standards. The use of dispersion techniques to manage tunnel air emissions is used in all countries including Norway and Japan.

4.2 Emission Controls

Globally the most significant technique of improving emitted tunnel air appeared from the discussions to have been improvements in vehicle emissions. This has resulted in redundancy of existing ventilation equipment in Europe and the re-design of proposed tunnel ventilation systems in a number of countries.

4.3 Alternative Technologies

It was confirmed at the workshop that other methods exist, are promoted and used for modifying the components of tunnel air. The overall effectiveness of the techniques on external air quality remains unclear – however it was well established they have been used.

4.3.1 Electrostatic Precipitators

Electrostatic precipitators remove particles. They have been successfully installed in tunnels for many years to improve tunnel visibility – and more recently Norway, Japan and possibly South Korea for external environmental reasons.

The effectiveness of these systems to vary outside tunnel air quality remains uncertain.

Such information should be available from Norway, Japan and South Korea.

4.3.2 Gas Cleaning

Technologies also exist to reduce the concentration of some gases; systems incorporating both gas and particulate removal have been designed (Wandlunge) and gas and particulate treatment technologies are being installed in the very long (24.5km) Laerdal tunnel in Norway.

4.4 Retrospective Installation

The importance to the urgency of determining whether technologies are available to clean tunnel air is whether they can be installed retrospectively into a project.

The ability to be able to retrospectively fit electrostatic precipitators and gas cleaning equipment is a requirement on the M5 East Project.
It was confirmed that sufficient land is available near the stack site to do this and that the construction of the stack would lend itself to retrospective fitting of such technologies.

Furthermore, as noted by Hans Anderl:

> *"…. I have seen some drawing of your tunnel and 800 - 900 metre tunnel you have to the outlet shaft and I can give you a lot of electrostatic precipitator in that line."*

There appeared to be no dispute that electrostatic precipitators could be constructed retrospectively in the current design.

It was agreed that both the NO2 cleaning technologies and the EP technologies could be retrospectively installed.

COMPARING MANAGEMENT ALTERNATIVES

5.1 General

The difficulty is determining how to assess the appropriateness of using such technology. (See for example the above section Tunnel Ventilation Philosophy - General)

However a view strongly expressed by some of the community representatives at the workshop was that this is not a difficult question at all – as put quite succinctly, by one delegate - *"if it works - use it!"*

Dr Zumsteg and other community representatives indicated that a holistic evaluation was needed – not simply whether a technology did something positive but whether from an

examination of many factors. Dr Zumsteg suggested at the very least this should include cost, energy and effectiveness of the technology. It was generally agreed this was just the beginning of the list of relevant factors.

On the other hand, the M5 East project tunnel engineers pointed to their detailed engineering analysis of the tunnel ventilation system performance modelling as clear proof that the dispersion method did work – as all environmental goals would be achieved and therefore by implication satisfactory health outcomes were also achieved.

It is not surprising that a number of the design engineers found it difficult to understand the often intense criticism of their design when they meet comparatively strict environmental conditions imposed by the New South Wales regulators.

Some participants strongly rejected this argument asserting the achievement of the environmental objectives was not relevant. They maintained these goals were "licenses to pollute" – and the key issue is how much change in the air quality will the project cause.

It is essential that the environmental and health implications of strict environmental performance standards are presented in a way that explains the environmental and health benefits they represent.

5.2 Cost Benefit Analysis

5.2.1 Capital Costs

In order to make informed decisions about the benefits of alternate air management technologies, a holistic view including consideration of the benefits the alternative brings compared with the costs, is required.

One of the undesirable outcomes that the experts discussed was the installation of technology that produces no tangible health benefit at a significant cost.

Perhaps even more undesirable would be the installation of technologies, which caused unacceptably adverse environmental outcomes. An example of such a situation would be a

system which consumed a disproportionate amount of energy for the environmental benefit it achieved.

Insufficient material was made available at the workshop to draw any conclusion on whether the technologies are cost effective, and whether they would represent value for money in terms of the potential public health benefits.

This report's recommendations in relation to health risk quantification will hopefully assist in quantifying the benefit component of the equation - the costings appear even more problematic.

Some material was provided during the workshop on the costs of installing electrostatic precipitators and NO2 cleaning equipment.

Mr Boekman said:

> *"I would guess that a gas cleaning system upstream of the stack including a electrostatic precipitator, including a gas filter to take out NO_2 gas and some VOC etc and say civil works in that context will cost in the magnitude I would think of AUS$30M to AUS$35M."*

On the other hand, Mr Henning from the Norwegian road authority said:

> *"I can say the cost for the equipment in the Laerdal Tunnel was approximately AUS$8M I think for this equipment, but that is for equipment handle 180 cubic metres per second so that different from tunnel to tunnel depending on the air which the equipment shall handle."*

However, Mr Anderl, of CTA technologies, asserted that he could provide electrostatic precipitators to treat nearly five times as much air for around the same price.

No costings were available on the Wandlunge method of tunnel air management – however it was suggested :

> "*Any useful cost analysis of the Wandlunge would have to consider both the initial cost plus the estimate maintenance cost over a period of say 25 years or more because its operating costs would be considerably cheaper than the current NSW tunnel designs which require enormous "on going power demands".*
> (George Hare – response to draft report, Australian Sales Representative, Wandlunge.)

Further investigation of these matters should be undertaken, including issues such as capital cost, maintenance cost, expected life span of apparatus, energy consumption, waste stream characteristics, and expected useful life.

Likewise NO_2 costings were not made available. This is not a criticism of the Workshop – it merely highlights its limitations.

The variability of cost estimates highlights the importance of understanding exactly what equipment is required and the task it must achieve. Until the performance required is defined, the cost estimates are likely to continue to vary.

5.2.2 Waste Streams

There remain outstanding questions about waste streams produced by different treatment technologies. Comparatively simple questions such as whether material collected by an EP should be burnt in a "high temperature incinerator" or whether other disposal options are appropriate, and their costs, are examples of issues that remain outstanding. They are issues that should be able to be resolved.

- **Further examination of alternative technologies is required to determine their costs and benefits.**

5.2.3 Running Costs

Mr Anderl highlighted the importance of budgeting for maintenance of the systems, when he suggested that, in Norway, the Norwegian road authority has not adequately provided for the maintenance of the systems - and thereby compromised the operation and long-term effectiveness of installed electrostatic precipitator systems.

It was also suggested that deficiencies in the control system, which determines when the electrostatic precipitators should operate, could render automatic control of the electrostatic precipitators ineffective. Mr Anderl indicated these control issues compromised the operation of the CTA systems in Norway and Southern Korea. These practical "engineering control" issues need further examination.
The cost of running technologies must be considered before introducing the technology.

5.3 Overseas Experience

5.3.1 General

During the course of the workshop, there were numerous references to the evolution of tunnel ventilation systems. Several examples were identified of tunnel ventilation systems that have been designed to provide external environmental protection. Many countries require environmental standards to be met outside tunnels – the majority of these use portal or stack emissions.

Mr Anderl identified a number of tunnels in which CTA International electrostatic precipitators had been installed.

Mr Henning from the Norwegian road authority indicated that:

> *" … it is in only one of our tunnels that planning authorities have said to us that we have to use cleaning equipment … "*

In Norway many factors in addition to simply technical issues have resulted in the increased unacceptability of ventilation stacks in urban areas. This phenomenon was also observed in France, USA and Australia.

However, from the discussions at the workshop, it became clear that while the reason for installing ceiling mounted electrostatic precipitators in the Nygard tunnel in Bergen (Norway) was external environmental conditions. The effectiveness of that installation to alter outside tunnel air quality is still the subject of ongoing debate and analysis.

Mr Henning indicated that measurements were taken around the Bergen tunnel before its operation and that there is a program in place to determine the overall effectiveness of the system in managing the external air quality.

When asked when those results would be available, Mr Henning said:

> *"Within a year or so… we will have the whole period, summer and winter period, before we conclude."*

While data on the performance of precipitators for removing particles from tunnel air was referred to at the workshop, there was no actual data presented on the effect of these systems on outside air quality. As a result there could be no detailed discussion on the actual effect of the equipment on outside air quality, although the modellers and tunnel ventilation engineers thought that even with 100% efficiency there would be no significant change of air quality near the stacks.

Given the fundamental importance of such information:

- **It is recommended that the relevant NSW department(s) formally request data from Norway, Japan and South Korea on the effect on external air quality of operating electrostatic precipitators.**

No detailed performance results were provided on the long term reliability or effectiveness of the EP's. Given the fundamental importance of such information:

- **It is recommend that the relevant NSW department(s) formally request data from Norway, Japan and Korea on the reliability and serviceability of operating electrostatic precipitators.**

No detailed results were provided on the quantity or composition of the waste streams produced by the EP systems.

- **It is recommended that the relevant NSW department(s) formally request data from Norway, Japan and Korea on the quantity and composition of wastes that electrostatic precipitators generate.**

The debate on the merits of NO_2 removal that occurred at the workshop left the issue unresolved. For example – it was suggested by some speakers that whilst NO_2 can be reduced within the tunnel, the resultant NO reverts to NO_2 once exhausted from the tunnel, and the technology has no positive effect on the surrounding air quality. The rate of NO reversions to NO_2 remained unresolved.

- **It is recommended that further analysis of the benefits of NO_2 removal should be undertaken.**

The Wandlunge system was promoted as an integrated fire – life safety and environmental management alternative for road tunnels. As such, it was recognised by a number of participants as an innovative and integrated engineering response to the demands of fire-life safety and environmental pollution. Detailed assessment of the system could not be undertaken at the workshop.

However design concepts like the Wandlunge system might not meet all current tunnel performance requirements in NSW.

This is one of the reasons this report urges the relevant regulators to review their strict environmental performance standards.

5.3.2 Japanese Electrostatic Precipitators

On Wednesday 21 June, a letter from the Matsushita Electric Industrial Co., Ltd System Sales Office, Promotion Section, Osaka (dated 6 June) was received which requested:

"If possible, please give us another chance to make presentation for Tunnel Ventilation System …".

This request followed a visit to the Japanese office of Matsushita, at which a copy of the workshop briefing CD was provided and a request that a representative of Matsushita attend the Sydney workshop to provide details of Japanese air cleaning technologies and experience was made.

At the meeting, the importance of providing details to the workshop of the retrospective installation of electrostatic precipitators in the Ten-nohzan tunnel between Nagoya and Kobe, Japan was conveyed.
The material received is in relation to the Ten-nohzan system.

This is relevant to the general consideration of matters arising at the workshop because it is (as far as can be determined from the workshop) one of, if not the only example, of the many hundreds of long tunnels in the world, of a:

- electrostatic precipitator in the stack;
- operational (and operated);
- high volume tunnel air;
- urban;
- retrospective (installed after tunnel construction and operation);
- electrostatic precipitation system;
- designed to improve outside tunnel air quality.

These materials are included as appendix 6 to this report.

The Japanese authorities may have considered the retrospective installation of the EP system carefully – and may also have assessed its post installation performance.

- **It is recommended that the relevant NSW department(s) formally request details of the rationale for retrospectively installing electrostatic precipitation systems for external air quality management from the appropriate Japanese authorities.**

- **It is recommended that the relevant NSW department(s) formally request data from the appropriate Japanese authorities:**

  - **of the effect on external air quality of the operation of the electrostatic precipitators.**

  - **on the reliability and serviceability of the electrostatic precipitators.**

  - **of the quantity, composition and disposal of wastes generated.**

  - **on the capital and operational costs of the electrostatic precipitators.**

5.4 Conclusion – Alternative Technologies

Clearly, alternative tunnel air cleaning technologies exist.

There was insufficient information presented at the workshop to determine, on a cost benefit basis, their appropriateness for inclusion in any project in New South Wales.

The further research recommended would assist in determining their appropriateness for any given situation.

ASSESSING TUNNEL DESIGN PHILOSOPHIES

6.1 The Importance of Time Lag

All major infrastructure projects discussed at the workshop took many years to progress from a concept to a reality. All projects discussed were described in terms of long design lives. This time dimension of projects became a common theme for discussion.

The relevance of the time lag to tunnel ventilation design are many and varied but a brief consideration of a number of examples from overseas is useful.

In Europe air quality has significantly improved and is expected to continue to improve as a result of government measures reducing vehicle emissions.

For example in Switzerland, there is a portal extraction system under design which exhausts part of the tunnel air up a stack. However that system may never be built as the latest models indicate direct portal emissions will not breach the Swiss environmental standards.

In short the Swiss environmental improvement programs are improving air quality so quickly that in the time it takes to construct a tunnel decreases in motor vehicle emissions may render the stack component of the tunnel ventilation system redundant.

In Norway, electrostatic precipitators have been installed in several tunnels primarily to address unacceptably high levels of particulates within the tunnels. Mr Henning from the Norwegian road authority indicated that one of these systems has now been turned off :

> *" . . . the concentration today is so low, so they have to reduce the cost and so on . .".*

Mr Henning said, on day 3,

> *"…the situation today is that the pollution is not so high that it is not necessary to use it. Therefore they have not used it and saved money in this way…"*

In the Norwegian example, it is anticipated that the tunnel will be lengthened after which time there may again be a need to use the electrostatic precipitators to remove particulates from the tunnel air.

The Ten-nohzan tunnel in Japan has retrospectively had electrostatic precipitators fitted as air quality decreased. It is understood the number of diesel vehicles using the tunnel had increased dramatically since the tunnel opened.

One of the objectives of a ventilation system design should be its ability to deal with both higher and lower pollution levels than is expected at the time of design. This means a tunnel ventilation design should be able to respond to changes in not only environmental standards but also changes in the vehicle emission characteristics.

6.1.1 Modelling Change

An understanding of the likely changes in vehicle emission composition and quantity with time may be an important fact in determining the most appropriate tunnel ventilation design system.

No material was presented during the workshop, which examined the likely period during which current environmental standards can be met outside the tunnel by only using dispersal methods.

Limited analysis of the predicted reduction in fleet emissions from improved engine technology and fuel standards was presented. There was limited examination of the likely consequences of other emissions controls such as on domestic pollution sources.

However it was noted that if the government were minded to spend money on say – the buy back of wood-heaters in the area around the M5 East there would be a substantial improvement in the ambient air quality.

In opposition to this proposition it was argued that even if it was true that a greater overall benefit for air quality could be achieved by implementing other air quality programs than the installation of air cleaning technology – the government was not committed to either – and the one which provided the immediate benefit was the installation of air cleaning technology in the road tunnel ventilation system.

Without a detailed program of ambient air improvement measures for Sydney, a cost benefit analysis of the use of ventilation stacks or other methodologies for achieving outside tunnel environmental objectives cannot be fully assessed.

6.1.2 Legislative Changes

There is likely to be an impact on air quality due to changes in motor vehicle emissions as a result of the phasing in of the European or equivalent Motor Vehicle Emission Standards and the introduction of more stringent fuel composition regulations. Further review of the implications of legislative changes for fleet emissions is needed.
During the workshop, the distinction between exposure to ambient pollution and the pollution generated within the tunnel was explored.

- **An analysis should be undertaken of the likely timing and effect of introduced fuel and emission standards on both motor vehicle emissions from tunnels and their effect on ambient air quality.**

This analysis will provide better understanding of future trends in exposure to pollution in the ambient air from that which is emitted from the tunnels of Sydney.

This information may play an important role in analysing both the effectiveness of tunnel air management systems including the quantity and type of pollutants they are likely to generate and the time over which such generation will occur.

These regulatory changes have only been put in place in the last few months. It is conceivable they will have significant impact on tunnel ventilation design philosophies in Australia as they have in Europe.

6.1.3 Local Effects

The focus of scientific community concern during the workshop was on individual and local effects of the ventilation of tunnel exhausts through ventilation stacks.

The importance of predicting the likely local effects of a particular tunnel ventilation design is central to the issues raised by the community during the workshop.

6.1.4 Regional Air Shed Changes

There was no material presented during the workshop analysing in detail the likely changes in tunnel pollution from motor vehicles and changes to ambient air as a result of changes to emission standards.

- **An examination is required of the effects of alternative measures such as emissions testing on motor vehicles - as was described from Switzerland - and the further regulation of other activities such as solid fuel heating will have on ambient air quality.**

There was broad discussion on the importance of regional air quality management as a tool in managing the exposure of the population to ambient air pollution and minimising the amount of pollution generated within a tunnel.

The costs and benefits of such regional programs are likely to assist the formulation of the design philosophies of infrastructure such as tunnels whose design life can reasonably be expected to span many decades.

IMPROVING THE PROCESS

7.1 General

The relationship between the community and statutory authorities was central to much of the discussion at the Workshop. It was apparent at the Workshop that there was a long history of conflict between government authorities and the community.

It is important that the government authorities respond positively to this conflict by responding to community concerns constructively.

Tangible initiatives should be put in place which demonstrate the government's commitment to managing air quality and ensuring that the community have access to information.

7.2 Measurement

There was general consensus that the prediction of the future can be difficult. Measurement of a reality is more reliable. The availability of those measurements to the community is highly desirable.

At the workshop, the Victorian Environment Protection Authority representatives indicated that data demonstrating the air quality of emissions from the Melbourne City Link project is available on the Internet.

The availability of data provides a simple mechanism to share information. Measurement of current air quality in areas around the discharge points for the ventilation system was identified during the workshop as important. Measurement of the air quality once a ventilation system is operational is also important.

The extent of the EPA's regional air monitoring activities was explored during the workshop. It was the subject of praise from international delegates. The value of that information should be maximised by distributing it in a timely and accessible way.

The rapid dissemination, if necessary, of even non-validated data, should be considered. Such information may not be validated, but the impression from the comments at the workshop is that the community would warmly welcome it and that in Victoria its availability has had positive results.

It became apparent during the workshop that when the M5 East tunnel ventilation system commences operation – with or without additional air cleaning technologies - information about the air quality in the region around the stack should be made generally available.

- **The availability of data to the public via the Internet in a manner similar to that currently provided in Victoria is recommended.**

- **It is recommended that the relevant NSW government department contact the Victorian EPA and request details of the Victoria system and the**

communities' response to it with a view to considering whether to implement a similar system.

7.3 Communication

The workshop also identified that engineers around the world fail to use units of measurements and express information in a consistent way that is useful for other professionals and the community. This workshop has highlighted the difficulties this can cause both health professionals and the community. This should be borne in mind in future communications.

7.4 Ventilation System Review

The performance of ventilation systems should be regularly reviewed in the context of:

- Changes in pollution reduction technology;
- Changes in emission characteristics;
- Changes in medical knowledge;
- Changes in community expectations.

A formal, transparent, multidisciplinary process that includes community input for the review of tunnel ventilation performance monitoring and philosophy for all urban road tunnels in Sydney should be implemented.

7.5 Modelling

Emphasis was placed on the role and relevance of modelling at the Workshop. This is because in very large projects it is the modelling which underlies the confidence that its ventilation system will perform at least as well as predicted.

During the 3 days, there was considerable debate about modelling. There were numerous debates about what modelling is: whether it was conducted appropriately; what the inherent errors are; fleet characteristics, emission rates; whether the correct meteorological files had been used; the implications of the use of those files and whether more modelling was required.

Many matters were raised by both presenters and community representatives about traffic volumes, composition, emission rates and future trends.

The ultimate view of the international modellers was that the methodology adopted was appropriate.

A key question raised about the modelling results for the M5 East project was whether what they in fact showed was that the emissions from the ventilation system were being "swamped" by the ambient air.

This could, it was suggested, partly explain why raising the stack height within the considered range appeared to make little difference to the predicted plume dispersal characteristics. It was also thought it might explain the observed differences in modelling outcomes.

Such an outcome from modelling is what is expected from a dispersion system, which disperses the exhaust air effectively with the ambient air.

As outlined elsewhere in this report, a more precise understanding of any changes in air quality effects at individual locations - where people live - is central to informed consideration of what is likely to occur.

- **An independent assessment of these models' results - preferably from a modeller not connected with the M5 East ventilation design - should be considered as part of the package of "reality check" measures identified in this report.**

The modellers were united in their ultimate preference for actual results as compared to predicted results.

During the workshop, details of predicted emissions from the Melbourne City Link project (from modelling) as compared with actual results that have been measured since opening were requested.

The rationale for seeking this information is that:

- the predictions for City Link were made using the same modelling tools and techniques used on the M5 East project
- many of the scientists and engineers working on the M5 East project also worked on the City Link project.
- During the City Link inquiry it was also claimed that the modelling was conservative and that the actual pollution levels experienced were likely to be less than predicted
- data must have been collected on actual pollution contributions, which would allow comparison with modelled contributions.

That information was not forthcoming during the workshop. It was not clear at the workshop whether similar information has been collected for the Eastern Distributor.

It is recommended that:

- **The relevant NSW government agencies formally ask their Victorian counterparts for that information.**

- **a comparison be made between predicted changes in air quality as a result of the operation of a tunnel ventilation system with the actual changes.**

Another area of detailed discussion at the workshop was the difference between the predicted outcomes from mathematical and physical modelling, and the possibility of conducting other types of modelling.

For many people opposition to the ventilation technologies proposed is not a question of science and engineering – they are simply opposed to stacks. Their concerns are more related to visual aspects equity, location and property values than scientific or engineering argument.

However, one suggestion from the overseas modelling experts, to help positively respond to public confidence issues, was to conduct a full height dispersion test at Turrella, to further test the accuracy of the predicted performance of the ventilation system.

Such testing would be another form of "reality check" with direct relevance to the detailed health risk methodology suggested.

- **It is recommended that the feasibility of conducting such tests be investigated - and if feasible, conducted prior to the operation of ventilation systems.**

The method of conveying data on the likely consequences of the operation of the M5 East ventilation system was of limited assistance to many participants of the workshop including some of the international presenters. International delegates suggested a number of methods that could better clarify the likely consequences of the operation of the ventilation stack.

These included: -

- Examining and quantifying the current air quality in the area which is predicted to have the most change in air quality as a result of the operation of the ventilation system in the tunnel. This analysis should focus on areas where it is predicted there will be a change in air quality.

- For the areas that are predicted to receive the greatest change in air quality as a result of the operation of the ventilation system, a comparison be undertaken between current air quality and predicted future air quality.

- A review of the implications of the comparative data be undertaken.

- Consideration be given to conducting a full-height dispersion test at Turrella, to determine whether the numerical and physical models are adequately predicting the dispersion of tunnel air.

These recommendations have been noted elsewhere in this report.

7.6 Modelling - Health - Risk

Analysis should already have been undertaken of the projected change in human exposure to vehicle emissions as a result of the operation of ventilation systems. This material was not produced at the workshop. If it exists it should be made available and explained to the community. If it does not exist such analysis should be conducted.

This material will allow an informed debate about actual health risks in a current health risk perspective.

From the dialogues of health professionals at the workshop it became clear there needs to be an attempt at reconciling statistical versus clinical approaches to the problems of health risk assessment. Whatever methodologies are adopted as most appropriate, the importance of communicating the change of air quality into a readily understandable health perspective, cannot be overemphasised. Strategies may be useful in determining how to best communicate health risk information. Consideration of local and sub-regional health implications is appropriate.

Until that analysis is conducted the debate that occurred at the workshop in relation to health implications of changes in air quality cannot be resolved.

The central importance of this issue will become apparent upon review of the full transcript of the workshop.

M5 EAST – WORKSHOP RESPONSE

The transparent scrutiny of the M5 East ventilation system was an important part of the workshop.

8.1 General

The likely performance of the M5 East projects ventilation system received particular attention as part of the Workshop deliberations on the design philosophies of tunnel ventilation in Sydney.

There was also general agreement that the design standards in NSW are amongst the most stringent found anywhere in the world.

The complex, remotely located M5 East single stack tunnel ventilation design can be distinguished from any other tunnel ventilation scheme in the world.

From an engineering perspective, it was generally agreed amongst the international ventilation experts that the design methodologies, and analysis conducted for the M5 East project (as described in the briefing CD - see appendix 1) led them to believe the operation of the tunnel ventilation system would result in the environmental standards prescribed for the project being met.

In this context, it is understandable that the Australian designers of the ventilation system expressed satisfaction with the outcomes of their expert analysis. On the basis of the best information they have available to them, the M5 East designers believe their system will ensure all of the strict environmental objectives are met for all regulated components of tunnel air.

However, it was strongly argued by a number of other participants, presenters and an expert at the workshop that:

- Even if the operation of the ventilation system resulted in these stringent levels being achieved; and

- There was sub-regional or regional air quality improvements for large numbers of people;

that did not justify what is perceived as a ventilation system that exposes a comparatively small group of people to worse conditions. (Even if the "worse" conditions met the comparatively strict Sydney environmental standards).

General debate in relation to this rationale led to a number of important observations, recommendations and conclusions being formulated:

Firstly, the likely net effect of the operation of the M5 East ventilation on a sub-regional and local scale was not presented at the workshop in a way which was readily comprehensible even to some of the international experts. What was detailed was "worst case" analysis that by its nature does not readily allow consideration of changes in air quality from the human perspective of a family living in a particular area. Community representatives requested data on long term forecasts and measurements, for example, for particulates, so that cumulative health risks can be assessed.

Until material is presented in a more useful way, the magnitude of any change in the air quality for families living in a particular area will remain the subject of speculation.

Without such analysis the "debate" in relation to health cannot be resolved because it will remain - as observed at the workshop - the subject of assertion and counter assertion.

Health professionals involved in the health risk assessment should focus their expertise on what data is required to determine the truth of health matters, rather than exploit deficiencies in the way information is expressed. Human health analysis demands intellectual rigour. My recommendations in relation to health issues are designed to help bring rigour to the debate - but of themselves they will not ensure it.

The health debate must be re-attached to reality. Health professionals are urged to assist the community by placing any health risk changes identified into a readily understandable perspective. The analysis of actual air quality change - present compared with future - was thought by many of the presenters to be an appropriate step in trying to achieve that reality check.

- **Present and future air quality analysis, examining the areas where change in air quality will most likely occur and the nature of any change should be conducted.**

- **A comparative health risk analysis of any change in air quality predicted should be undertaken which examines the nature and extent of the likely health impacts of any change in air quality identified.**
  (See also other sections including Health and modelling in this report)

Secondly - The location of the stack some distance away from the tunnel in a valley could reasonably be expected to cause anguish to nearby residents. Even leaving perceived health risks for the moment, this is because it is believed by some people in the local community that:

- It introduces a vertical element into the landscape that reads to the eye as an industrial element in a way that detracts from its beauty;

- It can be seen from many homes and is perceived as a source and symbol of pollution and therefore a potential health risk;

- It devalues homes.

- They receive no direct benefit from the tunnel.

It was beyond the scope and the expertise at the workshop to deal with these issues in detail.

However, it was generally agreed that these concerns were genuinely held and, judging by the critical comments from the international presenters readily understood.

Non engineering and scientific factors are relevant considerations when determining the detail of major infrastructure projects.

To consider the equity issues associated with these matters in detail would have required the attendance of representatives of other communities including those from other possible stack locations and from communities living near the portals - and the assistance of professionals expert in analysing environmental equity issues.

Although this may have resulted in debate on these issues, it is unlikely it would have assisted in facilitating constructive debate on tunnel ventilation alternatives for Sydney.

This position was also vindicated during the workshop as it was made very clear by one community group that they did not want to impose the M5 East “stack solution” on other communities - they wanted to resolve the matter absolutely.

Resolution of these equity issues will at least in part require an acknowledgment that the location of the stack some distance from the tunnel will more greatly effect people near the new stack than it would have had it been constructed over or adjoining the tunnel air is the international practice.

SUMMARY & RECOMMENDATIONS

The design and design review of tunnel ventilation systems for long urban tunnels in Sydney has been undertaken by competent local and international experts.

The designs of these ventilation systems are primarily a response to the comparatively strict environmental performance requirements of projects in Sydney. It is these comparatively strict standards which have in substantial part resulted in the ventilation designs for Sydney's road tunnels.

The experts on tunnel ventilation design at the workshop generally agreed that the results of the design analysis meant there should be confidence the M5 East project would meet the comparatively strict environmental standards set. (It must be remembered that each expert was provided with comprehensive technical data for review well before the workshop.) However it also became clear that other issues are relevant in considering the appropriateness of a particular tunnel ventilation design.

The location of the M5 East stack in a broad valley, distant from the tunnel, in full view of homes was criticised by the international presenters. Given the tunnel is being built under hills which are the optimal place to locate ventilation stacks from a strictly engineering perspective, the current location could be expected to generate discontent. However the tunnel ventilation engineers maintained that while the location was not "optimal" it would still function appropriately.

It was determined at the workshop, following a site inspection and general discussion, that the tunnel ventilation design of the M5 East project has been configured so as to allow devices such as electrostatic precipitators and/or NO_2 gas conversion plants to be installed in the future.

The discontent from the local community appeared partly the result of a failure of the approvals process to adequately deal with community concerns about scientific, engineering and health issues but perhaps even more importantly, consultation, property values and the physical/visual intrusiveness of a ventilation stack into their environment were also relevant.

Given the limitations of the Workshop there was insufficient information presented to determine, on a holistic basis, the appropriateness of installing devices such as electrostatic precipitators and/or NO_2 gas conversion plants in the M5 East project or in other NSW tunnel projects.

Information and methodologies arising from the detailed recommendations of this report are intended to provide a sound basis upon which decisions about tunnel ventilation design and the use of technologies for altering the composition of tunnel air can be made in the near future.

It is recommended, in relation to the general design for urban tunnels in New South Wales that the relevant authorities:

- **Review the strict environmental performance requirements of tunnel ventilation systems in the context of other environmental outcomes that such requirements may cause.**

- **An analysis should be undertaken of the likely timing and effect of introduced fuel and emission standards on both motor vehicle emissions from tunnels and their effect on ambient air quality.**

- **Implement a formal, transparent, multidisciplinary process for the regular review of tunnel design philosophy, ventilation performance monitoring and operational philosophy for all long urban road tunnels in Sydney.**

It is recommended, in relation to health risk evaluation of tunnel ventilation systems:

- **Methodologies for calculating and communicating comparative health risk assessment information should be established to better enable the assessment of the health implications of tunnel ventilation systems.**

- **The use of both worst-case emissions predictions, as well as cumulative and long term predictions for health risk assessment should be considered.**

- **That an explanation of the health risk implications of the standards, be prepared and made available to the public.**

- **Air quality analysis, examining where present and future changes in air quality will occur and the nature of any changes should be conducted for tunnelling projects.**

- **A health risk analysis of any change in air quality predicted should be undertaken which examines the nature and extent of the likely health impacts of any change in air quality identified.**

It is recommended, in relation to cost benefit analysis of alternative tunnel ventilation designs that as a matter of urgency the following information should be sought overseas:

- **The relevant NSW department(s) formally request details of the rationale for installing the electrostatic precipitation systems for external air quality management**

in the Norwegian, Korean and Japanese tunnels from the appropriate government authorities.

- **The relevant NSW department(s) formally request data from Norway, Japan and South Korea on the effect on external air quality of operating electrostatic precipitators.**

- **It is recommended that the relevant NSW department(s) formally request data from Norway, Japan and South Korea on:**

    - **the effect on external air quality of operating electrostatic precipitators.**

    - **the quantity and composition of wastes electrostatic precipitators generate.**

    - **how wastes from electrostatic precipitators are disposed.**

    - **the reliability of serviceability of operating electrostatic precipitators.**

In relation to more general issues about the Sydney context of future tunnel ventilation performance the following should be undertaken:

- **Further examination of alternative technologies is required to determine their actual costs and benefits.**

- **It is recommended that further analysis of the benefits of NO_2 removal should be undertaken.**

- **An analysis of the likely timing and effect of changes in fuel and emission standards on both motor vehicle emissions from tunnels and their effect on ambient air quality be conducted.**

- **An examination is required of the effects of alternative measures – such as emission testing on motor vehicles – as was described from Switzerland – and**

the further regulation of other activities such as solid fuel heating will have on ambient air quality.

It is recommended, in relation to the measurement of the environmental performance of long urban road tunnels that:

- **Data on air quality proximate to tunnels be made available to the public rapidly (such as via the Internet) in a manner similar to that currently deployed by the Victorian EPA.**

It is recommended, in relation to modelling that:

- **An independent assessment of the differences predicted by the numerical modelling as compared with the physical modelling of the M5 East ventilation system be undertaken.**

- **The relevant NSW government agencies formally request their Victorian counterparts for data demonstrating any differences between actual and predicted changes in air quality as a result of the operation of the City Link ventilation system.**

- **Investigation of the feasibility of conducting full height gas dispersion test for tunnel projects, and if feasible, conducted prior to the operation of ventilation systems.**

It is recommended in relation to this report and the materials associated with it that:

- **they be made freely accessible to the public.**

In relation to the recommendations of this report:

- **that any responses to the recommendations be made available at the same location as the report.**

COMMUNITY CONSULTATION

I recommend that there be a review of community consultation practices, particularly with respect to the substance of such practices as compared with what is written in legal and practice documentation.

CONCLUSION

This report contains key recommendations for further investigations in relation to tunnel air management philosophies in Sydney.

This report is no substitute for studying the materials accompanying this report.

The complex and often highly technical and emotional issues associated with management of the risks associated with the use of internal combustion engine driven vehicles can be dealt with equitably and rationally.

Given the importance of the relationship between human health and the quality of air people breath, action must be taken to manage air quality.

A holistic approach to decisions in relation to tunnel air management ultimately demands tangible actions by communities and government. Action is warranted with respect to polluted air.

The suggestions for action in this report, will contribute to the equitable and rational process of complex decision-making with respect to tunnel ventilation options for Sydney.

Arnold Dix
Facilitator
26 July 2000