# Communities Against the Tunnels

## Joint Submission to the North South Bypass Tunnel

## Environmental Impact Statement

## April 2005

***Urban planners and the general public are now in a key position to assess their roles in the development of cities. New goals and objectives can be defined in the transportation/land use modelling process based on balancing the roles of various transportation modes and minimising total travel in the urban system. The need to revitalise city centres and to protect neighbourhoods threatened by traffic means that the technical road planner using 1960's models cannot be the sole determinant of decision making.***

***Newman and Kenworthy, 1999 (p140)***

15 April 2005

The Coordinator General
c/- EIS Project Manager – North South Bypass Tunnel
Project Delivery and Infrastructure Planning
Department of State Development and Innovation
100 George Street
PO Box 15168
City East QLD 4002 CDE M60

Dear Coordinator General

'Communities Against the Tunnel' (CATT), represented by Ms Natasha Bowes seeks to provide comment on the Environmental Impact Statement for the North South Bypass Tunnel, proposed by the Brisbane City Council as a quasi Public Private Partnership arrangement.

CATT is a coalition of;

- residents living near the proposed tunnel and pollution stacks,
- professional bodies and organisations with an interest in transport infrastructure, urban design, town planning and urban amenity,
- interested communities across Brisbane, South East Queensland, Australia and internationally, and
- local and state political entities.

This coalition has formed as a result of the dire consequences for the health of our communities if the tunnel was to be approved, the inability of the proposal to address the stated objectives of solving congestion, and the disregard of other critical and effective alternatives.

CATT calls on you in your position as Coordinator General to refuse the application for a development approval outright, based on the ample grounds, facts, and circumstances contained in this and all other submissions provided to you.

Sincerely,

Name……..

*(For and on behalf of 'Communities Against the Tunnel')*

Address…….

……..

## EXECUTIVE SUMMARY

*It is certain that individuals would perceive a net benefit, but the total social and environmental impact could be negative. (Maunsell 1999 p 175)*

Communities Against the Tunnels (CATT) appeals to the Coordinator General to refuse the granting of a development approval on the substantial grounds provided herein. Further, to ensure similarly poor infrastructure options are not foisted on Brisbane without due consideration of all issues, CATT calls for an independent review of all aspects of the NSBT and TransApex proposals.

**Terms of Reference:**

CATT acknowledges that the TOR are plainly insufficient to guide a proper EIS process. However, even at the most basic level, the EIS fails to address key components of the TOR, including greenhouse gas reporting and comparison of the project with other options.

**Rationale and Need:**

CATT has shown that the stated objectives of the NSBT cannot be met, and indeed, it actually runs counter to the claim that it would solve congestion. As well, CATT has revealed that the NSBT will create problems that would then justify a further $5B expenditure in TransApex. For this reason alone, the EIS is considered invalid, as the full impacts of all tunnels and roads must be weighed in the context of TransApex. The "Pioneer Principle" is often used in development assessment and planning to describe a situation where the full development must be considered, not piecemeal proposals. This is a well recognised legal precedent in the courts of Queensland. This proposal offends this principle.

CATT has also determined that the NSBT is a local road that serves no regional function, other than to sabotage any efforts to deliver public transit outcomes, air quality improvements and social benefits. Its impacts run counter to all good regional policies and programs such as the SEQ Integrated Regional Transport Plan and the intent of the SEQ Regional Plan.

**Traffic and Transport:**

CATT has unearthed a myriad of false assumptions and incorrect modelling methods which render previous claims by the Lord Mayor false and misleading, especially in relation to travel time savings. The Lord Mayor has been noted to announce that the NSBT problems will only be solvable by TransApex, costing ratepayers an additional $5 billion in more tunnels and pollution stacks with no consideration given to how feeder roads will be managed.

- Congestion will be markedly worsened, based on Council's own figures. Travel time savings 'in tunnel' will be eroded away by dramatically increased congestion levels at each end.

- Core assumptions cannot be substantiated, indicating that modelling of traffic is fatally flawed even before other matter are considered.

- Induced traffic, or that which is attracted to the road as a result of more road space has been grossly underestimated.

- Land use changes have been ignored, even though Council has recognised that trip length will increase.

- Modelling analysis has determined that the proponent has either been deliberately deceptive or is simply not aware of commonly accepted modelling practices. Modelling figures used were based on practices that are described as "*inappropriate, unusual and not normal practice"* by advising traffic engineers.

**Economic Analysis:**

CATT has exposed the faulty analysis of the tunnels value, demonstrating that it is based on false assumptions and does not consider the impact of the Gateway duplication on traffic flows and hence, toll takings. The cost benefit analysis is deeply flawed and has not properly assessed alternative options that exclude the construction of tunnels.

CATT has confirmed that this project amounts to an increase in Council debt levels equal to at least an extra $90 per annum for every ratepayer. This does not include a further $5B in tunnels.

**Air Pollution:**

A failure to even consider a key pollutant for human health ($PM_{2.5}$) provides a poor basis for the air modelling of the NSBT. Other aspects include:

- unfiltered pollution stacks will spew out a toxic chemical cocktail over residential areas 24 hours a day 365 days a year,

- air quality modelling ignores the presence of the fine and ultrafine particulates ($<PM_{2.5}$) in the tunnel and in the fallout on residential areas (when inhaled, these particles are well known to affect the human heart and breathing),.

- Dispersion modelling ignores local wind flows around pollution stacks

- Freight vehicle movements are grossly underestimated, impacting on emission projections

- Australian vehicle emissions have been reported by CSIRO to be as high as 2 times what has been used for the NSBT.

- Greenhouse gas emissions have not been considered in the air quality technical paper, but Council seeks to mention them in the EIS without any research or analysis. The contribution of the tunnel to total greenhouse gas contribution will be significant when all factors are seriously considered. This is in complete disregard to the requirement of the TOR.

**Noise and Vibration:**

Both during construction when nearby residents will be forced to abandon their homes and during operations, noise and vibration levels will be extreme. The technical report has not been peer reviewed and based on experiences of residents during construction of the ICB, grossly underestimates the damage that will occur to buildings. As well,

- Regulatory levels for noise have been selected based upon what would best suit Council, not residents. In some cases, noise levels were considered appropriate according to Council's own noise policy, even though it contravened EPA requirements.

- The pollution stacks under full power will emit enough noise to drown out a jet aircraft.

- Noise barrier considerations are generally inappropriate and often do not seek to comply with EPA noise planning levels, rather, they generally seek to just maintain the existing noise environment even though it is noted to exceed specified levels currently.

**Health:**

Exposures and consequent health effects occur at up to 1 kilometre from stacks. Chronic effects include heart conditions, retardation of lung development in children, asthma and other breathing difficulties while acute short term exposure causes itchy eyes, sore throats, and odour sensitivity to name a few. Experiences of the poor human guinea pigs in Sydney around the M5 East tunnel (same modellers as NSBT) demonstrate what residents can expect. Child care centres, old age homes, hospitals and schools will jockey with residents and workers for increased exposures from the stacks. It is noted that the State's own analysis of air pollution lead to significant changes to the Neville Bonner Building.

**Hazard and Risk:**

The Council has not considered catastrophic impacts such as tunnel collapse or subsistence. It has proposed small escape areas for tunnel occupants to shelter in, however a European study on tunnel safety has slammed these as dangerous after several deaths. CATT calls on the Coordinator General to mandate for an emergency escape tunnel, connected to but not part of the two road tunnels to allow users out, but as importantly, let emergency crews in.

**Consultation:**

CATT has been informed that Council's attempts to consult have been farcical to all involved, with no consideration for participants' input. In several circumstances, Council has failed to even turn up for meetings. This has demonstrated the purely political impetus behind this proposal whereby, no amount of community angst would change the proposal. Communities have been left with a sour taste in their mouths. The process has been far from open an transparent.

**Recommendations:**

As a result of CATT's findings, this submission recommends that the Coordinator General refuse the NSBT proposal, and instigate an independent review. Further, an effective community participation program must be implemented as a part of that review and any outcomes arising from it.

# Analysis of EIS:

## 1 PRECAUTIONARY PRINCIPLE

The precautionary principle, a phrase coined circa 1988, is the ethical principle that if the consequences of an action, especially the use of technology, are unknown but are judged by some scientists to have a high risk of being negative from an ethical point of view, then it is better not to carry out the action rather than risk the uncertain, but possibly very negative, consequences. A study by the European Environment Agency, entitled "*Late lessons from early warnings: the precautionary principle 1896-2000*", sets out 12 principles to adhere to ensure a transparent and accurate regulatory role such as that of the Coordinator-General, is undertaken. Notably, the report outlines risk, uncertainty and ignorance in assessing matters.

> "*Once it is acknowledged that the likelihood of certain outcomes may not be fully quantifiable, or where certain possibilities may remain entirely unaddressed, then uncertainty and ignorance, rather than mere risk characterise the situation.*" *(European Environment Agency, p 170)*

It is CATT's firm belief, supported by many arguments in this submission, that the proposed NSBT project has many uncertainties, risks and indeed, ignorance of potential impacts, such as air quality health for many local residents near the stacks. On this basis, good judgment should declare the project to be refused.

## 2 TERMS OF REFERENCE

CATT has determined that the NSBT EIS Terms of Reference (TOR) is unacceptably narrow and inappropriate to guide an adequate assessment of the project's EIS. Whilst the TOR was provided to the community for review and submission, it is CATT's considered opinion that the requirement for a highly specialised knowledge of road tunnel design and impacts to evaluate the document precluded a vast proportion of the community from effectively providing comment. The inability of the community to be aware in advance of the negative impacts of the proposal negates to a significant degree the currency of that paper in guiding and regulating the EIS. The TOR even seeks to address its shortcomings, but this does not mandate Council to go beyond the limited scope of the paper.

> *"While every attempt has been made to ensure that these TOR address all of the major issues associated with this Project, they are not necessarily exhaustive and should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them or matters (currently unforeseen) that emerge as important or significant during the completion of scientific studies, from public consultation, or otherwise, during the course of preparation of the EIS." EIS Preparation Guidelines*

As a significant proportion of CATT's comments rely on highly technical analyses of modelling and the models' results, references back to the TOR will be few. That is not to say that the EIS complies with the TOR, as it has been noted on several occasions to either omit or provide incomplete evidence of fulfilling the requirements. However, CATT considers the effectiveness of the submission process to be compromised by the failure of the proponent to elucidate the potential negative impacts to the community in a manner which would inform submissions, particularly in regard to air quality and the acute and chronic health effects of short term and extended exposure.

Regrettably, the ability of CATT to also comprehensively review all documents pertaining to the proposal by way of a *Freedom of Information* request has been stymied by Cabinet calling in

the information of concern. The inability to review all documents further brings into question the effectiveness of this process. It would appear that openness and transparency have been sacrificed in the name of expediency.

To demonstrate Council's efforts to limit perusal of the EIS, one need only consider the exorbitant cost of $100 to attain a hard copy. The State Development and Public Works Organisation Act 1971 mandates that the EIS cost must not be more than the printing cost. Council's efforts to avoid openness and transparency have precluded it from subsidising the cost, ensuring the EIS was not freely available to the many young families and elderly residents immediately affected by the tunnel. Further, the EIS on compact disc contains many PDF files, all of which have been password protected to prevent the public from copying tables, figures and text. Fortunately for CATT, internal advisors to Council provided the password.

As a result of the poor TOR and Council's agenda to secrete negative impacts away, CATT believes the quality and quantity of submissions has been compromised. The inadequate TOR coupled with the withholding of documents the subject of an FOI calls into question the validity of the process.

## 3 RATIONALE AND NEED FOR THE PROJECT.

> *This section is to provide the justification for the project, with particular reference made to conclusions on economic and social benefits, including employment and spin-off business development. This section should also describe feasible alternatives, if any, including conceptual, technological and locality alternatives to the Project and include discussion of the consequences of not proceeding with the project*.
>
> *TOR Background and Project Rationale*

### i) Objectives of the project

The proponent professes to claim:

- *improved mobility and accessibility for important centres in the City's fabric and for residents at large for both essential and discretionary travel;*
- *greater efficiencies from the existing transport infrastructure through the re-direction of trips to more appropriate routes and modes of transport;*
- *enhanced opportunities for public transport and other modes of transport along the corridor due to the easing of traffic congestion on the surface streets;*
- *improved economic conditions through easing the costs of congestion to the City's businesses and residents;*
- *improved environmental conditions through improved air quality and reduced traffic noise in the presently congested, inner-city streets;*
- *improvements in the well-being of City's residents through better accessibility for both commuting and leisure-based travel; and*
- *enhanced opportunities for urban regeneration in areas presently constrained by traffic congestion, diminished accessibility and environmental conditions.*

This submission directly contradicts all of the above claims and notes that the tunnel will in fact worsen the already strained road system in Brisbane. To demonstrate, the EIS Executive Summary states that:

> *"The primary objective of the NSBT Project is to ease congestion in the inner city, including the CBD and Fortitude Valley areas…"*

This cannot physically occur. Within section 4 (iv) of this submission, evidence is presented to counter Council's claim of easing congestion. Indeed, buried in the technical papers of the EIS is hard factual data that demonstrates that congestion will markedly increase at all points around the tunnel entrances and exits. Even Lord Mayor Campbell Newman is on record as saying:

> *The NSBT would create problems only solvable by Transapex.*
>
> *Brisbane Development Association Luncheon 18th August 2004*

The "Pioneer Principle" is often used in development assessment and planning to describe a situation where the full development must be considered, not piecemeal proposals. This is a well recognised legal precedent in the courts of Queensland.

Consequently, the NSBT's primary objective is not achievable. Where it can be demonstrated that the primary objective of a project is not to be achieved, the proposal must be refused. To further support this argument, please note the comments provided in section 5 (v) regarding protection of the income stream for the operator.

ii) Traffic

The EIS bases all modelling work on an unsubstantiated report that around 40% of all vehicle movements are not city oriented trips. However, the EIS does not support this core assumption with any detailed origin/destination studies. Instead it relies on traffic counts in both directions at several points. This method is incredibly unreliable as it does not consider where the outbound traffic has originated from and where it is destined. For such a significant project with extraordinary costs economically, socially and environmentally, the inability to support this core assumption is remarkable. A proposal of this significance should be based on hard factual data achieved by monitoring traffic flows at all major northern and southern routes beyond portals over a period of one year using stationary cameras with number plate recognition. Only this method would ascertain the true number of through vehicles. A similar study was done recently for the Brisbane Urban Corridor to ascertain heavy vehicle movements along Granard Road to the Gateway Arterial.

Perhaps more importantly though is the question of what efficiencies will occur by targeting a nominal 40% of the weekday traffic stream, particularly when the Gateway Motorway will have a considerable effect on that traffic. Would not the argument be better placed if the proposed program targeted the 60% of traffic flows? As this is commuter traffic in the main, this is much easier and more cost effective to manage, with many facilities at Council's disposal such as cordon pricing, restrictions on car parking spaces for all new buildings in the CBD area, etc.

Consideration of many other trip attractors/generators has also not occurred in light of a stationary monitoring program, especially when one considers the significant flows of traffic to West End/South Brisbane, New Farm, hospitals and universities to name a few.

As a consequence of this failure to accurately monitor existing traffic flows through number plate recognition, the entire proposal has been based on a rubbery and unsubstantiated figure. CATT believes that the through traffic figure may have been grossly overestimated once other factors are considered. Implications of a lower through traffic count are:

- To significantly impact on the economic analysis of the tunnel, including toll revenues,
- Environmental effects such as air pollution and noise would be underestimated, as the tunnel would not remove any traffic on the surface but instead generate new traffic, especially heavy vehicles from the industrial centres of Ipswich/Wacol/Rocklea south of the tunnel, and
- Purported social benefits attributed to the tunnel must be disregarded.

Until this study has occurred to ascertain the exact number of vehicles travelling in peak hour flows that do not stop at any locations within or near to the tunnel length, no serious consideration can be made on any other matters. On this point alone, the EIS should be rejected out of hand.

### iii) Regional planning

- Transport

The EIS claims that the NSBT is a good fit with regional planning instruments, including the SEQ Regional Plan and the Integrated Regional Transport Plan for SEQ. This is ludicrous and cannot be supported with any credible review of the intentions of these and other regional planning instruments. Regrettably, the Lord Mayor has recently been reported to be actively seeking Commonwealth Auslink funding on this basis. CATT finds this unconscionable.

The proposed NSBT is a local road with no greater impact on road movements in the urban area than Inner City Bypass. It should not be awarded Commonwealth funding as it does not serve a role in the regional road network. To do otherwise is to commit Brisbane residents and commuters to increased freight volumes through the city. Serious consideration must be given to the role of roads at the regional level. Urban commuter roads should not be funded through Commonwealth programs as it encourages unsustainable and costly commuter trips. Congestion costs cannot and should not be addressed in this manner. Federal funding is better spent to provide alternatives such as augmented line haul commuter public transit infrastructure and effective ring roads for freight movements such as the Ipswich /Logan /Gateway Motorway link as well as a nominal western bypass. CATT opposes any Commonwealth funding for the proposed NSBT on these grounds, particularly as an independent analysis by CATT has shown that it is not feasible.

Section 2.1.5 of the EIS notes:

> In September 2002 the Brisbane City Council released the *Transport Plan for Brisbane 2002 – 2016*. The Transport Plan adopts many of the initiatives of the IRTP and Transport 2007, as evidenced in Table 2-3.
>
> **Table 2-3 Brisbane Transport Plan 2002 – 2016 Objectives**

| |
|---|
| *Developing a sustainable transport system* |
| *Restraining growth in peak period car travel demand* |
| *Providing efficient and sufficient road capacity* |
| *Ensuring efficient freight movement* |
| *Providing for pedestrians and cyclists* |
| *Coordinating transport and land use* |
| *Ensuring social justice* |
| *Maintaining environmental quality.* |

> Research for the Transport Plan showed that Brisbane roads will be extremely congested by 2016, if no new road, public transport or travel demand management initiatives are implemented now. The Transport Plan found that policy and infrastructure directions current when the document was released were not achieving the desired outcomes for Brisbane's transport system.

This is not a justification for the tunnel, merely a statement reflecting the disparity between regional and local transport policy and actual investment.

Firstly, the Brisbane Transport Plan is subordinate to the IRTP 2007 and does not dictate regional level infrastructure investment. Also, it is unclear whether the above statements were intended to provide justification to the NSBT, but it would appear that it only demonstrates that very few significant policy and infrastructure initiatives for public transit have been implemented apart from the development of integrated ticketing through Translink. Current Translink experience with this initiative demonstrated that consensus between the disparate transport service providers made any initiative to implement regional level transit policy extremely difficult. Brisbane City Council has no role in providing regional level infrastructure as it is a *city* council. Unfortunately, it has played a historical role in interfering with regional transit initiatives such as the failed efforts in the 1970s to establish a SEQ transit authority similar to Translink.

At the local and State level, a dis-investment in regional road infrastructure has been surpassed by a failure to invest in public transport services and infrastructure at the levels required to achieve the stated objectives. To demonstrate, the southern rail access for commuter rail into the CBD is highly constrained and will be terminal within 9 years but no firm policy or infrastructure program has been developed to address this important matter. Construction of the NSBT will dramatically increase the costs for any new rail tunnel as the alignments are almost identical.

Section 2.1.6 – *'Integrated transport planning'* of the draft EIS is intended to address section 2.2 of the TOR and states:

> *"the regional plan noted that private cars will continue to be used into the future for the majority of trips on SE Qld".*

However, during the "Your city Your say" session held recently (16 March, 2005) by BCC, Cr. Graham Quirk stated that since the integration of public transport ticketing, patronage of buses and ferries had increased by 40 % in February this year. The Minister for Transport has also claimed an overall 6.5% increase in patronage since integrated ticketing was introduced (ministerial media release, April 2005).

This is direct evidence from Council and the State that by improving public transport (even if it is not service or infrastructure enhancements!) the attraction of transit away from private car use increases, contradicting the above statement included in the draft EIS that refers to the regional plan and negates the rationale for the need for the tunnel.

- Land Use

There is a general consensus among all professions that planning objectives in SEQ are to increase densities near to the CBD and to focus on transit oriented development at strategic nodes. Further, with regard to transport planning, in urban areas, offering modal choice has been recognised as an imperative to provide a more sustainable and superior transport function in Brisbane. It is in this context that debate has raged about South East Queensland evolving into a new Southern California.

To achieve this from an urban land planning perspective, densification is critical to warrant high level services and indeed effect change from buses to light rail along the slowly developing Busway network. Newman and Kenworthy (1999) present a formidable body of knowledge on this subject. The authors present international examples of road space provision and CBD parking as a ratio of jobs and note that cities with low road space provision and CBD parking have a higher proportion of trips by public transit than cities which do not. Australian cities are noted to be world leaders in favouring the automobile on this basis.

The provision of the tunnel would further increase road space in the city, favouring automobile use over transit use and running counter to the intentions of all regional planning instruments. It would make transit less attractive and lead to spiralling dis-investment in public transport as a result of a subsequent drop in users. Congestion is known to be a natural limiter, in that once travel times and experience by automobile become unacceptable, other options are sought. Options include investigating alternative routes (rat running), car pooling and using public transit. Providing a new road actually reverses the more sustainable decisions away from transit – *"Why should I take the train to work when I can get there in half the time and in airconditioned comfort?"*

Experiences around the world have clearly demonstrated that new road provision theoretically reduces congestion in the short term but in actual fact, no new urban road has ever in reality demonstrated the ability to reduce congestion. The Brisbane Inner City Bypass is a case in point. Whilst Council claims it is of value because it carries more cars than they estimated, the facts remain that Council claimed it would actually reduce congestion. While Council has failed to honestly report on this objective after construction for obvious reasons, experiences of commuters indicate that congestion decreases have not occurred, and in fact, the ICB has only increased the amount of cars on the road. Almost instantly then, congestion levels will rise to meet pre-construction levels. Where road provision is in the context of a heavily urbanised environment with existing and potential alternatives, serious consideration must be made to invest in more sustainable alternatives to provide viable, cost effective options not only for CBD

commuters, but also for commuters wishing to travel beyond the CBD to other nodes of employment. Nodal transport options rather than CBD-centric options.

### iv) Investigation of options/alternatives

Similarly to requirements in the Environment Protection Act (1994) that require an EIS to investigate alternatives in the course of the project proposal, the TOR similarly request a review of options considered.

> *The EIS is to provide a description of the various options that were assessed in the development of the North-South Bypass Tunnel Project. Options should be discussed in sufficient detail to enable an understanding of the criteria for selecting the preferred option in terms of technical, commercial, social and natural environment aspects. The consequences of taking no action should also be discussed.*

CATT interprets this section of the TOR to require Council to undertake a study into the alternatives and options. This has clearly not been undertaken and is a show stopper when assessing the EIS. For reference, a list of alternatives, although not comprehensive, is provided. Options include:

- Removal of critical at grade intersections such as Stanley/Vulture St and Anne St with overpasses or smaller tunnels similar to the Nundah Bypass. Changes in elevation at some of these intersections enable shallow grade approaches.

- Adherence by Council to the Memorandum of Understanding with the State to ensure that traffic light sequencing along the route is coordinated effectively. The Brisbane Light Integration System (BLISS) is considered by CATT to be suboptimal currently. Further, several traffic lights could be considered for removal with appropriate turning allowed along Main Street for example Congestion limiting measures by this method have not been fully explored.

- Lane alterations to give greater preference to through traffic. Examples include – only one designated through lane at Kangaroo Point onto Main Street, recent removal of lanes for through traffic at South Brisbane, Paddington and Lutwyche Road, with the current effect being to provide bottlenecks and exacerbate congestion. Preferential treatment of through traffic lanes would serve to reduce congestion instantly at notorious choke points.

- Investment of $1.4B (nominal) into public transport infrastructure. If the NSBT is really dependent on the remainder of TransApex as admitted by the Lord Mayor, then this figure should be over $5B.

    - Given the critical bottleneck for trains from Gold Coast/Beenleigh/Cleveland at the Merivale Bridge, a rail tunnel would provide opportunities to dramatically increase levels of service on all commuter rail routes south as well as free up rail for freight movements. It would also provide an opportunity for a second CBD station.

    - Provide a frequent line haul light rail or bus service along the tunnel route without stopping in the city, but with free loop buses at the nearest points to the CBD connecting to this. No bus service currently operates this route at least form the PA Hospital to the RBH, requiring a trip into the CBD to change to another bus. A comprehensive service should seek to imitate the tunnel proposal in terms of routes.

- Implement a frequent light rail system along all Busway routes as well as over the Story Bridge.
- Provide effective off road designated bicycle and pedestrian paths along the tunnel routes.

- The Gateway duplication, including options to remove the tolls for all vehicles or even trucks only

- Resolution of the Brisbane Urban Corridor to not only improve quality of life for residents along the route but also facilitate effective freight movements. Multiple options exist, including putting all freight in a filtered tunnel from Ipswich Motorway to the Gateway Arterial.

The EIS has not undertaken an appropriate investigation of options as directed by the TOR. Even matters that are under the control of Council, such as bus and bike routes, traffic light sequencing and lane changes have not been considered. Other larger and more strategic alternatives also have not been considered. This clearly demonstrates the highly political and rushed decision to seek approval from the Coordinator General for the NSBT. Also, it demonstrates that Council cannot effectively solve the transport problems in Brisbane as they overlap with State interests, requiring Council to come up with an inferior and politically driven tunnel

Serious consideration must be given to all options before any further consideration is given to the NSBT. CATT, as a representative of Brisbane's liveable communities, decries the failure of Council to consider any other option but the NSBT. This is a critical component of the TOR that has been ignored in the name of expediency.

## 4 TRAFFIC AND TRANSPORT

### i) Inappropriate Transport Economic Analysis Framework

As noted in the previous section, the TOR are unacceptably narrow to guide an adequate assessment of the project. The latest version of Queensland Treasury guidelines is not yet available, and DMR Guidelines are cited as being primarily suitable for non-urban contexts. However, in defiance of these matters, section 10.9.2 of the *Maunsell Traffic and Transport Technical Paper* notes that the project was evaluated against the TOR, Queensland Treasury's Project Evaluation Guidelines, now superseded, and Main Roads' predominantly rural road Cost Benefit Analysis. This is not an acceptable means of analysis and should be disregarded for more robust analysis methods. Further, Treasury Project Evaluation Guidelines indicate that multiplier effects should not be included in economic analysis. The EIS incorporates multiplier effects into the cost benefit analysis (Table 16-19) therefore resulting in a false statement of estimated net benefit.

The analysis ignores the presence of the Gateway Motorway duplication, and potential variations that are not new projects but would clearly influence route choice, such as the removal of tolls from the Logan/Gateway Motorways. It is not acceptable to dismiss the Gateway duplication or other options as part of this analysis merely because:

> "*the economic evaluation carried out for the Gateway upgrade Project EIS …did not include the NSBT*" *(Maunsell 2005, p159)*.

A sensitivity analysis to compare the project both together with the Gateway project and also where neither is constructed is considered incomplete, as a truer analysis would consider the presence of one or the other project to determine whether the function of the Gateway

duplication would negate the need for the NSBT, or vice versa. Given that the NSBT and the Gateway duplication are both costly projects, it is inconceivable that no analysis has been done to evaluate one or the other in isolation.

Further, the economic modelling should not consider options to close traffic lanes though the northern CBD, HOV lanes or any number of a suite of tools to restrict traffic flows above ground as these are certainly not committed in the EIS and have historically received scant regard from BCC. In fact, the Quest newspaper editions for the week ending 15 April 2005 advertise one of Council's achievements as closing bus lanes.

The NSBT project is intended to "complete the orbital road network aimed at relieving existing and forecast traffic congestion in the inner city area" (Draft EIS, 2005, p.1-6). However, the EIS does not describe nor map such a network nor discuss its function or performance with and without the NSBT. A full "inner orbital road network" is likely to have serious social, environmental and economic impacts on Brisbane, few of which are covered in the NSBT EIS. These impacts need to be assessed fully within a sub-regional context. Given the Lord Mayor's comments (section 2 (i)) that the NSBT problems are only solvable by TransApex, it is incredulous that the EIS only summarises the anticipated impacts of the NSBT.

Within the limited scope of the NSBT EIS, the "Local Area of Study" includes only the Story Bridge corridor, rather than properly including the inner city network of roads (for example, Inner City Bypass, Hale Street, Riverside Expressway, and so on) directly and immediately affected by the proposed development. Also, the "Green Bridge" and second Gateway crossing were not included in the base network despite their status as more secure commitments than the NSBT. This failure to account for relevant elements of a "core" transport network is a serious flaw in the traffic and transport assessment and needs to be addressed fully. The EIS must be rejected by the State due to the failure to address these matters.

Similarly, of the "Inner City Precinct" likely to be seriously affected by the tunnel, only that part of the area north of the river (within the portals and therefore not potentially served by the NSBT) is shown. Equally, Kangaroo Point, Woolloongabba, South Brisbane, West End and Highgate Hill should be included as part of the "Inner City Precinct" as they share that characteristic. Inclusion of these suburbs would very likely affect the assumption of 40% "unrelated through traffic". For more on a critique of this assumption, refer to section 3(ii).

### ii) Misrepresentation of Regional Transport Agencies, Plans and Policies

The paper does not acknowledge TransLink's role as the primary contractor for public transport services throughout SEQ, nor public transport improvements attributable to TransLink's integrated ticketing, lower fare structures, or enhanced service contracts and network planning. These improvements are having significant impacts on public transport patronage and attractiveness across the region but have not been taken into account in the modelling, or in an analysis of 'without NSBT' scenario. In support of this argument, refer back to section 3 (iii).

The EIS makes some quite outlandish statements seeking unjustifiably to find a "head of power" in the SEQ Integrated Regional Transport Plan (IRTP) and Transport 2007 to support the NSBT. Such statements are directly contrary to the thrust of both IRTP's and Transport 2007's intent to address car-dependence. Neither the NSBT, nor the need for this kind of new inner city orbital network, has been identified in these documents. The statements in the EIS are false and misleading. An accurate representation of the NSBT's ability to fit with regional level instruments (regardless of the purely political decision to include the tunnel in the soon to be released SEQ Infrastructure Plan) must be stated wherein it is contrary to regional level transport and land use planning. This is further supported in section 3 (iii) of this submission.

### iii) Capacity Challenges Beyond the Portals

Road capacity projects beyond the portals would have to be "brought forward" as a direct consequence of the tunnel, yet the assessment does not accept the 'bring forward' costs (nor consequent amenity impacts) as part of the project impact. The downstream negative impacts beyond the portals will far outweigh any speculative marginal benefits between the portals. The EIS must take full account of all impacts beyond the portals. It is a fact that congestion will increase as a direct result of the tunnel, but the need for road widening and consequent property resumptions along all major access routes has not been considered.

### iv) Congestion

The traffic modelling undertaken for the Environmental Impact Statement (EIS) states that congestion will actually be increased by the project, not decreased, as concluded by the research team. Compounding and adding to this congestion this are other issues that have been ignored relating to the features of the model used to develop the traffic forecasts, failures to incorporate the full effects of induced traffic, failures to consider the full range of downstream congestion impacts, and the experience of recent road tunnel traffic projections for similar projects in Australia.

- Above the tunnel

The EIS states in Table 10.6 that travel time on the surface network will take longer with the tunnel built than it will take without the tunnel. The EIS also states that this is a requirement of the project to ensure that enough car drivers use the tunnel. However, almost all (93%) of the tunnel's cost benefits are attributable to travel time savings. Buried on page 178 of the Maunsell Traffic and Transport Technical Paper is the statement:

> *"A criterion for the proposed capacity restrictions (on the surface network) was that they should be sufficient to offset this decongestion effect and make travelling on the surface arterials no more attractive than without the tunnel."*

This guarantee to not reduce congestion between the tunnel portals is for the benefit of the private operator who builds the tunnel and collects the tolls. Before investing, the investor needs to be assured that they will receive a sufficient return on investment and potential for profit. They will insist on a contractual guarantee that the Council will implement a range of identified treatments to the surface network to ensure it remains congested for cars and, to a lesser extent, also doesn't give buses any significant advantage through time savings. A private operator ideally will want to force people to use the tunnel and pay the toll to maximise their profit. The contract also means that Council will not allow anyone else, including the State or Federal Government, to implement congestion reduction strategies on the surface roads in the area, as this would trigger hefty penalty payments to the tunnel operator.

Compounding this matter is the fact that all roads considered in this study are major feeder roads for the CBD. When one assumes some induced demand as road space theoretically is freed up to the city, coupled with the private contractor's natural desire to maximise what is already poor revenue through advancing surface congestion measures (failing to integrate lights, reducing lane capacities, poor road maintenance, etc), it is apparent that the surface network will be disadvantaged further to advantage the private operator.

Consequently, the tunnel will not relieve congestion above ground and we have a further guarantee that Council will stop anyone else from relieving congestion in the future.

- Getting to and from the tunnel

Only a small handful of people live on the tunnel portal and/or works at the other portal. Every trip using the tunnel will have to approach it from somewhere and leave it to get to the destination. The EIS is happy to report a forecast of up to a 10 to 14 minute saving between the tunnel entry and exit, however, it too shy to report on travel time changes on the approach and exit from the tunnel, especially in the context of its reported cost benefits.

- Congestion levels beyond the tunnel portals

The tunnels add capacity between Woolloongabba and Bowen Hills and it is claimed that it will save time for tunnel users for this portion of the trip. This will encourage more people to drive on the approaches and exits from the tunnels. Quite unusually, Council has sough to claim an extra 200 vehicle per hour (vph) per lane for Ipswich Road and Lutwyche Road, increasing capacity to 1400 vph/lane but with no committed road treatments. Council claims this will occur through 'peak spreading' of traffic, or an expansion of the peak period. In the opinion of CATT, it is hard to conceive of a more contrived and uninformed misuse of modelling practice. This is not accepted practice for transport modellers and must not be used here. No major roadworks are proposed to add to capacity on the approach and exit roads despite the modelled increase in traffic (Appendix E of Traffic and Transport Paper). Table 10.2 of the Maunsell Traffic and Transport Technical Paper reports the following increases in traffic directly as a result of the tunnel:

***Traffic Increases as a direct result of the NSBT (from Table 10.2, Maunsell 2005)***

| | |
|---|---|
| Lutwyche Rd traffic increases | **13%** |
| Shafston Ave traffic increases | **26%** |
| Wellington Rd traffic increases | **32%** |
| Ipswich Rd traffic increases | **25%** |
| O'Keefe St traffic increases | **31%** |
| South East Freeway traffic increases | **8%** |

These traffic increases are quite significant and occur on already heavily trafficked roads, so it is very likely that they will create some delays. In fact, it is reasonable to assume they will add significant delays. 'Levels of Service' beyond the tunnel portals will dramatically decrease.

The vast majority of inner city traffic that does not use the tunnel will experience additional delays because of it. The extra delays on the approaches and exits add to the guaranteed congestion on the surface and actually extends the congested area beyond that which is currently experienced.

The main roads are not the only roads expected to receive more traffic. Local roads surrounding the portals are estimated to be receptors for traffic wishing to skirt around the congestion forming at the portals. Data demonstrating this is not contained in the EIS itself. However, several statements and a missed inclusion in the technical papers give a clue as to what local residents around the portals can expect. Page 49 of the Operational Noise Technical Paper notes that Park Road (a local road lined with Character Queenslanders) will

receive almost 65% extra traffic as a result of the tunnel. Further, it estimates the noise to increase by 1.5dB on that road. It also attempts to hide noise impacts with noise being modelled over 18 hours, not peak flows.

Other local areas not associated wit the tunnel will also receive significant injections of cars. For example, the Traffic and Transport Paper notes:

> *This is likely to increase traffic in Qualtrough Street and Broadway Street as northbound traffic would seek to utilise Logan Road as an alternative route. The traffic increase is not expected to be large, however traffic from significant generators such as the Norman Hotel could be significant. If further development in the area were to occur, traffic could increase further. (p138)*

'Further development' may be an increase in density as directed by regional planning policies. Mitigation measures are suggested but nowhere in any document has a commitment been made to control residential area traffic increases. Traffic light alterations, intersection changes and portal entrances and exits which will restrict access to local areas all will increase and concentrate local vehicle movements. This will occur without any consultation and little reference in the EIS.

- Recent history of traffic forecasts for Australian tunnel projects

The long list of issues, above, is supported by recent experience with the forecasts for major tunnel projects in Australia, most notably in Sydney where comparable projects have both been developed and are under construction.

- Sydney Harbour Tunnel:

The *Sydney Morning Herald* reported that, only months after its opening, there was a total increase of 15,000 vehicles per day crossing the Harbour on completion of the Sydney Harbour Tunnel (which augmented the capacity of the adjacent Sydney Harbour Bridge). Over a period of three years since the opening, the Environmental Protection Authority found a 21.5% increase in the total amount of traffic crossing the Harbour (Diesendorf 1999).

- M5:

In the M5 East Road Tunnel Sydney, the initial design capacity of 50000 vehicles per day was exceeded by some 20,000 within 3 months or so of opening, with the final average capacity now running approximately at 100,000 vehicles per day (Pers Comm). The initial point to point journey time savings have now been lost with the surface roads, ostensibly to have been replaced by the tunnel, unexpectedly now carrying the same traffic as they did before the tunnel.

It is quite conceivable that the extra approach and exit traffic will create 5 or more minutes delay at either end of the tunnel. This would mean that even most of the tunnel users, who save 10 odd minutes on the tunnel part of their trip, still actually end up taking longer for the whole trip. Proceeding with the project will delay almost everyone. The EIS chooses not to report the data required to confirm or deny this, even though it could easily have been determined.

Unfortunately the EIS only presents the good news half of the story in detail and we must interrogate and decipher to try to find out where the problems might lie. Proponents of the NSBT quote the 10 minute saving. The proponent conspicuously neglects to point out that this saving is only for the few, and to get it they would miraculously avoid the congestion increases at either end of the tunnel. The loss of time as a result of the surface congestion could be more than 10 minutes. Tunnel users will be stopped in the tunnel awaiting traffic on the surface. This is a cynical exercise in manipulating public opinion through selective quoting of misleading information.

### v) Comparing apples and oranges

Comparing a 'with tunnel[1] and a 'without tunnel' scenario without making clear the costs of the tunnel and possible alternative uses for the money is unfair, particularly when that money is taken form the public purse.

The 'with tunnel' scenario is expected to cost Brisbane City Council $570M cash. They will not receive any toll revenue to pay for this as the tolls go to the private operator that funds the rest of the cost (probably an additional $1B). The cash will be from budget revenue and from an approximate $520M loan from the State Government. This one project will thus increase Brisbane City Council's (BCC) total debt by about 50%, use $120M over several years from the budget, and add an annual $30M debt bill for the next 30 years. This all gets paid for by the ratepayers of Brisbane in the form of an annual increase of around $90 each year to service the debt. This leads to the question, what else could be done with all this money - or would we rather have it in our own pockets.

For example, $120M is more than enough to provide grade separated through traffic on Ipswich Road across the Stanley and Vulture Street intersections and for grade separated through traffic on Lutwyche Road from O'Connell Terrace to north of Newmarket Road. Unlike the tunnel, this would relieve some congestion and leave money available for other projects.

These projects, or similar, need to be identified and included in the 'without tunnel' scenario so that we are closer to comparing apples with apples. Otherwise we are trying to compare a major investment in transport against no investment at all. Nevertheless, Council undertook a sensitivity analysis with the Gateway Duplication. Although it did not quote numbers, the fact that the Gateway had a significant Net Present Value demonstrates that the analysis found that the Gateway captures all the benefits and the NSBT may in actual fact have had a negative NPV. This must be expanded upon fully to demonstrate that the NSBT is economically viable with the Gateway. More on this is mentioned in section 4 (iv).

Most Brisbane residents, if given a genuine opportunity to express their opinion on the question armed with this information, would most likely rather BCC didn't increase our debt by 50%. If the money must be borrowed, use it to fund projects that give a return to all Brisbane residents – projects like suburban centre improvement programs (for example, Nundah and Stones Corner) increased bus services, traffic calming, bike paths and local road projects across the whole city, not just in the middle.

What other services will not be delivered if the tunnel goes ahead?

### vi) Input data

The outputs of the 2003/04 SEQ Household Travel Surveys have not been used as input for the modelling undertaken as part of the EIS. The consultants have used data that extrapolates the 1992 household survey travel data. The poor nature of this data-set, acknowledged by both Queensland Transport and Main Roads, introduces significant error and uncertainty to any traffic forecasting undertaken using it. This outdated 1992 travel behaviour data is used for trip generation without acknowledging its limited status.

This is a significant flaw which introduces a large margin of error at the beginning of the proponents analysis and is increased with each model (including air and noise) and variation to the point that the margin of error renders all further work unreliable.

### vii) Failure to consider land use changes

While population forecasts from DLGPRS (PIFU) have been used in the model, the likelihood of significant land use changes within and adjacent to the study area are not taken into account by the modelling. For instance, the Draft SEQ Regional Plan is aiming to achieve significant concentration of commercial and residential activities in transit-oriented-development nodes at locations such as Buranda and Albion. Indeed, Maunsell's Traffic and Transport Technical Paper suggests that:

> *"The provision of the tunnel could result in the relative travel times to competing attractions changing, such that trips are switched from closer to more distant destinations. To this end, there would be an increase in trip length." (p175)*

This is a remarkable statement in a document that attempts to justify the tunnel.

The paper further notes the total social and environmental consequences as a result of this trip redistribution could be negative. This cautiously worded statement provides an insight into the potential minefield of impacts as a result of the proponents hasty analysis.

The model used fails to consider any impacts of changes in land use, especially urban structure and form (as opposed to base population increases).

> "The modelling does not consider the implications of this trip redistribution." *(p175)*

This raises serious questions about the reliability of the model results.

### viii) Failure to include the full impacts of induced traffic

A number of problems may clearly be identified with the modelling of induced travel impacts.

First and most importantly, land use effects are totally dismissed and ignored (Maunsell 2005:175). This is entirely inappropriate given the significant size of the project proposal. The increased mobility provided by the project will affect both development location and development type - encouraging urban structures and forms that are car-dependent. The likelihood that this project will contribute to the continued development of automobile-oriented land uses within Brisbane is indisputable. The contribution of this project in conjunction with the others that comprise TransApex will clearly have large and significant land use effects, working to fundamentally stymie any efforts by other agencies to develop transit-oriented-development forms.

Secondly, the likelihood of the project also generating 'completely new trips' through creating greater choices is also dismissed and ignored (Maunsell 2005:176). The project, by the nature of its size and the fact that it crosses the Brisbane river (the largest barrier to movement in the city) will greatly increase the possible choices for a variety of travellers for a variety of trip options - that may lead them to make a travel trip instead of choosing an 'at home' or local area (walk) activity. As well, the EIS has dismissed any efforts to consider modal shifts away from public transport as part of its induced traffic modelling, but remarkably, attempts to claim a modal shift toward public transport, noting:

> *…the scope of opportunities to reallocate road space to public transport have not been fully developed. If opportunities were to be fully taken up the benefits would be high and the mode shift to public transport positive.*
>
> *Maunsell 1999, p176*

Given the wealth of independently proven world wide experience with modal shifts when completely new road infrastructure is provided, this statement would appear to be "sexing up" a

story. The only public transport service likely to be positively impacted (if all assumptions were shown to be correct) would be bus routes that traverse the Story Bridge. These routes account for around 3% of all bus trips to the CBD (Maunsell paper) and any modal shift as a result of a more on time service would be insignificant. Further, the perceived benefit of travel time savings would take commuters from public transit and put them on the road.

It is interesting to note that the EIS discounts the notion of new trips being generated claiming, against common wisdom, that apart from being hard to measure, it would not be much. However, the claim to increase public transport use on a poorly serviced bus route which accounts for around 3% of all services just because it may be a bit more on time is drawing a long bow.

Interestingly The Maunsell Traffic and Transport Technical Paper, which was repeated in the EIS (p158 and 5-49 respectively), in discussing dangerous goods movements notes that:

> *"The reduction in traffic using the route as a result of the tunnel would comparatively reduce the risk of these vehicles using the (surface) roads, although actual risk will increase because of general traffic growth on the road network"*

It would appear that the consultants recognise that traffic volumes will not be impacted upon on the surface in spite of the tunnel objectives, further justifying the case that induced traffic demand is real and has been considered only when it is necessary to do so for other reasons.

Thirdly, the argument that the constraints of approach roads and the effects of tolls will limit and constrain any induced travel effects (Maunsell 2005:177-178) is used inappropriately to justify a lower value for induced travel than would reasonably be the case. Tolls will no doubt be part of the decision-making process for persons making a trip, but the decisions of land use developers, land use occupiers, individual travellers and others will be effected by a project of this size over the course of the project life-cycle. The long term impacts of the project will not be affected by these suggested constraints given the likelihood of capacity increases on approaches (already announced in the case of the northern approach) and long-term acceptance of tolling of the facility and the incorporation of that into individual decision-making. Further, many tunnel users will not be making the trip based on the toll decision as a great proportion of the vehicle fleet is company cars. The decision is not one for individuals.

It is important to note that modelling for some other significant non-tunnel projects in Queensland has substantially underestimated induced traffic impacts including the Pacific Motorway, and Inner City Bypass//Bowen Bridge Road/Breakfast Creek Road. These projects are now experiencing far greater congestion at a much earlier stage than predicted by modelling, and these experiences have not been taken into account for the NSBT modelling.

Inappropriately diminishing the predicted land use impacts of induced travel within the NSBT methodology skews the outcomes of the modeling to support the 'build' scenario and greatly reduces the comparative performance of alternatives (in this case the 'do nothing' scenario). It also led to the decision not to incorporate these effects into economic analyses, which is a significant oversight.

### ix) Problems involving use of the Brisbane Strategic Transport Model itself

There are great uncertainties as to the reliability of any traffic forecasts produced by the Brisbane Strategic Transport Model (BSTM), which uses the conventional four-step transport model incorporating a gravity model. Errors accumulate and compound one another within these forecasting models at an extraordinary rate. Systematic errors occur within all stages of the process, including the trip generation, trip distribution, modal assignment and trip assignment phases - all included within the model used for the EIS traffic modelling. See

Beimborn (1995), Bureau of Transport Economics (1998) and Litman (1999) for source material on these issues. The study team's use of "Brisbane Strategic Transport Model" without allowing for its limitations is a serious concern for the reliability of the EIS, particularly since other significant sections of the EIS such as health and air pollution assessments are based on traffic model outputs. This is also discussed in previous sections as they relate to initial assumptions in particular.

- Trip generation

There are a number of common criticisms of the trip generation process within models such as the BSTM. These include:

The nature of travel behaviour is assumed to be independent [free from interference] when it is not. For instance, travel decisions are often dependent on someone else in the household, a child needing to go to child-care at a given time, for instance. Interdependencies in trip-making are not considered.

Only a limited number of trip purposes are considered. With usually only four to eight trip purposes considered, a very simplified trip pattern results. And often there are major simplifications in the trip purposes that are included too – i.e. all shopping trips usually being treated the same whether they are for higher order or lower order goods.

Limited variables are included in input data. Trip making is found as a function of only a few input variables. Factors such as the quality of public transport services within a zonal area, the ease of walking and cycling, ownership of a bicycle, fuel prices, land use density, and close proximity to a neighbourhood retail centre are generally ignored. And they all have a significant impact on travel patterns.

The full effects of trip chaining, the combining of trips to perform a variety of purposes, is ignored. People regularly combine numerous activities into a single journey. Modelling only treats this phenomena in a very limited fashion.

Feedback issues are also ignored. Many of the factors that are calculated into trip generation models may actually be dependent to a high degree on how many trips there actually are. For instance, shopping trip attractions are usually determined as a function of retail employment, but it may also be argued that the number of retail employees at a given shopping centre is entirely dependent on how many people travel to that centre for shopping purposes.

- Trip distribution (using gravity models)

The most common criticisms of the process include:

- The assumption that trip lengths will remain constant in the future. For the model to be used for forecasting they must simply assume that if there are improvements made to the transport network that increase average speeds and decrease travel times, that such changes will be balanced by a further separation of origins and destinations.

- The very use of travel times to represent distance is not necessarily accurate. That is why alternatives including other functions of distance are often included. If public transport travel times were included at the expense of automobile transit times a greatly different trip pattern would emerge. By denying the role of public transport travel times, there is a limit placed on the ability of the model to represent the urbanites who locate on public transport routes and travel to points along that route. International experience suggests that gravity models do not cope with rail transport systems particularly well - and Brisbane is a city with more than 200km of heavy rail track.

- There is neglect of many socio-cultural factors such as the visual attractiveness or perceived safety of a route. The gravity model only distributes trips according to the bulk of the trip productions and trip attractions in the study zones and the travel times between zones. It does not include any function that might consider the impact of drivers choosing routes that avoid certain urban areas or to favour other areas. Such issues are difficult to quantify and are therefore just left aside.

- Further feedback problems also exist. Travel times depend on the congestion on the routes between the zones and yet the congestion is only included later in the process. The travel times are often just assumed and then checked later. When the values differ from the values that are later determined, the model is then iterated a number of times to get the inputs and outputs all to balance as well as possible.

  - Modal assignment

There are a number of issues with the modal assignment process used within the BSTM. These include:

- Modal choice is only affected by time and cost characteristics, and not other socio-economic factors. As mentioned above, this may lead to an analysis that fails to account for travellers deliberately avoiding certain locations or choosing routes that provide a visually pleasing environment. Under this assumption, there would also be no new patrons ever attracted to a light rail system should it replace a bus service that offers exactly the same travel times and fares, but much better patron comfort and convenience. This may have implications should persons be choosing between a tunnel experience and a bridge experience. Omitted factors are all assumed to be picked up in the calibration process, however the different modes will have differing characteristics. And, as such, no change in those factors will be predicted by the model.

- Access times are grossly simplified within the model. Such factors as the walkability of the study area, or the characteristics of a transfer facility [public transport interchange] in the process of trip decision-making are not considered.

- Constant weightings are used. The importance of trip cost and convenience is assumed to be constant for each trip purpose category in the model. But this does not allow for differences for the separate trips within each category, or for changes across time of day or season.

  - Trip assignment

Errors emergent from the trip assignment process used in the BSTM include:

- Intersection delays do not appear to be fully incorporated into the model. The assignment procedures therefore must assume that the delay occurs on the links [streets] rather than at intersections, where they most often occur in reality. For freeways without restricted on-/off-ramp capacities, this assumption may be valid, but for most roadways this is not true.

- The impacts of electronic road pricing measures are not easily included in these models and the toll choice model incorporated in this process by its very nature grossly simplifies the set of complex inter-related decisions that a person takes in order to determine their route within a particular period of time in a particular context.

- There is no consideration of traffic that is not on the model's actual network. This means that all trips must begin and end at a single point in a zone within the network, and

occurs only on the links included in the study. But not every roadway is included in most road modelling exercises – most small roads are conveniently ignored. And what of origins or destinations that are far outside the study area where many trips will inevitably lie - such as is likely to be the case for the city centre of Brisbane? These are ignored. Also, many of the shortest trips are also not included – again forming the majority of walking and cycling trips.

- Capacities are simplified by the modeller. To calculate the capacity of each road or public transport system requires an extensive complex series of calculations incorporating many factors. This can be greatly simplified so as to be only based on the number of lanes in a road, and whether it is part of a freeway. Factors such as highway geometry, the proportion of vehicles that are heavy-vehicles, percentage share of non-motorised vehicles on the route and all sorts of other issues can seriously impact on capacity.

- Time period assignment models do not reflect the great variations according to the time of day. While travel demand forecasts are made on a daily basis for a typical weekday and then converted across to peak hour conditions, this assumption is highly problematic. The 'hour adjustment factor' used in the calculation, as stated previously, can make a major difference to the level of predicted congestion if adjusted by only plus or minus one percent.

- And there is the question of whether focusing on peak hour travel is actually valid. What happens for the other 23 hours of the day that the route is in operation? What about congestion around the peak hour period [the phenomena known as 'peak spreading']? These issues are not satisfactorily addressed.

### x) Implications

> *Recent announcements by Rail Corporation also suggest that the M5 East may have contributed to a reduction in patronage on the East Hills train line. These outcomes conflict with the aim of increasing the use of public transport. Up-front assessments of such broader impacts should be improved.*
>
> *Auditor General of NSW, April 2005*

The EIS contains many serious factual errors in the traffic and transport section as demonstrated in the above analysis. <u>The conclusions drawn at the end of the traffic and transport technical paper are unjustified</u> as they cannot be logically drawn from the data presented. As such, the traffic and transport section conclusions (and further analysis work in the EIS on economic benefits, air quality and health impacts) are based on <u>seriously flawed assumptions and unjustified inferences and should not be relied upon to support or justify the NSBT project</u>.

## 5 ECONOMIC ISSUES AND THE NSBT PROJECT

### i) Alternative uses of NSBT resources have not been considered

The resources to be used for the NSBT project are enormous. The alternative uses for these resources, finance, labour, equipment and so on, would create many alternative futures. The tunnel will not only immediately prevent these from being implemented, but will also render many potential alternatives impossible. For example, there are alternative river crossings that

can never be built (such as a rail tunnel option from the PA Hospital to Bowen Hills), alternative destinations and locations that are rendered less attractive by the tunnel. The tunnel will also prevent the community from investing in assets that might, in total, be more highly valued in the long term. Already there are hints from the Lord Mayor that there will have to be economies in spending on BCC activities that are highly valued. Many of these will be in areas that do not benefit from the tunnel, such as Redcliffe Peninsula or Brookfield, not to mention the northern and western corridors of the less affluent. Overall, the NSBT at its best will only carry 2/3 of the volume carried by the Story Bridge. This will buy very little road capacity "breathing room" at enormous cost in terms of funding and externalities.

### ii) Distributional aspect ignored

The distributional aspect of the project is important and totally neglected by the EIS. Some places and people will benefit, others will be harmed while a majority of ratepayers, residents or businesses, will enjoy neither benefit nor harm, except that the interest burden of the loans required to complete the project will mean rate bills somewhat higher than otherwise, for as long as the tunnel remains in private hands (ie, at least 30 years depending on final contractual arrangements adopted).

Major losers from the project will be residents and businesses in the 'funnel of attraction' beyond all three portals, especially those who do not often wish to cross the river near the city centre. The EIS is confined to a small area around the portals and above the tunnel itself. Detriments to those in the funnel beyond the study area are ignored, however, there are sure to be some substantial losers in that funnel area. One example is the users of the Ipswich Rd inbound from Granard Rd. The tunnel will attract some traffic that would otherwise use the Gateway, thus freight traffic along the already heavily used Ipswich Rd through Moorooka to O'Keefe St where the study area begins, will increase, reducing the urban amenity of the corridor and increasing the risk of accidents further. Currently, articulated vehicles are not allowed to use the Story Bridge. The EIS makes no such claim regarding the planned use of the tunnel. The same can be said of all the corridors to the tunnel from south, east and north. It must be gathered from this that articulated vehicles will further contribute to Brisbane's freight vehicle mix.

### iii) Inadequate Cost Benefit Analysis

The Cost Benefit Analysis (CBA) supporting the project is inadequate. Two inclusions as benefit flows are not valid. The first is the so-called multiplier effect, of about $181m. This is only a valid figure if the resources used to build the tunnel were otherwise unemployed. This is manifestly not the case. Demand for major built infrastructure construction in Queensland over the coming decade is likely to be much greater than current capacity to produce. Resources will have to be imported to SEQ to fill the gaps. If anything, the project will exacerbate price inflation in the heavy construction industry, if not add to inflationary pressures in the Queensland economy in general. The second is the Government's contribution of some $520m, at 6%. This offsets the shortfall expected in toll receipts. If the interest income enjoyed by the Government is lower than could be enjoyed from investing the funds in the best alternative the Queensland taxpayer will be bearing that cost. The projects that could have been financed with that money may also have had a higher social rate of return, or CBA, than this one.

Some specific elements of the CBA need to be re-considered:

- Even though the calculation of "induced" traffic was understated, the finding of increased VKT was erroneously claimed as a "benefit" in the economic assessment which assumed "decreased" VKT.
- The CBA fails to include disruption to traffic by roadworks and diversions, and the imposition of the spoil haulage activities in the economic modelling as a disbenefit during the construction phase.

The CBA is constructed in a vacuum, with the alternative considered as a Base Case 'nothing done'. This is inconsistent with the various government and BCC policies on traffic and transport covering much of the CBA period as well as the TOR. While there are some assertions that a wide range of alternatives were considered in the pre-feasibility period, these are not brought to bear on the CBA. The mere appearance of a positive NPV is therefore no assurance that resources are being wisely accounted for.

The CBA ignores costs that are even slightly difficult to quantify. Significant environmental and social costs are one example. The confined study area appears to be a deliberate attempt to avoid dealing with some major costs. For further information on specific environmental costs pertaining to air pollution factors for example as determined by the National Environmental Protection Council in a paper to the Australian Greenhouse Office, please refer to the Health section of this submission.

The CBA outcome is such a slight positive that a very few additional costs, such as the costs to residents and businesses within the 'funnels of attraction' but outside the study area, would render it negative, even on its own terms. When the fundamental weaknesses of the traffic and transport analyses are considered – the lack of consideration of likely changes to travel patterns and the deliberate understatement of generated traffic – the CBA is certain to be a solid negative. For more on this matter, please refer to section 4(iv and v)

### iv) Moral hazard

The EIS is subject to a significant moral hazard problem, in that the entities conducting the EIS have a direct interest in the project going ahead. SKM, Connell Wagner, Maunsell and the Major Projects Division of the BCC all stand to gain substantially in both a fiduciary and a professional way. Whether the non-BCC contractors for the EIS actually enjoy further work on the project does not greatly affect the scope of benefits that they may enjoy. Professional esteem and other work prospects will inevitably be affected by the technical success of the project (engineering feat, on-time, on-budget, etc). Individuals within each entity will enjoy improved career prospects from the project going ahead, even if the project proves to be a disaster in terms of achieving time-savings goals (the Toowong overpass from Frederick St to the Western Freeway cannot be described as an appropriate solution to the problem it is designed to solve, but it won a major award for concrete structure design).

What is often seen with projects such as this, especially where future work is proposed, is that an industry is generated around proving up the case. Consultants, the public service, academia and infrastructure contractors all have a direct or indirect interest in this work. Sadly, this has lead to a situation currently where many advisors to CATT (with a moral conscience and professional integrity) cannot air their concerns in public for fear of job losses, funding implications or professional issues. Although this submission attempts to pool the comments from hundreds of residents, professionals and academics, it has been hamstrung by the TransApex black hole sucking in resources, leading to the inability for active participants in the project needing to keep at arms distance.

### v) "Political" project will not solve the problem it was intended to deal with

The political origin of the project, from former Lord Mayor Jim Soorley to current Lord Mayor Campbell Newman, indicates that the project is the artefact of a political process, a brainstorm that pretended to cut through the orderly processes of planning and projecting for an imagined future that characterises normal bureaucratic procedure. This is seen by the politicians as a great advantage, thinking outside the square, cutting through the small-minded pettiness of bureaucrats who have no mind for the public imagination that can be harnessed to a great vision. Thus, the project is fundamentally at odds with bureaucrat-born policies on transport and mobility that attempt to moderate the pressures of popular demand for no traffic congestion. This is further brought to bear in section 3 (iii) of this submission. Sadly, the bureaucrats are usually correct, and the political brainstorm is simply that, a populist vision that doesn't work. TransApex, and Newman's tunnel, are in this class of event. They won't solve the problems they were designed to deal with. They will actually make the problems worse, as shown by even the EIS's figures for increased congestion in the three funnels of attraction.

Perhaps most importantly, the tunnel will be operated privately under contract. As has already been found in the EIS and revealed in this submission, Council intends to manipulate congestion to ensure a viable income stream for the operator. This will preclude other more effective and sustainable options, including cordon pricing such as that used successfully in London, traffic light sequencing or other road works designed to relieve congestion and public transport investment as this competes with the operator

### vi) Investment and financing decisions should be made separately under PPP guidelines

The PPP aspect of the project has been decided before the positive net social benefits of the tunnel have been demonstrated. PPP guidelines usually indicate that 'investment' and 'financing' decisions should be made separately. That is, first determine if the project can produce net social benefits, and then subsequently determine the best way to finance them. The EIS demonstrates only that the CBA is lacking in completeness and validity. However, it has already been decided that the project will be financed by PPP, rather than conventional government finance, or some other approach. The project has gone to tender, before its real benefits and impacts have been evaluated. Only then should financing have been analysed. This must be considered a 'fait accompli'. The fact that any PPP drives a profit wedge between the cost of the project and the financial burdens borne by the proponent, the BCC, and then by ratepayers and users, should give cause to wonder why such a large project has been foisted upon ratepayers and potential users at such a cost. The PPP Value for Money Framework was not considered at all. This is remarkable considering the framework and guidelines are well founded and considered.

## 6 AIR POLLUTION

### i) Pollution Dispersion Modelling

A difficulty with the decision-making process for Air Quality is that Dr Kerry Holmes uses the wind patterns from Eagle Farm and Rocklea instead of the wind patterns from South Brisbane, Woolloongabba and the CBD. Her main reason for using the outer stations is that the buildings and topography of the inner suburbs get in the way of the air flow. This is the modelling which is necessary to produce a true portrait of plume flow, but wind patterns from the inner City suburbs are not used. This seems highly illogical and a dangerous source of error on which to model wind flow data.

Kerry Holmes notes:

> *'In a built-up urban environment like central Brisbane, wind dispersion patterns will be complicated by the turbulence induced by buildings. There are wind data available from five monitoring sites in the greater Brisbane area, namely the CBD, Eagle Farm, Rocklea, South Brisbane and Woolloongabba. These locations are shown in Figure 4. The meteorological data collected from these sites include hourly records of temperature, wind speed, wind direction, sigma-theta (a measure of horizontal wind fluctuations) and relative humidity. Data available for the purposes of this study cover the period from January 2001 to December 2002 has been selected for development of the meteorological wind field.*
>
> *It was advised by the EPA that only two of their sites, Eagle Farm and Rocklea, would be unaffected by the surrounding urban environment. While the data from the remaining three sites provide information about the general pattern of winds in the area, they are likely to be affected by urban canyons created by city buildings which can steer the winds in ways that are not representative of the greater area. Data from these locations will therefore tend to be representative only of the area immediately surrounding the monitoring site. This is not to say that these data are not useful as they play a key role in understanding the nature of winds in built-up areas. They also provide a general indication of seasonal variations and trends for those locations. For the purposes of this study the Eagle Farm and Rocklea data have been considered to be the most suitable datasets for CALMET to establish wind patterns over the entire study area.' Air Quality Technical Paper , p11*

Why is windflow data not used to represent inner Brisbane patterns? The air exhaust stacks are only 30 metres high. It is precisely the twists and turns of air in the city which is significant to where pollution may strike buildings and the people in them and these patterns are not used for modelling future plume flow. These foreseen impacts are already being felt by Sydney residents and as a result, part of a CSIRO finding was to recommend the stacks be raised to above 50 metres.

An interesting point to note is that the two pollution stacks on the southside associated with the hospitals have significantly taller stacks and have heated emissions, further lifting the pollution plume. Even with these two factors, there is still ground strike and direct exposure by surrounding residents (pers comms). The tunnel pollution stack is less than half the height of the hospital stacks and does not have heated emissions to any significant degree. The fact that ambient air modelling at 80 metres up on the Telstra building showed no exposure only demonstrates that the plume probably does not even reach that height!

It is difficult for anyone who has visited the Sydney Residents Against Polluting Stacks web site (*www.savewollicreek.8m.com)* to feel confident with the same team of Dr Holmes and Tim O'Meara being the consultants of the Air Quality and health study, when there are so many dissatisfied people subject to the influence of the M5 East. As the tunnel/air stack model is repeated in Brisbane, it is most important that the air quality study is right. Experiences from the M5 East tunnel in Sydney demonstrate that dispersion patterns based around the utilisation of poor baseline data will lead to gross underestimations and a great degree of uncertainty as to plume strike on buildings and the ground.

> *"It is difficult to see that modelling of impacts is going to provide an adequate assessment of environmental exposure to traffic fume. Models of this nature can produce reliable long-term information related to exposure but in general are seldom able to provide information of verified reliability in dealing with shorter term individual exposures."*
>
> *Professor Michael Moore, National Research Centre for Environmental Technology, on toxicological aspects of the M5 East project, in Katestone Environmental*

ii) Model basis

The air quality study is in breach of the Terms of Reference as it only contemplates 2 models, the 'do something' tunnel model and the 'do nothing' model, rather than any real alternatives for public transport and air quality. The health consequences of magnifying greenhouse pollution over South East Queensland have also been completely ignored and there is grave danger is making this area hotter and drier, as it is becoming increasingly drought and bush-fire prone.

iii) Potential Impacts and Mitigation Measures

A recent mapping of predicted $PM_{2.5}$ levels currently being experienced within 1000 metres radius of the proposed Woolloongabba pollution stack indicates that much of the area is already suffering from severe exceedances of the NEPM standard for this pollutant both on a 24hr basis and an annual basis. These predicted levels are based upon actual roadside measurements of motor vehicle exhaust emissions made at roads local to the area.

The increase of ground level concentrations proposed from the pollution stack therefore will increase the number of days the ambient air will exceed the measure and also increase the severity of those exceedances. This will raise the risk status of consequent pollution related illnesses to one of severe risk for already compromised individuals. It may well be that activities normally carried out in the open air in the mornings and afternoons will have to be curtailed and avoided as the tunnel operation will be 24/7. This proscription most definitely applies to the young and the aged and anyone else already suffering from diseases medically recognised as associated negatively with fine and ultra fine particle pollution and nitrogen dioxides. Refer further to the Health section of this paper for impacts upon children, as well as NEPC weighting and estimates of air pollution health and economic impacts.

There is already a State Government precedent for such action in that some 5 years ago in the new Neville Bonner building in William St, measurements made of motor vehicle particulate emissions from the SE Expressway showed such a high risk to health, especially of young children, that a proposed child care centre at the building was cancelled and expensive air filtration precautions were taken to protect building occupants. The building does not receive a concentrated point source emission as would Woolloongabba and Bowen Hills but instead receives a more dispersed linear pollution plume.

Recently, measurements made in several Sydney road tunnels and reported in a NSW Health Department study showed that existing unfiltered tunnel designs lead to 'in tunnel' air quality which are always dangerous to the health of many of the tunnel users. Particularly at momentary risk are the 15% or so of tunnel users who suffer from asthma. The high $PM_{2.5}$ levels and associated $NO_x$ levels measured both within the tunnel and in vehicles traversing the tunnel are known to promote severe allergic response with this disease. This finding follows recent Swedish research. This research has been acted upon by the Swedish Government. This second pollutant, $NO_2$ is now also being filtered out in road tunnels overseas as an adjunct to particle filtration.

It is not difficult to see, therefore, that the existing tunnel design will promote legal challenges claiming negligence resulting in ill-health and financial loss against tunnel proponents, financiers and regulating authorities and could result in significant financial penalties.

It is not at all difficult for tunnel designers to build vehicle road tunnels to operate in such a way that only very small emissions of CO, well below the level causing ill health, will be the only pollutant emitted to atmosphere. The cost for such comprehensive filtration systems in the NSBT Stage 1 has been estimated at $400M. Significantly as a percentage of tunnel design

cost, this equates approximately to the cost percentage of mechanically ventilating an office building, the performance of which is legally required so that the building will not promote ill health to its occupants.

iv) $PM_{2.5}$

A preliminary point to be noted is that the Queensland EPA required that NEPM Air Quality standards were to be used in the EIS. Since 2002, these standards have included a $PM_{2.5}$ standard. However the modelling of Air Quality in the Air Quality technical Paper exclusively models $PM_{10}$ with only tacit admittance that the few measured values of $PM_{2.5}$ were available from the EPA and the project's own SIMTARS measurements at Campbell St Bowen Hills. Although these measurements clearly showed exceedences of this NEPM $PM_{2.5}$ standard, these exceedences were explained as most probably due to isolated events such as bush fires even though the SIMTARS results were the result of a 3 month continual measurement study.

The inference must be made therefore that to adequately model $PM_{2.5,}$ the work demanded far greater resources than the proponents or consultants were prepared to finance and or make time for. Thus it became necessary for BCC to ensure that $PM_{2.5}$ is therefore not the standard to be used as it is likely to impose severe and expensive additions to the current costed design.

Therefore contained within the Air Quality report of this EIS is a thinly disguised critique on this $PM_{2.5}$ standard. This is begun by the EIS noting that the annual average measurement of $PM_{2.5}$ at the national air monitoring station at Cape Grim, NE Tasmania is 5.8 micrograms per cubic metre and that the national standard is set at 8 micrograms per cubic metre, a comparison indicating that the NEPM is obviously asking far too much and should be revised upwards or either ignored for this project.

Cape Grim monitoring station is recognised as measuring the cleanest air in Australia, measuring as it does air quality arising from the prevailing westerly winds that have traversed the southern oceans, an extremely good cleaning agent. The EIS recognises that the Cape Grim particles will mainly comprise of sea salt crystals. (normally, from the literature about 60%). Air of comparable particulate properties is only found at one or two other World wide monitoring stations, all positioned to the lee of prevailing winds traversing long oceanic distances, again with most particles measured being of sea salt.

The majority of sea salt particles lifted aloft on the oceanic winds are larger than 5 micrometres and fall back into the oceans within a short time. The finer sea salt particles can and do travel substantial distances. However these finer sea salt crystals together with other soil particles are estimated to have a count median diameter of approximately 250-300 nanometres. Sea salt also has a higher density, this indicating that the Cape Grim number measurements are often between 100 and 200 particles per cubic centimetre, a figure quoted in the literature. The size of these sea salt particles is such that they will be unlikely to penetrate into the deepest part of the lungs. Also salt is a natural constituent of the human anatomy and is harmless.

- NEPM $PM_{2.5}$ Standard particle number concentration.

The difference in the numbers of vehicle exhaust particles that might be contained in 8 micro grams per cubic metre, the NEPM standard, can be determined. First, the density of vehicle exhaust particles can be less than half that of sea salt but more importantly the average count median diameter is only one fifth of the sea salt particles. Recalculating for $PM_{2.5}$ measurements of motor vehicle exhausts for an annual standard of 8 micrograms per cubic meter, the most probable number will be 15,000-25,000 particles per cubic centimetre, all of which can be inhaled into the deepest part of the lungs, the vast majority being potentially dangerous to living tissue and systems individually or together with others.

The EIS notes that this number of particles, derived in the main from motor vehicle exhausts, has been measured as the current average background measurement in 5 Australian cities.

This standard was promulgated in 2002 and will be subject to review in 2005 as will be all the NEPM Criteria Pollutant Standards. As noted earlier in this submission, the NSW Auditor General (April 2005) has acknowledged that current NEPM limits may not be appropriate to minimise health risks to people.

It must be inferred therefore that the NEPM $PM_{2.5}$ standard merely seeks to recognise the present air quality situation in urban areas and is a tool to ensure the air quality situation most injurious to human health, $PM_{2.5}$ does nor worsen as a result of planning and other development activities. Even at the level of this NEPM standard, the costs of the present air quality in urban areas is assessed annually at $12B.

The $PM_{2.5}$ standard has been increasingly criticised, especially by the motor vehicle industry. It is seen as a harbinger of increased capital costs as well as increased running costs for all petrol and diesel vehicles. This is because to satisfy this standard, especially in urban areas, all future petrol and diesel vehicles will be required to have particulate filters installed downstream of the normal catalytic filters in the case of petrol and at the tailpipe exhaust for diesels. Even for small petrol engines, the first installation costs are likely to be >$1000 per unit. As well there will need to be a regular in service examinations as to the continued efficacy in operation, such examinations likely to be an annual charge of > $100 for small petrol and diesel engines. Large diesel prime movers may have an installation cost > $5000 per unit with an annual charge of $500-$1000. Consideration of the social costs has not been made by industry groups.

The setting up of a State Government organisation to monitor particulate filters efficacy will also present an opportunity for many other vehicle standards to be enforced, much more rigorously than hitherto, a prospect not viewed with any favour by the Trucking industry and motoring organisations in particular or even some economists. A model for this operation could be based on the AirCare program in Vancouver, Canada ( http://www.aircare.ca/ ), where emissions standards must be met prior to registration of a vehicle.

CATT demands that the NEPM $PM_{2.5}$ standard be used as the primary design standard for air quality impacts both in and outside the tunnel. The EIS must be returned to the BCC for this revision to be undertaken.

v) Heavy/ Light vehicle Percentages

In the EIS modelling of pollution stack discharges, recourse was made to Table 7, which purported to show hour by hour the percentage breakdown between heavy vehicles and light vehicles expected to use the tunnel in 2001.

However, CATT notes that in a similar cross city bypass tunnel in Victoria, actual toll returns indicated that the daily average mix was more likely to be 17% heavy diesel vehicles rather than the 5.2 % assumed for the NSBT. (www.Transurban ASX release 5.7.00:Traffic and Revenue data.) This figure is likely to be the more pertinent for heavy vehicle prediction, especially in view of the recent announcement by the State Government that the stages 2 and 3 of the North South Bypass including the Airport link will be progressed with some urgency as a goods transportation route.

### vi) Vehicle Emissions

PIARC diesel emissions under full load conditions have been shown to have underestimated similar actual Australian diesel discharges by a factor of greater than 2. A diesel truck is expected to need full engine load to climb a gradient of 6% which is approximately half of the NSBT. *(CSIRO Investigation Report ET/IR 304R, August 2000, Page 9 - Appendix C.)* This is contrary to claims from Council's consultants who have stated that PIARC standards are conservative! Even the TOR acknowledges that other emissions considerations need to be made – this has not been done.

Further adding to air pollution is the introduction of Gasoline Direct Engine Technology (GDI). This is now well underway in Australia with some vehicles now on road. Ford, in particular, are to import over 50,000 in the very near future. Eminently more fuel efficient as a type, with a 20%+ decrease in fuel consumption, these vehicles are recognised to emit 3-4 times more fine particles ($PM_{2.5}$) than present petrol engine vehicles. *(CSIRO Investigation Report ET/IR 304R, August 2000, Page 10.)* CATT notes that these engines will emit higher levels of particles that EURO 4 Diesels.

It is unlikely that more stringent standards for petrol engine cars will be introduced in Australia within the next six years by which time some 20% of the car fleet may have these engines. In a recent NSW Parliamentary investigation of the likely effect of improvements in vehicle emission technology, a consensus was that little effect would be seen for another 15 years due to the slow turnover of diesel trucks in Australia. It therefore seems wise to discount this future as a factor in current assessment of pollution stack fallout.

### vii) Vehicle Numbers

In the M5 East Road Tunnel in Sydney, the initial design capacity of 50,000 vehicle per day (vpd) was exceeded by some 20,000 within 3 months or so of opening, with the final average capacity now running approximately at 100,000 vpd (*Pers Comm*). The initial point to point journey time savings have now been lost with the surface roads, ostensibly to have been replaced by the tunnel, unexpectedly now carrying the same traffic as they did before the tunnel. CATT believes it is essential that 15 minute, hourly and 24 hour average stack emissions be calculated on the fact that the tunnel may well have to carry 80% more than current design estimates.

### viii) Greenhouse emissions

CATT is aware of and involved in work to progress an enforceable greenhouse reduction strategy at both the National and State level. It is with concern that CATT views the added greenhouse contribution of the tunnel. It is speculated that if this tunnel was an industrial point source output, it would not be viable. Greenhouse emissions from the stack must be treated as a point source emission and added to the current traffic output to provide a realistic measure of traffic contribution to greenhouse commitments by the State. This submission has demonstrated that traffic in the tunnel will be newly generated traffic and will have no impact on relieving traffic numbers and congestion on the surface. Hence, the greenhouse emissions are all new as well. This has not been considered and certainly not calculated (a requirement of the TOR) in the EIS and serves to misinform the public and the State.

Further, when one considers a nominal fee of $40 per tonne for greenhouse emissions proposed for when trading commences either nationally or internationally, this would severely and fatally impact upon the economic viability of the tunnel operation, unless Council has proposed to cover these costs in an operational contract. If this is the case, this is a further

cost borne by the ratepayers. Consideration must be given to greenhouse contributions from the tunnel. The Auditor General of NSW (April 2005) has also acknowledged this fact.

### ix) Recommendations

> *Two separate Parliamentary Inquiries (2001 and 2002) have recommended filtration of tunnel emissions from the M5 East. It is not clear if the RTA will implement this recommendation. However, we noted that the RTA is investigating various tunnel filtration technologies for tunnel emissions.*
>
> *Tunnel filtration technology and compliance with air quality requirements add significant costs to road tunnel projects, as discussed in section 3.1. The whole lifecycle costs of building and operating tunnels and filtration systems, as part of road projects, are essential in evaluating project concepts. We believe cost estimations should be improved.*
>
> *Auditor General of NSW, April 2005*

In regard to air quality modelling and ambient measurements, CATT believes the following recommendation be mandated for the EIS.

- That the Air Quality modelling of vent stack exhaust be repeated using $PM_{2.5}$ as the criteria pollutant at 15 minute and hourly intervals, reflecting the short term exposure risk of that pollutant.
- That a sensitivity analysis be carried out using the Transurban mix of heavy/light vehicles.
- That another sensitivity analysis be carried out using the CSIRO Technical report findings, particularly for emissions standards typical of the Queensland fleet
    - using the findings of heavy diesel emissions under load
    - using the predicted GDI particle emission values.
- A final sensitivity analysis be done using all of the above, but also utilising the 3 hr continuous period 5 kph tunnel speed model of the EIS.
- That the ventilation and filtration system design be modelled using the following criteria
    - $PM_{2.5}$ maximum in tunnel concentration level 250 microgram/cubic metre or
    - using 190 ppm as the maximum limit.
- That the community must be involved in the monitoring of the air quality within the tunnel and ambient air quality and impacts on a monthly basis with results to be immediately accessible to the community and the findings tabled in parliament.
- That an effective and proven filtration system be installed operated and maintained as condition of development.

# 7 NOISE AND VIBRATION

Noise and vibration impacts from the tunnel are twofold – construction and operational. Further, noise sources are varied, namely construction vehicles and works, car movements related to the tunnel and the ventilation outlet. Excessive noise can affect sleep and can intrude into normal indoor living such as listening to the radio, conversation, talking on the phone, etc. Excessive noise has been clearly shown to have serious health effects, including high incidences of stress related problems and loss of sleep – especially important for shift workers such as nurses, air traffic controllers and emergency services. Standards exist to provide limits for noisy activities to adhere to.

## i) Construction

- Vibration and property impacts

The assessment guide values for transient and continuous vibration in order to ensure a minimal risk of cosmetic damage to buildings are given in Table 10-8 on page 10-9 of the draft EIS. The peak particle velocity for Heritage listed buildings of 2 mm/sec is either two and one half or five times that for residential and sensitive commercial buildings, depending on the length of duration of the vibration. The report states:

> *"it should be understood that these guide values are indicative only, as the actual degree of tolerance of any building depends in a complex way on both the structural characteristics of the building and the frequency spectrum of the exciting vibration".*

The draft EIS further states:

> *"it is a statutory requirement of BCC to conduct pre- and post-blasting Building Condition Surveys where it is considered there may be potential cosmetic building damage".*
> *(Paragraph 5, page 10-19)*

The criteria for a building to be considered for these surveys is not mentioned in the report but the report states:

> *"Examples of threshold or cosmetic cracking include minor non-structural effects such as superficial cracking in cement render or plaster" (paragraph 2, page 10-9)*

However, the Richard Heggie Technical Paper states in the second last paragraph on page 10-12

> *"due to the significant separation distances between the bulk earthworks on the worksite and the surrounding sensitive uses, significant vibration impacts are not anticipated".*

These matters raised in the EIS have not referenced the known effects from the vibrations caused by blasting of the Inner City Bypass as an indication of the effects of the anticipated vibration from construction of the NSBT. This is remarkable as all blasting and construction will be within the same rock formation as the ICB.

First hand experiences from the ICB blasting has revealed that buildings have suffered cracking of the internal plaster finishes, typically above and below openings at distances of 550 metres away from the blast site. It is the view of CATT that the statement from Richard Heggie above is not founded on good information and does not consider the serious impacts on buildings which in some cases will be around 10 metres away.

Further, prior experiences with the ICB construction shows that no advisories were given prior to blasting.

The Richard Heggie report does not consider the various types of construction and how they are affected by vibration. For instance timber buildings are far better at withstanding vibration than masonry structures, particularly older lime mortar masonry buildings.

Cultural Heritage experts including Heritage Architects have used the Richard Heggie Report as the basis for subsequent reports to evaluate the effects of vibration on buildings and to help determine which buildings require management of noise and vibration impacts. These subsequent reports have assumed that "*noise and vibration impacts are very localised*" (page 22-6). The old Woolloongabba Post Office, and Police Station, Leckhampton (Shaftson Avenue) and RNA Showgrounds are the only nominated buildings to be considered for management of noise and vibration impacts.

Importantly, the noise and vibration study by Richard Heggie and Associates has not been externally peer reviewed and is potentially flawed in its model. This has the potential to create far more damage to buildings than those within a 75 metre radius of the construction zone and leave the building owners with damaged buildings and no pre-construction Building Condition Survey for which to base their compensation claim on. These owners would have great difficulty seeking compensation from the BCC or contractor as they did not have a pre-construction building condition survey and were not identified as needing one.

Of note is that recently, Peter Zahnleiter (BCC) advised at a CRG meeting on Wednesday 1 March 2005 that the EIS Team had been surprised at the extent of potential problems from vibration during construction of the ICB.

CATT is deeply concerned that the EIS has not referenced the known effects from the vibrations caused by blasting of the ICB as an indication of the effects of the anticipated vibration from construction of the NSBT. Generally, all blasting and construction will be within the same rock formation as the ICB.

- Construction noise

Construction will occur for at least three years. Earthworks and equipment, including trucks will be present around every portal and worksite. Experiences in Sydney (overflight noise), Gladstone (industrial noise) and even more locally at Maroochy (overflight noise) points to the fact that it is very difficult to demonstrate noise disturbance, even though the Technical Paper in many cases describes the proposed noise as "*sufficiently intrusive*" and "*could interfere with normal indoor living*".

CATT believes that, similarly to the above cases, residents will be required to present a history of noise disturbance before any action is considered, which means suffering for long periods of time and recording noise events. In many cases, this will be difficult to prove as existing noise levels could be argued to be the dominant source of noise. Where a case can be proved, the proponents intend to make residents a prisoner in their own homes, by sealing windows, providing "temporary" upgrades to acoustic insulation with ventilation of rooms. Relocation in well proven cases is an option, but only for the period of most intense noise. Several residents in the portal areas and worksites are elderly, and have expressed concerns about being forced out.

Serious consideration has not been given to the trucks carrying spoil and deliveries once off site. For example, the Traffic and Transport Paper notes that around 1 spoil truck per 30 seconds will use Kingsford Smith Drive/Nudgee Road, either to deliver or return. The noise report bases its noise estimates on about half that number (table 66, page 135 and table 68, page 138, which doubles the volume for the return voyages), and does not account for deliveries such as concrete trucks, precast concrete deliveries, steel, etc. Based on these figures it estimates noise impacts on that route to be insignificant.

Clearly, the noise impacts for residents during construction will be excessive, particularly in the vicinity of worksites. Mitigation measures are recognised in some cases to be ineffective, and the final solution to potentially remove residents. Noise and vibration along truck routes has also been grossly underestimated based in varying truck movements.

### ii) Operational

Noise impacts from the operational aspect of the tunnel have been assessed around vehicles travelling on the traditional routes, vehicles entering and leaving the portals ("echoing" or "funnelling") and the ventilation outlets.

It is well recognised in the Traffic and Transport section of this submission that the EIS underestimates the induced traffic that will be generated from the tunnel. As a result, the noise modelling for existing routes such as Main Street show small decreases in the acoustic environment, regardless of the inappropriate modelling and the fact that freight movements which generate the loudest noise will still use the existing routes. Similar examples exist for other tunnel entry points. The noise environment on these roads would be expected to remain unchanged. Local roads such as Park Road at Woolloongabba is modelled to have an increase of around 65% (3000 extra vehicles) in traffic as a direct result of the tunnel in 2021, but no noise modelling has occurred to advise residents of the impact (table 16, p32). Heavy vehicles have been underestimated to remain static at 5% over the 20 year modelling prediction but freight movements in South East Queensland and through the corridor are increasing year after year. This error also reduces the modelled noise outputs.

- Portal funnelling

Echoing or funnelling occurs when cars enter or leave a portal and is quite distinct form general traffic noise. Trucks exiting the tunnels would be particularly noisy to overcome the incline or by engaging exhaust brakes to decelerate into the tunnel. In some cases the portals are quite near to residences, but the noise report does not fully account for this effect. On the South East Freeway for example, noise barriers are being relocated to facilitate road widening. Residents in this area are already subjected to noise in excess of EPA and Main Roads requirements. It is proposed to bring the barriers closer to affected residents which already overlook the freeway median, decreasing the effective height of these barriers due to the topography. However, the noise report seeks to reuse the barriers without significantly changing the height and further seeks to place the onus on meeting EPA requirements with Main Roads. CATT submits that if a proponent makes changes to the noise environment of a road as a result of new works such as freeway widening and especially tunnel portals, it should be expected to upgrade noise barriers to meet current standards. For Woolloongabba and indeed for many other areas such as Shafston Avenue, this means an increase in barrier height and length in that area.

To further demonstrate, the residences to the eastern end of Park Road at Woolloongabba are already in exceedances of noise requirements as a result of the freeway and Ipswich Road. Bringing the barriers closer to residences and increasing traffic flows will exacerbate the situation. As well, the removal of the ambulance station, which currently provides a solid barrier to road noise from Ipswich Road has not been modelled for impact. No noise barriers are proposed to be put in its place.

- Ventilation Stacks

The southern ventilation stack is proposed to be located in the semi-industrial block of Woolloongabba, near East Brisbane State School, the Gabba, and adjacent to many residences. Noise modelling should be expected to occur at the closest noise sensitive receptor, namely the nearest residence at East Brisbane/Woolloongabba. However, the noise report models the noise from the ventilation outlet at a house that is at least 250 metres away. Closer residences were not considered, including the proposed Gabba Central high density development.

Further, modelling was based on one fan operating with a noise output of around 100dB. At full capacity (refer to M5 East fan operating times, noting that all fans are running most of the time to lift the plume higher and to lower pollution 'in tunnel') 8 fans may be running, with around a 3dB increase per fan, equating to 120dB, or equivalent to standing next to a jet plane. Given that the noise levels at a house 250m away do not meet current EPA guidelines, what effect will occur at closer residences?

- Picking and choosing standards

Finally, the noise report seeks to pick and choose which standards, guidelines or planning levels it should consider to arrive at a figure that comes close to compliance. The most current guidelines which are used to guide noise are the EPA's Ecoaccess Guidelines. The noise report dismisses these as too stringent (they are 10-13dB less than the former guidelines) and not able to be realistically met. CAT considers this to be incredulous and must not be permitted. Guidelines have been developed to ensure amenity and health issues are addressed. To demonstrate:

> *"Refinements to the design, to include attenuation effects of straight duct runs and bends and refined fan sound power estimates, may yield substantial reductions compared with the simplified analysis presented above. Nevertheless, it may be difficult to fully achieve the Ecoaccess noise goals. "… hence it is concluded that it would be feasible for the ventilation outlets to be developed with negligible noticeable noise impact to residents, and in compliance with both the former EPA requirements and the (Brisbane City Council Noise Policy) requirements."* *Operational Noise Paper p56*

As a result of a review of the EIS and supporting technical reports, significant discrepancies and flaws have been uncovered which in some cases, appears to considerably underestimate the noise effects if the tunnel were completed, or, worse still, recommends less stringent, superseded or non-binding levels of noise output.

## 8 HEALTH

### i) Air pollution health risk

The World Health Organisation (2003,p10, uncited) suggests that:

> *The present information shows that fine particles (commonly measured as $PM_{2.5}$) are strongly associated with mortality and other endpoints such as hospitalization for cardio-pulmonary disease, so that it is recommended that Air Quality Guidelines for $PM_{2.5}$ be further developed. Revision of the PM10 WHO AQGs and continuation of PM10 measurement is indicated.'*

Indeed, the National Environmental Protection Council, in a paper to the Australian Greenhouse Office (uncited), has weighted air pollution mortality and costs, noting that $PM_{2.5}$ is

the most significant factor contributing to poor health and associated economic loss when weighted.

> The NEPM for Ambient Air Quality (National Environment Protection Council, 1998) provides estimates of the short-term health effects of the criteria pollutants.
>
> - CO - Loss of 1 day's earning for 50,000 people at a cost of $6 million. (National Environment Protection Council, 1998: p.52)
> - $NO_2$ - 10 to 15% of the population display respiratory symptoms at a cost of $5 million. (National Environment Protection Council, 1998: p. 61)
> - O3 - Up to 10 deaths per year in Australia, with total costs up to $810 million. (National Environment Protection Council, 1998: p.75-76)
> - PM - Up to 2,400 deaths per year in Australia, with an associated health cost of $17.2 billion. (National Environment Protection Council, 1998: pp.122 & 127)
> - In the absence of more detailed information, the health effects related to ozone ($O_3$) are ascribed equally to NOx and hydrocarbons. (National Environment Protection Council, 1998: p. 78)
> - In addition, hydrocarbons have long-term health effects that were examined by Hearn (1998) for Melbourne. If we extrapolate his figures to all of Australia then there are approximately 1250 to 1785 deaths per annum as a result of hydrocarbons (excluding deaths ascribed to the particulate matter in the hydrocarbons).
>
> Insufficient is known about the source of the particulate matter to determine how much of it is attributable to traffic, and how much of the health effects are attributable to traffic. Industry emits particles, but these are generally in the larger size ranges. Present evidence indicates that most health effects result from the smaller sizes below PM10. Traffic emits most particles in the PM2.5 size range. Information on emissions alone does not provide insights into the contribution of traffic to airborne concentration of particles other pollutants will form secondary particulate matter.

These findings demonstrate that $PM_{2.5}$ is the most notable pollutant in terms of health and consequent economic impacts in Australia.

It is interesting that Tim O'Meara of the Woolcock Institute in his study of the health effects from the tunnel quoted Petroeschevsky et al. (2001, p 6) who examined the associations between ambient nitrogen dioxide and particulate levels and hospital admissions for asthma, all respiratory conditions and cardiovascular disease. It is understood that Petroeschevsky found no significant associations between ambient nitrogen dioxide and asthma, respiratory or cardiovascular admissions in any age group or for all age groups combined in single or multi-pollutant models.

However, this study is not consistent with all other studies into the health effect of $NO_2$, especially where it is in association with other pollutants. For example, in Sydney, Morgan et al. (uncited, 1998, p33-4) found an increase in the daily maximum 1-hour nitrogen dioxide concentration from 0.015 to 0.044 ppm was associated with a 5.29% increase in asthma admission in 1-14 year olds. In Melbourne respiratory, asthma, cardiovascular and ischemic heart disease admissions were all significantly related to ambient $NO_2$. These associations were found across almost all age groups.

In considering the health effects of urban pollution, a New England Journal of Medicine study by Gauderman, W.J. et al (Sep 9, 2004) conducted a longitudinal study of children between the ages of 10 to 18. It conclusively demonstrated that the association of $PM_{2.5}$ with $NO_2$, acid vapour and elemental carbon resulted in clinically and statistically significant retardation of lung development and function.

> *Deficits in lung function were associated with a correlated set of pollutants that included nitrogen dioxide, acid vapor, fine-particulate matter ($PM_{2.5}$), and elemental carbon. In southern California, the primary source of these pollutants is motor vehicles, either through direct tailpipe emissions or downwind physical and photochemical reactions of vehicular emissions. Both gasoline- and diesel-powered engines contribute to the tons of pollutants exhausted into southern California's air every day, with diesel vehicles responsible for disproportionate amounts of nitrogen dioxide, $PM_{2.5}$, and elemental carbon.*
>
> *These pollutants are products of primary fuel combustion, and since they are present at similar levels in many other areas (37,38) we believe that our results can be generalized to children living outside southern California. Given the magnitude of the observed effects and the importance of lung function as a determinant of morbidity and mortality during adulthood, continued emphasis on the identification of strategies for reducing levels of urban air pollutants is warranted.*
>
> *(NEJM, Sept 9, 2004, pp 1023-4 and 1066)*

In considering $NO_2$, a similar study in southern California (uncited) stated:

> *'Lung function growth was significantly lower in children who spent more time outdoors in the afternoon compared to those who spent less time outdoors. Thus the impact of $NO_2$ was dependent upon the level of $NO_2$ and the amount of time spent outdoors.'*

This is significant. Child care centres within the inner city area such as on Hawthorne St and even as far afield as the Southbank TAFE child care and the East Brisbane State School will receive plume building strikes on particular occasions. Similarly, child care centres on the north such as the Herston First Steps Centre will be subjected to direct emissions form the northern pollution stack. Concentrated doses necessarily depend on wind direction and speed, turbulence, temperature of the pollution and the ambient air, and the frequent inversions at night during winter. However, these occasions are real and are well documented on an identical pollution stack on the M5 East. Coupled with the emissions that already exist from the linear source of the Pacific Motorway and Ipswich Road, or the Inner City Bypass and Lutwyche Road, as well as the stacks of the nearby hospitals and industrial areas, the ambient pollution in Woolloongabba and Bowen Hills should be considered toxic, with restrictions on the elderly and children living and working within a nominal two kilometre radius of each stack.

Of particular note is that child care centre routines have children playing in the ambient air every day from 7.30am-9.30am and again from 3.30pm to closure between 5.30-6pm (peak hour times). This means approximately 4 hours per day in the ambient air for most very young children under 5 in child care centres in inner Brisbane. The lung development and associated health impacts (pleurisy, bronchiolitis, asthma, etc) of young children near tunnel air exhaust stacks will be at significant risk. The TOR of the EIS is insufficient to document this. Regardless, the EIS air quality reports should have identified this as a significant risk when considering the placement and plume modelling of each ventilation stack.

Sports also may no longer be healthy. Sharman et al (2004) also demonstrated health effects on the cardiovascular system arising from exercising near traffic in Brisbane. And more recently, a Taiwanese study (uncited, reported in Courier Mail, March 2005) has found that the free radicals found in traffic pollution break down the human DNA structure.

Perhaps the most damning facts come from the experiences of residents in Sydney in a radius of about 1 km from the stack there. Modelling and subsequent health assurances were also provided to these residents To date, the local community has had several parliamentary enquiries and numerous reports into why they are suffering a raft of health impacts. Chief among them are issues of odour causing itchy eyes, sore throats, asthma attacks and so on. Human consequences are well reported, including hypersensitivity to odour and health deterioration.

Data has been provided that does not accurately represent the health effects of pollutants known to be emitted from pollution stacks and portals. The real life experiences incurred by the residents around the M5 East tunnel have been ignored; experiences attributable to a poor understanding of the interaction of pollutants and human health. The information presented in the EIS is now being used to cajole the Brisbane community into a false sense of safety regarding the health impacts. CATT considers this behaviour is deplorable when one considers the dire consequences.

With the above factual information before Council and the State Government, any decision must be cognisant of the precautionary principle. Impacts are well known and have now been alerted to the Coordinator General. A decision to proceed will lead to direct health impacts from poor air quality with an expectation that class action lawsuits against the State and the proponent as well as the private operator will ensue from the community at large.

A key difficulty with the existing Terms of Reference for the Environmental Impact Statement, is that information and consequent decisions regarding public health rely on advice from the National Environmental Protection Measure guidelines. These are antiquated guidelines from 1997. There is always a lag from research data to governmental guideline. This lag has the potential to severely impact on health and mortality, particularly the unborn the elderly, the asthmatic and children.

The Terms of Reference do not direct the air quality modeller or the health consultant to include this highly relevant recent information. The advisory NEPM (National Environmental Pollution Measure) similarly is locked into review of $PM_{10}$ standards only. The future population of Brisbane, post 2011 when the tunnel air stacks are operating, will consequently be locked into the conclusions drawn from pre1997 standards of research.

The combination of $NO_2$ with Volatile Organic Compounds and diesel exhaust particulate (DEP) is dangerous during tunnel construction. Air-conditioning offers no barrier to ultrafines and new diesel fleet standards do not address them either. Regardless, the tunnel will not be constructed with new fleet. There is grave danger in the hundreds of truck movements for spoil removal over 4 years from tunnel work depots, particularly in Kangaroo Point and Bowen Hills, as the current fleets will be emitting carcinogenic DEP's in concentrations at the worksites and along the designated routes.

Further, reports from the M5 East tunnel indicate that in tunnel particulate concentrations are such as they are producing in vehicle atmospheres approaching dangerous levels to some occupants. Under current design these conditions will be repeated in the NSBT. Approximately 30,000 asthmatics and some 20,000 others already compromised with respiratory or pulmonary disease are likely to use the NSBT each day (ABS Statistics), many of these at peak times. However, Council remarkably states that:

> *The report has not considered the health impact of the short-term elevated levels of pollutants to which motorists using the tunnel are likely to be exposed. (Health Technical Paper, p11)*

Indeed! It would appear to be the case that the proponent does not choose to consider the health on motorists through the tunnel to be worth noting. It has declared that the tunnel air quality does not need to comply with above ground standards. Clear evidence demonstrates that short term exposures as little as a few minutes may induce asthma attacks, sore throats, itchy eyes and in some cases for regular users, bring on heart problems.

> *Scientific evidence suggests that pollution exposure below these (NEPM) concentrations can affect health and that perhaps no completely safe threshold exists. Also, the cumulative and synergistic effects of pollutants on human health, and the effects of long-term exposure to pollution are not well understood worldwide.*
>
> *Auditor General of NSW, April 2005*

CATT urgently requests the Coordinator General to reject the project on these grounds. .

### ii) Noise

Though not considered at all in the EIS, the health impacts from noise are well documented. Studies that investigate health of residents near major roads have found increased stress related illnesses.

As no studies have been done, it is difficult to comment, except to note that it must be considered as part of the EIS. It must include noise during construction such as blasting, continual high levels of machinery noise and general construction activities over 4 years, as well as elevated noise levels from the proponents failure to commit to effective noise retention barriers and also its failure to even acknowledge the presence of funnelling or echoing as vehicles enter or exit a portal. Residents at the construction site at Park Road as well as Shafston Avenue will experience extreme levels of noise during construction. Further, with the freeway widening expected to bring the lanes closer with no increase or extension of noise barriers, road noise and funnelling around the Park Road area will increase ambient noise levels to in excess of 80dB LaMax.

## 9 HAZARD AND RISK

UNECE (Dec 2004) have published recommendations to be implemented throughout the European Union dealing with safety of the users of motor vehicle long road tunnels. The document resulted from investigations of working parties set up after a spate of serious tunnel accidents involving a great loss of human life and severe economic dislocation. This document provides an overview in particular of the minimum acceptable levels of escape in the event of a fire and accident hazard in either of the NSBT tubes.

### i) Hazards due to terrorist action, accidents and perceived improvements necessary for escape.

Although CATT has no intention of providing a detailed methodology of how to kill several thousands of innocent tunnel occupants using minimum locally obtained resources and at practically no risk to themselves, it is now accepted that in terms of maximum effect in both loss of life and injury followed by severe economic dislocations, electronically tolled tunnels such as the NSBT are probably the easiest targets in the terrorist handbook.

CATT has met with the tunnel proponents, Police and Emergency services together with Federal Police who have specific responsibilities with regard to possible actions by terrorists but regrets that in this regard they have not prevailed upon the tunnel proponents who have refused to provide a more sure and dependable escape from the tunnel solely on the grounds of cost.

The Lord Mayor in a personal communication did however refer to some changes to the tunnel design that will enable trapped tunnel users to shelter underground for a considerable time until

rescue. This type of shelter method has been strongly advised against by UNECE (Dec 2004 p 35) which bluntly states that they should not be built. Several horrifying and distressing accounts of fatalities of people trapped in such refuges by fire before rescue has caused this prohibition.

CATT recommends that a separate fire protected and independently ventilated escape gallery be mandated between the tunnel tubes or along side them and connected at regular intervals to the vehicle tubes for the whole length of the tunnel. Regular connections to the surface could also be achieved. This has been done elsewhere in varying configurations. It has been suggested that the cost of these galleries of a size suitable for Emergency Services requirements might be in the order of $450M. The Federal Attorney General has refused to contribute towards the cost of this extra terrorist protection claiming that the tunnel proponents must be held to be responsible for its provision. The $450M offered by the State Government should be therefore particularly reserved for this cost.

## 10 CONSULTATION PROCESSES

Whilst undertaking a review of the EIS, CATT has been made acutely aware of failures by Council to consult with residents, businesses and professional organisations at a stage where effective change could be made. Council sought to establish Community Reference Groups but then failed to manage any consultation process with fairness and equity. Council has sought to use the CRGs as information conduits, occasionally paying lip service to consultation by asking leading questions. As an example, instead of asking whether a pollution stack should be filtered, Council sought to ascertain what colour it should be.

A tide of complaints have been brought to CATT's attention that serve to demonstrate the political inevitability of the process. Participants in the process were made to feel unimportant and powerless to effect change. As one participant on the CRG meetings complained:

> These half truths and deception that started at the beginning of a process from June 2004 continued throughout the following 5 months.

This leads to CATT's charge of a closed process with no transparency in decision making. To this end, CATT had sought a freedom of information request to review the documents that contain information relevant to all stakeholders in this process, namely the ratepayers. Council has requested that the State Government hold all documentation by calling them into Cabinet. Remarkably, the State has obliged.

This calls into question not only Council's role in this process, but also the State Government's apparent conflict of interest as the decision maker in this process. Consequently, CATT questions the State's ability to be impartial and fair in deciding the fate of the NSBT.

To demonstrate a renewed commitment to the residents of Brisbane, the State must release all documents pertaining to the NSBT and TransApex proposals to CATT and immediately instigate an independent review and the EIS process, including traffic and air quality modelling. Further, it must expand the scope of the study to include the entire TransApex proposal, not a piecemeal development.

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Appendix A

Review of the M5 East Health Impact Studies

Report from Katestone Environmental to Lane Cove City Council – November 2004

Appendix E
REPORT BY PROFESSOR MICHAEL R MOORE, NATIONAL RESEARCH CENTRE FOR ENVIRONMENTAL TECHNOLOGY, ON TOXICOLOGICAL ASPECTS OF THE PROJECTS

(Reprinted with kind permission from Katestone Environmental 14th April 2005)

## Potential Health Risks Associated With The M5 East Tunnel Development

### E1 Introduction and caveats

I have been asked to review the Phase 1 and Phase 2 reports on "Investigations into the possible health impacts of the M5 East Motorway Stack on the Turella community", issued by NSW Health in 2003 and 2004. In particular I have been asked to review the reports from a human health risk and toxicological basis and address whether the different conclusions from the Phase 1 and Phase 2 reports can be recommended. Katestone Environmental has also provided 16 particular questions of concern which I have tried to address later in this report.

Before addressing these questions, I provide below some general comments on odour, annoyance and nuisance, irritation, regulation of odour, community perception, regulatory limits and the measurement or otherwise of potentially key pollutants.

I would note in making these responses that I have neither visited the site nor have the necessary engineering experience to properly evaluate the dispersion models used by the New South Wales Department of Health and CSIRO. I would note however that such models seem to carry the underlying assumption that all materials exhausted from the tunnel pass through the ventilation stack. The plume dispersion from the stack is then critical in any evaluation of modelled pollutant exposures. Consideration of past events shows that this is a simplistic view since in most tunnels including the M5 East tunnel there is strong evidence that pollutants will also often be released from the tunnel portals.
In my experience, high levels of traffic flow usually result in substantial increases in exposure to a number of pollutants. The most important forms of pollutant exposure from traffic relate to the presence of carbon monoxide, particulates, nitrogen oxides, ozone and sulphur oxides. In the past one would also have considered the presence of lead and potentially other metals. I will not mention these further because of the introduction of lead- free fuels. Measurement of carbon monoxide (CO), fine particulate ($PM_{10}$) and nitrogen oxides ($NO_x$) will not give a full descriptor of likely health impacts on humans and does not take into considerations the likely presence of unburnt hydrocarbons.

I note that the original complaints from local residents includes mention of various types of odours (e.g. rotten eggs, burning rubber, diesel fume, dusty, metallic, kerosene smells) that are not associated with the measured pollutants of CO, $PM_{10}$ and $NO_x$. A smell and symptom diary was completed by 25 of the 54 participants in the Phase 1 study - section 4.3 of the Phase 1 report gives little analysis of this information apart from confirming that symptoms are worse on still days and, unsurprisingly, between peak hour morning and afternoon periods. The Phase 2 questionnaire included only four very general questions on odour (Q50 on how often do you notice odour or smells from outside sources when you are at home or in your yard, Q50a on how much you are annoyed by the odour/smell, Q51 asking whether certain chemical odour or smells regularly make you unwell and Q52 asking whether you have ever been diagnosed with a chemical sensitivity). Odour complaints are often associated with short-term (acute) health impacts. As the Phase 1 study found that "odour was also an issue of major concern, most participants did notice odours and found them quite disturbing" and at least an annoyance

and that “the M5 East stack was identified as the main source of these odours”, it is very relevant to consider odour issues in some detail.
The key to understanding the sense of smell is to understand the way in which our brain interacts with all of our senses and, in this case, the sense of smell. The sense of smell is an extension of the brain itself into the atmosphere of the nasal cavity. It is able to detect many thousands of chemicals and combinations of these chemicals at extremely low concentrations over very short time intervals. It is not merely detection - that takes place once the brain is involved in the process. The perceived raw information is identified, compared to previous smell events, stored in memory and given a descriptor and meaning.

E3 Annoyance and Nuisance
All persons arrive at distinctions between pleasant odours and unpleasant odours by a complex process, which ultimately provides us with definitions on annoyance and nuisance:
- Annoyance is a complex of human reactions that occurs as a result of an immediate exposure to an ambient stressor, in this case, odour, that once perceived causes negative cognitive appraisal and requires a degree of coping.
- Nuisance is the cumulative effect on persons caused by repeated events of annoyance over an extended period of time that leads to modified or altered behaviour.

Nuisance can have a detrimental effect on a sense of well being and hence a negative health effect. Nuisance occurs when people are affected by a smell that they perceive in their living environment whether it be home, work or recreation where:
- appraisal of the odour is negative
- perception recurs repeatedly
- there is difficulty in avoiding perception of the smell
- odour is considered to have a negative effect on well being.

E4 Classification Of Odours and Irritants
Odours and Irritants generally predominate in one of two categories as determined by their water solubility and the nature of the physiological response to them. Highly water-soluble chemicals, such as ammonia, sulphur dioxide, and formaldehyde, readily dissolve into the aqueous, mucus fluids of the upper airways (especially the nose) and typically elicit sensory discomfort, hence their classification as ‘sensory’ irritants. Pulmonary irritation, the second general type of irritant response, usually occurs when less water-soluble chemicals (e.g. ozone and nitrogen dioxide) deposit and invoke their primary stimulus in the peripheral lung.
An appropriate classification of potential irritants is based on the acceptance that irritant compounds are either acidic or basic in the most general sense. Water solubility characteristics also impact on irritancy and the site of action on mucous membranes.

Although often associated with irritancy, olfactory sensation is not a necessary component of the nasal irritant response. Sensory irritation, also called pungency, is one of the factors prominent amongst the symptoms associated with polluted indoor air. It is notable that, in persons with no sense of smell (anosmics), pungency thresholds decrease

with the size and the carbon-chain length of aliphatic compounds. There is also a strong linear correlation between pungency threshold and saturated vapour concentrations, so that sensory thresholds decrease systematically with increasing carbon chain length. Agonistic effects increase with the number of components and lipophilicity.

Pungency thresholds, but not odour thresholds, show a uniform linear relationship of the saturated vapour concentration (with the slope close to unity), irrespective of the chemical functionality or carbon-chain length. This suggests that pungency from non-reactive airborne chemicals is heavily dependent on relatively unspecific physical interactions with susceptible biophases. Selective transport can account for 77% of odour detection thresholds. The remainder is due to specific size effects which may involve odour-binding proteins and a specific effect for aldehydes and carboxylic acids.

E6 Regulation Of Odour

The control and management of odour is difficult for planners, regulators, industry and the wider community because the impact of odours depends on differing sensitivities of different people and because odour levels vary significantly with alterations in meteorology. Although many are attempting to address this, the current measurement of odour is difficult and this has a direct bearing on the ability to provide a reliable measure of odour in respect of planning and regulations in relationship to odour. The measurement of odour by Dynamic Olfactometry has been standardised (AS / NZ 4323.3:2001 Stationary source emissions. Part 3: Determination of odour concentration by dynamic olfactometry) and has a defined capability (uncertainty). The effects and assessment of odours especially the psychometric assessment of odour annoyance has also been addressed by questionnaires developed by the VDI (1997) in Germany. Their approach to the matter describes investigative methods to determine the existence of possible annoyance due to odour-intensive substances. Their understanding of the matter is that, with annoyance parameters defined, it should be possible to:

- Classify the annoyance situation
- Identify differences in annoyance between affected zones and control zones
- Determine the variation in the annoyance effect from the relationships (response curves) between annoyance and ambient odour.
- In combination with emission measurements and calculations of dispersion, ascertain the amount of effect as a means of checking forecasts.

Most of the current Threshold Limit Values (TLVs) used in occupational health assessments are based on complaints of irritancy and discomfort (usually in the workplace). Irritants generally predominate in one of two categories determined by their water solubility and the nature of the response to the odour.

E7 Community Perception

The complex interactions of psychological phenomena together with odour perception, consequent annoyance and nuisance are sufficient to result in amplification of the perception of health impacts associated with odour. Previous studies dealing with this have shown there is a clear association between these two; there is consequent stress on the persons exposed to the odour. In that respect, the most rational way to deal with

community perceptions is through telephone surveys but these suffer substantially from selection procedures, particularly the substantial difficulties in identifying impacted sections of the population including a clear identification of those who are experiencing the greatest exposure as opposed to those with much briefer periods of exposure.

As noted previously, the areas that would be of greatest interest in respect of the M5 East Tunnel would not only be those likely to be influenced by stack plume exposure but also those adjacent to the portals to the Tunnel. There are some difficulties establishing likely levels of exposure because of the large number of variables that have to be evaluated (e.g. how often and when stack and portal emissions occur, how to model the aerodynamics and complex nature of stack and portal emissions). The predicted outcome of exposure to this suite of pollutants has to be consistent with the reported experiences of the residents and workers adjacent to the Tunnel. On the basis of concentrations and odour thresholds, it is unlikely that any one agent or combination of agents could be either causally or directly associated the odour or irritation reports.

E8 Regulatory Limits

Most of these compounds addressed in the M5 East air quality monitoring occur at ambient concentrations within regulatory limits. If the ventilation stack is indeed the source of the offending odours, this suggests that the composite effect of the volatile organic compounds such as unburnt hydrocarbons, together with the other components of the pollution are the likely descriptors of the odour events. It has previously been shown that, in such circumstances where the concentrations of individual components in the mixture of pollutants are small and odour detection limits are unavailable, there are other ways of describing contributions to odour. The model described in the paper “Use of partition models in setting health guidelines for volatile organic compounds” by Hau, Connell and Richardson (2000, Reg. Toxicol. Pharmacol., 31, 22-29) is of interest since it proposes that emission by weight of the total composition of the mixture will describe the smell.

This type of evaluation suffers from the need to time average measurements over relatively short periods. Critically, perception of odour is a very short time based phenomenon, substantially shorter than the normal time base involved in measurement or modelling of pollutants. All the regulatory limits for such pollutants are based on time averages substantially longer than the time for odour perception which means that the fluctuation in the concentrations of the various pollutants is disguised by the time averaging. Gaseous components and the particulate components of the pollution measured over very short time intervals (say less than one minute) will provide peak values which are many fold greater than the mean. Comparison of this type of data provides one with what is termed the peak-to- mean ratio, i.e. the ratio between the average value over a given time period against the peak values which are measured in the same time period. It would not be unusual in these circumstances for an elevated release to find peak-to-mean ratios greater than fifty to one.

Short exposures can be directly related to the perception of smell in the right conditions of humidity and to irritation of mucus membranes. This matter is difficult to deal with

because the measurements taken show that most of the pollutant concentrations that have been measured lie within regulatory limits.

E9 Pollutants

The presented data show that a number of important pollutants are not being measured, such as ultrafine particulates and fine particulates in the presence of volatile organic compounds. The health consequences of these exposures have to be predicated upon the actual concentrations of pollutants in the plume. Regrettably, regulations have to be couched in considerations of impacts of individual pollutants. In real life situations one is always dealing with mixtures of pollutants. It is the health impact of these mixtures that have to be considered. The risk factors for the mixture will differ substantially from the individual pollutants. One also has to remember the fugitive nature of volatile and gaseous materials and the absence of measured concentrations at the time of the various health impacts. Since these are not measured concurrently any consideration of prevalence rate ratios is futile. Though there are obvious economic and other factors associated with the timing of experimental work confining any evaluation to a short time period, four weeks in a year is hardly likely to give a representative evaluation of the likely kinds of pollution that would occur for the whole year.

E10 Answers to particular questions

In response to the various questions posed, I make the following notes:

1. From experience, what types of pollutant exposures could be responsible for the symptoms reported by the local residents and investigators in the Stage 1 report?

   From my experience, a wide range of different compounds could be responsible for the features experienced by those reporting symptoms associated with Tunnel emissions. These would include the particulates, nitrogen oxides and non-methane volatile organic compounds listed in the Phase 1 report. In addition to this, one would expect that there would be impacts of sulphur oxides, ozone and ultrafine particulates. Recent work in Queensland has strongly suggested that odour annoyance can be associated with short-term peaks in ultrafine particulate concentrations (when conventional concentrations of single pollutants do not suggest a major problem).

2. Are the reports of odour and physical discomfort possible results of exposure to tunnel pollutants, even though the monitoring of CO, $PM_{10}$ and $NO_x$ do not apparently show readily identifiable plume strikes? Are other pollutants likely to be of significance?

   The reports of odour and physical discomfort reported by respondents are a potential consequence of exposure to these pollutants. These do not need to be associated with unusual plume strikes. Normal dispersion processes will result in large fluctuations in the peak-to-mean ratios of these pollutants on a much shorter time basis than have been used in either the modelling or direct measurements on site.

3. Given the reported symptoms, what comments do you have on the relevance and efficacy of the health investigations of Phases 1 and 2?

The manner in which the studies have been carried out make it difficult to link exposure with self-reported symptoms. Measurements have largely been modelled from the telephone questionnaires undertaken to provide information which will inevitably be biased by those who believe they are impacted by the presence of the stack. No assessment of portal emissions have been included and there was no attempt to link observations to times of maximal exposure (rush hours). In addition to this, the relatively small number of subjects in Phase 1 would be unlikely to have sufficient power to show statistical differences between the various degrees of subject exposure. Both studies lack control groups who would be unequivocally unexposed to stack emissions.

4. Given the reported symptoms, what other issues are of importance in determining possible causes of the residents' responses and in recommending a suitable course of investigation and action?

There are two probable sources of bias that might distort the results of the studies. Selection bias occurs when one is dealing with telephone surveys although the investigators have taken appropriate measures to avoid this. Another source of bias would be measurement bias associated both with the measurement of the pollutants of the stack and the measurement of effect during questionnaire evaluation. Constraining the reporting of symptoms to four previous weeks at time of questioning is extremely restrictive in respect of likely meteorological changes and variations in traffic flow for a relatively short time period. Social aspects of exposure have not been considered in either of these studies.

5. What evidence is there elsewhere for temporary health ailments due to traffic pollutants at the levels likely to be due to the tunnel ventilation stack? How will community or individual stress influence the response of different types of people?
I have alluded previously to very large fluctuations in concentrations of pollutants over short time periods. This could be associated with brief acute effects of individual pollutants such as sulphur oxides and more importantly with the establishment of nuisance and outrage associated with the presence of odour associated with traffic activity. Formation of pressure groups in the community are a clear indicator of the reinforcement of response by the affected individuals in the community and with consequent reinforcement of individual stress associated with this outrage.
6. What variation in pollutant-sensitivity would be expected in the Turella community; would this change over time with sustained community awareness?

It is hard to judge how the community will react in the long term, in response to continued exposure to these pollutants. Sustained community awareness was almost certainly a matter at the forefront of the community's thoughts. When pressure groups were formed it was likely to be translated into demands for action.

7. How would you summarise and critique the findings of the Phase 1 report? How should these findings have influenced the design of the Phase 2 study – if findings were omitted, are they important? What are the available options for an "analytical study

with the aims of determining whether or not there is a real association between residential location and symptoms"? Is residential location the only important factor?
The primary criticism of the Phase 1 report was that limited numbers were involved and there was no satisfactory comparator group. This makes it difficult to judge whether or not any real effect is or is not taking place. There is particular concern in the lack of any form of exposure measurement as well as exposure modelling. Residential location is not the only determinant of likely effect since in this area there are a number of workplaces in which people are likely to be exposed to pollution as much as those within residential accommodation. Furthermore there is no attempt to correlate observed effect with the times of peak traffic flow. As the work is carried out on the basis of time-averaged information it is unlikely to be able to discriminate the effects of very short exposures to pollution. Another criticism of the study would be that the selected persons had different age demographics to those in the general population. There was a clear excess of older women. Finally there is no tying of the participant's location to pollutant concentrations at that location, meteorological conditions and the likelihood individual exposure at the time of the study. In defence of the study the authors clearly state that this is an exploratory descriptive study attempting to do what was possible with the available information and does not attempt to define exposures in a rigorous fashion. For this reason, the conclusions of the Phase 1 study are appropriate and led to Phase 2 study.

8. Is the Phase 1 literature review apt and comprehensive?

Section 5 of the Phase 1 report contains an impartial discussion of the main results and uncertainties and gives a good discussion of relevant Australian and international research. It notes the similarities to "Sick Building Syndrome" symptoms and discusses whether "health effects on eyes" can be associated with the cumulative effects of low levels of pollutants. The work of Shiffman on linkages between odour and health impacts is briefly covered, and the interaction of adverse health symptoms with environmental concern or worry is noted. The Phase 1 discussion ends with a reasonable suggestion that:

- a suite of objective and subjective eye irritation investigations, along with use of previous prevalence studies, opens the possibility of quantifying any effect of pollution in this area.
- environmental monitoring of volatile organic compounds, particulates and odour would be advantageous for future studies.

9. Does the Phase 2 study report have justification for the assertion of "best feasible epidemiological approach to determining if there are population health effects from the M5 East stack emissions"?

This is a self-reported quality statement for which justification is not provided. The study appears to have had only an internal reference group and steering committee and no outside review process is apparent.
There will always be dissent amongst epidemiologists about best ways of carrying out studies. The exploratory study in Phase 1 was as good as could be expected. The Phase 2 telephone survey was carried out rigorously but, like all cross-sectional telephone studies, has difficulties with effects on a population subgroup of the community. It is

likely that the effects seen in this subgroup will be greatly diluted by unaffected members of the population.

10. Was the determination of impact zones a reasonable approach to identifying spatial variability of the identified odour/health complaints?
    Critical to this argument is the means by which exposure has been estimated. Also critical to this is the outrage factor associated with the psychosocial impact on health and wellbeing of people who are impacted by the presence of fume from the tunnel.

    It is difficult to see that modelling of impacts is going to provide an adequate assessment of environmental exposure to traffic fume. Models of this nature can produce reliable long-term information related to exposure but in general are seldom able to provide information of verified reliability in dealing with shorter term individual exposures. This is particularly true when dealing with the complex topography and meteorological patterns of this site. I am not competent to comment on the models and merely observe that real-time measurement is usually more reliable to establish individual exposures.

11. What are the strengths and weaknesses of a telephone survey to identify pollution-sensitivity of any member of a selected household? Does random selection of a general population make sense when dealing with sensitive or stressed sub-groups within a community?

    The major strength of a telephone survey is that large numbers of persons can be accessed in a random fashion across a community. A weakness is that it will not necessarily identify those persons in the community who are abnormally sensitive or idiosyncratically affected by certain forms of pollution. Toxico-genomics states that, within any community, it is likely that ten percent will have abnormal reactions to certain types of pollution exposure. From that point of view a case-control study might have been seen to be a more satisfactory way of approaching this problem epidemiologically. This would involve, for example, looking at a number of affected people and suitably-matched controls well away from the stack, tracking their exposure dosages to the pollutants, establishing and looking for any statistically-significant relationships between health endpoints and pollutant dosage.

12. Are the questions on odour (Q50-51) and on eye/throat/mouth symptoms likely to provide useful information on pollution-affected conditions? Should other questions have been included?

    Another failing of telephone questionnaires is that they have to be reasonably brief. Questions 50, 51 and 52 are appropriate but necessarily short to accommodate all of the other questions that have to be asked in the allotted time.
    The same applies to other questions relating to the definition of likely exposure and the use of other measures of effect.

13. Are the epidemiological procedures used particularly sensitive to underlying assumptions such as “low impact zone”, use of dry eye prevalence etc?

It is likely that a better definition of low or no stack impact zone would have given less debate on the findings. The use of more specific indicators for odour exposure would probably have allowed a better tie-up of Phase 1 and 2 results.

14. Can a layperson explanation be given as to how the adjusted prevalence rate ratios in Tables 5,7 and 9 being typically 1.15-1.20 for the high zone relative to the low zone can be interpreted as "no evidence of an association between zones and symptoms".

    Information contained in Tables 5, 7 and 9 shows that, for the persons evaluated in the study, there is complete overlap in confidence intervals between each of the zones involved. The manner in which the studies have been carried out have been unable to identify any such difference. There needs to be better explanation of these datasets.

15. What assumptions are made by confining the Phase 2 investigation to a single 4-week period?

    Confining Phase 2 investigations to a single four week period makes the assumption that this four week period was representative of likely meteorology and traffic flows over the rest of the year. This is probably incorrect but the study is necessarily restricted to four weeks for obvious practical and economical reasons.

16. Are the study methods consistent with recent WHO reports such as given in the recent summary "Health aspects of air pollution" (June 2004).

    The World Health Organisation in its report to the meeting in January 2004 quite clearly brings out many of the factors that I have referred to previously in my comments. This includes inter-relationships between short time exposure and acute effects and the variation between 'hot spots' of pollutant exposure and background exposure. I also draw attention to the likely impacts of particulate-related health effects and the need to understand the precise nature of the particulates - both the composition and size where ultrafine particulates are likely to have the greatest effects upon health. The WHO document also points to the need to consider specific population groups who are potentially more vulnerable to the effects of exposure to pollutants, including genetic predisposition and acquired susceptibility to the exposure to pollutants. The WHO document refers to air pollution in a general sense and not in the specific sense of pollution generated by traffic.

    Professor Michael R Moore
    13 October 2004

Appendix B

# Inquiry into the M5 East Ventilation Stack (2001)
# CSIRO Submission to General Purpose Standing Committee No. 5 of Parliament of NSW Legislative Council

(Reprinted with permission from CSIRO 14th April 2005)

# Submission to General Purpose Standing Committee No. 5 of Parliament of NSW Legislative Council

## Inquiry into the M5 East Ventilation Stack (2001)

Committee Chair, the Hon. Richard Jones

Dear Mr Jones

At your invitation, and as a coauthor of the CSIRO review report to DUAP on "Air Quality Impact of the Emissions from the M5 East Tunnel", I would like to make the following submissions relevant to Term of Reference (a)

"The implementation of the recommendations of the General Purpose Standing Committee No 5 report on the Inquiry into the M5 East Ventilation Stack; the International Tunnel Ventilation Workshop, Sydney Australia 7–9 June 2000; the CSIRO and Department of Urban Affairs and Planning conditions of approval for the M5 East Ventilation Stack;"

I propose discussing

- The location of the vent
- Vehicle emissions determinations and the CSIRO review for DUAP
- Modelling results and the CSIRO review for DUAP
- The CSIRO recommendations on vent height and impacts and
- Monitoring for performance assessment.

### Location of Vent

Good environmental practice would never locate a pollution chimney in the bottom of a valley surrounded by residents. This is particularly so when the temperature of the emissions is close to that of the valley air temperature and the release velocity is low (and so the emitted pollutants do not rise very high into the atmosphere before dispersing back to ground level).

Figure 1, taken from the soon-to-be released Australia State of Environment 2001 chapter on The Atmosphere (coauthored by myself) shows in an extreme way, the kind of problem that occurs when pollutants are released into valleys.

**Figure 1: A sketch of pollution in a valley on a clear calm night. Drainage of cold air and radiative cooling of the valley leads to trapping of pollutants from vehicles and wood fires.**

### Vehicle Emissions Determinations and the CSIRO review for DUAP

There are very many issues regarding the emissions data used by the Hyder consultants for the design of the tunnel and the vent. I mention three key issues here, which indicate that emissions are likely to be higher than those used by the consultants.

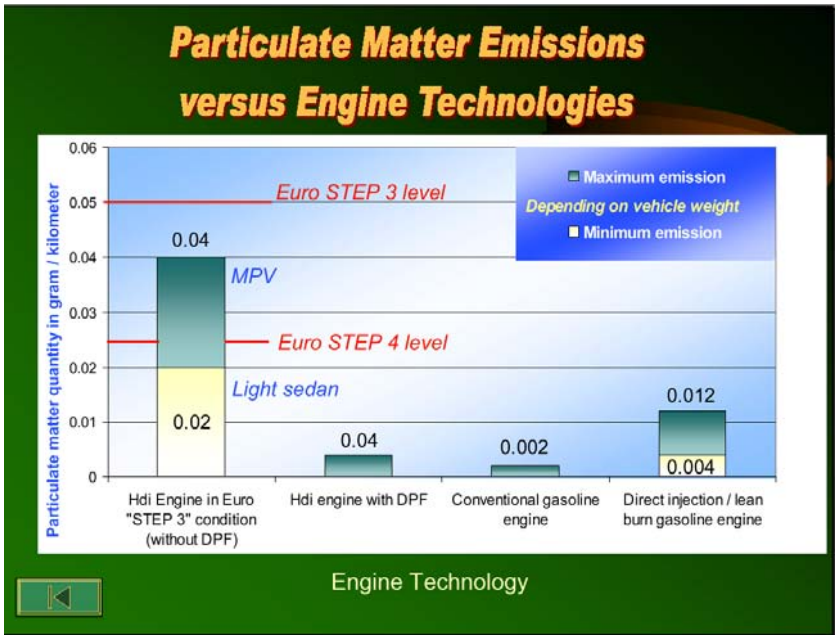
First, in its review for DUAP, CSIRO noted the large uncertainty in the emissions data employed by the Hyder consultants to demonstrate compliance with ambient air quality requirements imposed by EPA and DUAP. In particular, CSIRO drew on recent data from Parsons on particle

emissions from in-use diesel vehicles. These data were obtained as part of a project to develop a National Environment Protection Measure for Diesel Vehicles. Preliminary analysis of some of the data suggests that emissions from vehicles operating at full load may be two or more times higher than given by the PIARC methodology employed by Hyder consultants. This is particularly important because of the expected high usage by diesels trucks of the tunnel, and because the tunnel grades near exit are around 6%, which will require these trucks to operate at full load there. It should be emphasised that this conclusion awaits confirmation from more detailed data analyses.

Secondly, there are questions about light duty diesel trucks, which are mostly Japanese and so do not have any effective particle emissions restrictions imposed on them. This was highlighted in a submission to DUAP from EPA where they said "Recent emission testing data indicates that in-service emission levels of Japanese vehicles are much higher than European and US vehicles in similar model years [the same Diesel NEPM work mentioned above]. These Japanese vehicles dominate the import market of diesel cars and light-duty commercials." PIARC does not account for Japanese vehicle types.

Thirdly, the future emission estimates used by the Hyder consultants do not account for the likely trend in petrol vehicle technologies. There is a strong move toward GDI (gasoline direct injection) vehicles to meet required reductions in fuel consumption and NOx emissions. However GDI technology has an inherent problem of much higher particle emissions than multi-point injection — particle emissions are four to six times as high (see Figure 2 from Tokyo City Government Conference 2000- Say '*no*' to

**Figure 2: Particle emissions comparing GDI (right) with conventional multi-point fuel injection petrol engine and diesel engines with DPF particle combustion promoter.**
**http://www.kankyo.metro.tokyo.jp/dno/forum/01/ps.pdf**




Diesels; and SAE paper 2000-01-2017 to US Diesel Emission Control-Sulfur Effects Program Conference, 2000). As diesel emissions are reduced by imposition of Euro 3 and Euro 4 standards over the next five years, particle emissions from petrol vehicles are likely to increase. So much so that any hoped-for reduction in overall vehicle particle emissions may be cancelled out.

These points are made primarily to draw attention to the large uncertainties in the emissions estimates employed by RTA and the Hyder consultants, and therefore the expected air pollution consequences, for the M5 vent. Further, the uncertainties are mostly towards higher emissions and therefore higher air pollution consequences.

## Modelling Results and the CSIRO review for DUAP

CSIRO was asked by DUAP to review both the physical (wind tunnel) and the numerical modelling undertaken by Hyder consultants for RTA for the M5 vent. We found that the physical modelling was not very relevant since it could not be done at the necessarily low wind speeds when high ground level concentrations were expected. We also found that the numerical modelling, while in principal adequate for the task, made several assumptions that led to overpredictions of air pollution effects but combined highly uncertain background concentrations in such a way as to likely underpredict the cumulative air pollution effects.

## The CSIRO Recommendations on Vent Height and Impacts

CSIRO noted in the review that particle concentrations in the vicinity of the M5 vent were occasionally high due to sources unrelated to the vent. All the modelling results from the Hyder consultants showed that the highest cumulative concentrations would occur when the vent contribution was small, less than 5% contribution. Even after doubling or trebling this contribution, the vent emissions are not the major expected sources on high pollution days, and in any event, vent height is not greatly important since the standards to be met for particle concentrations involve a 24-hour average and the plume from the vent moves around a great deal over the course of a day.

However for oxides of nitrogen, the maximum cumulative concentrations and the maximum expected vent concentrations, according to the Hyder consultants, were all large, of order 50% or more of the ambient air quality standard. Information provided to CSIRO during the review showed that almost all of the highest predicted nitrogen dioxide levels due to emissions from the vent are expected to occur in light winds in the middle of the evening when traffic levels in the tunnel, and hence fan speeds in the vent, are reduced. Since the air quality standards for nitrogen dioxide involve a 1-hour average, relatively short-term conditions are important in meeting the requirements for nitrogen dioxide.

Compounding this problem is the fact that the top of the vent is below the level of many houses to the north and south. In the night-time light wind conditions mentioned above, the plume height and plume dilution are both low, so residences could be struck directly by the plume. To avoid this problem, the CSIRO review to DUAP recommended increasing the plume height by boosting the fan speeds in the vent at these times and in these wind conditions.

## Monitoring for Performance Assessment

Because the ambient air quality standard for particles involves an averaging period of 24 hours and the wind changes direction frequently, it is unlikely that a location in any particular direction from the vent will be more suitable than any other for monitoring an exceedence for this pollutant. Height above vent base may be a determinant.

However, for nitrogen dioxide, the standards require concentrations to be acceptable for averaging periods of an hour. Monitoring for maximum values is therefore feasible for nitrogen dioxide (really, nitrogen oxides), although it must be recognised that the likelihood of measuring the maximum concentration by monitoring at a particular place downwind of the vent is highly unlikely since it occurs at a place only once every 8760 hours.

RTA has located two monitoring stations to the north and north east of the vent for the purpose of monitoring for an exceedence of the standards, guided by the modelling which predicts the highest concentrations in these directions. They seem to believe they are monitoring for particle exceedences and discount the possibility of monitoring for high nitrogen dioxide levels (stated in answers to questions raised by AQCCC member Joanne Jones and received 2 April 2001). However in Working Paper WCR040-C they, through Hyder consultants, reverse this by proposing locating a monitoring station according to “the stack contribution of $NO_2$.”

RTA is required to “establish a protocol outlining procedures for deciding how an exceedence due to the stack will be determined” (Condition 73.4 of Schedule 1 of Conditions for Approval 23 August 2000). I understand that no such protocol has been presented to the Air Quality Community Consultative Committee, nor has a rationale for the selection of monitoring sites

except for brief references. Since the AQCCC is to oversee the running of at least one other monitoring station (Condition 73.6) and has been asked to select a site for this monitoring, these are very important pieces of missing information.

My experience is that monitoring the air quality effects of the vent would best be done by locating the additional monitoring station in a wind direction that is common in conditions conducive to high concentrations. Such a location might not be the direction of the maximum expected concentrations, indeed it need not be. It is more important that the plume be measured frequently enough and in such a manner that it is unambiguously identifiable. Then comparisons with model predictions and scaling the results to extreme conditions can be done with some confidence. The result would be a meaningful determination of the performance of the M5 vent and a confident expectation of maximum impact, whether or not this is an exceedence due to the vent.

The clear implication from the above discussion is that monitoring to the west of the vent or at distances greater than a kilometre, as was proposed by RTA in practically all their suggestions to AQCCC in Hyder working paper WCR040-B, is not relevant to the issue. The meteorological conditions for impact in that direction and at these larger distances are quite different to those relevant to the highest concentrations due to the vent. Furthermore, any impact to the west of the stack would be confounded by emissions from Sydney airport.

Since light evening winds are more likely to be northerlies than southerlies in the region (due to turning of the sea breeze from Botany Bay during the evening), and the terrain near the vent is high both to the south and to the north, it appears that an elevated close monitoring site to the south or south south west of the vent would provide a useful watch on the operation of the vent, and would complement the RTA stations to the north and east north east. Such a suggestion was evidently put to RTA by AQCCC in late March. The lay community cannot be expected to make expert judgements on such a matter and need sound advice from RTA and their advisors. It seems that such advice may be lacking.

Peter Manins
Chief Research Scientist
Leader, Atmospheric Pollution Program
12 April 2001

Appendix C

# Air Quality Impacts of Air Emissions form the M5 East Tunnel

CSIRO Investigation Report ET/IR304R
(reprinted with permission from CSIRO, 14th April 2005)

# INVESTIGATION REPORT ET/IR304R

# AIR QUALITY IMPACT OF THE EMISSIONS FROM THE M5 EAST TUNEL

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# Air Quality Impact of the Emissions from the M5 East Tunnel

## CONTEXT and CONCLUSIONS

DUAP has requested CSIRO to advise:

1. whether the procedures and data used by Hyder Consulting to assess the air quality impacts of emissions from the M5 East tunnel vented through a single stack at Turrella are appropriate;
2. if the procedures and data have been used appropriately;
3. if the conclusions in the report are credible;
4. what stack height is required to meet the air quality goals;
5. other considerations.

We advise that, based on the information in the main Hyder Reports (2000a, b), further information supplied informally, and supplementary reports on modelling using 1998 meteorology (Hyder 2000c) and air quality modelling for incident management (Hyder 2000d) that:

1. The methods employed by the Consultants are appropriate for making an assessment of the impacts of emissions.
2. There are a number of points that we have not been able to satisfy ourselves about in reviewing the procedures employed. We believe the estimates of emissions are reasonable except for particles, which may be underestimated by a factor of two or more. We also believe the reliance on the wind tunnel results to support a claim that the numerical modelling is conservative, has not been justified.
3. The Hyder Reports conclude that predicted ground-level concentrations are below the Air NEPM Standards. We believe this may be the case for nitrogen dioxide if stack height and efflux velocities are appropriate (see point 5), but although the modelling shows that $PM_{10}$ Standards are not exceeded, it is possible that at other times this may not be the case, principally because background $PM_{10}$ levels are occasionally high, and because the emissions estimates used by Hyder Consultants may be too low. These exceedences may occur irrespective of the stack emissions, which, in principal, could increase the number of potential exceedences.
4. The 1998 background data for $PM_{10}$ and $NO_2$ show generally similar peaks to those observed in the 1995 data, except for the maximum $NO_2$ value of 180 µg $m^{-3}$, which is substantially greater than the highest 1995 value of 136 µg $m^{-3}$. This indicates that conclusions based on Hyder's 1995 modelling may underestimate the potential for exceedence of the NEPM goals for $NO_2$. An unexplained feature of the 1998 glc predictions (Hyder 2000c) is that the highest stack contributions to $PM_{10}$ levels are about 30% lower than those predicted using the 1995 meteorology. Although the results of modelling 1995 and 1998 are broadly similar, it must be noted that, there are data for other years that show higher concentrations, particularly for $PM_{10}$. As high $PM_{10}$ is often associated with bushfires, some allowance is made in connection with exceedences. Nevertheless, some numerical modelling for these higher background occasions may provide a better estimate of the likely frequency of exceedence over a number of years.
5. In order to prevent exceedence of the $NO_2$ goal, which is predicted when using a conservative method for including background concentrations, we believe that the effective plume height needs to be increased in light wind conditions. This can be achieved with a higher physical stack height (i.e. 35 m or higher) or the use of enhanced stack exit velocities at night (i.e. at hours 20-23) or a combination of both. For example, it has been shown that if stack exit velocities were to be increased for these hours (see Section 8 for details), then maximum ground level concentrations of $NO_2$ at these times would be below the guidelines, even for the 25 m stack height, and when using a conservative approach to inclusion of background concentrations. This may also reduce the frequency of $PM_{10}$ exceedences.
6. We also believe the possibility of plume strike on tall buildings needs to be taken as a serious possibility and that building height restrictions be imposed in the region following modelling studies.
7. If further numerical modelling is undertaken, we recommend that the influence of thermal buoyancy and fan speed on plume rise should be included and that the background concentrations and plume strikes should be combined stochastically.

These conclusions are supported by the review presented here. In preparing it, we also have attempted to address residents and other citizens concerns raised at a meeting with DUAP on 14 June. This is largely achieved through a discussion of the inherent uncertainty in the estimates of ground level impacts from the Turrella plume.

Issues such as

- the adequacy or otherwise of the air quality goals
- the suitability of the stack location
- the advisability of treating the ventilation air to reduce emissions

were not included in the scope of the current review.

## Introduction

The Hyder Reports (2000 a, b) present an impact assessment of the performance of the Turrella stack based on a modelling simulation using a numerical model called ISC3, a widely used numerical air pollution model from United States Environment Protection Agency. The results are supported by a physical modelling simulation performed in the Monash wind tunnel. The Reports develop the modelling assessment by dealing with each of the components described above. Here we review each of the components and reach conclusions about the appropriateness of the assessment presented in the Hyder Reports. An assessment of the information contained in the supplementary reports (Hyder 2000c, d) is included in the relevant sections of this review.

In arriving at estimates of ground level concentrations (glc) of pollutants, whether by physical or numerical modelling, there are a number of essential components that need evaluating:

- the estimates of traffic volumes
- the estimates of traffic emissions
- the emission flux from the stack to be located at Turrella
- the emission buoyancy flux from the stack
- the stack height
- terrain features
- meteorology
- background ground level concentrations.

Some of these components have a diurnal variability associated with them such as emission flux and the meteorology, others may have an inherent uncertainty, such as the emission flux and background $PM_{10}$. Some, such as background glc and traffic volumes and emissions are likely to vary over the years. In addition, assumptions that are inherent in the simulations to model the real world introduce further uncertainties.

The sections include:

- A review of the Hyder Reports' estimates of the emission flux from the stack by considering the estimates of traffic, the traffic emissions in the main M5 East tunnel, and the expected change in temperature of emissions due to the flow of hot exhaust gases through the 700 m long lateral tunnel to the Turrella stack.
- A review of the numerical modelling presented in the Hyder Reports, considering the meteorology used for the modelling, choice of background pollutant levels, terrain features and consideration of plume strikes on homes and tall buildings that might be located in the region.
- A review of the physical modelling presented in the Hyder Reports, which was said to be more representative of the real situation than the numerical modelling and therefore showing that the numerical modelling has a substantial factor of safety built into it.
- A statement of overall conclusions and recommendations to DUAP.

## The Emission Flux

Estimation of the emission flux of a given pollutant at any time requires knowledge of the number of vehicles within the tunnel of each of the major engine and exhaust treatment technology classes, their speed, and their characteristic exhaust emission fluxes for the specified speed and grade along the tunnel.

### 2.1 Traffic Estimates

Hourly estimates of traffic in terms of passenger cars, LCVs, articulated and rigid trucks have been provided by the RTA. RTA advises that the M5 East tunnel will be managed as a component of the road network instead of being managed in isolation. From when the tunnel opens, traffic is expected to be near capacity. Maximum capacity of a single lane is ~ 2500 vehicles per hour (vph), hence a maximum total flow of ~ 5000 vph can be accommodated in the tunnel in any one direction. At 0700h, the number of vehicles, eastbound, is estimated at 4116 vph according to the Hyder Reports, and this is indeed close to design capacity. The number of heavy diesel vehicles within this flow is 429, which increases to a maximum of 508 at 1100h.

The heavy vehicle fleet is categorised into rigid trucks and semis (articulated trucks plus B doubles), the proportions of each being derived from a combination of data from RTA weighing stations in the Sydney region and Marulan plus traffic surveys in Bexley and St Peters. Data from the M5 tollway and the Bexley - St Peters surveys have been used to estimate the traffic flow and its diurnal variation; these data split the traffic into passenger and commercial vehicles. The estimates of the traffic flows, its diurnal profile and mix, appear to be well based. The major sources of any uncertainty would appear to be the numbers of rigid trucks and the split between articulated and B doubles.

The sensitivity of the emissions to the proportion of diesel traffic is explored in the next section.

### 2.2 Traffic Emissions

The Hyder report used the PIARC methodology, which provides a tabulation of the emissions (g/h) of CO, VOC, $NO_x$ and diesel $PM_{10}$ for a range of speeds and road grades. The estimates are tabulated for petrol- and diesel-fuelled vehicles for a range of design regulations and are based on tests on European vehicles, mostly using chassis dynamometers. Whilst the PIARC methodology is state of the art, it must be borne in mind that there are significant uncertainties associated with this or other approaches. These are due, in part, to the relatively small size of databases, particularly emissions from in-use diesel traffic, and the degree to which drive cycle tests correspond to the real world.

We have compared the PIARC estimates with our own estimates based on Australian data for petrol and diesel vehicles and found them to be very similar (within the range of uncertainty that might be expected in such data) except possibly for diesel $PM_{10}$ which we believe could be underestimated. To illustrate this we use a preliminary analysis of some data from a recently completed study of emissions from 80 in-use diesel-fuelled vehicles carried out for Environment Australia by ParsonsAustralia and CSIRO Energy Technology. (These data were not available to Hyder at the time of their estimates.)

A second by second analysis of particle emissions from in-use heavy-duty diesel vehicles for half maximum load (plus tare) was carried out in which the particle emission rates were binned according to the fraction of maximum test power experienced by the dynamometer. The vehicles were tested at half maximum load (plus tare) and the emissions were measured by a fast response monitor. The data are shown in Figure 1. The data point at eg 0.6 is the average emission rate for fractional maximum test powers ranging from 0.5 to 0.7 during a drive cycle and that for 0.8 covers the range 0.7 to 1. Negative power occurs during deceleration. The emission rate at 1 is an extrapolation of the data. The emission rates have been normalised so that the emission rate at zero power (-0.5 to +0.5 Pmax) is unity, and are shown in the attached figure for NC category heavy vehicles. Other categories show similar characteristics. The non-linear increase in emission is consistent with the increase in fuel/air ratio with increasing engine power.

PIARC emission rates for zero grade and 60 kph agree reasonable well with the Parsons data. Calculations suggest that at 60 kph, a HGV operates at about 20% of maximum power, but on a 6% grade

it is at full power. The PIARC data have been overlaid on the attached figure by putting the PIARC emission rate for zero grade and 60 kph equal to the Parsons results at 0.2P and the estimate for 6% grade at P=1. The PIARC estimates are effectively linear with power. The difference between the two sets of data will depend on how the PIARC data overlay the Australian results and the degree of non-linearity in the emissions as a function of engine power - this awaits further study.

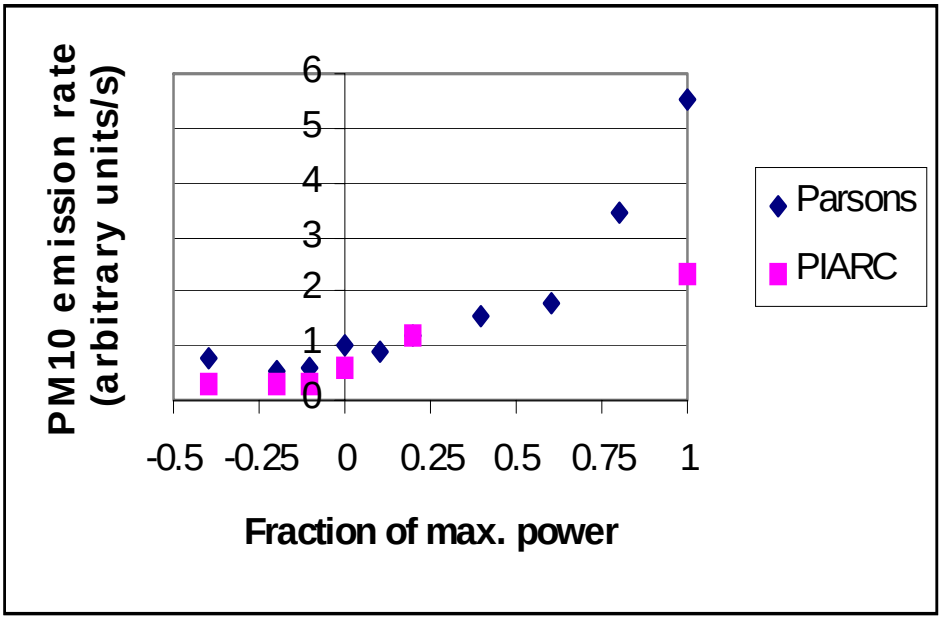


Figure 1. Variation of particle emission rate with applied power.

In our view, it is quite possible that actual $PM_{10}$ emissions could be a factor of two or more higher than the PIARC estimates at full engine load as the majority of the emission will in fact, come from high power operation. It should be re-emphasised that this is new knowledge, not available to Hyder, but in view of the possible potential for exceedence this aspect needs to be taken into consideration.

The sensitivity of the estimates to the proportion of the heavy-duty diesel traffic is such that, using the PIARC methodology, a 20% increase in heavy vehicle traffic results in approximately a 20% increase in $PM_{10}$ as most of this comes from heavy duty diesels with $NO_x$ going up by ~10% at morning peak and ~16% in the middle of the day when diesel traffic is at a maximum. The impact on other emissions is very small.

With regard to the air toxic compounds, benzene, 1:3 butadiene, formaldehyde and acetaldehyde, knowledge of the emission factors is more uncertain than for CO, $NO_x$ and VOCs. However, even taking this into account, the emissions are sufficiently low that the air quality goals are in no way threatened.

We conclude that the traffic emissions factors used in the Hyder Reports are appropriate except that they may underestimate present $PM_{10}$ emissions by a factor of two or more.

The Reports point to the expected improvement of vehicle emissions with the introduction of Euro standards over the next seven years or more. They conclude that this means that year 2002 conditions in the tunnel are the worst case since improvements in emissions per vehicle will outweigh the increase in traffic overall. This seems to be a well-supported assertion for light and heavy diesel vehicles but at least for particle emissions from petrol vehicles the support is far from certain.

Indeed, Euro standards for petrol vehicles do not address particle emissions at all and they are not included in the M5 assessment. Euro4 diesel vehicles will emit no more than approximately 45 mg $km^{-1}$ of particles. Evidence available to us (SAEA, 2000) is that in the near future, petrol vehicles are highly likely to use a technology called GDI (gasoline direct injection), a variant of the existing fuel injection technology available on most new cars. Although GDI gives a 20% improvement in fuel economy, it will lead to an increase of particle emissions of three to four times as great as present conditions (SAEA, 2000). Emissions would be in the range 40–60 mg $km^{-1}$, comparable to new diesel vehicles. Since petrol vehicles are, according to the Hyder Reports, likely to represent 60–76% of the fleet in the M5 tunnels, their contribution to particle emissions may need to be re-assessed.

We conclude that the assumption that the year 2002 represents worst case ('critical design conditions') may well be true for most pollutants but it may not be for particles.

### 2. 3 Buoyancy Flux of Emissions

An important aspect of modelling the ground level impact of stack plumes is the calculation of plume rise, which increases the effective stack height. This is due to a combination of momentum (due to the velocity and mass of the efflux) and thermal buoyancy due to temperature induced density difference between the emissions and the ambient air. In the numerical modelling, it has been assumed that the emissions will be $5^oC$ cooler than ambient due to passage of the ventilation air through a tunnel. As is shown below, this is a conservative approach for the cooler part of the year, but it is worth examining this issue in more detail.

We have carried out a simple heat transfer calculation, assuming a rock temperature of $17^oC$, a tunnel of radius 7 m and a tunnel inlet gas temperature $10^oC$ above rock temperature due to a combination of the temperature of the ambient air being sucked into the tunnel and heat release from the vehicle exhausts. Some measurements in the Sydney Harbour Tunnel showed that heat release from vehicles raised the ambient temperature by ~$6^oC$ (Williams, personal communication). For a *well-mixed* airflow of 800 $m^3/s$, the ventilation air reached rock temperature after about 600 m as shown in Figure 2. At slower flows, the distance will be shorter. It would appear, if these calculations are confirmed, that the exit temperature from the stack will be close to that of the rock at all times. The consequence of this is that during cold winter mornings at morning peak, when stable meteorology dominates and which can give rise to maximum impact at the ground, there will be a substantial positive thermal buoyancy to the plume.

This buoyancy could enhance the effective stack height by 20 m or more. Whilst the reverse will be the case for summer afternoons, the higher dispersion rates, characteristic of neutral to unstable conditions at these times, means that the impact of negative buoyancy will be much less and also closer to the predictions of plume behaviour presented in the Hyder Reports.

As the degree of thermal buoyancy is proportional to the volume flow rate for a given temperature difference, it becomes quite small at the lowest fan speeds projected for minimum traffic flow so that there may well be only a small benefit for overnight plume strike conditions throughout the year.

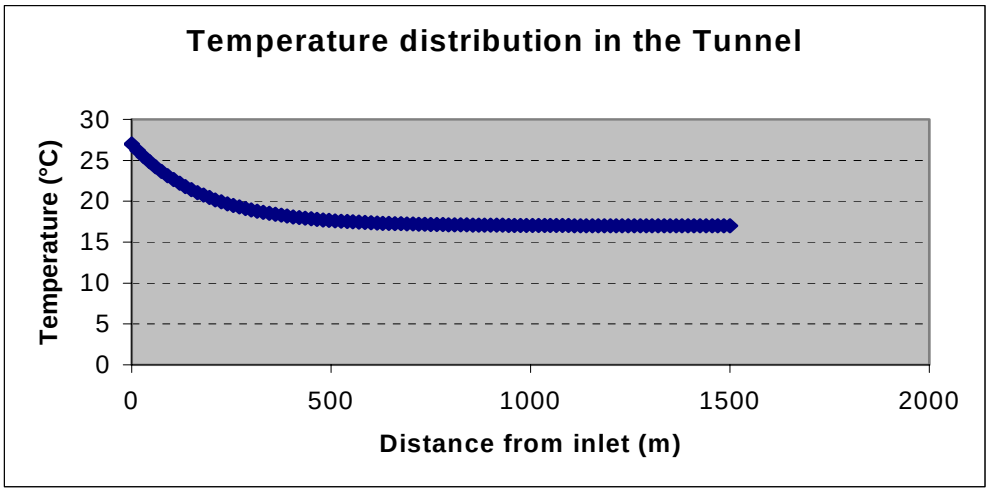


Figure 2. Effect of heat transfer within a road tunnel. Vent flow = 800 $m^3/s$,

## Meteorological And Background Conditions

The Hyder Reports used surface meteorological conditions as measured at Earlwood Monitoring Station rather than as measured at the airport. We regard this as an appropriate selection of meteorology for the purpose of assessment of plume impacts where the conditions within a distance of a few kilometres of the stack are of concern.

Only one year of meteorological data was used (1995) in the main Reports (Hyder 2000a, b). While this is common practice, consideration of results from use of another year or more, given that they are available, would have led to an ability to assess the robustness of the predictions. For example, the supplementary report (Hyder 2000c) using 1998 meteorology shows that the ten highest 24-hour average $PM_{10}$ contributions by the stack are substantially lower than in 1995. For the 25 m stack, the top ten values are on average 35% lower (range 30–45%), and for the 35 m stack they are on average 23% lower (range 18–30%) than those predicted using 1995 meteorology. Note that these differences are due solely to differences in the meteorology; the background is not included. We are surprised by the magnitude of these year-to-year differences, especially for 24-hour averages, and suggest that further work may be needed to confirm these results.

Background air pollution conditions were for the same year (1995) and location (Earlwood Monitoring Station) as the meteorology. We regard the use of background pollution data from the Earlwood Monitoring Station as appropriate in the circumstances but we also note that there could well be large local differences due to the regional terrain trapping local pollutants such as domestic wood smoke. The Hyder Reports note that data from some other years were influenced by broad-scale fires. However the Reports do not comment on the change in variation in the $PM_{10}$ record halfway through the year as presented in Figure 5.2 of the Reports. Our inquiries of EPA NSW resulted in them noting that during 1995 the Earlwood TEOM was tested with various measuring heads, and other changes were made to try to reduce the sensitivity to vibration that TEOMs of that vintage were particularly subject to. EPA has provided us with data from 1998 as measured at Earlwood and these for 1-hour average $NO_2$ and 24-hour average $PM_{10}$ are presented here in Figures 3 and 4.

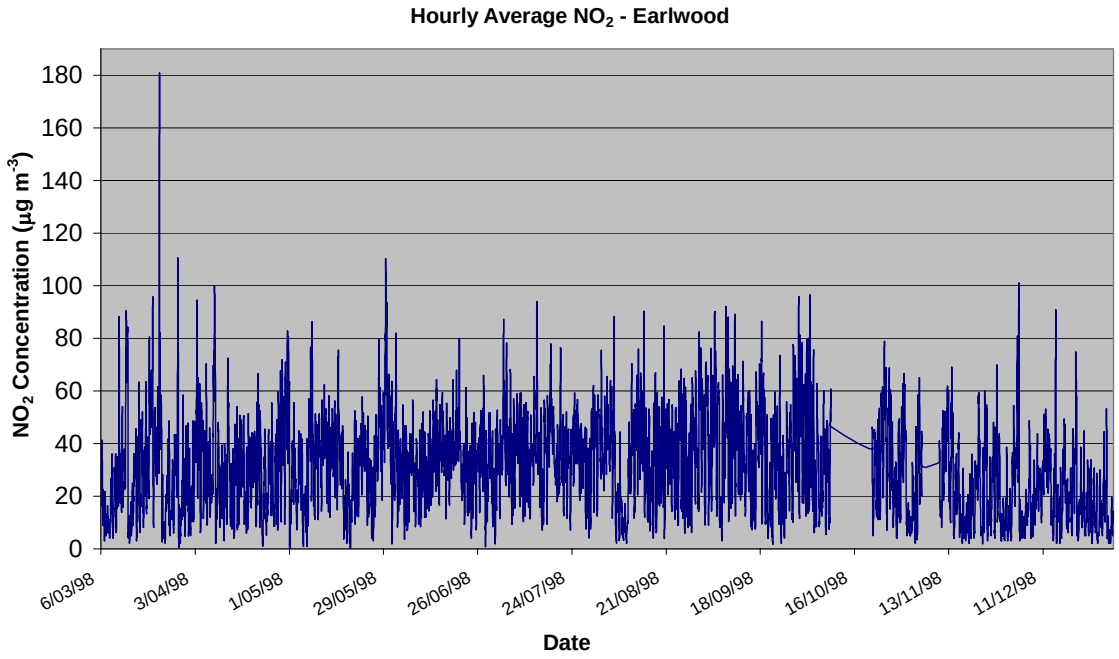


Figure 3. Nitrogen dioxide monitoring data for 1998 provided by EPA NSW.

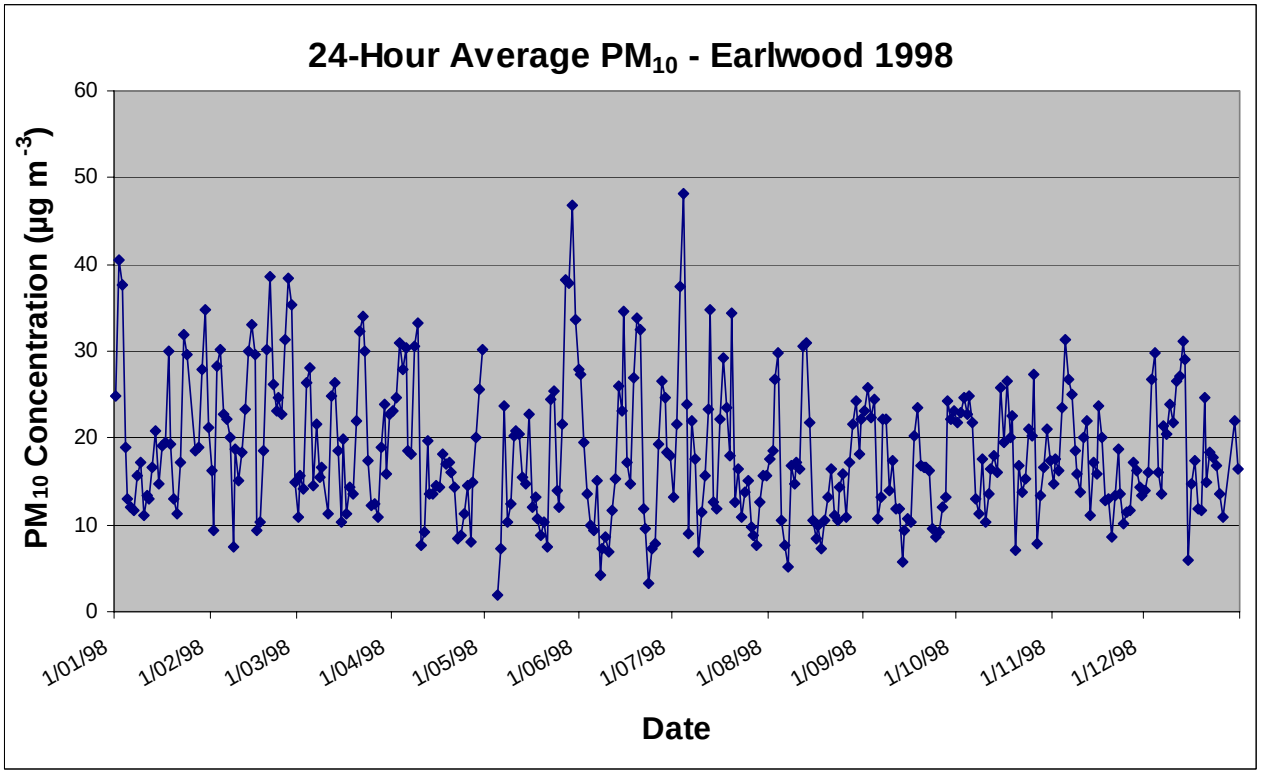


Figure 4. $PM_{10}$ monitoring data for 1998 provided by EPA NSW.

We note that the 1998 $NO_2$ data indicate fewer values above 100 µg $m^{-3}$ than in 1995 although the peak value of 180 µg $m^{-3}$ is substantially higher than the peak of 136 µg $m^{-3}$ in 1995. The overall average levels are similar to 1995. For the 1998 $PM_{10}$ data, it is clear that there is a much greater uniformity of fluctuations throughout the year than as reported for 1995. There are fewer excursions to higher values and these occur at about the same time (winter) as for 1995, but the overall average levels are about the same as for 1995.

The supplementary report (Hyder 2000c) of modelling results for $PM_{10}$ for 1998 shows very similar peak cumulative 24-hour average $PM_{10}$ concentrations as for 1995, due to the similarity in the peak background concentrations (see also section 5.2). There were no exceedences of the NEPM guideline of 50 µg $m^{-3}$, In all cases, the stack contribution on these top ten days was less than 3.5 µg $m^{-3}$, so that the fewer number of days with background concentrations above 45 µg $m^{-3}$ (two in 1998 compared to five in 1995) is the controlling factor for these extreme values. However if $PM_{10}$ emissions were a factor of two or so higher, there would be exceedences.

The obvious differences between day-by-day levels of $NO_2$ and $PM_{10}$ for 1995 and 1998 support a conclusion that we wish to make strongly: we do not agree with the approach followed in the Hyder Reports of attempting to simulate the cumulative air pollution effects hour by hour throughout the year by whatever modelling method selected and then adding the corresponding monitored background concentrations. Whilst we are aware of the approaches recommended by the USEPA, and that the NSWEPA had agreed to the use of the "Tier 3" approach of using hour-by-hour (day-by-day) background concentrations with the hour-by-hour (day-by-day) model predictions for $NO_2$, there is far too much variation in the real atmosphere for the Tier 3 methodology to be considered conservative. It is far more informative to select background conditions that reflect the range of values that could be expected at a particular hour of day at a particular time of the year. In other words, instead of using a given measured background value derived from monitoring data, impose on this value a range which reflects the variability. We revisit this point in the review of the numerical modelling work, discussed in section 5.

Finally, we aware that there are monitoring data for other years that show higher background $PM_{10}$ levels than 1995 or 1998. It is believed that high levels of $PM_{10}$ are often associated with bushfires and while, under NEPM, some allowance is made by permitting five exceedences per year, it is likely that there that there would still be a number of occasions when background levels are higher than the periods modelled in this report. To better estimate any likely exceedences over a longer timeframe, it would be advisable to include such data in such an assessment.

## Health Criteria used as Goals for Assessment of Impacts

The major goals used to judge the air pollution impacts of the M5 tunnel stack emissions are about the same as the recently agreed National Environment Protection Measure for Ambient Air Quality — the Air NEPM. Refer to the extensive discussion documented in the Air NEPM for the reasons for their selection (see http://www.nepc.gov.au ). We believe these are appropriate design goals.

## Review of Numerical Modelling of Impacts

### 5.1 General Impression of ISC3 Methodology

The model ISC3 was judged by EPA NSW and Hyder Consulting to be suitable to the task. We agree with that judgement. There are alternative modelling approaches that could have been used, which would have some advantages and some disadvantages compared to the approach used, but these alternatives have not been considered here.

The Hyder Reports would have been more readily appreciated if they had included more information about the options actually used, rather than just a general listing of the available options, for the modelling work. Similarly, a list of meteorological conditions and background ozone concentrations that were associated with the determined maximum stack concentrations would have helped us to understand the conditions

that led to these values. Some of these issues (and others) have been addressed in subsequent informal question and answer sessions.

### 5.2 General Impression of ISC3 Results

$NO_2$ stack contributions are moderate compared to the air quality goal (up to 66% of the goal for the 25 m stack and up to 54% of the goal for the 35 m stack), without considering background values. Note that $NO_x$ emissions may be overestimated by 10–20%, and plume rise underestimated overnight and in winter, according to our judgement.

$NO_2$ maximum stack concentrations are dominated by values during hours 21, 22 and 23, on nearby elevated terrain of height up to 45 m above the stack base (see Figure 5), under light wind conditions (1–3 m $s^{-1}$), and for stable atmospheric conditions (Pasquill-Gifford stability category E–G).

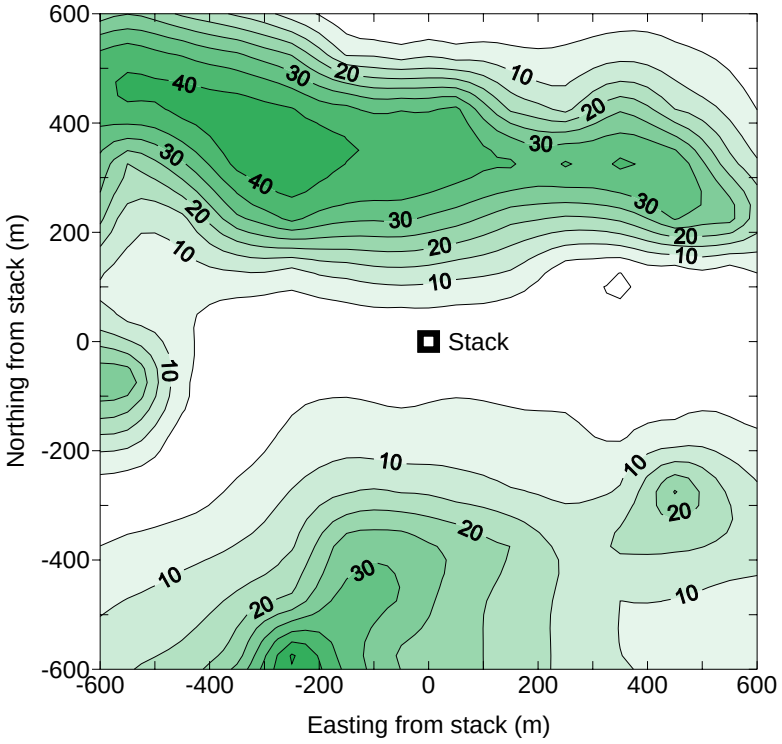


Figure 5. Topography of the region around the stack.

$PM_{10}$ stack contributions could be said to be small compared to the air quality goal (up to 23% of the goal for the 25 m stack and up to 13% of the goal for the 35 m stack), without considering background values. However, $PM_{10}$ emissions may actually be two or more times higher than assumed in the Hyder Reports so the observation that the glcs are small may not be correct. Some mitigation would be possible due to enhanced plume rise overnight from heat transfer in the vent tunnel (Section 2.3) or by increasing the stack exit velocities in the late evening, however an exploration of this would require further modelling (and extra care with ISC3 would be required due to the way it switches between buoyant and momentum plume rise).

Maximum concentrations of other pollutants considered are below air quality goals,

### 5.3 Degree of Conservatism of the Modelling Approach

ISC3 is generally considered to be a conservative model, as stated in the Hyder Reports, but no substantiating evidence is presented, nor is an assessment of the degree of conservatism attempted except to point to the physical modelling — but see below (Section 6).

The modelling approach used in the assessment is not necessarily conservative in every aspect, and a list of assumptions and whether they are conservative or not is given below.

Conservative Assumptions:

- General dispersion assumptions;
- Complex terrain algorithms;
- Building wake screening algorithms;
- Conversion of available NO to $NO_2$ using available $O_3$ background;
- Assume a negatively buoyant plume at all times, especially in winter;
- Comparing maximum concentrations to air quality goal, without accounting for allowed exceedences of the goals (e.g. for the Air NEPM this is one day per year for $NO_2$, and five days per year for $PM_{10}$).

Non-Conservative Assumptions:

- Cannot handle calm winds or recirculation of pollutants by local winds;
- Vertical extrapolation of surface conditions to plume height in complex terrain;
- Hour-by-hour addition of model concentration with effective background concentration for $NO_2$;
- Day-by-day addition of model concentration with background concentration for $PM_{10}$;
- Ignore the expectation that the plume may be substantially negatively buoyant during summer days;
- Ignores hydrocarbon contribution to photochemical production of $NO_2$ and $O_3$;
- Ignores secondary formation of $PM_{10}$ through photochemical reactions;
- Ignores possibility of plume strikes on tall buildings that may exist now or be proposed at a later date.

In general, the conservative assumptions should out-weigh the non-conservative assumptions, but, in particular, the use of hour-by hour effective $NO_2$ backgrounds is potentially the largest of the non-conservative assumptions. This may not be such a problem for $PM_{10}$, due to the use of 24 hour averages, rather than hourly averages.

In order to explore the use of alternative (more conservative) backgrounds, we selected monthly maximum backgrounds from the 1995/96 $NO_2$ record as reported and added them to the predicted maximum $NO_2$ stack values. The results for the top ten stack contributions listed in Hyder Report for the 25 m stack option are: 296, 296, 291, 282, 277, 270, 269, 269, 257, and 250 µg $m^{-3}$; and for the 35 m stack option are: 263, 260, 260, 252, 238, 238, 236, 223, 217 and 214 µg $m^{-3}$.

These top values for the 25 m stack are mostly over, and for the 35 m stack are at or slightly over, the air quality goal for $NO_2$. It could be argued that this approach is too conservative, and something like using observed daily maximum or monthly maximum by hour of the day would be preferable. This consideration illustrates the difficulty in deciding how to add measured backgrounds to modelled values, when models are generally not considered capable of accurately predicting hour-by-hour concentrations.

## Review of Physical Modelling of Impacts

### 6.1 Overview of Physical Modelling Results

The physical modelling was carried out in the Monash wind tunnel with a 1:400 scale model using a 1:5 velocity ratio, and hence a 1:80 timescale ratio. The Reynolds number of the modelled stack efflux ranged from 280 to 4400 depending on the efflux velocity. We believe these values are sufficiently high for these dispersion studies. Stack heights of 25 and 35 m were modelled. Most of the measurements were undertaken in neutral conditions, but stable conditions (PG stability F) were used for one series and weakly convective conditions (PG stability C) for another series of measurements.

A 90-second averaging period was used for the concentration measurements. This is equivalent to 2 hours in the atmosphere, but because of the fixed wind direction in the wind tunnel, these averages are equivalent to the 1-hour averages predicted by the mathematical modelling where the wind direction and speed changes each hour. We note that the physical modelling results are not used to predict 24-hour averages, because of the dominant influence of changes in wind speed and direction over such averaging times. All of the wind tunnel results are reported as dispersion ratios. This is the ratio of the concentration observed at the receptor to that in the stack gas.

The overall quality of the presentation of the physical modelling results in the Hyder Reports is poor. There are over 200 pages of Figures in each Report showing results from each of the individual tests, but almost no summary plots other than Figure 8. In order to interpret the physical modelling results, contour plots of maximum dispersion ratios (Figures 6 and 7) have been extracted to determine the internal consistency and the influence of the topography. At each location, the maximum dispersion ratio has been extracted from the Figures in the Reports. Note that the contouring has been done to assist in visualising the results and no significance should be given to contour lines in regions where there are no data.

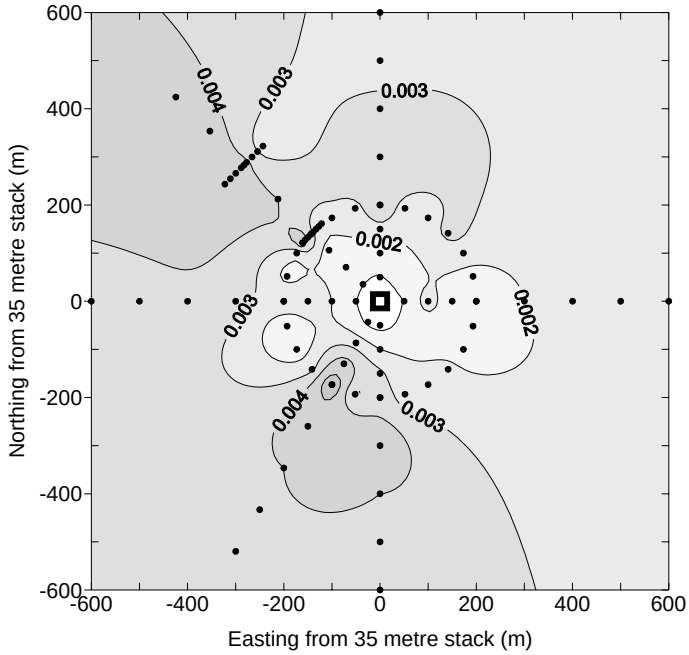


Figure 6 Contour map of the maximum dispersion ratios based on measurements (at the sites indicated by dots) in the physical modelling of neutral flow conditions for the 35 m stack.

Both contour plots (Figures 6 and 7) show good internal consistency between the data measured in the various series for each stack, although the data for the 25 m stack appear to be slightly noisier. In both cases, the maximum dispersion ratios are observed 200–300 m downwind from the stack, possibly slightly further downwind for the higher stack. The peaks tend to occur on the hills to the north and south, as indicated by the topographic contours shown in Figure 5.

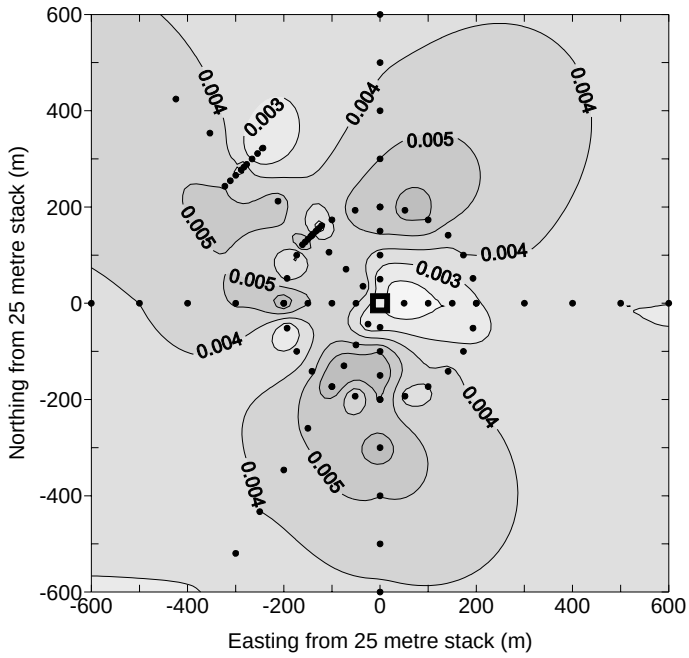


Figure 7. Contour map of the maximum dispersion ratios measured at each site (indicated by dots) in the physical modelling of neutral flow conditions for the 25 m stack.

### 6.2 Uncertainty in dispersion ratios

An estimate of the uncertainty in the measured dispersion ratios can be obtained from the repeat measurements at the same site in different test series listed in the Hyder Reports. The comparison in Table 1 indicates differences of up to 40%. This is consistent with the above contour plots of the maximum dispersion ratios, and helps to explain some of the apparently anomalous points for the 25 m stack. The magnitude of these discrepancies is also consistent with the statement in the Hyder Reports that 1-hour averages in the atmosphere are likely to be within ±50% of the concentrations predicted from the model data.

Table 1. Estimates of differences in physical modelling of similar conditions (V = 9 m $s^{-1}$, wind speed 10 m $s^{-1}$ at sites 200 m downwind from the 25 m stack).

| Direction from stack | Dispersion ratios | Relative difference between measurements |
|---|---|---|
| 0º | 0.056, 0 | |
| 90º | 0.0028, 0.0018 | 44% |
| 180º | 0.0047, 0.0052 | 10% |
| 210º | 0.0037, 0.0056 | 40% |
| 270º | 0.0023, 0.0032 | 32% |
| 315º | 0.0047, 0.0039 | 19% |

### 6.3 Stable vs. neutral flow conditions

For the wind speeds and stack efflux velocities producing the highest dispersion ratios, the physical modelling showed remarkably little change in the maximum dispersion ratios at ground level when the flow conditions were changed from neutral to stable, as shown by our analysis presented in Figure 8. This is all the more surprising because the stability of 0.077 K $m^{-1}$ used in the physical modelling is twice as large as that assumed in the corresponding mathematical modelling. This lack of influence of stability was not commented on in the report, although it has been explained in later communication with Hyder as being due to high low-level turbulence in the high wind speed conditions. It should be noted that at lower wind speeds and higher efflux velocities, the modelling results do show significantly lower glcs in stable conditions.

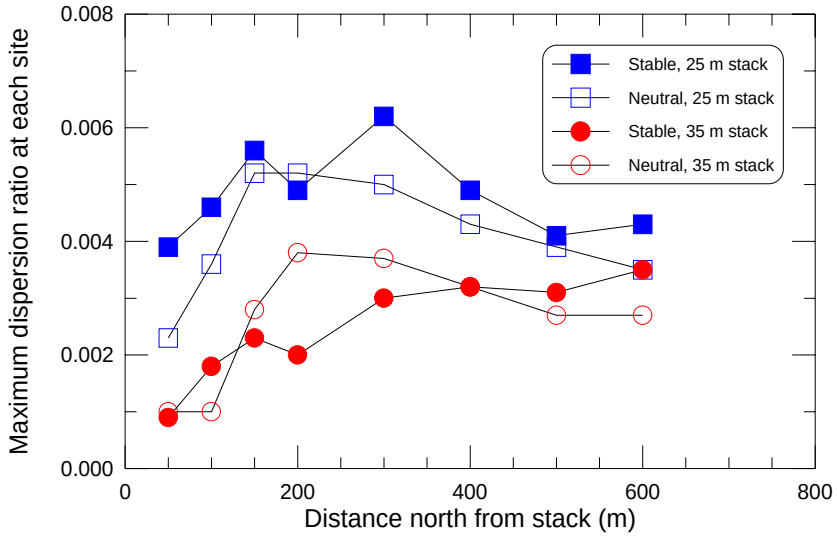


Figure 8. Comparison of maximum dispersion ratios for neutral and stable flow conditions as measured in the physical modelling for a southerly wind.

Some doubt about the reliability of the wind tunnel measurements in stable conditions is indicated by our analysis presented in Figure 9, which compares the vertical profiles measured 400 m downwind from the stack in neutral and stable conditions at the same efflux velocity and wind speed. Although the plume is not mixed to the ground as effectively in stable conditions, the figure shows that more of the plume is transported to higher levels in the stable case than in the neutral case. For the stack height of 35 m, the plume released into the stable environment is distributed more evenly between elevations of 25 m and 125 m, and the concentration at 125 m is more than five times greater than in the neutral case. This is counter to our expectation that stable conditions should inhibit vertical transport of the plume.

Moreover, a simple pollutant flux estimate using the concentration profiles in Figure 9 and assuming a power law velocity profile shows more than twice as much pollutant flux in the stable case as in the neutral case. The shapes of the upper parts of the concentration profiles also suggest that this difference would be greater if measurements had been made to higher elevations. If both profiles are on the plume centreline, there would need to be considerably more horizontal dispersion in the neutral case (against expectations) in order to match the pollutant fluxes in the two cases. This surprising result suggests a lack of consistency between the emissions for the two cases.

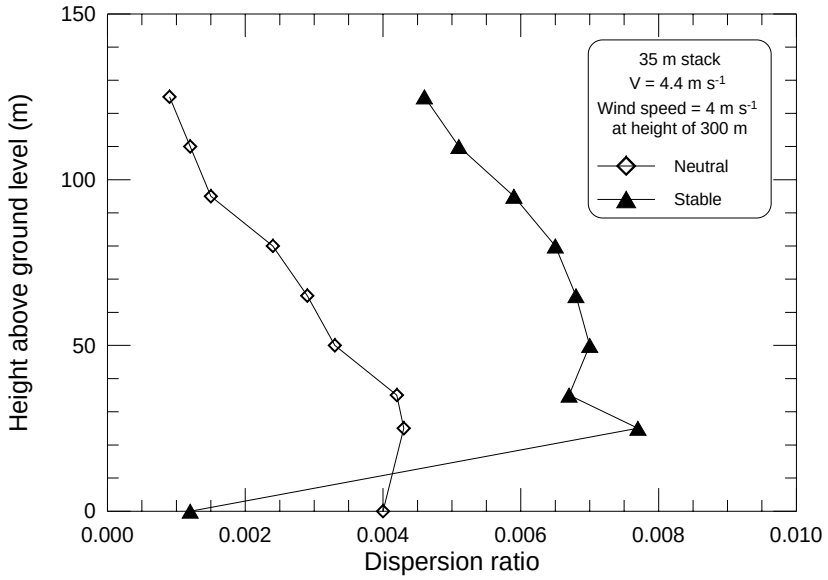


Figure 9. Comparison of vertical concentration profiles for neutral and stable flow conditions at sites 400 m downwind from the stack. The neutral profile was measured NW from the stack, and the stable profile due north of the stack.

We conclude that the physical modelling for neutral flow conditions is close to reality for the modelled conditions. However, the lack of data for wind speeds below 4 m $s^{-1}$ (equivalent to 2.7 m $s^{-1}$ at 10 m above ground level) is a significant limitation of the physical modelling. In particular, it makes it impossible to compare the physical modelling with the mathematical modelling at the wind speeds as low as 1 m $s^{-1}$, which existed at the times of the highest glcs predicted by the mathematical modelling.

We also conclude that the reliability of the wind tunnel simulation of the very important stable conditions is unclear. This is because the vertical concentration profiles indicated greater vertical transport of the plume in stable conditions than in neutral conditions, which is against expectations of weaker vertical dispersion (transport) in stable conditions.

## Comparison between physical and numerical modelling

The comparison in the Hyder Reports between the physical and mathematical modelling used to support an assertion that the numerical modelling is conservative by a factor of two or more is based on comparing maximum dispersion ratios at various efflux velocities. However, there is no indication in Table 4.1 of Part 3 of the Hyder Reports of the wind speeds nor stability classes corresponding to the reported ratios for the mathematical modelling.

Furthermore, the minimum wind speed in test series 1–5 of the physical modelling was equivalent to 2.7 m $s^{-1}$ (at 10m above ground level), although Appendix C1 of the Hyder Reports shows that the actual ambient wind speed at Earlwood is below 3 m $s^{-1}$ for 50% of the year, and wind speeds at the times of the highest glcs predicted by the mathematical modelling were often as low as 1 m $s^{-1}$. (Note that the wind speeds quoted for the physical modelling in the Hyder Report are at 300 m, whereas the mathematical modelling uses wind speeds 10 m above ground level; these are assumed to be a factor of 1.48 smaller). Figure 10 shows that the lack of lower wind speeds undermines the comparison between the maximum dispersion ratios obtained from the physical and mathematical modelling. The values at 2.7 m $s^{-1}$ were taken to be the maximum dispersion ratios, but with all the curves rising at this point, it is most likely that higher dispersion ratios would have been measured at lower wind speeds. While recognising that the wind tunnel may not be able to operate at lower wind speeds, we point out that comparisons between the physical and mathematical modelling are only valid if done for equivalent conditions.

We conclude that with the data provided in the Hyder Reports it is impossible to make a valid comparison between the physical and mathematical modelling. This is in part because of the absence of physical modelling at wind speeds below 2.7 m $s^{-1}$ for neutral conditions, and also because of the problems with the physical modelling of stable conditions. However, if the wind speeds, directions and stability classes corresponding to the maximum dispersion ratios for each efflux velocity (Table 4.1 of Part 3 of the Hyder Reports) were available, it may be possible to make a comparison for conditions for which both physical and mathematical modelling results were obtained. At present it is not possible to appeal to the physical modelling to prove that the numerical model predictions are conservative estimates of real-world conditions with the M5 East stack operating.

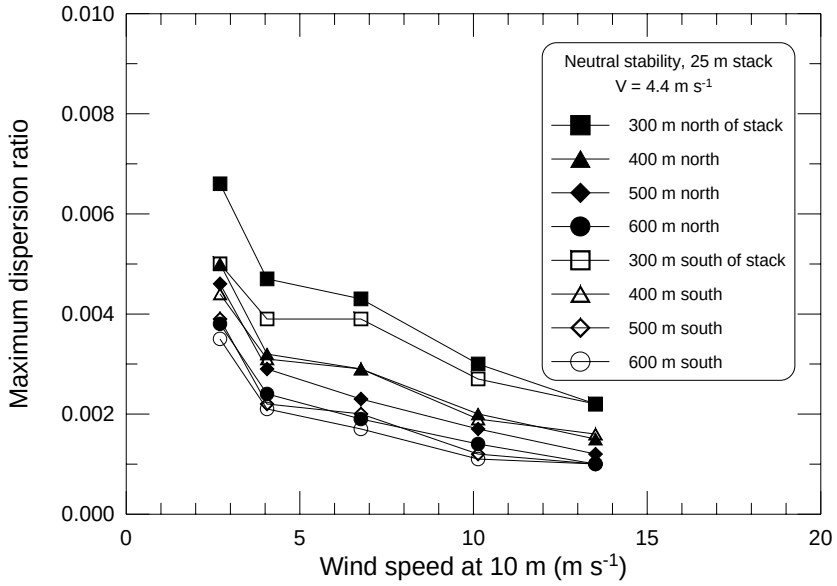


Figure 10. Examples showing the limitation of the maximum dispersion ratios determined from the physical modelling. In each modelled case, the maximum dispersion ratio value was taken to be the value at a wind speed of 2.7 m $s^{-1}$. However, with all the curves rising at the lowest wind speed, it is

most likely that higher dispersion ratios occur at lower wind speeds. (Data from the physical modelling, Figures 18, 20, 22, 24, 50, 52, 54, and 56 of the Hyder Report for 25 m stack.)

## Stack Height Considerations

### 8.1 Stack Heights of 25 and 35 m

The effect of changing the stack height on the maximum dispersion ratios is shown in Figure 11 for the physical modelling. The Figure plots the ratio of results from the modelled 35 m stack to the modelled 25 m stack. Increasing the stack height from 25 m to 35 m generally reduces the concentrations by about 50% within 200 m of the stack (the exception 100 m east of the stack is probably due to an unfavourable combination of errors). The locations with slightly larger dispersion ratios (400 m NW and 600 m SW of the stack) correspond to elevated regions, and probably reflect an increase in plume impact. Note that these results are for neutral stability.

From the numerical modelling, if stack height was increased from 25 m to 35 m, maximum ground level concentrations (stack contributions only) would be reduced by a factor of 0.8 (a factor range of 0.74-0.85, based on eight of the top ten maximum $NO_2$ stack concentrations common to the 25 m and 35 m stack data in the Hyder Reports). This sensitivity is in general agreement with the physical modelling, even though the modelled conditions differ in the ways described above.

We conclude that with the stack exit conditions listed in the main Hyder Reports (2000a, b), the higher stack height (35 m) would be advantageous, especially given that conservative methods of including background $NO_2$ (hour-by-hour addition is not necessarily conservative), would increase the total $NO_2$ closer towards the air quality goals.

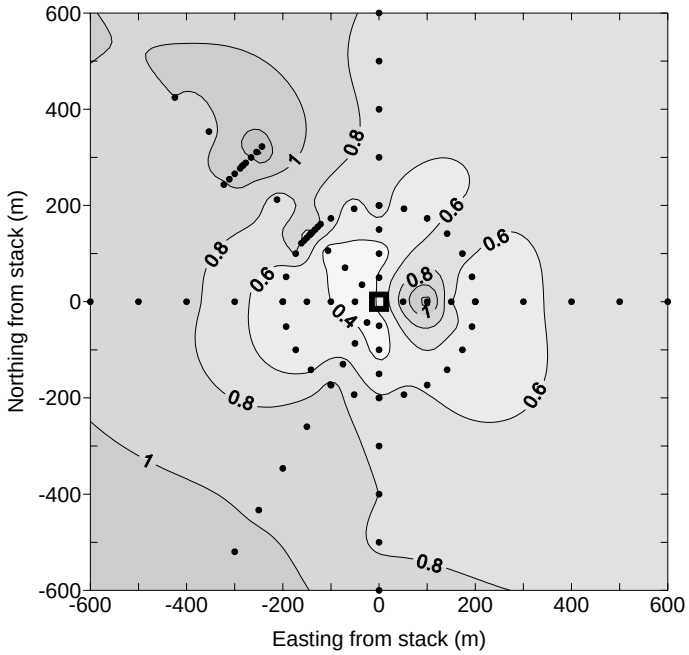


Figure 11. Contour map of the ratio of maximum dispersion ratios for the 35 m and 25 m stacks for neutral flow conditions as determined by the physical modelling.

### 8.2 Stack Height and Plume Strikes

Given that the highest concentrations are expected to occur as impacts on nearby terrain (approximately 500 m from the stack), and that this terrain is up to 45 m above the physical stack height, it would be

advantageous to have an effective plume height (stack height – stack tip downwash + plume rise height increment) that was at least 50 m above the stack base. This could be achieved either by having a physical stack height of 50 m with the current diurnal pattern of stack exit velocities, or by using a combination of physical stack height and a modified diurnal profile of stack exit velocities in order to achieve a minimum plume height of 50 m. This second option is briefly explored below.

If stack exit velocity was increased for hours 21, 22 and 23 (currently 5.4, 4.5, 2.5 m $s^{-1}$ respectively), then ten (nine) of the top ten listed maximum stack concentrations, listed in the Hyder Report for a 25 m (35 m) stack, would decrease due to an increase in the effective plume height (see Figure 12). Note that stack-tip downwash is important when the ratio of the exit velocity to the wind speed at stack height becomes less than a ratio of 1.5, and this is predicted to be having a significant effect on maximum stack concentrations, particularly at hours 21–23.

The effect on maximum $NO_2$ ground level concentration of increasing stack exit velocity for hours 21 and 23 has been explored in the Hyder report (2000d) on air quality modelling for incident management. It was shown that by increasing the stack exit velocity from 5.4 m $s^{-1}$ to 9.0 m $s^{-1}$, the ground level concentration due to the 25 m stack for hour 21 on 29/10/95 was decreased from 169.1 to 111.6 µg $m^{-3}$. When using the conservative maximum monthly background approach, this results in a cumulative concentration of 225 µg $m^{-3}$. It was also shown that by increasing the stack exit velocity from 2.5 m $s^{-1}$ to 4.5 m $s^{-1}$, the ground level concentration due to the 25 m stack for hour 23 on 08/10/95 was decreased from 164.1 to 110.5 µg $m^{-3}$. When using the conservative maximum monthly background approach, this results in a cumulative concentration of 224 µg $m^{-3}$. These results illustrate that simply by increasing the stack exit velocity for certain night-time hours (e.g. hours 20-23), the air quality goals for $NO_2$ can be achieved, even for the 25 m stack, and when using a conservative approach to include background $NO_2$ concentrations.

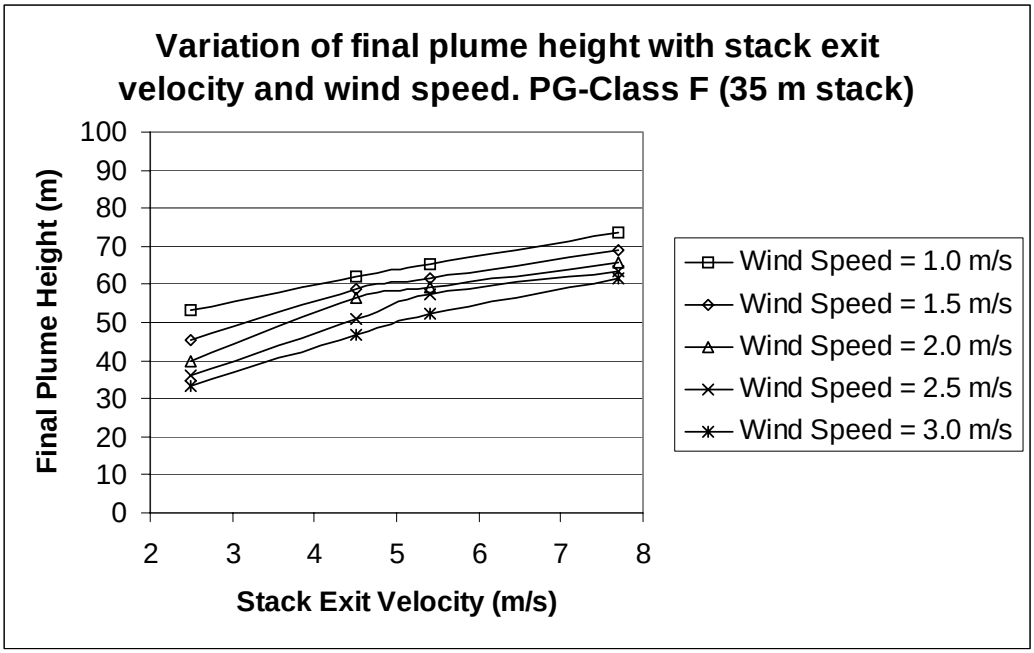


Figure 12. Sensitivity test of final plume height to stack exit velocity for the 35 m stack.

Another factor that determines the effective stack height is thermal buoyancy. In the numerical modelling it was assumption that the exit temperature is 5°C below ambient, ie negative. As indicated in section 2.3, the exit temperature of the ventilation air is likely to be at surrounding rock temperature (~17°C), even allowing for heat release from the vehicle exhausts. For the winter period, at high ventilation flow rates, this

could represent a substantial positive buoyancy, and hence higher effective stack height. It is noteworthy that if ventilation flows were enhanced to gain extra momentum rise as discussed above, there would also be extra thermal rise in cold conditions. In summer, the effect will be reversed, but this is much less significant, as highly dispersive convective conditions are likely to be present.

As it is quite possible that another 20 m of plume rise could result from thermal buoyancy, a more detailed assessment of heat transfer within the tunnel and its impact on the effective stack height should be undertaken, particularly if there are strong community or other objections to the higher stack height.

## Recommendations

Whilst the Hyder Reports have presented a reasonable estimate of the air quality impacts of emissions from the M5 East tunnel, there are some gaps and clarifications that could benefit from some extra modelling work, because of the potential for exceeding air quality goals. These concern:

- a revised procedure for combining background concentrations with the plume footprint to account for variability in background concentrations
- the combined effect of fan speed and thermal buoyancy on effective stack height, and hence glcs
- the use of monitoring datasets for other years to better quantify the potential exceedence of air quality goals. It is acknowledged that these may not be as complete as those used by Hyder, but may widen the representativeness of the assessment.

## References


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Hyder, 2000b. M5 East Motorway driven tunnel services - mainline tunnel air quality (35 m stack). Document # WCR020, revision B. Report by Hyder Consulting.

Hyder, 2000c. Draft of results: 1998 Meteorology Assessment by ANE, Ref # 032.7.

Hyder, 2000d. M5 East Motorway Mainline Tunnel – Air quality modelling for incident management plan; Results and recommendations. Ref. # 032, revision 00 (draft). Report by Hyder Consulting.

SAEA, 2000. Response to Request for Comment on Environment Australia's Review of Fuel in Quality Requirements for Australian Transport Study. Society of Automotive Engineers, Australasia — Energy and Environment Committee Chair, Professor Harry Watson


## Appendix - Responses to Community Questions

1. To what extent has the background ambient concentration in the tunnel been taken into consideration. For example it appears that a fixed value of 25µg/$m^{-3}$ is assumed. However on worst days the ambient levels in the tunnel would be much higher. To what extent could this affect the predictions?

*The addition of emissions from the vehicle fleet into the tunnel air swamp any background levels sucked into the ventilation air.*

2. How much benzene will come out of the exhaust stack per day?

*About 2.3 grams*

3. What is the source of PM10 in the ambient air? Is it mainly motor vehicle emission related or solid fuel? Is there a different particle size distribution between the different sources and how would this change affected residents with the stack?

*The major contributor to high $PM_{10}$ levels is from burning vegetation, mostly domestic wood fires, but with spasmodic episodes of bush fires either wild or prescribed. These are ingested into the lung in similar fashion to diesel soot.*

4. Concern about the poor correlation between the numerical and physical modelling.

*This has been addressed in our review report, and follow-up response to comments.*

5. What extent of local air quality improvements are likely as a result of increasing the stack height?

*This has been addressed in our report.*

6. How valid is the Marulan truck percentage information which formed the basis of the trucks using the tunnel? Would this be a conservative assumption?

*This has been addressed in the report.*

7. How relevant are the new Californian air quality goals?

*This is outside the scope of our review*

8. To what extent can air quality impacts be reduced further (even if the goals are met) to minimise impacts to the greatest extent possible?

*See answer to question Number 17 below.*

9. Would the potential increase in diesel trains on the East Hills line change the background air quality?

*Unable to comment*

10. If the tunnel is at capacity, is there a major safety issue for motorists in the tunnel? That is, the ventilation design assumes motorists in front of a fire can escape. However if the tunnel is full this is not possible.

*This was not an issue addressed by our study, however, we have been informed by the RTA that this aspect is an important part of their tunnel management strategy*

11. What proportion of $NO_2$ is in the stack emissions?

*Approximately 10% of total $NO_x$*

12. Concern about the build up of particulate matter in the ventilation shaft particularly if large chunks get dislodged.

*If soot, that has built up on surfaces, gets dislodged, it is generally in larger particle sizes, ie greater than 10 microns.*

13. Appropriateness of single year background data. Is 1995 a representative year? (I expect this would be covered in detail in your report.)

*Yes, this is covered in both the Hyder reports and ours. Recently, modelling for 1998 data has been undertaken and the results reviewed in this report .*

14. Should there be an error statement? How would this affect the conclusions?

*Placing errors on modelling is difficult, but we have addressed the degree of conservatism of the modelling approach in our report, and we have raised some issues concerning various components of the study, which we understand are currently being addressed by the consultants. If a statement can be made that the modelling is conservative, then this would be adequate to address these concerns.*

15. To what extent is particle mass an appropriate surrogate for particle frequency?

*Not an easy question to answer. Fine atmospheric particles tend to coagulate and end up with a similar distribution of sizes, so that mass is a fairly good surrogate.*

16. How valid is the PIARC data for the M5 East situation?

*PIARC is state of the art methodology, any concerns are addressed in the report*

17. To what extent can air quality impacts be reduced further even if the goals are met to minimise impacts? That is, the project should not be designed to pollute up to the goals.

*Theoretically, a reduction in concentrations could be obtained by increasing the effective plume height (via stack height, stack exit velocity, stack exit temperature), or by reducing emissions. The degree to which some of these measures are explored is up to the regulatory authorities. For pollutants that already have a high background concentration (such as PM10), even zero emissions from the M5 development would still result in concentrations close to the goals due to existing background concentrations.*