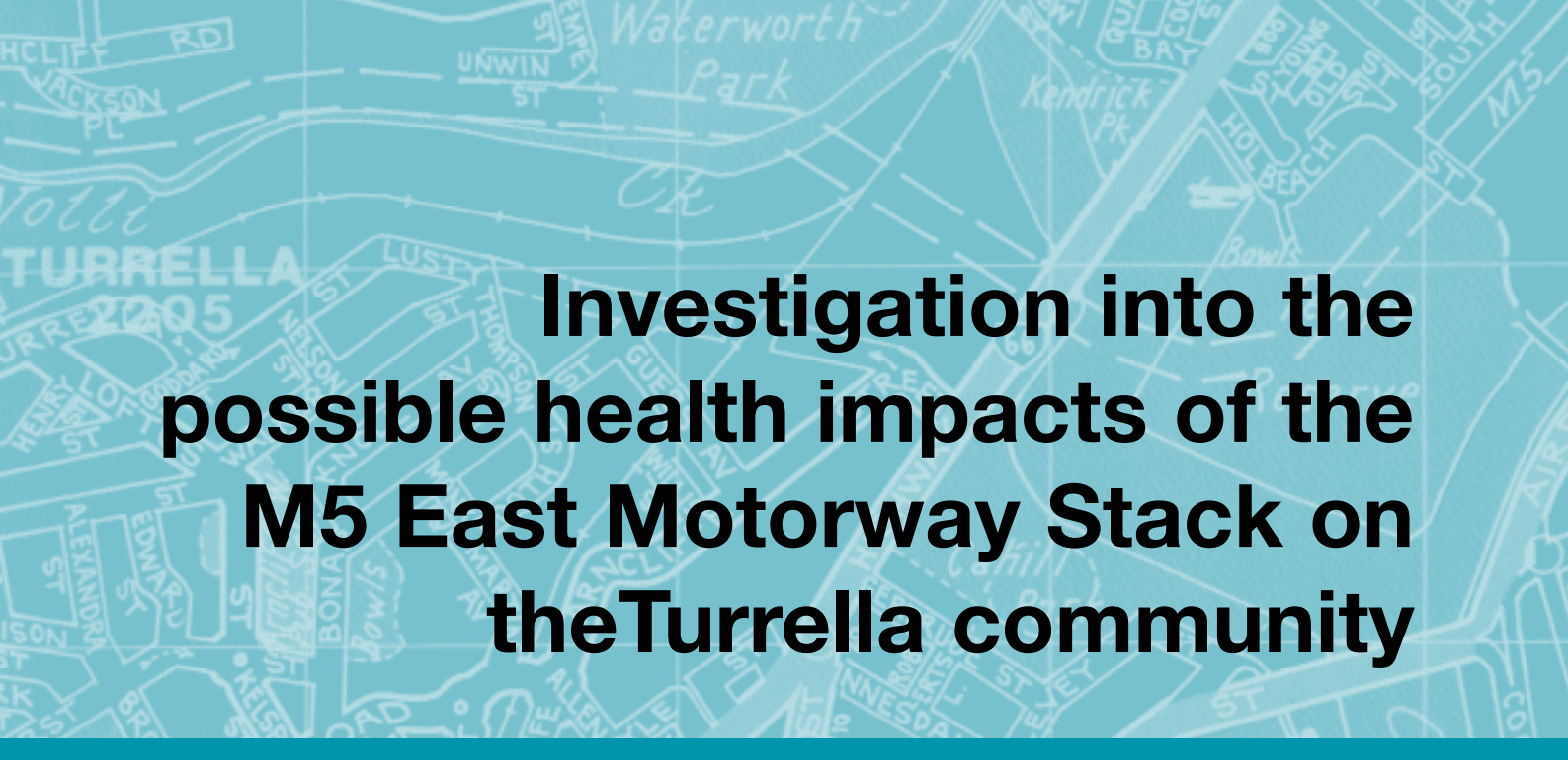

Investigation into the possible health impacts of the M5 East Motorway Stack on theTurrella community

Phase 2 – a cross-sectional survey of symptom prevalence

NSW HEALTH
Working as a Team

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SHPN (EHB) 040055
ISBN 0 7347 36592

Further copies of this document can be downloaded
from the NSW Health website: www.health.nsw.gov.au

April 2004

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Acknowledgments

This study into the possible health impacts of the M5 East exhaust stack was conducted on behalf of NSW Health by the Environmental Health Branch, NSW Health.

The NSW Health Survey Program's Computer Assisted Telephone Interview (CATI) facility, Centre for Epidemiology and Research, NSW Department of Health conducted the interview and compiled the interview data.

The Roads and Traffic Authority (RTA) supplied stack emission, pollutant monitoring and traffic data.

Dr Mark Hibberd, CSIRO Division of Atmospheric Research was commissioned to model the exposure levels.

Alan Willmore of the Centre for Epidemiology and Research outlined level-of-exposure zones from the modelled stack emission data, geocoded residential address data and created the sample for the survey.

Katie Irvine of the Centre for Epidemiology and Research weighted the survey dataset, calculated the prevalence estimates, the 95 per cent Confidence Intervals and analysed the data in SUDDAN using the models proposed by the steering group.

Adam Capon undertook SAS coding and preliminary analysis of data.

Margo Eyeson-Annan of the Centre for Epidemiology and Research provided advice on questionnaire design and interviewing protocols.

NSW Department of Health provided the funds.

The research team wishes to thank CATI survey supervisors and programmers Lindy Latham and Matt Gorringe and all the interviewers in the CATI facility.

The research team also wishes to thank all respondents for their interest and willingness to be part of this study.

The steering group for the health investigation includes:

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Executive Summary

This report details the outcomes of the second phase of the investigation into potential community health impacts around the M5 East stack. It was designed after considering the findings of the first phase of this investigation, which identified symptoms with a possible relationship to the M5 East stack among community members who perceived that the M5 East stack was affecting their health.

We conducted a survey to compare the prevalence of eye, nose and throat symptoms between areas with relatively high, medium and low levels of exposure to emissions from the M5 East stack. These areas were defined by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) - Atmospheric Research using an analysis of emitted stack pollutants and pollutant readings at local monitoring sites from February 2002 to January 2003.

Within each of the three areas households and individuals were selected at random for telephone interview. Information was collected from 1431 individuals on eye, nose and throat symptoms, as well as demographic characteristics, general health, exposure to tobacco smoke and other indoor pollutants.

We found no evidence of an association between prevalence of reported symptoms and modelled emissions from the M5 East stack. The methodology used represents the best feasible epidemiological approach to determining if there are population health effects from the M5 East stack emissions.

On the basis of these findings we believe that there is no scientific justification to conduct further epidemiological studies into the reported health effects on the community surrounding the M5 East stack.

Background

1

The M5 East motorway is a 10 km long, four-lane dual carriage motorway, which links central Sydney with Sydney's southwest. Four kilometres of the M5 East motorway is a tunnelled section which is ventilated via a single exhaust stack, located in Turrella. The tunnels opened to traffic in December 2001 and are used by over 82 000 vehicles daily, with 6.9 per cent being heavy vehicles.

In the first half of 2002, immediately after the opening of the M5 East tunnels, NSW Health received over 80 complaints from local residents who believed their health was being adversely affected by the M5 East stack exhaust. Monitoring in the local area showed that the levels of measured pollutants had not changed from before the tunnel opening to after the tunnel opening. Following consultation with key stakeholders and experts, NSW Health developed a multi-phase investigation strategy to examine the health concerns and symptoms of the local residents.

In April and May 2003 physicians from the Royal Prince Alfred Hospital, in conjunction with officers of NSW Health, undertook the first phase of the investigation. This phase formed a base for the second phase of the investigation by identifying which symptom(s) reported by concerned local residents had a potential relation to the M5 East stack. Symptoms of eye, nose and throat irritation were identified as having an apparent association with the stack warranting further investigation.

Following advice from epidemiologists, respiratory physicians and environmental health professionals, it was decided that the second phase of the investigation should be a cross-sectional analytical study. This study would compare the prevalence of eye, nose and throat symptoms in the local community across different exposure areas. These areas were defined according to their estimated level of exposure to stack emissions.

In July 2003 the protocol for this second phase of the investigation was submitted to the Ethics Review Committee (Southern Section) of South Eastern Sydney Area Health Service and the Ethics Review Committee of the Central Sydney Area Health Service. Approval to proceed with Phase 2 was granted in August and September 2003 respectively.

2 Objectives

The objectives of this study were:

1 To measure the prevalence of eye, nose and throat symptoms, as identified in the Phase 1 study, in the community around the M5 East stack.

2 To determine whether the prevalence of symptoms is associated with the level of modelled pollutant exposure from the M5 East stack.

3 To determine whether further epidemiological investigation of possible health effects is indicated.

Study Methods 3

We undertook a cross-sectional survey among adults living in the vicinity of the M5 East stack. The survey was designed to compare the prevalence of eye, nose and throat symptoms between zones with relatively low, medium and high exposure to modelled M5 East stack emissions, so that an exposure-response relationship could be explored.

Symptoms of interest, identified in Phase 1, related to eyes (soreness, scratchiness, dryness, grittiness, burning and watering), the nose (itchiness, sneezing, dryness, runny, congestion) and throat (soreness, dryness).

3.1 Study area and eligible population

The study area was defined as a 6 km x 6 km region centred on the M5 East stack. This ensured an adequate number of households for the study including areas relatively free of exposure from M5 East stack emissions. The eligible population were permanent residents of the study area aged over 17 years.

3.2 Assessment of exposure in the study area

Modelling of exposure emissions from the M5 East stack was based on in-stack hourly averaged data from February 2002 to January 2003. This information was supplied by the Roads and Traffic Authority (RTA) and included: number of fans operating; volume flow rate; temperature; concentrations of fine particles with a diameter small than 10 micrometres (PM_{10}) and oxides of nitrogen (NOx).

Background pollutant concentrations were determined by four continuous monitoring stations around the M5 East stack (T1, U1, X1, CBMS). These monitoring stations provided continuous five-minute averages of pollutant and meteorological data.

Modelling was undertaken using The Air Pollution Model (TAPM) version 2.3.

The pollutants modelled included particles **(PM_{10})**, oxides of nitrogen **(NOx)** and non–methane volatile organic compounds **(NMVOC)**. As there was no in-stack data for NMVOC, a fleet averaged NMVOC/NOx ratio of 0.69 was used.

The modelling consisted of two separate steps:

- **Modelling of stack emissions** - Stack emissions were modelled using the in-stack data supplied by the RTA and meteorological data supplied from the four monitoring stations.
- **Modelling of background pollutant levels** - A background concentration (ie a concentration free of stack emissions) was calculated by determining the hourly average pollutant concentrations upwind of the stack.

Concentrations of pollutants were modelled to generate ground level exposure contours. The annual average, annual daytime average, annual night-time average, highest one-hour and 10th highest one-hour emissions were modelled for the three pollutants. Appendix A contains a complete description and outputs from this modelling.

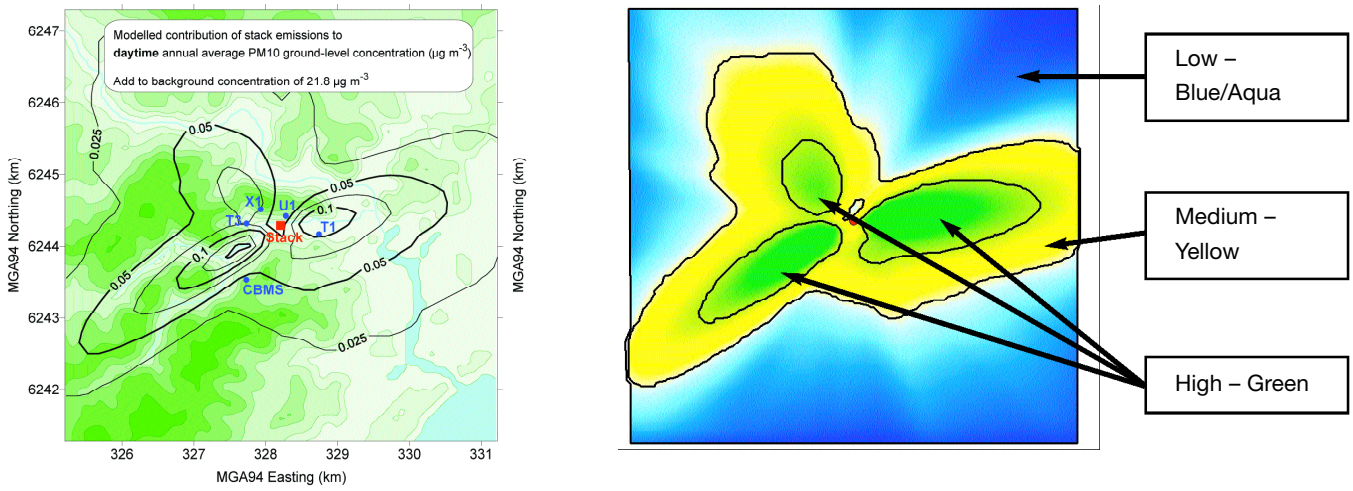
3.3 Definition of study exposure zones

The modelled annual ground level concentrations of oxides of nitrogen from the M5 East stack were used to delineate three exposure zones using ERMapper v6.4 image processing and enhancement software:

High exposure zone	greater than 0.36μg/m³ NOx
Medium exposure zone	between 0.20μg/m³ and 0.36μg/m³ NOx
Low exposure zone	less than 0.20μg/m³ NOx

Modelling of the 10th highest one-hour stack emissions demonstrated a similar geographical pattern.

Figure1: Modelled contours of annual ground level concentrations of oxides of nitrogen from stack emissions, and assigned exposure zones.



3.4 Sampling strategy for the telephone survey

The target population for the survey was all residents living in households with private telephones located within the three identified exposure zones. To accurately locate residences in the three exposure zones full address records from the Australia on Disk electronic Residential White Pages were geocoded using MapInfo MapMarker v8.0 software[3]. Geocoded households were then assigned to exposure zones using MapInfo Professional v6.5 software[4]. The resulting lists of residential telephone numbers in each exposure zone were randomly sorted and supplied to the Computer Assisted Telephone Interview (CATI) facility for survey interviewing.

The high exposure zone consisted of 2,361 households, the medium exposure zone 7,658 households and the low exposure zone 25,637 households.

3.4.1 Sample size calculation

The sample size required to give 80 per cent power (with 95 per cent confidence) to detect a difference of 6 per cent or greater in the prevalence of dry eyes between two exposure zones was calculated using PASS2000[5]. The assumed baseline prevalence of dry eyes was 10 per cent. The estimated sample size required was 524 in each exposure zone, that is 1572 in total.

3.5 Administration of the telephone survey

Telephone interviews were undertaken using the NSW Health Survey methodology[6]. Each selected household received a letter advising them that they had been selected to participate in a 'local health survey' approximately one week before initial telephone contact. A 1800 freecall contact number was provided for potential respondents to verify the authenticity of the survey and to ask any questions regarding the survey. Trained interviewers at the NSW Health Survey (CATI) facility carried out the interviews. Up to seven calls were made to make initial contact with a household. Once the household was contacted the number of persons occupying the household who were over 17 years old was determined. One person from this number of persons was then randomly selected to take part in the study. If the person selected was unavailable at that point in time, an appointment was made to speak with that person at a later date. Up to five calls were made in order to contact the selected respondent. The questionnaire was administered in English, Greek, Italian and Chinese.

Telephone interviews were conducted by the NSW Health Survey CATI facility from October 1 to November 18 2003*. As questions on the symptoms of

* Interviews in languages other than English were undertaken until 21 December 2003. No difference was found between including or excluding these interviews from the data set.

interest related to the participants' experience in the previous four weeks, the telephone survey assessed symptomatology during Spring 2003.

3.6 Outcome assessment – questionnaire

The questionnaire for this survey was designed to assess the primary outcome measures (symptoms) and also to measure those factors that could confound or modify any potential association between the exposure zones and these outcomes.

Principal outcome measures were eye, nose and throat symptoms. Potential confounders were age, sex, exposure to cigarette smoke and the presence of internal garaging• and potential effect modifiers were age, general health, asthma and time spent at home.

Questions on demographics, general and mental health, asthma, chemical sensitivity, smoking status and household characteristics such as environmental tobacco smoke exposure, garaging of vehicle and home heating were taken from the NSW Health Survey[7]. By using questions that were consistent with the NSW Health Survey comparisons between the survey area and the state could be undertaken.

Questions on eye symptoms were developed using the McMonnies Dry Eye Questionnaire[8]. Questions on environmental worry were developed from Lipscomb et al[9] and Shusterman et al[10]. The research team developed questions on nose, throat and mouth symptoms, time usually spent at home, awareness of the study and odour. (See attached questionnaire Appendix B)

3.6.1 Eye, nose, throat and mouth

The McMonnies Dry Eye Questionnaire is a standardised and validated dry eye questionnaire that has been used extensively in Australian dry eye and contact lens research. Its primary focus is the detection of dry eye symptoms and their possible causes. Causes of dry eye include contact lens wear, medication use, thyroid problems and lifestyle habits. Eye symptoms from this questionnaire (soreness, scratchiness, dryness, grittiness, burning and watering*) were modified to allow for in-depth analysis. This modification was consistent with that used by the Cornea and Contact Lens Research Unit, University of NSW to include an assessment of frequency (constant, often, sometimes, never) and severity (mild, moderate, severe). Questions on the use of eye drops were excluded from our questionnaire due to the difficulty of assessing such information via a telephone survey. Questions on arthritis were also excluded to keep the survey to a reasonable length of time. The exclusion of these questions from the McMonnies instrument required an adjustment of the referent value for dry eye diagnosis from 14.5 to 12.

Following consultation with leading clinical researchers we developed questions to assess symptoms related to the nose (itchiness, sneezing, dryness, runny, congestion) and throat (soreness, dryness). Frequency and severity of these symptoms were assessed using the same format as for eye symptoms.

We also included a question related to symptoms of 'teeth and gums' to assess bias arising from possible awareness of the purpose of the study.

To minimise recall bias, participants were asked to only report on symptoms experienced within the last four weeks.

3.6.2 Demographics and household characteristics

In order to describe the demographic profile of the community around the M5 East stack, participants were asked general questions about themselves and their lifestyle. The questions included age, sex, confirmation that the respondent lived in the study area, length of residency, language spoken at home, country of birth, home owner or renter, employment status and education level. In addition questions on possible indoor pollution sources such as smoking, garaging of vehicle and home heating were included.

• Internal garaging has been linked with increased levels of the motor vehicle pollutant benzene in the household. (National Industrial Chemicals Notification and Assessment Scheme (NICNAS) *Benzene – Priority Existing Chemical Assessment Report No. 21* NICNAS 2001)

* Eye watering symptom does not appear in the McMonnies Questionnaire. This symptom was added as a result of Phase 1of the investigation.

3.6.3 General health

This section consisted of three standardised and validated questions about the participants' general health from the NSW Health Survey. These questions were adopted as self-rated health is a fundamental measure of health status and health outcomes and is believed to principally re flect physical health problems. By asking these questions we were able to gain an insight into the self-rated general health status of the participants living in the three exposure zones and compare these rates to the rest of NSW. The general health rating was determined from the question

Overall, how would you rate your health during the past 4 weeks: Excellent, Very Good, Good, Fair, Poor, Very Poor?

The prevalence reported in the result section represents those who answered either excellent, very good or good to this question. This is consistent with how general health is assessed in the NSW Health Survey.

3.6.4 Mental health

Mental health was measured using the Kessler 6 (K6) mental health questionnaire. The K6 is a truncated version of the Kessler 10 (K10) and scores from both scales are comparable. The K6 is a six-item self-report questionnaire intended to determine a global measure of 'psychological distress' based on questions about the level of restlessness, anxiety, and depressive symptoms in the most recent four-week period. It is designed to span the range from few or minimal symptoms through to extreme levels of distress. It is extensively used around the world in general health surveys. The NSW Health Survey uses the K10 as its mental health instrument. This has allowed a comparison of self-reported mental health amongst the M5 East stack community with that of the general NSW population. Our survey used the K6 and not the K10 to keep the survey to a reasonable length of time. The prevalence of those rated with high or very high psychological distress is represented in the results section.

3.6.5 Asthma

The asthma questions were taken directly from the NSW Health Survey. They are designed to determine asthma prevalence, allowing the comparison of asthma prevalence around the M5 East stack with the rest of the state. The questions on asthma were undertaken as asthma is known to be associated with air pollutants. The prevalence of asthma in the results section was determined by answering 'yes' to the following questions

Have you ever been told by a doctor or at a hospital that you have asthma: Yes, No?

Have you had symptoms of asthma or taken treatment for asthma in the last 12 months: Yes, No?

3.6.6 Chemical sensitivity and odour

Multiple chemical sensitivity is most usually defined as a chronic condition, with symptoms that recur in response to low levels of exposure to multiple unrelated chemicals and improve or resolve when those unrelated chemicals are removed[10]. As there was an unknown relationship with multiple chemical sensitivity and the M5 East stack, chemical sensitivity questions from the NSW Health Survey were included so that self-reported prevalence of chemical sensitivity within the M5 East community may be compared with that of the state. This prevalence was based on the following question:

Have you ever been diagnosed with a chemical sensitivity: Yes, No?

Participants were also asked to rate the frequency and annoyance of any foreign odours they had noticed when they were at home. The prevalence of odour in the results section is based on the question:

How often do you notice odours or smells from outside sources when you are at home or in your yard: Every day, A few days a week, A few days a month, Never?

The prevalence of participants who answered either every day or a few days a week is reported in the results section.

3.6.7 Exposure time

To account for differential exposure due to the time spent within the designated zone, a question was introduced that asked about the proportion of the day typically spent at home.

Which of the following phrases best describes where you spend most of your time: I live here and spend most of my time at this address, I live here but work or study elsewhere, I spend little time at this address?

The rate presented in the results section represents the participants that live and spend most of their time at their address.

3.6.8 Environmental worry

Environmental worry has been documented previously in studies of this type[9,10]. The questions enquire into the participants' concern about environmental hazards in their neighbourhood. Participants are invited to rate their level of worry and then specify if they felt these environmental hazards had affected their health. The prevalence of environmental worry was generated from the following question:

How worried or concerned are you about any environmental hazards in your neighbourhood: Not at all, Somewhat worried, Very worried?

The results section reports the prevalence of 'very worried' only.

3.6.9 Did the participant realise this study was about the M5?

The survey was described to participants as a 'local health survey' in an attempt to minimise bias that could arise out of participants being aware of its purpose. If however the participant asked the interviewer if the survey related to the M5 East stack investigation the interviewers were instructed to confirm this. The interviewer was instructed to then note this fact with the participants' responses. The *Aware* category in the results section is the percentage of those interviewed for whom the interviewer noted this fact on their questionnaire.

3.7 Analysis

The survey sample was weighted to adjust for the differences in the probabilities of selecting a particular person in a household, based on the number of eligible adults in that household. Post stratification weights were used to reduce the effect of differing non-response rates among males and females and age groups on the survey estimates. These weights were adjusted for differences between the age and sex structure of the survey sample and population estimates for each exposure zone. Further information about the general weighting process is provided elsewhere[6]. The population estimates were derived from Australian Bureau of Statistics 2001 Census Community Profiles Series[12]. Zone populations were estimated by the allocation of collector district populations to the zone in which collector district centroids were located.

Design-based analysis was performed to account for features of the sample design[13] and provide approximately unbiased estimates and appropriate standard errors[14]. Call and interview data were manipulated and analysed using SAS v.8.0 statistical software package[15]. The SURVEYMEANS procedure was used to calculate 95 per cent confidence intervals for descriptive analysis. Additional analysis and multivariable modelling were undertaken using SUDAAN 8.0.1 statistical software package[16]. The SURVIVAL procedure was used for multivariable modelling with Taylor series linearization methods used for variance estimation.

The association between exposure zone and symptom outcomes was examined using Cox's proportional hazards models with constant follow-up time. This approach was used since the odds ratio, a measure of effect derived from logistic regression models, is a poor estimate of the risk ratio with common outcomes (>10 per cent)[17,18].

The independent predictor of exposure zone was modelled as a categorical variable using the low zone as the reference category. The following covariates were included in the multivariable analysis as clinically relevant confounders: sex, age in years (continuous scale), exposure to cigarette smoke (exposed/unexposed), and exposure to emissions from garaged vehicles (exposed/unexposed). Effect modification was tested for clinically plausible effect modifiers: current asthma (yes/no), general health (excellent, very good, good/fair, poor) and age group.

The analysis comprised two major areas:

1 Profile of the zones compared to each other and the state where possible –

Age, sex, education level, general health (rated good or above), mental health (scored as high or very high psychological distress), asthma, indoor air pollution sources, smoking, home ownership and chemical sensitivity were compared between zones, and between the study area as a whole and NSW.

Environmental worry, exposure time, odour and awareness that the survey related to the M5 investigation, were compared across the three zones only.

2 Comparison of symptoms of interest across zones –

i Scores were calculated from individual reports of symptoms by the following method:

a *Calculation of eye symptom/nose symptom/throat symptom scores:* If the participant answered 'yes' to any one of the six eye symptoms they were noted as having an 'Eye Symptom'. Likewise if a participant answered 'yes' to any one of the five nasal symptoms they were noted as having a 'Nose Symptom' and if a participant answered 'yes' to any of the two throat symptoms, they were noted as having a 'Throat Symptom'.

b *Calculation of more frequent and/or severe index for eye nose and throat:* To calculate the more frequent and/or severe score, each frequency (sometimes, often, constantly) and severity response (mild, moderate, severe) was assigned a value from 1-3. The frequency and severity were then multiplied together to come up with a frequent and/or severe score. If that score was over one (that is if the participant had a symptom greater than *sometimes* of a *mild* nature) then the participant was defined as having a more frequent and/or severe eye, nose or throat symptom.

c *Dry Eye Score:* Responses to the questions from the McMonnie's Dry Eye Questionnaire were scored according to standard methodology. The dry eye prevalence was determined by a score greater than 11. Dry eye prevalence was then compared across zones, and to prevalence identified in separate studies* on the populations of Melbourne, Victoria[19] and Mackay, Queensland[20].

ii Symptom scores were compared across exposure zones by:

a Calculating crude point prevalence estimates with 95 per cent confidence intervals across exposure zones.

b Calculating crude prevalence rate ratios with 95 per cent confidence intervals across exposure zones. This was done for the high and medium zones using the low exposure zone as the reference category.

c Modelling adjusted prevalence rate ratios with 95 per cent confidence intervals. Again this was done for the high and medium zones using the low exposure zone as the reference category.

* Indicative prevalence rates only as measurement techniques varied.

Results 4

4.1 Survey participants

After a maximum of seven attempts, telephone contact was made with 2433 eligible households within the study area. As a result of these contacts, 1431 interviews were conducted with eligible participants (59 per cent participation rate). The number of participants in each zone was: high exposure zone 485 subjects (59 per cent participation), medium exposure zone 481 subjects (58 per cent participation rate), and low exposure zone 465 subjects (59 per cent participation rate). There were 75 interviews (5.2 per cent) conducted in a language other than English. The age, sex and education level of participants did not differ between the zones (Table 1).

The overall prevalence of certain common conditions in the study area was similar to that observed, using the same NSW Health Survey instrument, across the whole of NSW (Table 2).

A few of the characteristics measured in this survey did differ between the study zones (Table 2). Those that were significantly different across zones included environmental worry, the presence of internal garaging and awareness about the survey being related to the M5 East stack. Of those participants who were worried about environmental hazards (environmental worry), 48 per cent believed that these hazards had affected their health. This belief was similar irrespective of zone.

Table 1 Age, Sex and Total Participants by Zone

		High Zone (n=485)	Medium Zone (n=481)	Low Zone (n=465)	Overall (n=1431)
Age	Mean	51	51	49	50
	SD	18	17	18	17
Sex	Female%	58	57	54	57
Education Level	Year 10 (%)	24.3	24.9	25.4	25.2
	(95%CI)	*(19.7–28.9)*	*(20.4–29.3)*	*(20.6–30.2)*	*(21.7–28.7)*
	HSC (%)	23.5	21.6	23.3	22.9
	(95%CI)	*(18.1–28.9)*	*(16.6–27.1)*	*(18.4–28.2)*	*(19.3–26.5)*
	TAFE (%)	23.5	23.7	22.2	22.7
	(95%CI)	*(19.1–27.9)*	*(19.1–28.3)*	*(17.7–26.7)*	*(19.4–25.9)*
	University (%)	28.7	29.8	29.1	29.2
	(95%CI)	*(23.8–33.5)*	*(24.7–35.0)*	*(24.0–34.2)*	*(25.5–33.0)*

Table 2 Respondent Characteristics by Zone

	High Zone % (95%CI)	Medium Zone % (95%CI)	Low Zone % (95%CI)	Overall % (95%CI)	State* % (95%CI)
General Health[i]	80.0 *(75.9–84.1)*	79.6 *(75.2–84.1)*	80.9 *(77.0–84.8)*	80.5 *(77.6–83.4)*	80.7 *(79.7–81.7)*
Mental Health[ii]	12.6 *(8.7–16.6)*	13.8 *(9.8–17.7)*	13.3 *(9.6–16.9)*	13.3 *(10.6–16.1)*	12.2 *(11.4–13.1)*
Diagnosed Asthma[iii]	9.8 *(6.5–13.2)*	9.4 *(5.7–13.1)*	11.4 *(7.8–15.0)*	10.8 *(8.1–13.43)*	10.6 *(9.8–11.3)*
Environmental Worry[iv]	18.9 *(14.6–23.2)*	14.6 *(10.8–18.5)*	11.3 *(8.0–14.6)*	12.6 *(10.1–15.1)*	N/A
Exposure Time[v]	53.0 *(47.5–58.6)*	49.8 *(44.2–55.4)*	49.9 *(44.4–55.3)*	50.1 *(46.1–54.1)*	N/A
Odour Detection[vi]	22.0 *(17.5–26.5)*	23.3 *(18.4–28.1)*	24.6 *(20.1–29.1)*	24.1 *(20.8–27.4)*	N/A
Awareness of survey link to M5 stack[vii]	17.2 *(13.6–20.9)*	9.7 *(6.8–12.6)*	2.5 *(1.2–3.9)*	5.2 *(4.0–6.4)*	N/A
Indoor Heating Pollution[viii]	26.1 *(21.2–31.1)*	28.2 *(23.2–33.1)*	27.6 *(22.5–32.6)*	27.6 *(23.9–31.3)*	22.6 *(20.6–24.7)*
Home Ownership[ix]	71.1 *(65.4–76.9)*	62.3 *(56.4–68.3)*	59.7 *(54.2–65.1)*	61.1 *(57.0–65.1)*	N/A
Personal Smoking[x]	18.6 *(14.4–22.8)*	24.0 *(19.2–28.8)*	26.5 *(21.7–31.3)*	25.4 *(21.9–28.9)*	21.4 *(20.3–22.4)*
Smoke Free Households[xi]	81.5 *(77.3–85.7)*	86.2 *(82.1–90.2)*	78.9 *(74.4–83.3)*	80.8 *(77.6–84.0)*	81.0 *(80.0–82.0)*
Internal garaging[xii]	14.2 *(9.7–18.8)*	9.8 *(6.5–13.1)*	11.0 *(7.5–14.5)*	10.9 *(8.4–13.5)*	22.2 *(20.0–24.3)*
Chemical Sensitivity[xiii]	1.6 *(0.2–3.0)*	2.6 *(0.9–4.3)*	2.7 *(0.8–4.6)*	2.6 *(1.2–4.0)*	2.9 *(2.5–3.4)*
Teeth and Gums Symptoms[xiv]	18.7 *(14.5–22.8)*	21.9 *(17.3–26.6)*	18.3 *(13.9–22.8)*	19.2 *(16.0–22.5)*	N/A

* Values reported only where there are State-wide data

[i] General health rated as excellent, very good or good

[ii] Kessler 6 scored at high or very high psychological distress.

[iii] Been told by a doctor or at a hospital that they had asthma AND had symptoms of asthma or taken treatment for asthma in the past 12 months.

[iv] Prevalence of the very worried category

[v] Most of time spent at this address.

[vi] Foreign odours detected everyday or few days per week.

[vii] Participant aware that survey was about the M5 East stack.

[viii] Unflued gas heater, slow burning combustion heater, open fire place or kerosene heater being the usual way to heat areas in the home

[ix] Home owner, mortgagee, life tenure or rent / buy scheme.

[x] Participant smoked daily or occasionally

[xi] Household is smoke free

[xii] Garage is attached to house and has internal access

[xiii] Participant has been diagnosed with chemical sensitivity

[xiv] Soreness of teeth or gums constantly, often or sometimes.

4.2 Symptoms by zone

4.2.1 Eye symptoms

4.2.1.1 Prevalence

Overall, 50 per cent of people reported any occurrence of one or more of the six eye symptoms and 17.2 per cent reported one or more 'More Frequent and/or Severe Eye Symptoms'. Table 3 presents the prevalence of eye symptoms by exposure zone.

Table 3 Eye Symptoms, Frequency and Severity by Zone

	Any Eye Symptom		More Frequent &/or Severe Eye Symptoms	
	%	(95%CI)	%	(95%CI)
High Zone	50.1	(44.6–55.6)	19.9	(15.7–24.0)
Medium Zone	54.7	(49.2–60.3)	16.4	(12.6–20.3)
Low Zone	48.3	(42.9–53.7)	17.2	(13.2–21.2)
Overall	50.0	(46.0–54.0)	17.2	(14.2–20.1)

The prevalence of dry eye, classified according to the modified McMonnies Dry Eye Questionnaire, was 6.7 per cent (Table 4). This is within the range observed in two previous general population surveys in Melbourne, Victoria and Mackay, Queensland (1.5 – 16.3 per cent)*.

Table 4 McMonnies Dry Eye Prevalence by Zone

	%	(95%CI)
High Zone	5.1	(2.9–7.3)
Medium Zone	8.4	(5.3–11.4)
Low Zone	6.2	(3.6–8.8)
Overall	6.7	(4.7–8.6)

The crude prevalence rate ratios of 'Eye Symptoms' and 'More Frequent and/or Severe Eye Symptoms' did not differ between the high and low exposure zones or between the medium and low exposure zones (Table 5).

4.2.1.2 Modelling

When adjusting the crude prevalence rate ratios for the potential confounders of age, sex, exposure to cigarette smoke and internal garaging there was still no evidence of an association between zones and symptoms (Table 5).

Table 5 Crude and adjusted prevalence rate ratios for eyes.

	Any Eye Symptom		More Frequent &/or Severe Eye Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
High Zone	1.04 (0.89–1.22)	1.05 (0.90–1.23)	1.15 (0.84–1.57)	1.16 (0.86–1.58)
Medium Zone	1.12 (0.96–1.31)	1.13 (0.97–1.31)	0.95 (0.68–1.32)	0.96 (0.69–1.33)
Low Zone	1.00 (REF)	1.00(REF)	1.00 (REF)	1.00(REF)

Prevalence rate ratio adjusted for age, sex, exposure to cigarette smoke and internal garaging. Crude prevalence rate ratios of these confounders may be found in Appendix C.

* Taken from the studies of McCarty[19] and Albertz[20]. These studies did not use the McMonnies Dry Eye Questionnaire to diagnose dry eye and are only indicative of the prevalence of dry eye.

4.2.2 Nose symptoms

4.2.2.1 Prevalence

Overall, 66.6 per cent of people reported any occurrence of one or more of the five nose symptoms and 32.9 per cent reported one or more 'More Frequent and/or Severe Nose Symptoms'. Table 6 presents prevalence of nose symptoms by exposure zone.

Table 6 Nose Symptoms, Frequency and Severity by Zone

	Any Nose Symptom		More Frequent &/or Severe Nose Symptoms	
	%	(95%CI)	%	(95%CI)
High Zone	68.9	(64.1–73.7)	37.8	(32.4–43.3)
Medium Zone	66.4	(61.0–71.6)	35.1	(29.8–40.4)
Low Zone	66.5	(61.4–71.6)	31.6	(26.7–36.6)
Overall	66.6	(62.9–70.4)	32.9	(29.3–36.6)

The crude prevalence rate ratios of 'Nose Symptoms' and 'More Frequent and/or Severe Nose Symptoms' did not differ between the high and low exposure zones or between the medium and low exposure zones (Table 7).

4.2.2.2 Modelling

Once adjusting for the potential confounders of age, sex, exposure to cigarette smoke and internal garaging there was still no evidence of an association between zones and symptoms (Table 7).

Table 7 Crude and adjusted prevalence rate ratios for nose.

	Any Nose Symptom		More Frequent &/or Severe Nose Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
High Zone	1.04 (0.94–1.15)	1.04 (0.94–1.16)	1.19 (0.96–1.48)	1.20 (0.97–1.48)
Medium Zone	1.00 (0.89–1.11)	1.00 (0.89–1.11)	1.10 (0.88–1.36)	1.09 (0.88–1.35)
Low Zone	1.00 (REF)	1.00(REF)	1.00 (REF)	1.00(REF)

Prevalence rate ratio adjusted for age, sex, exposure to cigarette smoke and internal garaging. Crude prevalence rate ratios of these confounders may be found in Appendix C.

4.2.3 Throat symptoms

6.2.3.1 Prevalence

Overall, 33.1 per cent of people reported any occurrence of one or more of the two throat symptoms and 14.9 per cent reported one or more 'More Frequent and/or Severe Throat Symptoms'. Table 8 presents prevalence of throat symptoms by exposure zone.

Table 8 Throat Symptoms, Frequency and Severity by Zone

	Any Throat Symptom		More Frequent &/or Severe Throat Symptoms	
	%	(95%CI)	%	(95%CI)
High Zone	29.6	(24.6–34.6)	16.3	(12.1–20.5)
Medium Zone	36.6	(31.0–42.3)	17.1	(12.8–21.5)
Low Zone	32.2	(27.1–37.3)	14.0	(10.3–17.7)
Overall	33.1	(29.3–36.9)	14.9	(12.1–17.7)

The crude prevalence rate ratios of 'Throat Symptoms' and 'More Frequent and/or Severe Throat Symptoms' did not differ between the high and low exposure zones or between the medium and low exposure zones (Table 9).

4.2.3.2 Modelling

When adjusting the crude prevalence rate ratios for the potential confounders of age, sex, exposure to cigarette smoke and internal garaging there was still no evidence of an association between zones and symptoms (Table 9).

Table 9 Crude and adjusted prevalence rate ratios for throat.

	Any Throat Symptom		More Frequent &/or Severe Throat Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
High Zone	0.92 (0.73–1.16)	0.94 (0.74–1.18)	1.17 (0.81–1.70)	1.18 (0.81–1.72)
Medium Zone	1.12 (0.90–1.40)	1.13 (0.91–1.41)	1.19 (0.83–1.72)	1.20 (0.83–1.74)
Low Zone	1.00 (REF)	1.00(REF)	1.00 (REF)	1.00(REF)

Prevalence rate ratio adjusted for age, sex, exposure to cigarette smoke and internal garaging. Crude prevalence rate ratios of these confounders may be found in Appendix C.

5 Discussion

This study has not demonstrated an association between the emissions from the M5 East stack and reports of eye, nose and throat symptoms. These results were unchanged when adjusted for potential confounders (age, sex, exposure to cigarette smoke and internal garaging). In interpreting this finding it is important to consider the strengths and the limitations of this study.

5.1 Study design

The objective of Phase 1 of this investigation was to characterise the nature of health effects that residents were experiencing and to develop a hypothesis, to be investigated in Phase 2, that these health effects were associated with emissions from the M5 East stack. A cross-sectional study design was chosen for Phase 2 as it allowed the testing of this hypothesis by comparing the prevalence of symptoms among groups at different exposure levels (zones). A limitation of this study design is that the findings may only be interpreted on a population level and not at an individual level. This study design was chosen as individual exposure measurements were unavailable and impractical for such a large study. Furthermore, the nature of any specific exposure that might be causing the symptoms was unknown.

The survey respondents were restricted to individuals older than 17 years. As few children presented for assessment in Phase 1 we were unable to formulate a case definition for children.

5.1.1 Study power and response rate

The ability of the study to establish a 'true' association between exposure and health effects (study power) is determined by the number of individuals surveyed, the prevalence of the symptom and the minimum effect size to be detected. Depending on the prevalence of the symptom, our study had enough power to be able to detect a 5 to 10 per cent or greater difference in symptom prevalence between the low and high exposure zones. Therefore any 'true difference' below this 5 to 10 per cent level will not be detected. The final number of respondents was slightly less than anticipated which resulted in a small decrease in the power of the study.

The response rates were similar across the exposure zones but were slightly lower than other studies of this nature*.

5.1.2 Exposure assessment

Exposure assessment at an individual level was not feasible for this phase of the study and consequently representative zone exposure levels were modelled. Direct monitoring of exposure levels is problematic due to the difficulty in separating relatively large background pollutant levels from predicted stack emission contributions and the lack of a hypothesis about the causative role of any specific pollutant.

Hence we chose to estimate individual's exposure to pollutants. One simple way to estimate exposure is by distance from the point source of exposure. However we considered this method not adequate for this study due to the complex nature of the study area's topography. Modelling exposure based on local measurements, known topography and meteorology provided a more valid exposure estimate. Exposure modelling used in this study was performed by an independent expert agency with considerable experience in this area, using data collected over one year of operation of the M5 East stack. We believe it represents the most feasible measure of exposure to M5 East stack emissions.

i Annual averages vs peaks

A potential limitation of the exposure assessment is that it uses modelled annual averages rather than peak levels to determine exposure zones. However given that the first phase of the study identified health effects that were relatively constant over time it is unlikely that peak emissions are the cause of these symptoms. Hence, annual averages are likely to be the more appropriate exposure measure.

* Response rate for the 1997 and 1998 Health Survey are 70.8% and 65.0% respectively.

ii Limited exposure assessment of volatiles

Exposure modelling was performed for PM_{10} and NOx without direct modelling of non-methane volatile organic compounds (NMVOC). NMVOC were modelled indirectly as a ratio of NMVOC to NOx. This was validated against representative vehicle count data for the M5 tunnel and fleet averaged emissions rates.

iii 'Proxy measure' concept

The modelled increase in levels of particles and NOx above documented background levels is in the order of one per cent. This level of increase is unlikely to explain a detectable increase in health effects and consequently it has been postulated that other compounds that are not currently being monitored might be causing the observed health effects. Should this be the case it is reasonable to presume that these unknown compounds would be distributed in the same pattern as particles and NOx. As such, particle or NOx levels were used as proxy measures for these unknown compounds.

5.1.3 Symptom assessment

Symptoms were assessed by means of a telephone survey methodology that is widely used and has been validated for the collection of health information at a community level•. Many of the questions used in this survey were the same as those used in the NSW Health Survey. This enabled us to compare the survey population with the NSW population as a whole.

Respondents were asked about symptoms occurring in the preceding four weeks. This relatively brief recall period ensures a reliable recall of events. However, if M5 East stack exposures during the specific four week recall period were not representative of exposures at other times, this may give unrepresentative results. We have data to confirm that stack emissions during the study period were representative of average year levels (Appendix D).

5.1.4 Acute symptoms and chronic health effects

The study design used was unable to assess the potential long-term or cumulative effects of M5 East stack emissions. Such an assessment would require long-term follow-up of study participants.

5.2 Potential biases

There are two main forms of bias or sources of error that might distort a study's results, measurement bias and selection bias. The study design used was subject to both these biases.

An important potential measurement bias in this study was recall bias. Recall bias occurs when the participant is unable to accurately report the extent, frequency or nature of past events. To overcome this bias, respondents were limited to reporting symptoms from the previous four weeks. Another potential form of bias would arise if respondents who were aware of the purpose of the survey, to assess the impact of the M5 East stack, had altered their responses because of this knowledge.

Selection bias may have occurred by our survey selecting out a non-representative group of the community. This may have occurred if those with unlisted telephone numbers, those without a telephone in their household or those who declined to participate in the survey were different from those who participated in the survey. Selection bias may also have resulted through our ability to only interview current residents. It is possible that previous residents experiencing symptoms may have moved away from the area, limiting our ability to detect an association between the M5 East stack emissions and symptoms. This bias due to selective migration could only have been overcome by initiating a cohort study prior to the commencement of emissions from the stack.

• Information on the NSW Health Survey may be obtained from the following website: http://www.health.nsw.gov.au/public-health/survey/hsurvey.html

5.3 Use of a group control

The study design used did not include a control group from an area entirely remote from the M5 East stack. Instead, the study relied on using the lower exposure area as a reference area and compared symptoms from the medium and high zones with this area. Comparisons with a control group from a distant area would have led to difficulties in adjusting for differences in background pollutants levels and other regionally specific factors (eg ethnicity, socio-economic status).

5.4 Adjusting for confounders and effect modifiers

Age, sex, exposure to cigarette smoke and internal garaging of motor vehicle were factors that had the potential to be associated with the eye, nose and throat symptoms. Unless these factors were equal across all zones they had the potential to confound (or distort) our results. We adjusted for these known potential confounders using Cox's proportional hazard modelling.

It is also possible that environmental pollutants may only cause symptoms under certain circumstances raising the question of effect modifiers present in the relationship between symptoms and pollutant exposure. However statistical analysis undertaken in this study found no evidence of any effect modifiers.

5.5 Environmental worry

Other environmental health studies have explored the association between environmental worry and adverse health symptoms reported in communities exposed to levels of pollutants below recognised toxic effect levels [9,10,22,23]. These studies have argued that a participant's level of environmental worry may affect how and if they report symptoms, either through direct reporting or through the worrying, helping the participant to recall symptoms that would otherwise have been forgotten. If this was the case then it may be appropriate to adjust for environmental worry in the analysis. Alternatively it could be argued that environmental worry is on the causal pathway of environmental exposure causing a health effect and therefore should not be adjusted for.

Phase 2 of the study has identified a higher degree of environmental worry in the high exposure zone than in the medium and low exposure zone. Consequently adjusting for environmental worry would have made it less likely to find an association between residence in the higher exposure zone and symptoms. We did not adjust for environmental worry in this study.

Conclusion 6

This report relates to the second phase of an investigation to determine if community health complaints are related to emissions from the M5 East stack. We find no evidence of an association between prevalence of reported symptoms and modelled emissions from the M5 East stack. The methodology used represents the best available epidemiological approach to determining if there are population health effects from the M5 East stack emissions.

With any epidemiological study, there are limits in the study's ability to detect an effect. This study was not designed to assess long-term health impacts of emissions. It does not exclude the possibility that certain sensitive individuals do experience symptoms which are related to the M5 East stack. There is no feasible scientific method to establish or disprove either of these possibilities.

As no association has been detected we conclude that there is no scientific justification to conduct further epidemiological studies into the reported health effects in the community surrounding the M5 East stack.

Glossary

Causal Pathway – The sequence of actions, factors or events (risk factors), which lead to the outcome of interest. An intervening factor lies on the casual pathway and can cause the outcome of interest, but is itself determined by another factor. An example would be that a person's cholesterol level can determine their risk of having a heart attack but a person's cholesterol level is itself determined by their diet. In other words cholesterol is an intervening factor lying on the causal pathway between diet and heart attack.

Confidence Interval (95%) – The 95 per cent confidence interval provides a range of values that should contain the actual value 95 per cent of the time. In general, a wider confidence interval reflects less certainty in an indicator estimate. If two confidence intervals do not overlap then the observed point estimates are significantly different.

Confounder – A third variable that distorts the association being studied between an exposure and an outcome. For this to occur the confounder needs to be associated with both the exposure and, independent of that exposure, be a risk factor for the outcome. An example can be seen in the relationship between asbestos exposure, lung cancer and smoking. If asbestos workers were generally non smokers and you compared lung cancer rates in this group to a population where smoking was common you may see similar rates of cancer in the two groups. This may lead you to falsely conclude asbestos exposure is not associated with lung cancer due to the protective effect of low smoking rates among asbestos workers – smoking is a confounder in this case.

Effect modification – Effect modification occurs when the association between the exposure and the outcome being studied varies dependent upon the level of a third factor (the effect modifier). An example of such a situation could be seen if exercise prevented men getting heart attacks to a greater extent than for women. In this case the exposure would be exercise, the outcome is having a heart attack and the effect modifier would be gender.

P-Value - The p-value indicates the probability that the result obtained in a statistical test is due to chance rather than a true relationship between measures. Small p-values indicate that it is very unlikely that the results were due to chance. Therefore, if the p-value is small, statisticians would be confident that the result obtained is 'real.' When p is less than 0.05 ($P<0.05$)- this means that there is a less than 5 per cent chance that the relationship is due to chance - statisticians usually conclude that the relationship is strong enough that it is probably not just due to chance. A p-value of 0.05 or less is the commonly used standard to determine that a relationship between variables is significant.

Appendix A – CSIRO Report

Appendix B – Questionnaire

Good morning/afternoon/evening, my name is …… and I am calling from the NSW Health Department. We are conducting a localised study on the health and wellbeing of people in your local area and we would like to interview someone in your household. The survey is used to let us know about current health issues.

We would greatly appreciate your household's participation in this study and I would like to introduce it to you briefly and explain how it works. Would it be convenient to talk to you now?

Your phone number has been chosen at random from all possible telephone numbers in your area. We would like to make a random selection of a person in your household to interview.

So that we can randomly select one person from your household can you please tell me, how many people, including yourself, live in your household over the age of 17?

We have done the random selection and we would like to interview the …….. oldest person in your household.

Q1 Firstly can I just confirm that you live in the Canterbury, Rockdale or Marrickville local government area?

1 Yes - Canterbury, Rockdale or Marrickville
2 No
R Refused

Q2 Could you please tell me how old you are today?

Q3 Gender
1 Male
2 Female

General health

Now I'm going to ask some questions about aspects of your health.

Q4 Overall, how would you rate your health during the past 4 weeks?
1 Excellent
2 Very Good
3 Good
4 Fair
5 Poor
6 Very Poor
X Don't know
R Refused

Q5 During the past 4 weeks how much difficulty did you have doing your daily work or activities?
1 No difficulty at all
2 A little bit of difficulty
3 Some difficulty
4 Much difficulty
5 Could not do work/activities
X Don't know
R Refused

Q6 During the past four weeks how much bodily pain have you generally had?
1 No pain
2 Very mild pain
3 Mild pain
4 Moderate pain
5 Severe pain
X Don't know
R Refused

Asthma

The next questions are about asthma.

Q7 Have you ever been told by a doctor or at a hospital that you have asthma?
1 Yes
2 No
X Don't know
R Refused

Q7A Have you had symptoms of asthma or taken treatment for asthma in the last 12 months?
1 Yes
2 No
X Don't know
R Refused

Q7B In the last four weeks how often have you used reliever medication?
1 Every day
2 Most days
3 About half the days
4 Less than half the days
5 Not at all
X Don't know
R Refused

Q7C In the last four weeks how often have you used preventer medication?
1 Every day
2 Most days
3 About half the days
4 Less than half the days
5 Not at all
X Don't know
R Refused

Q7D Have you visited a GP or local doctor for an attack of asthma in the last four weeks?
1 Yes
2 No
X Don't know
R Refused

Q7E Have you visited a hospital emergency department for an attack of asthma in the last four weeks?
1 Yes
2 No
X Don't know
R Refused

Q7F During the past four weeks, did your asthma interfere with your ability to manage your day-to-day activities?
1 Yes
2 No
X Don't know
R Refused

Q7Fa How much did it interfere with these activities?
1 A little bit
2 Moderately
3 Quite a lot
4 Extremely
X Don't know
R Refused

Eye, throat, nose and mouth

The next series of questions are about your eyes, nose, throat and mouth.

Q8 Do you regard your eyes as being unusually sensitive to cigarette smoke, smog, air conditioning or central heating?
1 Yes
2 No
3 Uncertain
R Refused

Q9 Do your eyes easily become very red and irritated when swimming in chlorinated fresh water?
1 Yes
2 No
3 Uncertain
4 Not Applicable (do not swim is chlorinated water)
R Refused

Q10 Are your eyes dry and irritated the day after drinking alcohol?
1 Yes
2 No
3 Sometimes
4 Not Applicable (do not drink alcohol)
X Don't Know
R Refused

Q11 Do you suffer from a thyroid abnormality?
1 Yes
2 No
3 Uncertain
R Refused

Q12 Are you known to sleep with your eyes partly open?
1 Yes
2 No
3 Uncertain
R Refused

Q13 Do you have eye irritation as you wake from sleep?
1 Yes
2 No
3 Uncertain
R Refused

Q14 Do you currently wear contact lenses?
1 Yes
2 No
3 Uncertain
R Refused

In the last four weeks have you had any of the following eye problems?
Q15 Eye soreness (Yes/No)
Q16 Eye scratchiness (Yes/No)
Q17 Eye dryness (Yes/No)
Q18 Eye grittiness (Yes/No)
Q19 Burning of your eyes (Yes/No)
Q20 Eye watering (Yes/No)

Q15a Did you have eye soreness…
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q15b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q16a Did you have eye scratchiness...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q16b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q17a Did you have eye dryness...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q17b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q18a Did you have eye grittiness…
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q18b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q19a Did you have a burning feeling in your eyes…
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q19b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q20a Did you have eye watering...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q20b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

In the last 4 weeks have you had any of the following nasal problems?
Q21 Nasal itchiness (Yes/No)
Q22 Sneezing (Yes/No)
Q23 Nasal dryness (Yes/No)
Q24 Runny nose (Yes/No)
Q25 Nasal congestion/blocked nose (Yes/No)

Q21a Did you have nasal itchiness...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q21b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q22a Did you sneeze…
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q22b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q23a Did you have nasal dryness...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q23b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q24a Did you have a runny nose...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q24b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q25a Did you have nasal congestion or a blocked nose…
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q25b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

In the last four weeks have you had any of the following throat problems?
Q26 A sore throat (Yes/No)
Q27 A dry throat (Yes/No)

Q26a Did you have a sore throat...
1 Constantly
2 Often
3 Sometimes (in the last four weeks)
X Don't Know
R Refused

Q26b Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Q27a Did you have a dry throat...
1 Constantly
2 Often
3 Sometimes (in the last 4 weeks)
X Don't Know
R Refused

Q27b Was that...

Q28 In the last four weeks have you had any soreness of your teeth or gums?
1 Constantly
2 Often
3 Sometimes
4 Never (in the last four weeks)
X Don't Know
R Refused

Q28a Was that...
1 Mild
2 Moderate
3 Severe
X Don't Know
R Refused

Are you taking any of the following types of medication?

Q29 Anti depressants
1 Yes
2 No
3 Uncertain
R Refused

Q30 Decongestants
1 Yes
2 No
3 Uncertain
R Refused

Q31 Anti-histamines
1 Yes
2 No
3 Uncertain
R Refused

Q32 Hormone replacement therapy (HRT)
1 Yes
2 No
3 Uncertain
R Refused

Q33 Ulcer medication
1 Yes
2 No
3 Uncertain
R Refused

Q34 Tranquillisers
1 Yes
2 No
3 Uncertain
R Refused

Q35 Blood pressure medication
1 Yes
2 No
3 Uncertain
R Refused

Q36 Diuretics
1 Yes
2 No
3 Uncertain
R Refused

Q37 Beta blockers
1 Yes
2 No
3 Uncertain
R Refused

Mental health

The next questions are about how you have been feeling in the past four weeks.

Q38 In the past four weeks, about how often did you feel nervous?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Q39 In the past four weeks, about how often did you feel hopeless?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Q40 In the past four weeks, about how often did you feel restless or fidgety?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Q41 In the past four weeks, about how often did you feel that everything was an effort?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Q42 In the past four weeks, about how often did you feel so sad that nothing could cheer you up?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Q43 In the past four weeks, about how often did you feel worthless?
1 All of the time
2 Most of the time
3 Some of the time
4 A little of the time
5 None of the time
X Don't know
R Refused

Lifestyle and home environment

The following questions are about your general lifestyle and home environment

Q44 Which of the following best describes your smoking status?
1 I smoke daily
2 I smoke occasionally
3 I don't smoke now, but I used to
4 I've tried it a few times but never smoked regularly
5 I've never smoked
X Don't know
R Refused

Q45 Which of the following best describes your home situation?
1 My home is smoke free (includes smoking is allowed outside only)
2 People occasionally smoke in the house
3 People frequently smoke in the house
X Don't know
R Refused

Q46 What is the usual way you heat the living areas of your home?
1A gas heater with flue (a pipe or vent to the outside)
2 A gas heater without a flue
3 An electric space heater - this includes oil column heaters.
4 Reverse cycle air conditioning
5 Slow burning combustion heater
6 An open fireplace
7 A kerosene heater
8 Other type of heater [SPECIFY]
9 Don't have heating
X Don't know
R Refused

Q47 Do you have a garage?
1 Yes
2 No
X Don't Know
R Refused

Q47a Which of the following best describes the access to your garage?
1 The garage can be accessed internally from the house
2 The garage is attached but there is no internal access from the house
3 The garage is separate
X Don't Know
R Refused

Q48 How worried or concerned are you about any environmental hazards in your neighbourhood?
1 Not at all
2 Somewhat worried
3 Very worried
X Don't know
R Refused

Q48a Do you think these environmental hazards have affected your health?
1 Yes
2 No
X Don't know
R Refused

Q49 Which of the following phrases best describes where you spend most of your time?
1 I live here and spend most of my time at this address
2 I live here but work or study elsewhere
3 I spend little time at this address
X Don't know
R Refused.

Q50 How often do you notice odours or smells from outside sources when you are at home or in your yard?
1 Every day
2 A few days a week
3 A few days a month
4 Never
X Don't Know
R Refused

Q50a What number between zero and ten shows how much you are annoyed by the ODOUR/SMELL, with 0 being not annoyed at all and ten being very much annoyed.

Q51 Do certain chemical odours or smells regularly make you unwell?
1 Yes
2 No
X Don't Know
R Refused

Q52 Have you ever been diagnosed with a chemical sensitivity?
1 Yes
2 No
X Don't Know
R Refused

Demographics

Now we are coming to the last section of the survey. I am going to ask some routine questions about your background.

Q53 In which country were you born?
1 Australia
2 Other [SPECIFY]
X Don't know
R Refused

Q54 Do you usually speak a language other than English at home?
1 Yes
2 No
X Don't know
R Refused

Q54a What language do you usually speak at home?

Q55 What is the level of the highest qualification you have completed?
1 Completed School Certificate/ Intermediate/ Year 10/4th Form
2 Completed HSC/Leaving/Year 12/ 6th Form
3 TAFE Certificate or Diploma
4 University, CAE or some other tertiary institute degree or higher
5 Other (Specify)
6 Completed primary school
7 Completed years 7–9
X Don't know
R Refused

Q56 In the last week, which of the following best describes your employment status?
1 Worked for payment or profit
2 Worked for payment/profit but absent on paid leave, holidays, on strike/stood down
3 Unpaid work in a family business
4 Other unpaid work
5 Did not have a job
X Don't know/Not sure
R Refused

Q57 I would like to ask some questions about your housing arrangements.

Are you:
1 Paying rent or board
2 Paying off this dwelling
3 Outright owner/Fully owned
4 Living rent free
5 Purchasing under a rent/buy scheme
6 Occupying your dwelling under a life tenure scheme
7 Other
X Don't know
R Refused

Q58 How long have you lived in your local area?
1 Answer in years
X Don't know
R Refused

Q59 What is the name of the suburb where you live?

Q60 Could you please tell me your postcode?

Q61 As part of our quality control procedures our supervisors call back roughly 10 per cent of respondents to check 3 or 4 questions.

It would take no more than 1 minute of your time.

Would you be willing to be called back?
1 Yes
2 No
X Don't know
R Refused

Q62 Would you be happy to participate in further research about the health of people in your area?
1 Yes
2 No
X Don't know
R Refused

Q62a So that we know who to speak with when we call back could you please tell me your given name?

That completes the survey. Thank you for taking the time to help us.

<Interviewer> Did the participant mention the M5 study?
1 Yes
2 No

Appendix C – Crude and adjusted prevalence rate ratios of potential confounders

Crude Prevalence Rate Ratios of Potential Confounders by Eye Symptoms

	Eye Symptom		More Frequent &/or Severe Eye Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
Age (1 yr)	1.00 (0.99–1.00)	1.00 (0.99–1.00)	**1.01 (1.00–1.02)+**	**1.01 (1.00–1.02)+**
Sex (female)	1.03 (0.87–1.21)	1.04 (0.88–1.22)	1.30 (0.92–1.84)	1.30 (0.92–1.84)
Exposure to cigarette smoke	1.16 (0.99–1.37)	1.17 (0.99–1.38)	1.37 (0.96–1.96)	**1.51 (1.07–2.13)+**
Internal garaging	0.98 (0.81–1.19)	0.98 (0.75–1.27)	0.79 (0.51–1.22)	0.80 (0.43–1.46)

Crude Prevalence Rate Ratios of Potential Confounders by Nose Symptoms

	Nose Symptom		More Frequent &/or Severe Nose Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
Age (1 yr)	1.00 (1.00–1.00)	1.00 (1.00–1.00)	1.00 (0.99–1.01)	1.00 (0.99–1.01)
Sex (female)	1.02 (0.91–1.14)	1.02 (0.91–1.14)	1.23 (0.98–1.54)	1.22 (0.97–1.52)
Exposure to cigarette smoke	0.98 (0.87–1.11)	0.98 (0.87–1.11)	0.90 (0.71–1.15)	0.93 (0.73–1.20)
Internal garaging	0.93 (0.81–1.07)	0.89 (0.72–1.09)	0.78 (0.58–1.05)	0.71 (0.46–1.11)

Crude Prevalence Rate Ratios of Potential Confounders by Throat Symptoms

	Throat Symptom		More Frequent &/or Severe Throat Symptoms	
	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)	Crude prevalence rate ratio (95%CI)	Adjusted prevalence rate ratio (95%CI)
Age (1 yr)	**0.99 (0.98–1.00)+**	**0.99 (0.98–1.00)+**	1.00 (0.99–1.01)	1.00 (0.99–1.01)
Sex (female)	1.16 (0.92–1.47)	1.19 (0.94–1.49)	1.38 (0.94–2.02)	1.39 (0.94–2.04)
Exposure to cigarette smoke	1.20 (0.94–1.52)	1.17 (0.92–1.48)	1.19 (0.81–1.76)	1.27 (0.85–1.89)
Internal garaging	1.08 (0.82–1.41)	1.10 (0.77–1.57)	0.83 (0.53–1.30)	0.86 (0.44–1.69)

+ P-value <0.05

Appendix D – Comparison of modelled period stack emissions with study period stack emissions

Emissions Data

In order to determine if M5 East stack emissions during our study period (August 2003 to November 2003) differed from the modelled period (February 2002 to January 2003), averaged hourly stack emissions data for the study period were compared against emissions data for the modelled period using SPSS v.11 statistical software package.

Eight thousand seven hundred and sixty (8760) observations were recorded for the modelled period (February 2002 to January 2003) to be compared against two thousand eight hundred and eighty nine (2889) for the study period (August 2003 to November 2003).

Flow Rate

The mean level of NOx flow rate for the study period (5.8 g/s) was greater than the mean level of NOx flow rate (4.5g/s) for the modelled period. The maximum NOx flow rate for the study period (14.4g/s) was slightly lower than that of the modelled period (14.8g/s) (Table 1).

Table 1 Comparison of NOx flow rates

	Modelled period (g/s)	Study period (g/s)
Mean	4.5	5.8
Median	4.1	5.2
Maximum	14.8	14.4

The mean level of PM_{10} flow rate for the study period (0.32g/s) was lower than that for the modelled period (0.34 g/s). The maximum PM_{10} flow rate for the interview period (1.47g/s) was slightly lower than that of the modelled period (1.48g/s) (Table 2).

Table 2 Comparison of PM10 flow rates

	Modelled period (g/s)	Study period (g/s)
Mean	0.34	0.32
Median	0.17	0.18
Maximum	1.48	1.47

Concentration

The mean NOx concentration in stack emissions for the study period (3.4 ppm) was greater than the mean NOx concentration (2.6 ppm) for the modelled period. The maximum concentration for the study period (8.5 ppm) was larger than that of the modelled period (7.6 ppm) (Table 3).

Table 3 Comparison of NOx concentration levels

	Modelled period (ppm)	Study period (ppm)
Mean	2.6	3.4
Median	2.4	3.0
Maximum	7.6	8.5

The mean PM_{10} concentration for the study period (370 ug/m3) was lower than the mean PM_{10} concentration (390 ug/m3) for the modelled period. The maximum concentration for the study period (1609 ug/m3) was equal to that of the modelled period (1609 ug/m3) (Table 4).

Table 4 Comparison of PM10 concentration levels

	Modelled period (ug/m^3)	Study period (ug/m^3)
Mean	390	370
Median	220	226
Maximum	1609	1609

Discussion

The mean levels of NOx over the study period were higher than over the modelled period while the levels of PM_{10} were slightly lower over the study period when compared with the modelled period. Should the difference in NOx levels between the periods have had an affect on population exposure levels, it would have made it more likely for the study to detect any association between stack emissions and population health. Although the PM_{10} levels were slightly lower during the study period, a difference of this magnitude is unlikely to cause a biologically significant effect.

References 7

1 Capon A, Rutherford A, Sheppeard V, Emmett K, Loblay R, Marks G, *Investigation into the Possible Health Impacts of the M5 East Motorway Stack on the Turrella Community – Phase 1 A Cross-Sectional Clinical Assessment of Potentially Affected Residents.* [Online http://www.health.nsw.gov.au/pubs/m/pdf/m5_stackreport.pdf] NSW Health Department.

2 Earth Resource Mapping Ltd. 2003, *ER Mapper 6.4,* Perth, WA.

3 MapInfo Corporation, *MapMarker Australia Version 8.00.0.01, Data Revision: SP801a 2003,* Troy, NY.

4 MapInfo Corporation. *MapInfo Professional Version 6.5 2001.* Troy, NY.

5 Hintze J 2001, *NCSS and PASS number cruncher statistical systems,* Kaysville, Utah USA.

6 Williamson M, Baker D and Jorm L 2001, *The NSW Health Survey Program: Overview and methods, 1996–2000*. Sydney: NSW Department of Health. Note that zone and not Area Health Service is the stratification variable for weighting.

7 Online [http://www.health.nsw.gov.au/public-health/survey/hsurvey.html] NSW Health Department

8 McMonnies CW Ho A 1987, *Patient history in screening for dry eye conditions*, Journal of the American Optometric Association: 58 (4), pp 296-301

9 Lipscomb J, Goldman L, Satin K, Smith D, Vance W, Neutra R 2001, *A Follow-up Study of the Community near the McColl Waste Disposal Site,* Environmental Health Perspectives, vol 94, pp 15-24.

10 Shusterman D, Lipscomb J, Neutra R, Satin K 1991, *Symptom Prevalence and Odor-Worry Interaction near Hazardous Waste Sites,* Environmental Health Perspectives, vol 94, pp 25-30.

11 NSW Health, *The NSW Adult Health Survey 2002*. NSW Public Health Bulletin Supplement 2003; 14(S-4). NSW Health Department

12 Australian Bureau of Statistics 2001, *Census*, Community Profiles Series. Basic Community Profiles Catalog No. 2001.0

13 Levy PS, Lemeshow S 1999, *Sampling of populations: Methods and Applications.* Third edition. New York: John Wiley & Sons.

14 Korn EL, Graubard BI 1995, *Analysis of Large Health Surveys: Accounting for the Sampling Design, Journal of the Royal Statistical Society,* A 158, 263-295.

15 SAS Institute 2001, *The SAS System for Windows version 8.02*. Cary NC: SAS Institute Inc.

16 Research Triangle Institute 2002, *SUDAAN. Software for the Statistical Analysis of Correlated Data*. Research Triangle Institute.

17 Davies HTO, Crombie IK, Tavakoli M 1998, *When can odds ratios mislead?* BMJ, 316, pp 989-991.

18 Greenland S 1987, *Interpretation and choice of effect measure in epidemiologic analyses. American Journal of Epidemiology,* 125(5), pp 761-768.

19 McCartyC, Bansal A, Livingston P, Stanislavsky Y, Taylor H 1998, *The Epidemiology of Dry Eye in Melbourne, Australia.* Ophthalmology, 105(6), 1114–1119.

20 Albietz J 2000, *Prevalence of Dry Eye Subtypes in Clinical Optometry Practice.* Optometry and Vision Science, 77 (7), pp 357–363.

21 Gonzalez C, Bosch A, Kogevinas M, Bleda M, Gadea E, Huici A, Ergo OP, *Biomonitoring Study of People Living near or Working at a Municipal Solid-Waste Incinerator Before and After Two Years of Operation,* Archives of Environmental Health July/August 2000, vol 55 (No.4), pp 259-267.

22 Brender J, Pichette J, Suaez L, Hendricks K, Holt M 2003, *Health Risks of Residential Exposure to Polycyclic Aromatic Hydrocarbons.* Archives of Environmental Health, February, vol 58 (No.2), pp 111-118.

23 Neutra R, Lipscomb J, Satin K, Shusterman D 1991, *Hypotheses to Explain the Higher Symptom Rates Observed around Hazardous Waste Sites,* Environmental Health Perspectives, vol 94, pp 31-38.