Submission to NSW Dept of Planning & Infrastructure
Opposing PWCS T4 Coal Loader
Preferred Project Report

7 November, 2013

To: Rebecca Sommer
Department of Planning
GPO Box 39
Sydney 2001

From: Newcastle Public Health Professionals

Contributors

Nick Higginbotham, PhD

Ben Ewald, MBBS, PhD

Graeme Horton, MEnvStud, MBBS, PhD Candidate

John Hall, MBBS, MTH, FAFPHM

Kypros Kypri, PhD

Abul Hasnat Milton, MBBS, M.Sc (Epidemiology), PhD

Mark McEvoy, Grad. Dip. (Genetic Counseling),
MMedSci (Clinical Epidemiology), PhD Candidate

Recommendations Related to Air Quality

As public health professionals, we regard the Port Waratah Coal Services Terminal 4 (T4) Preferred Project Report (PPR) as a significant threat to public health.

Based on our analysis of the PWCS T4 PPR, we recommend:

1) That the PAC ensure there is no increase in emissions into the Newcastle regional air shed. Particulate pollution PM10 has now reached the annual WHO standard of 20ug/m3 (Newcastle monitor 2012) and the NEPM annual guideline for PM2.5 of 8ug/m3 (Beresfield monitor2012).

2) That the PAC consider applying the WHO standard for PM10 to the assessment of T4, and encourage a whole of government and industry effort be made to reduce regional air pollution to reap the population health benefits of reducing particulates.

3) That the PAC consider recent science and policy advances based on evaluation of 'incremental increases' in pollution. New standards and emission reduction aspirations (from both WHO and NEPM) are likely to come into effect well before T4 construction begins but have not been utilized for PWCS' assessment.

4) That PAC members consider the recent decision by the World Health Organization's International Agency for Research on Cancer (IARC 2013) to classify air pollution as 'carcinogenic to humans,' and WHO's (2013) renewed judgment that exposure to PM2.5 and the coarse fraction of PM10 cause morbidity and mortality. These classifications must be incorporated into the assessment of pollution and health impacts.

5) That T4 proponents be required to undertake a formal **Health Impact Assessment** showing the potential risk of hospitalization, symptoms, disease and death among local residents exposed to current coal loader operations and the additional attributable impact of T4. The Health Statement, Appendix D, does not meet this requirement.

6) That the Health Impact Assessment include impacts on residents adjacent to the coal rail corridor, including modeling of particulate dispersion either side of the rail line based on a redesigned rail pollution study involving community stakeholders on the design team.

7) That the PPR air quality modeling be repeated based on at least 10 years accumulation of monitoring data 2003 to 2012 (and include the Fullerton St, Stockton monitor). The current modeling based on the year 2010 alone cannot be used as a basis for decision-making.

8) That T4 emissions be recalculated taking into consideration three locomotives per full train throughput (not two), the actual amount of time each train remains on site (including frequent delays), and worst case scenarios under climate change extreme events that would cause greater fugitive emissions.

9) That failsafe mitigation and control measures be applied to the T4 site preventing fugitive coal dust emissions from entering adjacent residential areas even in extreme weather events, which are predicted to become more frequent. Mitigation should include rules to cease operations during hot dry winds, wind barriers and other infrastructure.

10) That all trains hauling coal to T4 prevent fugitive coal dust emissions through proven means such as covering the coal wagons and washing the empty wagons before they leave the T4 site. All locomotives entering T4 site should be certified as **tier 2 compliant** in terms of diesel exhaust emissions (a known carcinogen).

11) That Dr. McKenzie's assessment that T4 will not produce noticeable harm be rejected by the PAC as not tenable, inasmuch as eleven generalisations he adopts are contradicted by evidence in the international air pollution and health literature.

Findings Against Approval of T4

1. Clean Air

Access to **clean air** is essential for supporting life on our planet. Unpolluted air is priceless and worth all our efforts to maintain it. Once air is polluted, it is hard to reverse course. That polluted air becomes the new starting point for the next development application. Leading air pollution and health scientist, Arden Pope III, concludes that polluting the cleanest air produces the most harm (i.e., the slope of the dose-effect curve is steepest at the lowest levels of air pollution). The main effort of government should be towards protecting clean air and reducing existing pollution (Pope, September 24, 2013; Pope et al., 2009; WHO, 2013).

2. Outdated T4 Air Assessment Method

The approach taken in the T4 air quality assessment is outdated; it does not keep pace with current knowledge in air science and evolving air quality policy (e.g., WHO, 2013). The now established linear relationship between particulate concentrations (PM10/PM2.5), disease and death, means there is no **absolute threshold** below which polluted air is safe (WHO, 2013). Something is lost in health terms from every increase in pollution, even short term; conversely, something is gained from every decrease in pollution, irrespective of formal standards (Guy Marks, September 23, 2013). (Australia's air pollution standards

(NEPM) were set in 1998.) To simply aim for air within the NEPM standard is an overly simplistic approach, one that does not account for the well-documented health effects of particulate pollution at lower levels.

The T4 EA air modeling only considers whether the coal loader will add more days when the standard is exceeded. This is woefully inadequate for allowing the public and project reviewers to know the increased relative risk of premature death and disease, as well as increased health services use, and associated costs of medical care and fatalities. Prof Guy Marks states: "The current model of air pollution regulation, which sets targets and regulates to these targets, does not in fact encourage emission reductions below those target levels and therefore would not achieve those health gains which are available [by pollution reductions]" (Senate Hearings, 16 April, 2013, p 30).

NSW State Environmental Health division, in conjunction with the National Environmental Health Council, is developing an approach termed "incremental air-quality standards above baseline." It aims to establish an "incremental level above which you should not pollute" (Prof Wayne Smith, Senate Hearings, 16 April, 2013, page 6). This evaluates the harm of increments of pollution added into an existing airshed in conjunction with community 'appetite' for increased risk. For example, adding 10ug/m3 of PM2.5 into an airshed (with a known 6% increased risk of mortality; Krewski, et al 2009) could trigger a rejection of that development by health officials. Such decisions would not be based on the size of the jurisdiction as is currently the case.

Air quality standards are rapidly evolving worldwide. WHO standards for annual PM10 (20ug/m3; WHO 2006) are stricter than those of NSW OEH (30ug/m3). Current WHO scientific review shows that adverse health effects can occur at air pollution concentrations lower than those used for the 2005 guidelines, thus giving impetus for further downward revisions (WHO, 2013). Australia's NEPM standards have been under review since 2005, with COAG releasing review recommendations in September 2011. The review's recommendations are being responded to through the development of the National Plan for Clean Air, a robust framework for identifying cost effective emission reduction actions, and implementation arrangements (COAG, 2013).

These science and policy advances merit PAC deliberation in relation to T4 air quality assessment, inasmuch as new standards and emission reduction aspirations would likely come into effect well before any T4 construction might begin.

It would be unfortunate in the extreme if Hunter residents were condemned to live under the cloud of pollution for decades into the future, based on understandings of pollution assessment that are decades old.

3. **Harm from Particulates: WHO 2013 & other literature**

Although T4 consultants did not cite it, the WHO released a comprehensive review of evidence on health aspects of pollution in January 2013 (WHO, 2013).

The review confirms the causal link between both *short term* and *long term* exposure to PM2.5 (fine) particles and premature death and disease. Previous research shows that fine particulate exposure increases respiratory diseases such as asthma, bronchitis, COPD, and lung cancer (WHO 2006). The WHO experts conclude that long-term exposure also causes fatal and non-fatal heart disease, and is linked to new health outcomes including childhood respiratory disease, atherosclerosis and adverse birth outcomes.

Very significantly in relation to T4 air quality, the WHO review reaffirmed the importance of assessing the coarse fraction particle sizes, PM2.5 to PM10. This size is strongly linked to respiratory tract disease (e.g., COPD, asthma, respiratory admissions) as well as daily mortality (see Brunekreef & Forsberg, 2005). PM10 has its own unique pathway to disease, beyond that of PM2.5, and should continue to be given weight in air assessment separately from PM2.5. In particular, coal dust is found in the 'mechanical' PM10 fraction (less so in the PM2.5 'combustion fraction'), and is emitted into the air through T4 coal train movements, dumping, conveying and wind erosion from the coal stockpiles.

Adding to evidence of harms from pollution, WHO's International Agency for Research on Cancer (IARC) just released state-of-the-art overview classifying air pollution as 'carcinogenic to humans' (IARC, 2013). While "the precise chemical and physical features of ambient air pollution vary around the world… the mixtures of ambient air pollution invariably contain specific chemicals known to be carcinogenic". In particular, IARC found sufficient evidence that exposure to outdoor air pollution is a cause of lung cancer and estimated 220,000 premature deaths globally from this cause (IARC, 2013).

4. No Health Impact Assessment

a. Vulnerable populations

A significant failure of the T4 EA is its lack of a Health Impact Assessment (HIA). Without a proper HIA of the areas surrounding T4 and the coal corridor, we cannot know how T4 pollution will affect local residents. To analyse quantitatively T4's impact on health, the proponents should provide information on air pollution concentrations and exposure, the population groups exposed, background incidence of mortality and morbidity, and concentration–response (CR) functions (WHO 2006, p 153). Negative impacts fall disproportionately on the most vulnerable: those with least economic resources to buffer pollution, people with chronic heart and respiratory disease, asthmatics, infants, children and the elderly (e.g., WHO 2006, p.111).

2011 Census data show that 25,680 people live in the 10 suburbs adjacent to T4 (within approximately 2km), from Sandgate in the west to Fern Bay and Stockton in the east. Demographically, compared to the NSW state average, those living close to the T4 site have lower household incomes and a higher rate of unemployment (excluding Warabrook). Importantly nearly one third of residents are children 14 years or younger and the elderly (65 years and older). These neighbourhoods include 24 schools, preschools and nursing homes.

Health status data are not readily available at the neighbourhood level in NSW. However, the demographic profile of these local areas indicates that the increased pollution from T4 will disproportionately harm the vulnerable—children, those most likely to have lower health status (elderly), and those least likely to have economic resources to buffer poor air quality impacts.

The NSW Department of Health (2010) reported the Mayfield area is:

- 10^{th} of 32 postcodes, 0-4 years age, for Emergency Department (ED) respiratory illness;
- 5^{th} for 65+ years ED for respiratory illness;
- 4^{th} of 32 areas for 0-14 years ED visits for asthma;
- Hunter death rate for all causes & cardiovascular disease higher than state average

b. Existing poor air

T4 will make already poor air quality around the Port of Newcastle even worse. Industry monitoring sites near Kooragang Island are already at or above the WHO PM10 annual standards of 20ug/m3 as shown in the T4 EA. The recently established Fullerton Street Stockton monitoring station regularly records exceedences of NEPM particulate standards. In the first two weeks of October, prior to the onset of bushfires, there were 4 failures of the 50 ug/m3 24-hour limit. These failures arose from NW winds blowing across Kooragang Island toward Stockton as shown in Figure 1 below.
http://www.stocktonairqualitymonitoring.com/downloads.html)

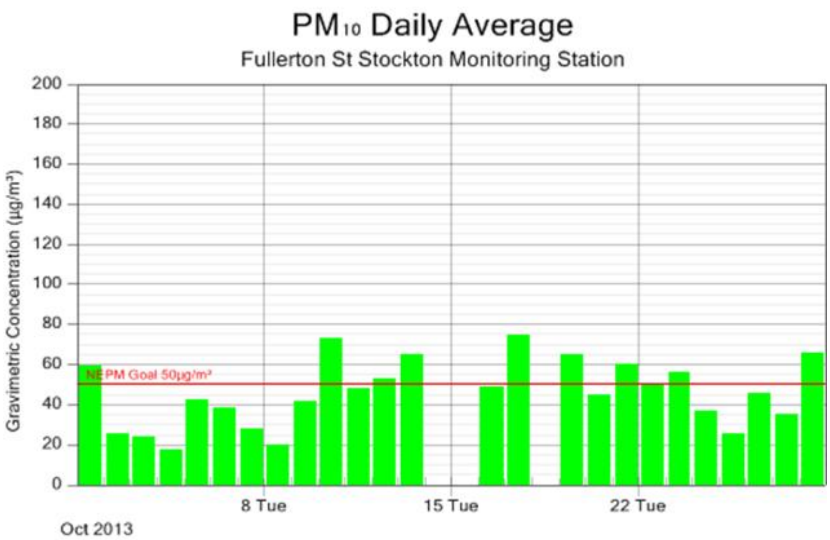


Figure 1: PM10 24 hour Values and Exceedances for October 2013 – Stockton Fullerton St. Monitoring Station,

Moreover, the 2012 annual PM10 readings for the EPA ambient sites in Newcastle and Beresfield were also above the WHO standard (20ug/m3) and

Beresfield reached the annual guideline for PM2.5 (8ug/m3).

Air monitoring data collected in December 2012, by the CTAG Dust and Health Committee, add further evidence of poor air quality near Newcastle Port (CTAG, March 2013). Three Osiris instruments for continuous measurement of PM10 and PM2.5 particulates were set up at residences in the vicinity of the coal rail line and Carrington coal loader. The instruments were carefully placed over one week, following advice from air scientist Professor Howard Bridgman, who also analysed the Osiris data.

The results showed that at 7 of 11 residences, the PM10 NEPM standard of 50ug/m3 was not met on at least one day. At one Carrington residence, the NEPM standard was exceeded on all 5 days the Osiris was in place, including two readings at the 80 ug/m3 level. At Tighes Hill, 5 of 7 days were over the limit, with a maximum reading of 67 ug/m3 in 24 hours. Higher levels of particulate pollution tended to be recorded when the wind came from nearby coal stockpiles or the coal train line.

These populated areas close to the T4 site are 'hot spots' of industrial pollution that deserve establishment of formal EPA air monitoring and pollution reduction action. The Osiris monitors are used routinely by industry, but are not the official TEOM instruments the EPA deploy for ambient measurements. For example, the Australian Rail Track Corporation (ARTC) used Osiris equipment in a study undertaken to comply with their EPA Pollution Reduction Program (Environ, September 2012).

c. Train line pollution

Loaded and unloaded coal trains moving along the coal corridor and within the T4 site are a significant and poorly understood source of harmful emissions from: 1) diesel combustion; 2) wind erosion of loaded coal wagons and wind scouring of residual coal dust from empty wagons; 3) re-suspension of coal dust spilled along the corridor; and 4) entrainment of all of these particulates and their dispersion into the air shed.

The world literature estimates that from 0.001% to 1% of the coal load is lost during transport (e.g., Ferreira et al., 2003; one estimate is 3%, BNSF, 2011). Ferreira et al. (2003 & 2004) found that uncovered wagons could emit up to 5 times more than semi-covered wagons, or 8.57g/km/wagon (Connell Hatch, 2008). Extensive load losses can destabilize ballast, causing derailment. BNSF Railway in the USA advises:

> "BNSF has determined that coal dust poses a serious threat to the stability of the track structure and thus to the operational integrity of our lines in the Powder River Basin." http://www.bnsf.com/customers/what-can-i-ship/coal/coal-dust.html

Entrainment of carcinogenic diesel combustion emissions plus fugitive coal dust exposes residents living near the rail line to particulate pollution depending on their distance from the track, weather, moisture, wind speed and direction, train speed and the number of train pass-bys.

The PPR (Vol 5 p73) states that 26.6 trains will haul 7200 tonnes of coal daily to achieve 70mt annual volume at T4. Table 1 shows the impact of this additional 25% in rail volume to the existing and approved coal tonnage, and the cumulative daily pass-bys imposed upon residents near the rail corridor.

Table 1: Newcastle Port coal tonnage & daily train movements

		Daily loaded trains	Daily round-trip pass-bys	Annual Pass-bys
2013	140mt	53.2	106.4	38,836
Approved	210mt	79.8	159.6	58,254
With T4	280mt	106.4	212.8	77,672
(T4 alone)	(+70mt)	(26.6)	(53.2)	(19,418)

Coal throughput of 280mt at Newcastle port requires one coal train pass-by every 6.7 minutes. GIS mapping shows there are 32,000 house residents and 23,000 school children attending schools within 500m of the coal corridor (between the Port and Rutherford). Residents and students face the ever-expanding impact of having the equivalent of a heavy industrial workplace coming into their homes and classroom.

d. Train Pollution Averages

Given the number of residents and children located close to the rail corridor, and the dramatically increased frequency of coal train pass-bys (1 @ 6.7 minutes), how much pollution does each train contribute to the air shed during a pass-by? The ARTC commissioned two studies to address this issue, a pilot study (Environ, Sept. 2012) in two locations and a further study at Metford (Katestone May 2013). Unfortunately, the pilot study was methodologically flawed and it's results are not informative, while the Katestone study awaits independent statistical analysis and has other significant shortcomings (see critique below).

Despite its limitations, the Katestone study has some information that may be indicative of coal corridor pollution. Over the December to January 2013 recording periods, when the wind past the tracks was toward the Osiris monitor, the average background particulates (no train present) was PM10 = 32ug/m3 and PM2.5 = 10 ug/m3 (averaged over 2 months). While we are critical of their method of calculation, Katestone did report that on average, unloaded coal trains added 7.6ug/m3 (24%) of PM10, and 2.1 ug/m3 (21%) of PM2.5 into the corridor above 'no train' background. Loaded trains were about half those figures (Katestone, May, 2013, Figures B5 & B6).

CTAG undertook Osiris trackside monitoring in July 2013 seeking to overcome Katestone's methodological weaknesses by: 1) locating the monitors downwind of the rail line; 2) calibrating the monitors with the nearby Beresfield EPA site; 3) having Osiris Industry expert Mike Fry supervise the instrument deployment; 4) including two sites (Beresfield & Hexham) to increase variability in train circumstances; and, 5) undertaking intensive observations of trackside conditions over the whole time the monitor was in place. Seventy coal trains were measured during three days of monitoring, plus passenger and freight trains.

Table 2 summarises the contribution of coal train pollution above background levels by subtracting a standardized 2-minute average of recorded pass-by particulates with a two-minute prior period when no train was present (CTAG, August 2013).

Table 2: Coal train particulates added into air shed above background Levels (average ug/m3) (CTAG, August 2013)

	PM10 loaded Coal train	PM10 unloaded coal train	PM2.5 loaded coal train	PM2.5 unloaded coal train
Monday 15/7/13 Beresfield	11.8ug/m3 (n=9)	22.4ug/me (n=11)		
Tuesday 16/7/13 Hexham	7.2ug/m3 (n=13)	18.9 ug/m3 (n=11)	2.9ug/m3 (n=13)	7.1ug/m3 (n=11)

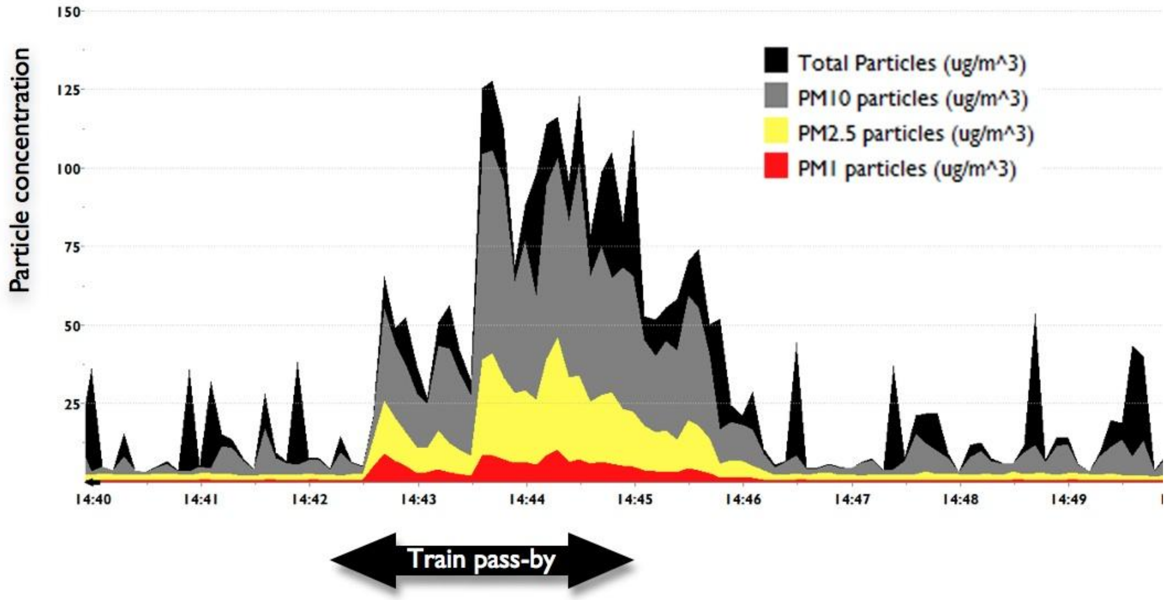
While the Katestone and CTAG study used different averaging methods, and the latter found much higher emissions, both indicate per train contributions are significant sources of constant corridor pollution. Modeling these concentrations from trains passing by every 6.7 minutes, with an already high corridor background level, severely challenges the trustworthiness of Environ's figures on air quality impacts along the rail corridor (peak 24 hour PM10 of 1.5 to 6.4ug/m3) (Appendix O, pg. 46).

If the 'no train' background PM2.5 in the corridor is 10.1 as per Katestone, and each train adds between 2 and 7 ug/m3, every 6.7 minutes, then annual averages may well exceed standards in nearby residences. A characteristic of PM2.5 is longer airborne time, wider area coverage (Hibberd et al., 2013), and strong link with a range of diseases and mortality (Pope et al., 2009).

e. Train Pollution Signatures

The unique contribution of the CTAG trackside monitoring is its intense scrutiny of each train pass-by enabling researchers to characterize train 'signatures' for different types of trains. Such signatures show the profile of particulate pollution when near continuous measurements (every 6 seconds) are taken during the period when the coal train moves past the Osiris monitor. This profile reveals the upward development to the peak particulate concentrations, proportions of different particulate sizes, as well as the entrainment of suspended particulates after the train has passed, until they diminish to pre-train levels. Figure 1 shows how this method produces fine-grained understandings of the dynamics of train pollution emissions (CTAG, August, 2013, pg. 13).

Figure 1. Signature 2 - Unloaded Coal Train Monday 14:42pm



Signature 2 is indicative of an unloaded coal train pass-by. Unloaded coal trains generally approached the Beresfield Osiris monitor at higher speeds than loaded coal trains. This unloaded coal train (with 3 locomotives and 98 wagons) slowed to an average speed of 35km/hr. The wind was moving at 0.13km/hr and turned from N to the direction of the train, which was SE/SSE during the pass-by.

This signature shows two initial spikes in particulate matter with a one-minute delay and then a third, larger and more sustained pollution plume. The signature shows a clear indication of diesel emissions (PM1) and strong PM2.5 levels accompanying the high levels of PM10. The two-minute average of PM10 was 66.7μg/m3 compared to the two-minute average pre-train level of 6.6μg/m3. An entrainment of more than four minutes is noted.

The CTAG study found that 80% of coal trains produced a recognisable pollution signature. Overall, the signatures compromise a sharp rise in TSP, PM10, PM2.5 and PM1 particulates, lasting 3.5 to 5 minutes. They show initial bursts of ultrafine PM1 and fine PM2.5 particulates indicating diesel combustion and chemical reaction processes. The ultrafine and fine particulates are contained within larger spikes of dust, mostly PM10.

Professor Howard Bridgman has stated that coal dust is most likely to be associated with particle sizes between PM2.5 and PM10. Signature magnitude is influenced by factors such as wind speed and direction, train speed and distance from the monitor. The analysis of two-minute segments of these signatures showed that PM10 levels were at least double pre-train particulate levels, and ranged up to 13 times larger. It was not uncommon to have PM10 spikes beyond 100 ug/m3 and PM2.5 spikes between 25 - 50ug/m3 while trains passed the monitor.

f. Years of Life Lost due to PM2.5 pollution

NSW Department of Health estimated the number of annual deaths in the Hunter from anthropogenic PM2.5 fine particulates (Broome, September 24, 2013) (See Table 3.). After removing natural 'background' levels (assumed to be 4ug/m3), attributable PM2.5 pollution deaths and number of years of life lost (YLL) were calculated based on census data. Krewski et al's (2009) concentration-response function was used to determine total mortality (i.e., 6% increase in deaths (RR1.06) for each10ug/m3 increase in PM2.5). It can be noted that fatalities from cardiopulmonary disease rise by 13% with such increases in fine particulates; ischemic heart disease, which is above state average in the Hunter, has an especially strong relationship with increased pollution.

Table 3: Mortality and Years of Life Lost from 'beyond baseline' PM2.5 particulates in the Hunter (NSW Health)

	Newcastle	Muswellbrook	Singleton	Sydney
Attributable deaths	25	2	2	223
Years of Life Lost	296	30	31	2805
Days Loss of life expectancy: men	34	101	72	30
Days Loss of life expectancy: women	31	94	66	28

In brief, 296 years of life are lost in the Newcastle area associated with exposure to PM2.5 levels (minus the background of 4ug/m3) along with 25 deaths. A male and female born today in Newcastle can expect to have their life shortened by 34 and 31 days, respectively. These figures are based on Newcastle having an annual average PM2.5 of 5.7ug/m3 (RR1.01), Muswellbrook 9.1ug/m3 (RR1.03) and Singleton 7.6ug/m3 (RR1.02).

It is striking that Sydney, with many times higher population density and sources of pollution, actually has fewer days of life lost, in comparison with Newcastle, and particularly in contrast with Muswellbrook and Singleton—areas most affected by coal mining, transport and combustion for electricity.

g. Lack of Health Impact Assessment: Conclusion

It is profoundly negligent for T4 proponents to avoid undertaking a Health Impact Assessment. This failure means the community will not know what inequitable harms to human health will incur from adding more pollution into the air shed of residents adjacent to T4 and those living alongside the coal rail corridor leading into T4. The data cited provide the threads of a Health Impact Assessment, showing that: 'hot spot' neighbourhoods are already badly affected by industrial pollution; the residents exposed are most vulnerable in terms of socioeconomic status and age groups; residents rank highly in hospital emergency visits for respiratory illness; and they have greater days of life expectancy loss than Sydney.

The coal rail line is becoming a toxic corridor with continuous high spikes of diesel combustion and coarse level particulates entrained and spread beyond the rail line. Concentrations will invariably double from present levels as the coal industry's aspirations for 280mt throughput (with T4) are realized. The health costs, in terms of attributable deaths, years of life lost, treatment service expenditure, and days of lost productivity due to illness, are significant 'externalities' that are ignored by the T4 proponents (e.g., ATSE, 2009; Muller et al, 2011) How can a true picture of the T4 development's merits be formed without careful consideration of the health costs that it will accrue?

5. Unsafe Assumptions underlying air quality modeling

PPR T4 particulate modeling states that at 70Mtpa operations generated (incremental) pollution for 24-hour average PM10 will range from 1.0ug/m3 to 6.8ug/m3 at adjacent residential locations (R1 –R10). Annual incremental averages for PM10 will range from 0.1 – 1.0ug/m3. Maximum increases of 24-hour average PM2.5 will range from 0.5 to 4.0ug/m3 with annual averages ranging from 0.1 to 0.6ug/m3. Compared with 2010 background levels, these increments were not expected to create any additional exceedences of OEH criteria.

We believe the air quality modeling makes numerous unsafe assumptions in the calculation of these levels, resulting in underestimates of what the particulate concentrations will actually be and the number of exceedences.

a) Choice of 2010 as background

2010 is a poor representation of regional air quality. Over the past 8 years, 2010 had the lowest level of PM10 for Newcastle and Beresfield. With the expansion of coal handling activities since 2010, later years should be included in background calculations. Indeed, a more defensible practice would be to combine background levels for the past ten years. Selecting the lowest recorded year in recent times for PM10 could be interpreted as an attempt to minimize the chance for additional exceedences to be predicted.

b) Number of locomotives per train, train time on site & staging areas

T4 site emissions are underestimated by assuming that only two locos are required to pull 7200 tonnes of coal per train movement. CTAG observations of loaded coal trains showed that 76% with 72 wagons or more had three locomotives in the train composition. With virtually no diesel locomotives having any PM emission controls (Appendix O, pg 73), and producing 1.321 grams of PM10 per litre of diesel combusted (Environ, June 21, 2012, pg. 27), these movements are a major source of carcinogenic fine and ultrafine particulates, as recorded in the CTAG train signature study.

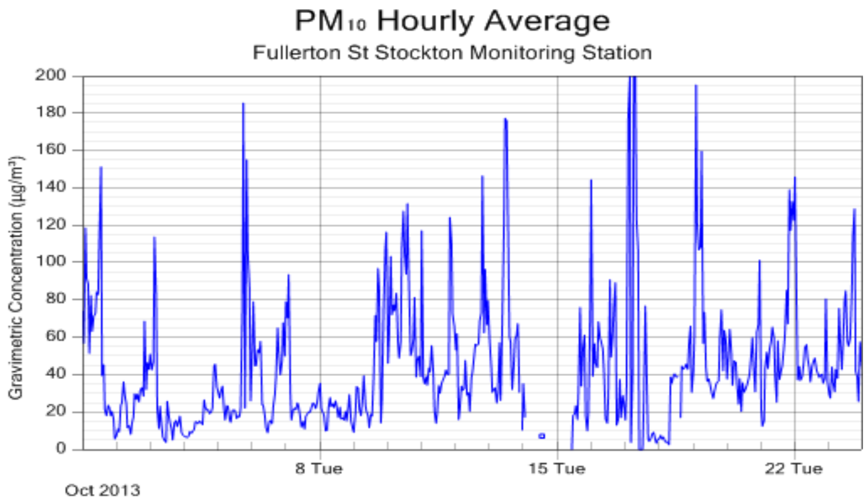
Furthermore, no evidence was given to support the assumption that coal trains only spend **2 hours** on the site. Anecdotal information from talking with train drivers is that **4 hours** is a better average and that delays are common. Given that the locomotives are run continuously during the process of unloading, it is critical to have accurate time specifications of how long each remains on Kooragang, and the number of delays that occur, adding further hours on site.

Furthermore, trains standing by on the tracks at Hexham and Sandgate waiting to enter the coal loading area must also be included in these calculations. These locations should be considered extensions of the T4 operations as they are in daily use as staging areas.

In brief, T4 emissions estimates are highly sensitive to these types of assumptions buried in the report appendices. Combustion gases and particulate concentrations need to be reanalyzed to reflect additional locomotive engagement (add 1/3rd to present levels), additional time spent on site (double present levels), and the staging time of trains along the tracks outside the entrance to T4 .

c) Are 'best practices' failsafe?

Kooragang Island, Newcastle Coal Infrastructure Group,
Thursday, 17 October, 11am.



The photo above of the Kooragang NCIG stacker/reclaimer (October 17, 2013, 11am) indicates that 'best practice' techniques to control fugitive coal dust emissions can fail, especially when testing weather conditions occur. The dust coming off the stacker is blowing toward Stockton, which had a dramatic PM10 exceedence on the monitor that day (shown in the graph below the photo).

Increases in extreme weather events leading to wind erosion like this will occur more often under climate change scenarios (Scott, et al., 2013). A better understanding of the El Nino-Southern Oscillation (ENSO) indicates that ENSO-induced drought and floods will be more intense in the future. This raises the question of whether the increased frequency of such events can be effectively handled by 'predictive/reactive monitoring', which is central to PPR's approach.

In essence, reactive monitoring involves adding more water to the stacks. The repeated events of poor air quality in Stockton, when dry northwesterly winds blow across Kooragang island, indicates that 'best practice' in coal loading does not mitigate fugitive emissions in such conditions. Further air quality modeling should be performed under scenarios of minimal, moderate and 'best practice' control of PWCS fugitive emissions.

6. Rail Line 'Off Limits' to T4 assessment

PWCS does not acknowledge responsibility for coal rail corridor impacts, but states it would work with ARTC and miners 'around' reducing train fugitive emissions. Yet, the proven failure of ARTC Katestone consultants to properly measure coal train emissions (see below), and the immediate endorsement of that failed study by the ARTC, EPA and the miners, suggests serious mitigation of rail corridor pollution will not happen.

The construction of the new coal loader is subject to a planning process, and the increase of train movements is a necessary part of the new coal loader proposal but the proponent argues that the train movements should not be considered. The train movements are not being considered by any other planning assessment process, and have significant community impacts through air quality and noise, so we argue that they should be considered under this PAC process.

7. Criticism of ARTC Rail Corridor Study

The two ARTC funded studies of coal train pollution along the rail corridor merit attention when assessing T4 for two reasons: 1) they contain obvious methodological flaws and yet the results were accepted uncritically by the project's consultants (as well as the ARTC and EPA) as giving evidence that train emissions are unimportant; 2) the EPA immediately used the second study to decide against covering coal wagons, suggesting the regulator's position is to act hastily to reassure industry about its practices, and downplay clear community concerns about coal transport pollution.

a) ARTC Pilot Study (Environ, September 2012)

Pilot studies can be extremely valuable for testing procedures, instruments and field sites under real life conditions and trialing analytic methods and techniques. Results are normally given little weight, especially when flaws are detected in the pilot methods. It is worrying, therefore, that Environ and Dr David McKenzie (see below) go into some detail about the pilot results, comparing differences between trains, and so forth, with no caution about its significant limitations.

Dr James Whelan articulated a detailed critique of the study's limitations (see Appendix A). However, from our perspective, the study's results are not publically reportable because:

i) The Osiris dust monitors set up on Mayfield and Metford were only capturing pass-by emissions every one minute (later adjusted to every 30 seconds), giving invalid measurements because train types have highly variable pass-by times (between 2 seconds [passenger] and 90--180 seconds [coal and freight]);

ii) The Mayfield monitor had a flawed "train movement system that may have resulted in a misalignment of air quality data to the relevant train movement" (Environ, September, 2012 pg7);

iii) The concentration time series ('signature') of each train pass-by is unique (it may begin some time after the front of the train passes and continue well after it fully passes); the monitor logging intervals were too crude to capture this variability; choosing a factor of 3 to extend the averaging time during low wind conditions (pg 57) would lead to markedly lower concentration levels.

b) Second ARTC Study (Katestone, May 2013)

The Katestone study in Metford in early 2013 improved train emissions measurement by logging particulates every six seconds. However, other problems with instrument failure, unusable data, inappropriate outcome measure, and incorrect statistics (identified in independent review; Knibbs, July, 2013) greatly undermined the study's interpretations.

Appendix B provides our detailed critical appraisal of Katestone's study, but an obvious validity problem is their use of Osiris results when the wind direction was blowing rail particulates away from the monitor. Only 10-19% of train pass-bys remain in the sample when the appropriate wind direction is included.

Setting aside lack of statistical testing, the biggest problem of data analysis is use of an invalid outcome measure for comparing train emissions. Katestone chose to calculate an average particulate concentration level for each train type. The problem with this is that it ignores an extremely important aspect of health risk: the duration of exposure to these particulates—i.e., how long the elevated pollution is in the air and can be inhaled. By Katestone's method, a 100 wagon 3 locomotive coal train and an 8 car XPT passenger train could produce the same average PM10 particulates, although one passes in six seconds and the other takes 3.5 minutes plus the lingering entrainment of dust.

Valid comparisons between trains requires measurement of the 'area under the curve' of each train pass-by. The area under the curve involves both the concentrations of particulates at each logged measurement (e.g., every 6 seconds the Osiris gives), plus the total **duration** of emissions coming from that individual train. The CTAG signature study demonstrated that wind speed, wind direction and train speed influence the variability of the pollution plume (signature), which often begin several seconds after wagons had passed and lingered for seconds or a minute or two after the end of the train. A new measure of 'microgram seconds' or 'microgram minutes' is proposed to more accurately capture the unique plume of each train passing a monitor; it would allow appropriate comparisons between trains (See Appendix B section 7 for how to calculate microgram seconds).

In sum, it is profoundly worrying that industry-contracted experts could produce such unreliable results and that the industry regulator would then uncritically accept those flawed findings and quickly adopt policy favourable to industry polluters. Such practices undermine community trust in any research findings communicated by either industry or the regulator.

8. Comments on Dr. McKenzie's 'Response to Health Matters' (Appendix D).

Dr McKenzie is a respiratory and sleep physician with expertise in occupational lung disorders. He provides expert witness services for the coal mining industry. In his response to health matters raised in T4 submissions, he argues against any measurable health impacts from the project.

His underlying messages, which we believe are not supported by evidence, are:

i) Air quality criteria based on urban studies (i.e. heavy vehicle emissions; diesel 'black smoke') don't apply to the T4 location. It is in a coastal river with low population and PM10 would have smaller proportion of the more harmful PM2.5.

ii) Air quality criteria provide safe levels for the majority of susceptible people, apart from only a small number with compromised health;

iii) Coal dust liberated during mining, transport and handling will be primarily larger PM10 fraction, and less harmful than combustion formed PM2.5.

iv) Overseas studies are unlikely to apply to Australian conditions; in particular, Hendryx's research on adverse impacts of living near Appalachian coal mines aren't relevant and can be explained by confounders such as poverty.

v) Coal miners are exposed to dust levels during their working lives hundreds of times higher than criteria allowed for ambient air and very few develop symptoms.

vi) Exceedences of air quality standards from time to time for areas surrounding T4 are acceptable; levels would have to increase considerably before adverse effects would be detected. Even PM10 exceedences in the range 50-80ug/m3 represent a relatively small increase in health risk.

vii) The population surrounding T4 is not large enough to observe any increase in morbidity or mortality due to project exceedences.

viii) Most predicted exceedences will be from regional events like bushfires and dust storms.

ix) Screening analysis and the ARTC pilot study show that there will be no air quality impacts along the rail corridor.

x) Particulates, fumes and gas emissions will disperse quickly from the source into the atmosphere and will not provide a health risk.

xi) In sum, T4 will not produce a measurable increase in morbidity and mortality.

Our criticism of Dr. McKenzie's opinion about T4 health impacts are threefold: First, some of his generalisations are contrary to the current epidemiology of air pollution and health; second, he fails to provide a health impact assessment framework applicable to T4 or any health burden and cost of air pollution commentary; third, he brings no independent critical appraisal to the information provided by the proponent, rather, he accepts flawed information at face value.

a) Flawed Generalisations

i) T4 coastal, low urban location, criteria don't apply

Every capital city in Australia is "coastal and on a river", apart from Canberra, so if urban air quality criteria are inapplicable to Newcastle then they are inapplicable nation wide. More than 25,000 residents live in 10 suburbs within 2kms or so of T4; 32,000 reside within 1/2km of the rail corridor. These neighbourhoods have a past history of heavy industrial pollution and particulate levels are building again as new polluters develop on Kooragang island and other port sites. Background emission sources include two main arterial roads bordering the T4 site with high levels of commuter and commercial diesel traffic (Industrial Highway/Maitland Rd and Cormorant Rd). These emissions sources are not unlike heavy use roads found in other cities.

Air science and health research experts testified at the Senate hearings on coal industry pollution that 'hot spots' (such as T4 impacted neighbourhoods) merit localized air quality monitoring and control action despite not fitting NEPM location criteria for ambient monitoring (See 2013 Senate Hearings testimony of Prof. Guy Marks, Prof. Wayne Smith, Dr. Steve Hambleton). Strengthening this argument are findings from the *Dust in our Neighbourhoods* study (CTAG, March, 2013) indicating for 7 of 11 residences monitored, the PM10 NEPM standard of 50ug/m3 was not met on at least one day.

ii) Air quality criteria are conservative (i.e., offer a large margin of safety)

This assertion contradicts the conclusions of research scientists in this field who argue that air pollution standards give a false sense of security. There is a linear dose-response relationship between concentrations and adverse effects that extends down to lower levels (below standards) without an apparent threshold (WHO, 2013; Morgan, 24 September, 2013). Because of this, "There is something to be gained from every decrease in pollution and something lost from every increase in pollution, irrespective of standards" (Guy Marks, 23 September, 2013). The latest WHO (2013) review concludes:

> "The data suggest the absence of a threshold below which no one would be affected…There are suggestions of a steeper exposure-response relation at lower levels (supra-linear) from analyses comprising studies from different areas across the globe and with different ranges and source of exposure (pg. 8-9)."

iii) Coal dust is primarily PM10 and less harmful than PM2.5

While 2.5 has become the 'magic number' in studies of adverse health events, it is misleading to suggest that the coarse PM10 fraction (i.e., particles >PM2) associated with coal mining operations is less important or less toxic. Brunekreef & Forsberg (2005) reviewed the coarse fraction of PM10 and concluded that in studies of COPD, asthma and respiratory admissions, coarse PM has a stronger or as strong short-term effects as fine PM. There was also some evidence of an independent effect of coarse PM on daily mortality (p309)."

WHO 2013 found there are benefits to reducing long-term mean concentrations of PM10 at levels far below the current EU limit value (i.e., 50ug/m3). Importantly, "Coarse and fine particles deposit at different locations in the respiratory tract, have difference sources and composition and act through partly different biological mechanisms and result in different health outcomes (p8)."

iv) <u>Australian conditions are too different from sites of overseas research</u>

The rejection of or suspicious regard for overseas studies because they are based solely on large urban zones in North America or Europe is no longer tenable. Arden Pope et al.'s (2009) analysis of air pollution and life expectancy in the USA included 51 metropolitan areas from coast to coast and border to boarder, including hot and arid southwestern sites (San Diego, Phoenix, Denver, Albuquerque, El Paso). WHO (2013) reports that desert dust episodes have been linked with CV hospital admissions and mortality in a number of recent epidemiological studies. While it is recognized that locations differ, the American European studies give the only high quality evidence available. The work showing smoking tobacco causes disease was mostly conducted outside Australia as well.

Dr McKenzie adopts the tactic of the Environ literature review in the original EA (and other coal company consultants; e.g., Entech, February, 2010) in seeking to dismiss Michael Hendryx body of research linking Appalachian coal mining with higher rates of ill health. However, more than 15 peer reviewed research publications over the past seven years provide a consistent and coherent result that a range of human health impacts are associated with proximity to coal mining (both mountaintop and non-mountaintop); most likely through contact with streams and exposure to airborne toxins and dust (Palmer, et al 2010). In one study, they found (for both sexes) that hospitalisations for chronic pulmonary disorders and hypertension were elevated as a function of county-level coal production, as were rates of mortality; lung cancer; and chronic heart, lung and kidney disease (Hendryx & Ahern, 2009).

Colagiuri et al.'s (2012) review of the world literature (not cited by Dr McKenzie) found 38 peer-reviewed articles from 11 countries reporting on adverse coal mining and coal combustion effects, suggesting that coal mining harms are not restricted to the poor residents of Appalachia. Indeed, it is difficult to see the difference between Appalachian mountaintop mining techniques (where the overburden is pushed into adjacent valleys burying existing streams), and the wholesale transformation of Upper Hunter hills, valleys and watercourses into a moonscape terrain while leaving a series immense toxic final voids. (See Palmer et al, Science, 8 Jan 2010, for details of how mountaintop mining causes ecological losses and downstream impacts.)

v) <u>Occupational exposure to coal dust is hundred-fold community exposure</u>

Dr. McKenzie blurs the line between mineworker exposure to particulate emissions at work and population exposure to environmental coal dust in order to downplay population risk. His message is, If workers who have hundredfold more exposure than community members seldom have symptoms, then why worry?

As public health professionals this is a disturbing argument, given the knowledge that even a small additional risk distributed within a wider population will produce measurable harm among some individuals. Residents vulnerable to air pollution (such as infants, children, people with asthma and existing cardiopulmonary and cardiovascular disorders) don't have occupational health and safety protective measures in place, don't have their everyday personal environments monitored, are not 'healthy workers', are not being paid to undertake work in a polluted space, and don't choose to live with particulate exposure.

Furthermore, it is also misleading to suggest that working in mines is rarely a health problem these days, when NIOSH (2010) reports a rising prevalence of Coal Workers' Pneumoconiosis in the USA. Workers less than 50 years of age are developing this disease, which may be caused, in part, by increases in crystalline silica exposure. This increase is occurring despite the 1969 Coal Mine Health and Safety Act as shown in Figure 2 below.

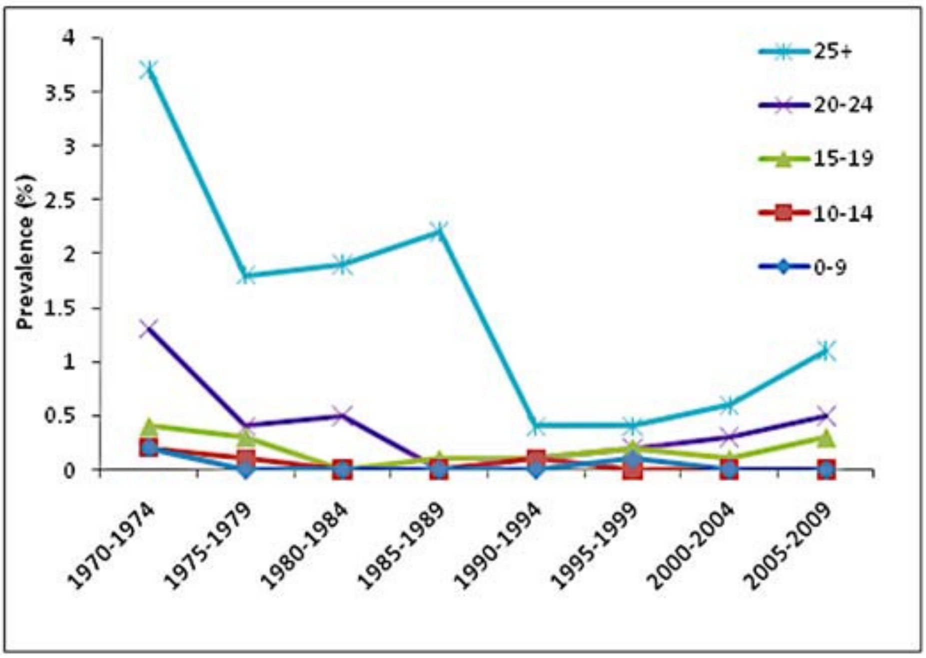


Figure 2: Percentage of miners examined with PMF from the NIOSH Coal Workers' X-ray Program from 1970–2009, by tenure in coal mining. (Source: NIOSH CWXSP data

Dr. McKenzie also fails to note the unexplained but scientifically documented cancer cluster among PWCS coal loading workers employed at the site where T4 would be constructed (Guest, Attia, et al. 2012).

vi) <u>Air quality exceedences from time to time are not a problem</u>

The table below from Air Quality Guidelines for Europe, 2nd Ed (WHO, 2000) contradicts Dr McKenzie's generalization that occasional exceedences don't really matter. This table shows that if a population of 1 million residences was faced with a three-day episode where PM10 was **at the daily standard**, there would still be 4 deaths in that population. Such a period exceedence would clearly matter to the four deceased individuals and their families.

Table 25. Estimated number of people (in a population of 1 million) experiencing health effects over a period of 3 days characterized by a mean PM_{10} concentration of 50 or 100 μg/m³

Health effect indicator	No. of people affected by a three-day episode of PM_{10} at:	
	50 μg/m³	100 μg/m³
No. of deaths	4	8
No. of hospital admissions due to respiratory problems	3	6
Person-days of bronchodilator use	4 863	10 514
Person-days of symptom exacerbation	5 185	11 267

What Dr. McKenzie does not present is the current state of knowledge about the 'concentration-response function,' whereby an increase in particulate concentrations is associated with a linear increase in mortality. Krewski (2009) summarises what has been derived from the American Cancer Society Prevention Study II, a cohort investigation, shown in the table below (Krewski, 2009, p. 414). The American Cancer Society cohort includes more than 1.1 million people followed since 1980. For a each 10ug/m3 increase in PM2.5 concentrations, deaths from cardiopulmonary disease increase up to 10% and by 15% for ischemic heart disease.

Table 1. Estimates of Increased Mortality Associated with an Increase in $PM_{2.5}$ Concentrations of 10 μg per Cubic Meter Based on Extended Follow-up of the American Cancer Society Cancer Prevention Study II.*

Cause of Death	Krewski et al., 2000†	Pope et al., 2002‡		Krewski et al., 2008§	
	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 1989	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 1998	$PM_{2.5}$ Monitoring 1999–2000, Follow-up 1998	$PM_{2.5}$ Monitoring 1979–1983, Follow-up 2000	$PM_{2.5}$ Monitoring, 1999–2000, Follow-up 2000
	percent increase in mortality (95% CI)				
All causes	4.8 (2.2 to 7.6)	3.1 (1.5 to 4.7)	3.2 (1.2 to 5.3)	2.8 (1.4 to 4.3)	3.6 (1.7 to 5.4)
Cardiopulmonary disease	10.1 (6.1 to 14.3)	7.1 (4.8 to 9.5)	9.2 (6.3 to 12.3)	7.0 (4.9 to 9.2)	10.0 (7.3 to 12.9)
Ischemic heart disease	12.2 (6.6 to 18.1)	13.0 (9.4 to 16.6)	14.3 (9.9 to 19.0)	13.3 (10.0 to 16.7)	15.5 (11.3 to 19.9)
Lung cancer	5.3 (−3.7 to 15.0)	8.9 (3.1 to 15.1)	11.6 (4.1 to 19.7)	7.5 (2.1 to 13.2)	10.9 (3.9 to 18.5)
All other causes	−0.2 (−4.2 to 4.0)	−1.9 (−4.3 to 0.5)	−4.7 (−7.6 to 1.8)	−2.1 (−4.3 to 0.0)	−4.7 (−7.3 to 2.0)

* Estimates are based on a Cox regression analysis stratifying the baseline hazard function by age (1-year groupings), sex, and race. All analyses of $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 μm) for the years 1979 through 1983 were conducted using the same 342,521 study subjects. Follow-up year is the most recent year of follow-up for the American Cancer Society (ACS) study cohort available at the time of analysis. $PM_{2.5}$ monitoring data were compiled from publicly available data sources independently of the ACS study. All analyses of $PM_{2.5}$ for the years 1999 through 2000 were conducted using the same 488,370 subjects. Adapted from Krewski et al.[9]
† Data are from Krewski et al.[10]
‡ Data are from Pope et al.[11]
§ Data are from Krewski et al.[9]

Dr. Mckenzie states that exceedences in the range of 50-80ug/m3 for PM10 will have relative small increases in health risk. However, Newcastle has an annual average PM10 concentration of about 20ug/m3. So, an exceedence of 80ug/m3, actually represents an incremental jump of 60ug/m3 over baseline.

We calculated excess hospital admissions from respiratory and cardiovascular illness for the Newcastle and Maitland areas (population 223,049) based on admission rates for these illnesses (NSW Health, 2010). We applied Burnett, et al.'s (1997) concentration-response functions for a PM10 increase of 10ug/m3 (as described in Brunekreef & Forsberg's (2005).

Table 4 shows the excess respiratory and cardiovascular hospital admissions if PM10 levels increase from its annual level of 20ug/m3 to 50ug/m3 (NEPM 24 -hour standard) for the period of one week. Also shown is the health impact of increasing PM10 to 80ug/m3 for a one week episode. Such figures would not be considered 'relatively small' by Newcastle citizens.

Table 4: Extra respiratory and CVD hospital admissions Newcastle region with a one-week episode of PM10 increasing from 20ug/m3 at baseline to 50ug/m3 or 80ug/m3

Hospital admission	PM10 @ 50ug/m3	PM10 @ 80ug/m3
Respiratory admissions increase (RR1.048/per 10ug/m3)	7.6 (3.3-12.4)	16.4 (6.7-27.9)
Cardiovascular admissions increase (RR1.076/per 10ug/m3)	12.4 (5.0-20.3)	27.9 (10.5-48.7)

vii) The population surrounding T4 is not large enough to observe any increase in morbidity or mortality due to project exceedences.

The same '*dose-effect*' chain operates no matter how large or small the human receptor population may be (Briggs, 2003). When the absorbed dose entering the body as a whole is sufficient, then adverse health consequences follow. Small scale communities should not be excluded from surveillance monitoring risk exposure and protection from hazardous sources just because it is difficult to identify excess deaths and disease from low background numbers.

viii) Most exceedences are from bushfires or dust storms

Dr McKenzie frequently repeats the familiar assertion of Hunter coal miners that their operations are not the source of dust problems, but rather they arise from bush fires or dust storms. With over 325 square kms of open cut mines in the Upper Hunter, putting into the atmosphere almost 60,000 tonnes annually of PM10, from vast areas of raw overburden, unpaved roads, continuous dragline use, blasting and coal transport, this denial is not credible.

For the first time the public has access to hourly monitoring data showing the extent of coal dust escaping from Kooragang Island and polluting the air shed of nearby Stockton when the north westerlies blow. The regular exceedences of PM10 standards at Fullerton Street Stockton (17 failures from 1 January to 5 November 2013) soundly contradict assertions of Dr McKenzie and the coal industry that such dusty conditions are only due to regional events, not coal handling sources.

ix) Screening analysis and the ARTC pilot study show that there will be no air quality impacts along the rail corridor.

Our literature review above describing train line pollution, train pollution averages and signatures (4c-4e), refutes the assumption that air quality along the rail corridor will not be affected by a further movement of 70mt of coal into Newcastle Port.

x) Particulates, fumes and gas emissions will disperse quickly from the source into the atmosphere and will not provide a health risk.

This generalization contradicts other statements made by Dr McKenzie that respirable dust fractions, PM10 and PM2.5, can remain airborne for tens of kilometers before they settle. We agree dust disperses and settles, but over what distance and how many people are exposed before it settles is the major issue about the health impacts of T4. PM2.5 particulates can travel the farthest, with evidence that sulfate particulates have a residence time of 3-5 days in the atmosphere (Hibberd, et al CSIRO 2013).

xi) T4 will not produce a measurable increase in morbidity and mortality

The weight of evidence we've presented undermines Dr. McKenzie's opinion that T4 will cause no harm, although one interpretation of his conclusion is that while there may be harm, it won't be measurable. Any release of additional particulates into the breathable airspace of people increases risk of harm, especially among those who are most vulnerable. Our evidence that the real pollution concentrations on site are considerably underestimated, only strengthens our belief that measurable risk is present.

b) Lack of Health Impact Assessment and Burden of Pollution Context

Dr. McKenzie's 'response to health matters' does not mention the most important health analysis for T4 decision-making. Namely, a **Health Impact Assessment (HIA)** that would give fine detail about how hazards produced by this project will potentially harm the specific individuals living nearby based on their unique socio-demographic and health profiles (Harris & Harris-Roxas, 2010). We've touched upon the vulnerabilities of these specific low-income residents in Point 4 above. A HIA should be the central focus of 'health matters' before T4 goes before a PAC, a process Doctors for the Environment also call for (2011).

What is the overall **disease burden** of ambient pollution and what are the health costs to society? Dr. McKenzie does not inform planners that the 2010 Global Burden of Disease (GBD) study found ambient pollution was the cause of 3.2 million deaths globally, causing 76 million years of healthy life lost, and is ranked 9th out of 67 risk factors for disease (Lim et al., 2012). The GBD study noted that ambient air pollution contributed to about 1.2 million premature deaths in China that year and was the 4th leading cause of death (Health Effects Institute, 2013).

Burning coal contributes significantly to China's pollution burden, as it does in India, where particulate emissions from coal-fired power plants, resulted in an estimated 80,000 to 115,000 premature deaths and more than 20 million asthma cases in 2011-2012 (Goenka & Guttikunda, 2013). European Union-wide coal impacts are set at 18,200 premature deaths, about 8,500 new cases of chronic bronchitis, and over 4 million lost working days each year (HEAL, 2013)

What is the **full costing** to taxpayers of pollution from burning coal? The public health costs of treating disease caused by coal-fired electricity in Australia is $2.6 billion per year (ATSE, 2009). Such costs in the USA are between 0.8 and 5.6 times the value of electricity produced (Muller, et al. 2011). Coal combustion costs EU governments an estimated €42.8 billion per year (HEAL, 2013). In India, pollution from coal generated electricity costs the public and the government approximately USD $3.2 – $4.6 Billion annually (Goenka & Guttikunda, 2013).

Unfortunately, highly damaging externalities such as these are left out of merit assessments of coal projects in Australia. Nevertheless, these costs are paid for by people who are made ill and die prematurely due to coal pollution. Were global warming contributions of coal burning to be added into these externalities, the costs would be many-fold higher (Garnaut, 2011).

c) No Independent Critical Appraisal of Industry Information

Dr. McKenzie's opinions about T4 pollution are undermined when we observe that he does not bring an independent critical appraisal to the information provided by industry. Rather, he accepts flawed information at face value without raising caveats or directing attention to limitations. This is nowhere more apparent than his paraphrasing the results of the ARTC rail pollution pilot study as if they contained undisputed facts that support his argument. Even the ARTC pilot report authors were circumspect about some findings and listed a number of major limitations. A careful reading of the study's methods should bring an independent, critical thinker to the realization that the pilot study, while perhaps a useful exercise in testing methods, did not produce reportable findings that could be used for arguing one way or the other about rail pollution.

Community members frequently voice mistrust in the findings of experts employed by industry that show proposed projects will not cause impacts or the sources of pollution they experience are not from the industry in question. Residents rarely have experts on their side disputing the claims of industry or showing how industry consultant reports are flawed. In this context, **environmental injustice** comes to dominate the planning process (Higginbotham, et al., 2010), whereby those facing the greatest harm from a project's environmental impacts have the least say in whether or not it will proceed.

References

The Australian Academy of Technological Sciences and Engineering (ATSE) (2009). The hidden costs of electricity: Externalities of power generation in Australia. ATSE, Parkville, VIC: Ian McLennan House.

Briggs, D. (2003). Environmental pollution and the global burden of disease. *British Medical Journal*. 68, 1, 1-24.

Broome, R. (24 September, 2013). Calculation of deaths as life years lost or saved by increases or decreases in ambient PM2.5 particulates. Lecture presented at the Air Pollution and Health Symposium, Newcastle City Hall, Newcastle, NSW

Brunekreef, B. & Forsberg, B. (2005). Epidemiological evidence of effects of coarse airborne particles on health. *European Respiratory Journal,* 26, 309-318.

Burnett, R.T., Cakmak, S., Brook, J.R., Krewski, D. (1997). The role of particulate size and chemistry in the association between summertime ambient air pollution and hospitalization for cardiorespiratory diseases. *Environmental Health Perspective*, 105, 614–620.

Caiazzo, F., et al (2013). Air pollution and early deaths in the United Sates. Part I: Quantifying the impact of major sectors in 2005*. Atmospheric Environment,* 79, 198-208.

COAG, Standing Council on Environment and Water (SCEW). 2013. http://www.scew.gov.au/nepms/ambient-air-quality accessed 18/10/13).

Colagiuri, R. et al (October, 2012). Health and social harms of coal mining in local communities. Boden Institute for Obesity, Nutrition and Exercise, University of Sydney. http://sydney.edu.au/medicine/research/units/boden/PDF_Mining_Report_FINAL_October_2012.pdf

Connell Hatch (2008). Environmental evaluation on fugitive coal dust emissions from coal trains: Goonyella, Blackwater and Moura Coal Rail Systems, Final report, Project undertaken on behalf of Queensland Rail Limited, 31 March, 2008.

CTAG. (March, 2013). Coal dust in our suburbs: A community-led study of particulate pollution in Newcastle and Lower Hunter rail corridor. Coal Terminal Action Group, Dust and Health Committee. Hunter Community Environment Centre, Parry St, Newcastle, NSW.

CTAG (August, 2013). Coal train pollution signature study. Coal Terminal Action Group, Dust and Health Committee. Hunter Community Environment Centre, Parry St, Newcastle, NSW.

Doctors for the Environment, Australia (DEA) (2011). Briefing from DEA on the health impacts of coal mining and pollution.

(http://dea.org.au/topics/article/briefing_paper_on_the_health_aspects_of_coal_and_renewables)

Entec (February, 2010). Fine particulate matter from surface coal mining and public health. Final report. Report compiled by the consultancy Entec UK Ltd onb behalf of the Scottish Resource Group.

Environ (June 21, 2012). Locomotive Emissions Project: Potential Measures to Reduce Emissions from New and In- service Locomotives in NSW and Australia Industry Presentation, ENVIRON North Sydney Offices.

Environ (September, 2012). Pollution Reduction Program (PRP)4—Particulate Emissions from Coal Trains, Report compiled by ENVIRON Australiat Pty Ltd on behalf of the Australian Rail Track Corporation.

Ferreira, A.D., et al (2003). Full-scale measurements for evaluation of coal dust release from train wagons with two different shelter covers. *Journal of Wind Engineering and Industrial Aerodynamics*. 91, 1271-1283.

Ferreira, A.D & Vaz, P.A. (2004). Wind tunnel study of coal dust release from train wagons. *Journal of Wind Engineering and Industrial Aerodynamics.* 92, 565–577.

Garnaut, R. (2011). Climate Change Review, Update. http://www.garnautreview.org.au

Goenka, D., & Guttikunda, S. (2013). Coal Kills: An Assessment of Death and Disease caused by India's Dirtiest Energy Source http://www.greenpeace.org/india/Global/india/report/Coal_Kills.pdf

Guest, M., Attia, J. et al (2012). PWCS cancer cluster investigation report. University of Newcastle, School of Medicine & Public Health.

Harris, P. & Harris-Roxas, B. (2010). Assessment of human health and wellbeing in project environmental assessment. In Project environmental clearance: Engineering and management aspects. Wide Publishing, 357-379.

Health Effects Institute (2013). Outdoor air pollution among top global health risks in 2010; Risks Especially High in China and Other Developing Countries of Asia http://www.healtheffects.org/International/HEI-China-GBD-PressRelease033113.pdf

Health and Environment Alliance (HEAL) (March, 2013). Unpaid health bill. www.env-health.org/unpaidhealthbill

Hendryx, M. & Ahern, M.M. (2009). Mortality in Appalachian coal mining regions: The value of statistical life lost. *Public Health Reports*, Jul-Aug; 124(4): 541–550.

Hibberd, M et al. (2013). Upper Hunter Valley Particle Characterization Study. CSIRO Marine & Atmospheric Research, Australia.

Higginbotham, N. et al (2010). Environmental injustice and air pollution in coal affected communities, Hunter Valley, Australia. *Health and Place,* 16 (2), 259-266.

International Agency for Research on Cancer (IARC, 2013). Air pollution and cancer. IARC Scientific Publication No. 161. WHO, Geneva.

Katestone Environmental (May, 2013). Pollution reduction program 4.2 particulate emissions from coal trains. Prepared for Australian Rail Track Corporation. Milton, Queensland.

Knibbs, L. (July 2013). Peer review of Australian Rail Track Corporation (ARTC) Pollution Reduction Program (PRP) 4.2 - Particulate Emissions from Coal Trains. http://www.epa.nsw.gov.au/resources/air/ARTC_report_review_Jul_01_2013.pdf

Krewski, D., Jerrett, M., Burnett, R.T., et al (2009). Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. *Health Effects Institute Research Report* 140.

Krewski, D. (2009). Evaluating the effects of ambient air pollution on life expectancy. *New England Journal of Medicine*, 360, January 22, 413-415.

Krewski D, Burnett RT, Goldberg MS, Hoover K, Siemiatycki J, Jerrett M, et al. (2000). Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality. A Special Report of the Institute's Particle Epidemiology Reanalysis Project. Boston: Health Effects Institute.

Lim, S.S. et al (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990—2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet,* 380, 9859, 2224 – 2260.

Marks, G. (September 23, 2013). How to investigate the relationship between air pollution and health. Lecture presented at the Air Pollution and Health Symposium, Newcastle City Hall, Newcastle, NSW.

Morgan, et al. (2005). Air pollution economics. Health costs of air pollution in the greater Sydney metropolitan region. NSW Department of Environment and Conservation.

Muller, N.Z., Mendelsohn, R., & Nordhaus, W. (August, 2011). Environmental Accounting for Pollution in the United States Economy. *American Economic Review.* 101, 1649–1675.

National Institute for Occupational Safety and Health (NIOSH). (2011). Coal mine dust exposures and associated health outcomes: A review of information published since 1995. *Current Intelligence Bulletin* 64.

NSW Department of Health, Environmental Health Branch. 2010 review of hospital separation etc Respiratory and cardiovascular diseases and cancer among residents in the Hunter New England Area Health Service. May 2010 http://www0.health.nsw.gov.au/pubs/2010/hne_respi_cardio.html

Palmer, M.A., et al. (2010). Mountaintop mining consequences. *Science* 327, 8 January, 148-149.

Pope, A. (September 24, 2013). Particulate matter air pollution: science, controversy and impact on public health. Lecture presented at the Air Pollution and Health Symposium, Newcastle City Hall, Newcastle, NSW

Pope, A., Ezzati, M., Dockery, D.W. (2009). Fine-particle air pollution and life expectancy in the United States. *New England Journal of Medicine,* 360, 4, 376-386.

Power, S., et al. (2013). Robust twenty-first-century projections of El Niño and related precipitation variability. *Nature,* October 13, published online. doi:10.1038/nature12580

Rushton, L. (2012). The problem with diesel. *Journal of National Cancer Institute*. 104 (11), 1-2.

Rushton, L., Bagga, S., & Bevan, R., et al. (2010). Occupation and cancer in Britain. *British Journal of Cancer.* 102(9), 1428–1437.

Senate, Commonwealth of Australia, Community Affairs References Committee, Impacts on health of air quality in Australia. Hearing Testimony, Tuesday, 16 April, 2013, Newcastle.

WHO (2000). Air Quality Guidelines for Europe, 2nd Ed. WHO-Europe.

WHO (2006). Air Quality Guidelines Global Update 2005: Particulate matter, ozone, nitrogen dioxide and sulphur dioxide. World Health Organisation Regional Office for Europe, Copenhagen, Denmark.

WHO-Europe (2013). Review of evidence on health aspects of air pollution—REVIHAPP Project, First Results. Copenhagen, Denmark: WHO Regional Office for Europe.

Appendix A

CTAG Critique of ARTC Pilot Study

Coal Terminal Action Group
167 Parry Street
Hamilton East 2303

To:
The Honourable Barry O'Farrell MP
GPO Box 5341
SYDNEY NSW 2300

Dear Mr O'Farrell,
I am writing to express the serious concerns of the Newcastle and broader Hunter community with the recent ARTC air quality monitoring study, the resulting report and the response of the NSW EPA to the report. The Coal Terminal Action Group (CTAG) has 18 member groups which represent a broad cross section of local and regional community and environmental groups. We are deeply concerned that the EPA is knowingly compromising the health of the Newcastle & Hunter community and is unduly protecting industry from proper scrutiny and regulation.

At the outset, we wish to make clear our disappointment that the Pollution Reduction Program (PRP) 3, which specified that ARTC should attempt to quantify coal drain dust emissions, has not been carried out, or at least no report has been made public. The community still wants to know how much dust and coal comes off coal trains (year round), not just a comparison with other train types at un-representative sites along the coal rail corridor. Expansion of the coal port (including the T4 project) will result in 100 or more additional train movements per day; whereas the number of passenger train movements is **not** predicted to appreciably change.

ARTC engaged a consultant, Environ, to undertake limited air quality monitoring at Mayfield and Metford from 13th February to 20th March 2012, coinciding with a particularly wet period as Bureau of Meteorology records show. ARTC produced a draft report for the EPA in June 2012. The EPA reviewed this internally and apparently requested modifications from ARTC. A final report was provided by ARTC to the EPA in September. The report was released publicly on the afternoon of Friday 28th September to coincide with the NRL and AFL Grand Finals long weekend, when relatively very little attention was paid to it by the public. We are deeply concerned by the EPA Chair Barry Buffier, 'cherry picking' statements from the report out of context, which gives the false impression to the public that coal trains do not pose health concerns.

Having scrutinised the report in detail, we have identified a substantial list of serious flaws in methodology, data analysis and interpretation; and as a result we question the validity of the report and its findings. We also note that the report authors acknowledge the limitations and shortcomings of the methodology and data capture and the significant impacts these have had on the results and conclusions of the study. The list of reasons is provided below; please see the attachment for detailed explanations of these.

1) Limited Scope of Study
2) Poor siting of equipment
3) Poor timing of study
4) Inadequate target pollutants
5) Questionable methodology:
   a) Estimation of train movements
   b) Estimation of background dust emissions
   c) Minority of coal trains included
   d) Unsuitable data logging frequency and duration
   e) Large Particulate Matter
   f) Grain trains not included in the study
6) Questionable conclusions
7) Inaccurate reporting

On behalf of the Newcastle community we seek the following commitments from you:

1. An acknowledgement that the ARTC study did not address community concerns about the dust burden experienced by communities living along the coal corridor and that further studies are necessary.
2. A commitment that the ARTC study will not be considered by the PAC as any kind of evidence that coal wagons do not increase particle pollution along the coal corridor.
3. A commitment to further studies to actually address the community and EPA's concerns about the particle pollution generated by the EXISTING volume of coal trains - with independent oversight and review - BEFORE the consideration of T4.
4. Release by the ARTC and/or EPA of all raw data collected during the study, as well as the EPA to release the two internal reports (statistics and air quality) it undertook between June and September 2012, so that the community can assess for itself the validity of this study.

We look forward to your prompt response to these issues.

Kind regards,
Dr James Whelan
For the Coal Terminal Action Group.

Coal Terminal Action Group
167 Parry Street
Hamilton East 2303

ATTACHMENT
Key limitations and failings of the ARTC investigation and report

1) **Limited Scope of Study**. Newcastle's air quality regularly exceeds National Standards at present, and particle pollution from coal trains clearly contributes to these exceedences. There is currently a proposal to potentially treble the number of coal trains, which will result in up to three times the particulate emissions by volume and mass. Quantifying and assessing these emissions should be of primary concern to the EPA and ARTC, not simply comparing train types in an attempt to distract attention from the issue at hand. Furthermore, ARTC reported monitoring results for PM10 (particles of up to 10 microns in diameter) and PM2.5 (two microns), but not PM1 (one micron); even though the equipment used also simultaneously measures PM1. It is well established that the finest particles are most directly responsible for adverse health impacts. The study should have counted and characterised these very small particles, which typically contain a relatively high proportion of diesel emissions, which are known to cause cancer. This suggests that the EPA and ARTC have disregarded the public health implications of coal train pollution and this is unacceptable to the community.

   In addition, both loaded and unloaded coal trains have a detailed history of loss of coal from trains whilst in transit. This large matter is a major source of dust re-entrained from the rail corridor by train turbulence. Reports from overseas specify gross losses as much as 3% of the total coal load's mass. Large matter should have been included in the PRP and we look forward to seeing this issue addressed by ARTC and the EPA in future.

2) **Poor siting of equipment.** Monitoring was undertaken at just two locations. The study's authors acknowledge faults in the selection of one of these sites (Mayfield). The report is misleading when it states the monitors were located as close as 3m to the rail line; the photographs clearly show they are considerably further away, and furthermore are located in a position that favours capture of passenger train emissions over coal train emissions. At the Mayfield site, coal trains rarely move much faster than walking speed, and therefore are expected to generate considerably less particulate pollution compared to faster-travelling passenger trains.

3) **Poor timing of study.** ARTC's monitoring was conducted from 13th February to 20th March this year, coinciding with a particularly wet period, as Bureau of Meteorology records show. Wet weather damps down dust on

coal trains and tracks and has very likely impacted on the monitor readings compared to normal (i.e. drier) weather for this season. NSW Health rightly notes in one response to the study that monitoring during dry times is necessary to arrive at reliable conclusions.

4) **Target pollutants.** The finest particles are most directly responsible for health impacts. Mass indicators of particle pollution are dominated by the largest (heaviest) particles. For several years, studies of particle pollution have focused instead on particle count and characterisation. That has not been attempted in this instance, and is not proposed. Also, the EPA has claimed since the study was released that coal dust is typically in the PM2.5-PM10 size range, and for this reason PM1 was not monitored in this study. We categorically reject this claim as international studies show clearly that coal dust also exists in significant abundance in PM1 and finer size categories. Furthermore, diesel exhaust emissions are often PM1 or finer, and coal trains with their very large diesel engines are significant sources of this pollutant, which was recently listed by the World Health Organisation as a Level 1 carcinogen.

5) **Questionable methodology.** We identified numerous flaws in the methodology, the more serious of which are outlined below:

   a) **Estimation of train movements.** At Mayfield, GPS equipment was used to estimate the presence of trains at the monitoring site, based on train positions 500 m either side of the monitor and an estimation of train speed. The report states that "the use of more accurate train movement data for this site may alter the conclusion" (p. 2). Trains were identified 500m away from monitoring sites to the nearest minute, speeds were estimated, and analysis was then carried out. This is highly questionable, especially given that passenger trains on this section of the rail line are generally only 2 carriages long; and therefore the pass time could be as little as a few seconds. Therefore the estimate of particulates at 30-60sec intervals is likely to be at best guess work and certainly cannot be regarded as measurements. Accurate train movement data (such as by video recording or manual survey) and more frequent interval measurements of particular matter are required.

   b) **Estimation of background dust emissions.** To estimate background levels of ambient particulate matter, the data that was assumed to coincide with train movements was excluded. Given the author acknowledges the shortcomings of the train movement data throughout the report, and the other limitations of the Mayfield methodology in particular, this method is questionable. In addition, the report does not recognise the time taken for the particles in the atmosphere to settle.

c) **Minority of coal trains included.** Only 101 loaded coal train movements were included, out of a total of 3578 train movements during the study period. Multiple train passes were eliminated, & train passes where wind speeds exceeded 2m/s were eliminated. Only 279 out of a total of 945 (29.5%) coal train movements (loaded & unloaded) were included in the analysis. Just 6.4% of loaded coal train movements at Mayfield were analysed. Clearly, when determining total contribution of particular matter from coal trains, multiple passes where all trains are coal trains (a common occurrence at the Mayfield site in particular) would be the most relevant to answering this question (the second part of PRP4). Multiple pass events are also likely to give greater readings due to the air turbulence and higher air speeds. Given current proposals to potentially treble the number of coal train movements under proposed expansion of the port, multiple train passes will increase and contribute to cumulative increases in particulate matter and resultant health impacts.

d) **Unsuitable data logging frequency and duration.** The preferred data logging frequency of 10-15 seconds apparently became "unavailable for hire at the time of commencement of monitoring" (p. 5) and 60 second intervals were used (this was apparently "altered to 30 seconds to improve time resolution" (p. 5), though the report does not indicate when this change occurred and what the implications might be to the results). Furthermore, the frequency of monitoring was geared to potentially over-represent coal train emissions and under-represent passenger train emissions. Given that the time of monitoring was particularly wet, and the more suitable equipment was unavailable, we feel that it was entirely inappropriate to undertake monitoring during the study period. It would have been more scientifically robust to have undertaken the monitoring earlier, or later with the most appropriate equipment and representative climatic conditions.

e) **Large Particulate Matter.** Both loaded and unloaded coal trains have a detailed history of loss of coal from trains whilst in transit. This particulate matter is the prime source of dust and emissions re-entrained from the rail corridor by train turbulence. Reports from the USA show coal losses as high as 3% of the total load mass. The ARTC report makes no effort record the train's losses of particles greater than 50 micron.

f) **Grain trains not included in the study.** There was no measurement of grain trains in the report, even though the PRP specifically request they be included. This is very significant as the wagons are very similar in design to coal wagons except that they have lids fitted.

6) **Questionable conclusions.** Based on the shortcomings of the methodology as outlined above, drawing conclusions from these skewed data is questionable. The situation was made much worse by the EPA selecting certain facts and relaying them out of context, to give the false impression that coal trains and passenger trains produce the same dust emissions, when this is plainly not the case, as the report states:

   "At Metford, the difference in average concentrations when comparing loaded coal to the 'no train' dataset show that the loaded coal trains increase the concentration in the rail corridor by 7.1 μg/m^3 for TSP; 4.8 μg/m^3 for PM10; and 1.2 μg/m^3 for PM2.5". (ARTC 2012 p.58)

   "Based on the average, median and 95th percentile and confidence limits around the average concentration, it is concluded that concentrations coinciding with loaded and unloaded coal train passes are statistically higher for PM10 than concentrations recorded during passenger train passes. The PM2.5 concentrations that were recorded to coincide with freight, unloaded coal and loaded coal are statistically higher than concentrations recorded during passenger train passes (ARTC 2012 p.59)

7) The report concludes that particle pollution levels are elevated by the current number of trains at Metford by 4.8 μg/m^3 and Mayfield by 2.2 μg/m^3. This is very likely to directly contribute to increased incidence of respiratory and cardiovascular illness; as there is no safe threshold for particulate matter below which there are no health impacts (as stated by the National Pollutant Inventory). The number of coal train movements in Newcastle will potentially triple if T4 is approved.

Appendix B

Briefing Notes from University of Newcastle, Public Health Academics meeting (7/6/13) to review Katestone May 2013 ARTC PRP Study

Compiled by
Associate Professor Nick Higginbotham

Given the public health implications of planned increases in the transportation of coal along the Newcastle rail corridor, a group of academics met to review the methods, measures and conclusions of the recent ARTC funded study to measure particulates at the rail line at Metford.

1. **Train sampling**
   Concern was raised about the number of trains passing by the monitoring station that were not included in the analysis; only 26% to 52% of different trains had measurements recorded. Information is provided about how representative the data capture was, but the amount of loss is puzzling and significant, and an 'audit trail' of what and why should be given.

2. **Usable Data**
   Only the results based on wind direction blowing from the rail line towards the monitoring station are useful for understanding train emissions. Approximately 60% of particulate recordings occurred when the wind was blowing emissions away from the monitors; these should not be used to calculate results. When the appropriate wind direction is included, this leaves 10-19% of original train pass-bys still in the sample.

3. **Appropriate Measure to Compare Train Types**
   From a health perspective, it is inappropriate to compare different train types (e.g., passenger train vs loaded coal train) by calculating the average particulate concentration. This ignores an extremely important aspect of health risk which is the **duration** of exposure to the particulates, or how long the elevated particulates are in the air and can be inhaled.

   The study found that emissions from each passenger train were captured in a single 6-second sample of air, whereas a coal train required 45 6-second air samples to capture. On average, passenger trains pass by in very few seconds (e.g, 2 seconds), while coal trains take about 90 seconds to pass by and the 'entrainment' of dust behind them takes another 270 seconds to return to the level before the train arrived.

   This requires calculating the **'area under the curve'** in the time series distribution of dust concentration levels shown in Figure 3. What you end up with as an appropriate measure is 'microgram seconds' exposure of 'new dust.' This can be derived from a standard trapezoidal method, as described in point 7 below.

4. **Statistical Tests**
   No statistical testing was reported apart from visual inspection of overlap of confidence intervals between train types. This is inadequate. Even though confidence intervals overlap, there can still be a statistical difference between train type emissions. This is most notable when using the data that controlled for wind direction, where you can see means that are wide apart.

5. **Reportable Findings**
   Figures B4-B7 offer interpretable findings, as they show results controlling for wind direction. In essence:

   a) **Coal trains** (loaded and unloaded) at Metford add a significant amount of particulates into a rail corridor that is already more polluted than ambient air measured at nearby Beresfield.

   b) **Unloaded coal trains** consistently show the highest particulate concentrations; 23%, 24% & 21% above average concentration for TSP, PM10 and PM2.5 respectively, compared to No Trains. Reasons for this should be investigated (e.g., greater area of wagons and residual coal exposed to wind).

   c) **Loaded coal trains** contributed an additional 14%, 14% and 11% increase in average concentrations for TSP, PM10 and PM2.5 respectively, over the two months of this study.

   d) **Passenger train** particulate readings are essentially the same as No Trains.

6. **Other Issues**
   a) How generalizable are the findings from one location? It may be that unloaded coal trains emit more particulates closer to the port, while loaded coal trains are dustier closer to their loading source?

   b) This stationary monitor method does not indicate how much dust is actually lost from a coal train moving down from the mines; this should be investigated using a monitor on the train itself, as suggested by Prof John Lucas.

   c) Can these findings be used to model future particulate concentrations with increasing number of coal train movements planned by the coal industry?

   d) Diesel emissions from the locomotives are of considerable interest due to their potential health damage. How can they be included?

e) The ARTC media release of the study emphasized 'no difference between train types' as the leading and main message. This is gravely misleading both with respect to the inappropriate method of measurement and the problem of controlling for wind direction. ARTC should require another full analysis only using the proper wind direction, and give another media release correcting this misinformation.

7. Calculating An Appropriate Measure for Comparing Train Types: An Example

If we review Figure 3 in the report, we can see the last 1 minute of **unloaded coal train** dust 'entrainment' is declining from TSP of about 47.5 ug/m3 to 42 ug/m3 as the dust moves away or settles. With a baseline rail air of 40ug/m3, this is an additional 7.5 ug/m3 of new dust added into the air from the train, at the start of the decline (minute 100 of Figure 3). Each of the 10, 6-second segments of 'new dust' is averaged, then multiplied by 6, and added in the group of 10 (e.g., 7ug/m3 + 6.5ug/m3 + etc) = 285 microgram seconds of particulate exposure. Now, compare this with the microgram seconds of exposure from a passenger train (assuming it also reached a peak of 47.5ug/m3 in the 6 second recording). We would get this value by taking the 'new dust', 7ug/m3 times 6 = 42 microgram seconds of particulate exposure.

However, to get the total area of 'new dust' added under the curve for the coal train, we must start with the time point where the train first enters. So, we need to add together 45 6-second estimates of 'new' dust from a coal train, and compare that with the one 6-second estimate of a passenger train. Clearly, time required for train pass-by is a substantial factor determining what people are exposed to. Through this method it is possible to compare a passenger and coal train sensibly.