Infrastructure Victoria Second Container Port Advice

Social amenity impacts of port-related freight movement

24 April 2017

Contents

Glossary

Term	Description
AWE	Average Weekly Earnings
CHS	Children Health Study (US)
CO	Carbon Monoxide
EC	Elemental Carbon
EPA	Environmental Protection Agency
FHWA	Federal Highway Association
IV	Infrastructure Victoria
M	Metre
Microscopic Traffic Simulation	Observes individual vehicles in traffic simulation and their behaviour rather than macroscopic simulation which observes traffic flow as a whole
NASA	National Aeronautics and Space Administration
NCES	National Centre for Education Statistics (US)
NM	Nanometre
OD	Origin Destination
NO_2	Nitrous Oxide
NO_x	Oxides of nitrogen
PM	Particulate Matter
PM_x	Particulate Matter of x micrometre diameter
SBPB	San Pedro Bay Port
TEU	Twenty Foot Equivalent Unit
UFP	Ultrafine Particles (particles <1 micrometre diameter)
WTP	Willingness to Pay

1 Overview and purpose

This document seeks to identify:

1. Whether poor health impacts can be associated with port-related activity, as evidenced by recent literature included in this report; and

2. To what extent these impacts have been considered in the economic appraisal for the Infrastructure Victoria Port strategy development in Australia.

Port activity by its very nature generates air emissions. Activity from ships, trucks, trains, cars, non-road mobile machinery, rubber tyred gantry cranes, and conveyor vehicles release a number of pollutants into the atmosphere. This includes carbon dioxide, black carbon, nitrogen oxides (NO_x) and particulate matter (PM)[1].

Port-related truck movement may be a significant factor when considering social amenity impacts of port activity, particularly to those living in close proximity to roads which are used to enter and exit the port. Generally, the trucks entering the port are fuelled by diesel which is a known source of nitrogen oxides (NO_x) and particulate matter (PM). For example, the United States Department of Transportation's Federal Highway Association (FHWA) published a study comparing pollutants emitted from trucks, which suggested that a standard diesel truck in 2010 emitted 25% more NO_x and 62% more PM of 10 micrometre diameter (PM_{10}) than petrol trucks[2].

A range of health issues have been associated with air emissions, including:

- Impaired lung growth in children
- Increased asthma, coughs, bronchitis and other respiratory problems
- Cardiovascular problems
- Cancer
- Worsening of existing health problems in people with chronic disease[2]

These emissions are costly to the Australian economy; it has been estimated that the annual emissions of PM_{10} and NO_2 in major Australian cities costs the economy $235,000 and $1,000 respectively in health care costs per tonne of pollutants emitted[3].

The economic appraisal undertaken for Infrastructure Victoria's Port Strategy attributes a cost to these emissions which form part of the environmental externalities. In addition to these emissions, the appraisal also includes other social amenity impacts such as crash costs and the value of time saved.

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[1] Clear Air, Clean Air in Ports: EU Life+ "Project Clean Air", NABU. (https://en.nabu.de/);

[2] ICF Consulting (2005), Assessing the Effects of Freight Movement on Air Quality at the National and Regional Level, US Federal Highway Admin.

[3] Environmental Justice Australia, Clearing the Air: Why Australia urgently needs effective national air pollution laws, Environmental Justice Australia.

2 Port strategy economic appraisal methodology

The port strategy economic appraisal has calculated land transport costs and externalities generated by port activity and potential development. The economic parameters used to measure the extent of these costs and externalities include:

1. Capital, Operating and Maintenance Costs;
2. Sea Freight Transport Costs;
3. Change in Port Charges;
4. Change in Travel Patterns;
5. Vehicle Operating Costs;
6. Residual Value;
7. **Travel Time Dis-Benefits;**
8. **Crash Cost Externalities; and**
9. **Environmental Externalities**

→ Cost of increased truck movement to social amenity considered

Economic externality costs include travel time dis-benefit, crash costs and environmental costs. These have been summarised below.

2.1 Travel Time Dis-benefits

Travel Time Dis-benefits reflect the opportunity cost associated with travel time on the transport network that could otherwise be used for other purposes. The framework uses the parameter value set by the Australian Transport and Infrastructure Council whereby 129.8% of Average Weekly Earnings (AWE) are used to estimate the value of time for business travel (to reflect foregone productivity) and 40% of AWE is used to capture people's willingness-to-pay to reduce travel time for commuting and leisure trips[4].

2.2 Crash cost externalities

Crash costs are estimated using the hybrid human capital approach and the willingness to pay (WTP) approach[5]. The hybrid human capital approach seeks to capture the loss of economic value through foregone income producing capacity and the resources consumed to mitigate the damage caused by accidents including hospital costs and repair costs. The WTP approach seeks to capture people's willingness to pay to avoid fatalities, major and minor injuries. Table 1 below sets out the crash cost externalities.

[4] *Australian Transport Assessment and Planning Guidelines, PV2 Roads parameter values*, Transport and Infrastructure Council, 2016

[5] Ibid.

Table 1: Summary of crash cost externalities

Human Costs	Vehicle Costs	General Costs	Willingness to pay approach
• Ambulance costs • Hospital in-patient costs • Other medical costs • Long term care • Labour in the workplace • Labour in the household • Quality of life • Insurance claims • Criminal prosecution • Correctional services • Workplace disruptions • Funeral • Coroner	• Repairs • Unavailability of vehicles • Towing	• Travel delays • Insurance administration • Police • Property • Fire	• Value of statistical life (VSL) • Value of serious injury • Value of hospitalised injuries • Value of minor injuries

2.3 Environmental Externalities

The economic appraisal considers and costs a number of environmental externalities that affect social amenity. Air pollution, an externality which considers the health impacts of NO_2 and PM, has parameter value apportioned to it in the form of cents per vehicle km for passenger cars, cents per tonne km for heavy vehicles, and cents per net tonne km for rail freight.

These environmental externalities are set out in Table 2.

Table 2: Environmental Externalities

Externality	Basis of Valuation
Air pollution	Impact of exposure to carbon monoxide, oxides of nitrogen, particulate matter and hydrocarbons
Greenhouse gas emissions	Costs associated with avoiding the damage associated with climate change caused by greenhouse gas emissions. Valuations reflect a cost of carbon of ~$50 per tonne of CO_2
Noise pollution	Personal preferences for avoiding noise as well as the health costs associated with noise exposure
Water pollution	Personal preference for avoiding water pollution as well as the cost of mitigation using devices including vegetation, sedimentation tanks and water treatment to deal with contaminated run-off from roads.
Nature and landscape	Impact of infrastructure on habitat loss, loss of natural vegetation or reduction in visual amenity
Urban separation	Reflects time loss due to separation for pedestrians, lack of non-motorised transport provision and visual intrusion
Upstream and downstream costs	Indirect costs of transport including energy generation, vehicle production and maintenance, infrastructure construction and maintenance.

3 Summary of literature

In addition to the environmental externalities included in the economic appraisal, six case studies have been presented in this document to demonstrate the social amenity impacts associated with truck activity occurring in the local areas surrounding ports or truck activity on major highways. The majority of these studies observe the impact of PM and NO_x on public health. These studies have been summarized below, and are detailed further in Section 4.

- **Case Study 1:** A simulation study of the San Pedro Bay Port (SPBP) in Los Angeles estimated the health impact of truck and rail freight to local residents. A catchment area for the study spanned between the SPBP and downtown LA (a boundary 35 kilometres north of SPBP). The study estimated the public health cost of resulting emissions, and found;
  - Children aged 5 to 12 suffering from asthma exacerbation due to NO_x exposure are estimated to cost the economy $37 million in summer and $41 million in winter, in health care costs.
  - Local residents suffering from chronic bronchitis or mortality due to PM of 2.5 micrometre diameter ($PM_{2.5}$) cost the economy $165 million in summer and $200 million in winter, in health care costs.
- **Case Study 2:** A 12 month air and noise monitoring program was conducted on Francis Street, Yarraville. It found that the average PM_{10}, $PM_{2.5}$ and NO_2 daily concentration at the site was higher than other sites monitored over the study period. For comparison, other sites considered under the monitoring program were located in Alphington and Footscray.
- **Case Study 3:** A study observing the relationship between distance and ultrafine particles (UFP) emitted from vehicles on a major road, including $PM_{2.5}$ and smaller, suggested that UFP's can travel further than 300m from its source.
- **Case Study 4:** A study observing chronic absenteeism (absent >10% of school year) on public schools in Massachusetts found that the concentration of $PM_{2.5}$, amongst other environmental exposures, surrounding public schools was "nearly as large as those for income and race" on the level of absenteeism in each school's county.
- **Case Study 5:** A study which undertook 6000 student surveys found that an increased level of PM_{10}, $PM_{2.5}$ and ozone at the student's respective school resulted in increased prevalence of bronchitis. Using the same data, a cohort of 4000 student surveys found an inverse relationship between the distance (m) from the student's home to a major road, and chance of new-onset asthma.
- **Case Study 6:** A study exposing healthy volunteers to diesel exhaust in an exposure chamber found marked cellular inflammatory response in the volunteers.
- **Case Study 7:** A retrospective study on over 58,000 workers in the trucking industry found a positive relationship between PM exposure and lung cancer mortality.

4 Detailed summary of case studies

4.1 Case Study 1: Public health impacts of freight-related activity using simulation

<table>
<tr><th colspan="2">Assessing the Environmental and Health Impacts of Port-Related Freight Movement in a Major Urban Transportation Corridor (Lee et al., 2010)</th></tr>
<tr><td>Aim</td><td>To explore the health impacts of freight operations in a catchment area between San Pedro Bay Ports (SPBP), Los Angeles and Downtown Los Angeles. SPBP includes the Port of Los Angeles and Port of Long Beach.</td></tr>
<tr><td>Background</td><td>SPBP is one of the largest container ports in the United States and as a result has seen a significant increase in air pollution and congestion in the areas over the past decade. Specifically, the Los Angeles area is:
• Responsible for one-third of goods movement related emissions in the U.S
• 400 tonnes per day of nitrogen oxide (NO_x) generated from SPBP activity and at least 14 tonnes per day of particulate matter (PM) from South Coast air basin.
Key health issues related to diesel emissions have been identified, with 3,700 premature deaths annually in the U.S estimated by the American lung association.</td></tr>
<tr><td>Methodology</td><td>Study Area
Two major freeways (Interstate -710 and Interstate -110) serve the SPBP port precinct and the Alameda corridor rail link. This study observes the area surrounding the Interstate -710, Interstate-110 and Alameda corridor rail link, including seven railyards, and extends to downtown Los Angeles, 34 kilometres north of SPBP complex (see Figure 1 below).
Figure 1: Case Study 1 catchment area

</td></tr>
</table>

Assessing the Environmental and Health Impacts of Port-Related Freight Movement in a Major Urban Transportation Corridor (Lee et al., 2010)

Methodology (cont.)

Road freight movements

A traffic simulation was taken on daily truck-related freight movements to inform the traffic flow on the Interstate-710 and Interstate-110 freeways. The results of this simulation informed the emissions simulation undertaken to determine the dispersion of pollutants across the catchment area. These two simulations are summarised below.

Traffic Simulation
A 'microscopic' traffic simulation model was adopted to allow the researchers to observe individual vehicle's speeds and accelerations (known as the 'Transmodeler'). Data inputs for 'Transmodeler' included a Travel Demand Model and Origin Destination estimation.

- The SPBP precinct service time assumed in the microsimulation is between 8AM and 6PM as well as truck movements before and after official service hours, equating to a total of 13 hours of port-related truck movement per day.
- Using simulation, the percentage of trucks out of total vehicle movements in the catchment area was determined. The simulation was repeated 30 times to provide a robust sample size.
- The simulated number of trucks was compared with the actual number of container trucks per day based on the recorded daily TEU's for 9th March 2005 to determine the proportion of port-related trucks in the simulation.

The results of this simulation informed the emissions simulation below.

Emissions Simulation
Emissions were determined using 'EMFAC', a model built specifically for Californian emission estimates. Using 'Transmodeler' simulation data and 'EMFAC' outputs, the average amount of emissions (kg) of various pollutants (CO, NOx, $PM_{2.5}$, PM_{10}) were predicted for the day across vehicle types, including port trucks.

Rail freight movements

In addition to road movement modelling, a study was undertaken on daily rail-related freight movement, which identified two types of rail emission sources. These included line-haul, which refers to cargo movement over long distances, and railyard emissions, which is emissions generated from locomotives, road trucks and cargo handling equipment.

Line-haul emissions
Distance of rail segments was first observed, and then the travel time to move across these segments was determined. It was assumed that rail moves at the speed limit, and the number of locomotives per train, and number of trains per hour, were assumed using estimates from previous research. An emissions factor was applied (grams/hour) to determine PM and NO_x emissions (tonne/year). PM or NO_x was calculated using the following formula:

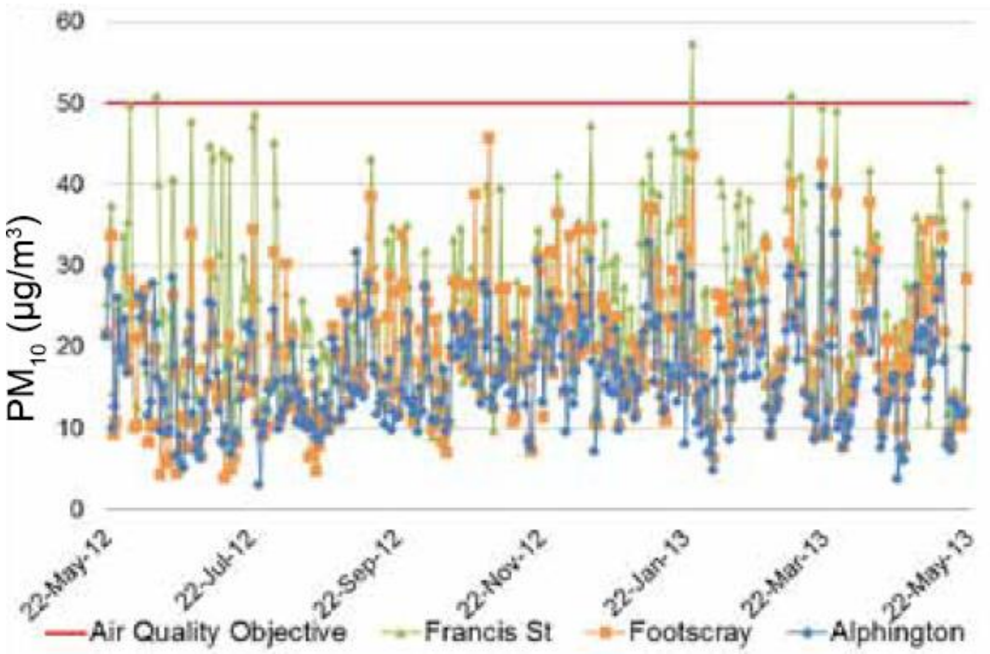
$$PM\ (or\ NO_x)/locomotive = travel\ time\ \times no.locomotives/train\ \times no.train/hour \times emissions\ factor$$

Assessing the Environmental and Health Impacts of Port-Related Freight Movement in a Major Urban Transportation Corridor (Lee et al., 2010)	
Methodology (cont.)	<u>Railyard Emissions</u> • Assumptions relevant to the study were made for the modelling. **Total Health Costs** To understand the health impacts of road and rail freight movements, the dispersion of air pollutants was assessed to identify the area's that were affected most; the time of day that dispersion was the highest; and the rate of dispersion. In this study, 'CALPUFF View' software (highlights the rate and extent of dispersion) was used to estimate the dispersion, with the study area divided into: • 31 segments for traffic. • 7 segments for rail yards. • 3 segments along the Alameda corridor. In addition, the United States Environmental Protection Agency's 'BenMAP' (Benefit Mapping and Analysis) software was used to assess the impacts of the pollutants, which relies on "local concentrations of air pollution, population distribution and health impact functions". 'BenMAP' includes the functionality of monetizing these health impacts.
Findings	**Traffic simulation** Researchers found that: • Trucks movements represent ~8.5% of total vehicle movement in the catchment area. • Container trucks comprised ~60% of total trucks in the catchment area. **Emission simulation** Researchers found that: • As a proportion of total traffic, port trucks were found to contribute ~33% of NO_x emissions, ~26% of $PM_{2.5}$ emissions, and ~20% of PM_{10} emissions. • Rail line-haul emissions are less, on a daily basis, than port truck emissions. PM and NO_x estimated to be ~35% and 40% less, respectively, than emissions from port trucks. • Railyard emissions are less, on a daily basis, than port truck emissions. PM and NO_x estimated to be ~30% and 22% less, respectively, than emissions from port trucks. **Emission simulation** Researchers found that (study size 191, 780 cases): • Children aged 5 to 12 suffering from asthma exacerbation due to NO_x exposure cost the economy $37m in summer and $41m in winter, in health care costs. • Local residents suffering from chronic bronchitis or mortality due to $PM_{2.5}$ exposure, cost the economy $165m in summer and $200m in winter, in health care costs.

4.2 Case Study 2: Monitoring program in Melbourne, Australia

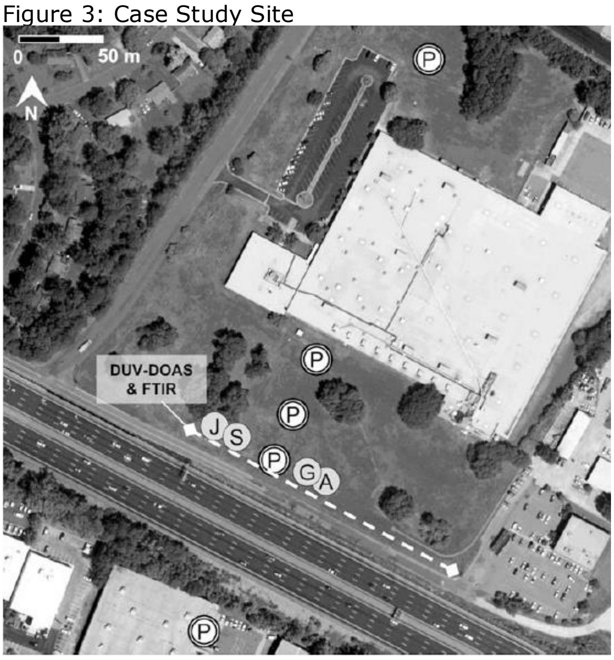
Francis Street Monitoring Program – Final report (2013)	
Aim	To undergo a 12 month air quality monitoring and noise assessment in Francis Street, Yarraville, Victoria.
Background	Francis Street, Yarraville has an estimated 20,000 cars and trucks travelling each weekday between Williamstown Road and Whitehall Street. The Environment Protection Authority Victoria (EPA) completed a 12 month air quality and noise assessment study to assess the impacts of car and truck movements on residents in the local area.
Methodology	In this study, EPA researchers measured major air pollutants and noise associated with motor vehicle emissions at three locations around Melbourne (Yarraville, Footscray and Alphington). The air pollutants tested were PM_{10}, $PM_{2.5}$, NO_2, and benzo(a)pyrene where: • PM_{10} and NO_2 levels were measured against state and national air quality guidelines. • $PM_{2.5}$ levels were measured against the Ambient Air Quality National Environment Protection Measure. Noise monitoring was also undertaken at three sites in Francis Street in fortnightly blocks throughout the study period.
Findings	Researchers found that: • Francis Street average PM_{10} (micrograms/m^3) was higher than Footscray and Alphington (Figure 2). • $PM_{2.5}$ emissions on Francis Street did not exceed standards but were, on average, higher than levels recorded at Alphington and Footscray. • NO_2 levels in Francis Street did not exceed state or national daily levels over the year, however they observed a 50% higher 12 month daily average than Dandenong.

Figure 2: Daily PM10 averages recorded at Francis Street



4.3 Case Study 3: Distance travelled by particulate matter

<table>
<tr><th colspan="2">Ultrafine particles near a major roadway in Raleigh, North Carolina: Downwind attenuation and correlation with traffic-related pollutants (Hagler et al., 2008)</th></tr>
<tr><td>Aim</td><td>To measure ultrafine particles (UFPs) upwind and downwind of a major roadway using a spatial matrix of five samplers (measuring total counts of 20-1000 nanometre particles).</td></tr>
<tr><td>Background</td><td>UFPs have been shown to affect the respiratory system and even transfer to extra pulmonary organs, including the central nervous system. The study highlighted that roadway traffic has been shown to be a major source of UFPs and heavily influences air concentrations in the nearby vicinity of major roads.</td></tr>
<tr><td>Methodology</td><td>The study adopted real time measurement techniques (unique compared to other similar studies) to understand the impact of UFPs. The study parameters included were:
• Industrial hygiene instruments were used to measure total particle number concentration in the size range of 20-1000nm.
• Near-road monitoring alongside a major roadway (~125,000 vehicles per day) in Raleigh, North Carolina, United States.
• Measuring UFPs along 5 sites parallel to the road, marked as J, S, P, G and A in Figure 3.
• Measuring UFPs at three 'downwind' sites facing North-East of the road in Figure 3, labelled P and one 'upwind' site facing South-West of the road, labelled P. These sites spanned 20 metres to 100 metres from the major road.

Figure 3: Case Study Site

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</table>

Ultrafine particles near a major roadway in Raleigh, North Carolina: Downwind attenuation and correlation with traffic-related pollutants (Hagler et al., 2008)

Findings

The study found:

- A five-fold difference between upwind background site and downwind background site during rush hour (between 7:30AM and 8:00AM) (Figure 4).
- The 300m site 'downwind' had two-fold higher concentrations than the upwind location, suggesting that the region of impact extends further than 300m.
- After rush hour period, the concentration of UFPs at all four downwind sites dropped and were indistinguishable from upwind locations (Figure 4).
- The findings of this study were consistent with previous research that compared UFP gradients (see Figure 5 below).

Figure 4: UFP concentrations over time at distances ranging 20-300 metres

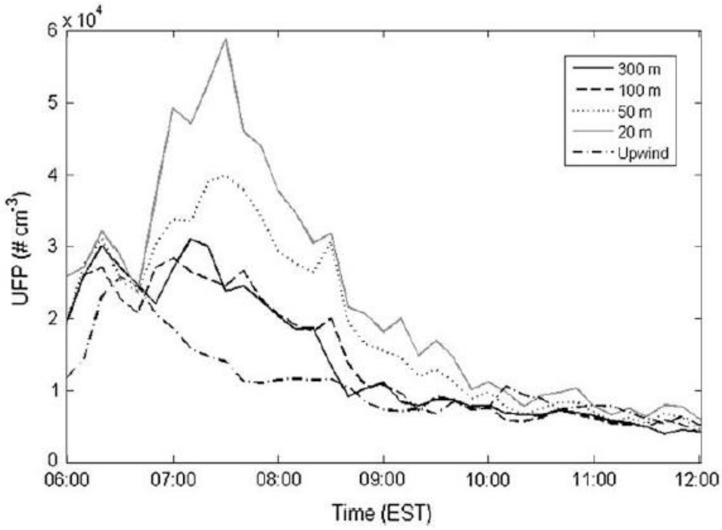
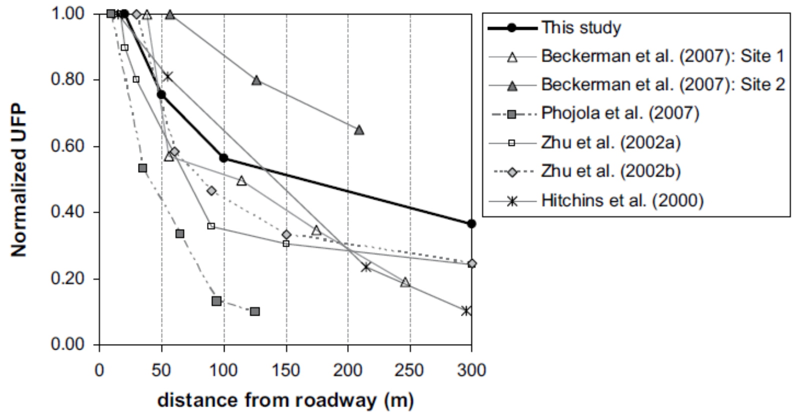


Figure 5: Comparison of UFP gradient measured the study and previous research



4.4 Case Study 4: Relationship between particulate matter and chronic absenteeism in public schools

Impact of Particulate Matter Exposure and Surrounding "Greenness" on Chronic Absenteeism in Massachusetts Public Schools (MacNaughton et al., 2017)	
Aim	To examine the effect of two variables, local PM concentration and local vegetation on chronic absenteeism
Background	The United States Department of Education recently reported chronic absenteeism data for nearly every public school in the country where: • Over 6.5 million students were absent at least 15 days (10% of school year). Being absent a total of three or more weeks of school has proven to lead to low academic achievement. • Children are particularly vulnerable to $PM_{2.5}$ due to their developing immune systems, larger lung surface areas, and breathe 50% more air per kilogram of body weight compared to adults. Further, research has demonstrated that exposure to air pollution has led to decreased cognitive function as well as lower intelligence quotient in children.
Methodology	To assess the impact $PM_{2.5}$ had on the children, the study estimated $PM_{2.5}$ dispersion within 250m and 1,000m of 1772 public schools in Massachusetts where: • $PM_{2.5}$ concentrations were obtained using a hybrid regression that combine NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imaging system, land use and meteorology; and • $PM_{2.5}$ was modelled against chronic absenteeism data released by U.S. Department of Education. A comparison was made between the effect of PM, race and income on chronic absenteeism. Datasets were collected for: • *Race:* using NCES annual data reports that includes student body information such as enrolment by race. • *Income:* using American Community Survey data conducted by the U.S. Census Bureau.
Findings	The study found: • There was a linear relationship between $PM_{2.5}$ and chronic absenteeism. • "Greener" areas, with increased vegetation, were associated with lower absenteeism rates • The magnitude of the effect of local vegetation and $PM_{2.5}$ on chronic absenteeism was "nearly as large as those for income and race" in public schools in Massachusetts.

4.5 Case Study 5: Effect of particulate matter on children suffering from asthma

<table>
<tr><th colspan="2">Outdoor Air Pollution, Genetic Susceptibility, and Asthma Management: Opportunities for Intervention to Reduce the Burden of Asthma (Gilliland., 2017)</th></tr>
<tr><td>Aim</td><td>Using the Children's Health Study (CHS) and California Health Interview Survey to explore intervention strategies to reduce the burden of asthma</td></tr>
<tr><td>Background</td><td>The study highlighted:
• Children living in environments near traffic have increased risks of new-onset asthma, asthma symptoms, exacerbations, school absences, and asthma-related hospitalizations.
• Children are vulnerable to the effects of air pollution because their lungs and immune systems are developing through adolescents.</td></tr>
<tr><td>Methodology</td><td>The study adopted the methodologies used in the CHS to observe the effects of PM on children with:
• Pre-existing asthma; and
• No pre-existing asthma
These case studies have been summarised below:
1. Case Study 5A: Air pollution effects on children with asthma
• More than 6000 school children were selected from classrooms in 12 communities across California. The study commenced in 1996 and continued until high school graduation, yearly questionnaires assessed the development of respiratory symptoms and current activity patterns, and lung function was also measured annually through spirometry, which is the measurement of air in and out of the lungs.
• Outdoor concentrations of ozone, $PM_{2.5}$, PM_{10}, and nitrogen dioxide were measured at central monitoring stations.
2. Case Study 5B: Outdoor air pollution and new-onset asthma
• As part of the CHS, a cohort of 4000 children were monitored from fourth grade until high school graduation. New-onset cases of asthma were ascertained annually.
• Regional air pollutants were monitored continuously during the 8-year follow-up period.</td></tr>
<tr><td>Findings</td><td>The findings suggested that:
• Children with pre-existing asthma living in communities with the highest levels of PM or nitrogen dioxide levels had up to twice the prevalence of bronchitis as children with pre-existing asthma living in communities with cleaner air (Figure 6).
• Traffic-related air pollutants seem to increase the risk of asthma for children with no pre-existing asthma conditions. Further, research suggested the chance of having asthma increases as the distance from children's' home to a major road decreased (Figure 7)</td></tr>
</table>

Outdoor Air Pollution, Genetic Susceptibility, and Asthma Management: Opportunities for Intervention to Reduce the Burden of Asthma (Gilliland., 2017)

Findings
(cont.)

Figure 6: Incidence of bronchitis due to PM in children with and without asthma in the CHS

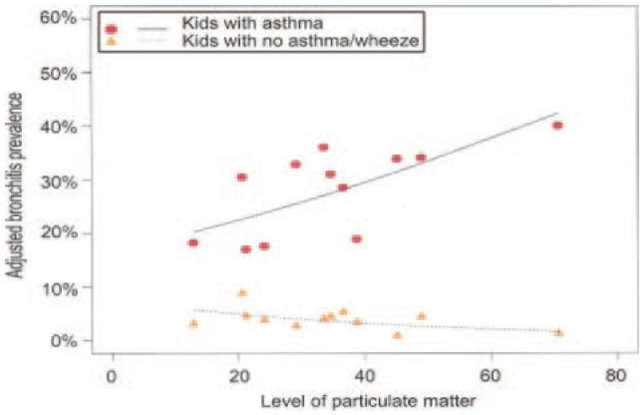
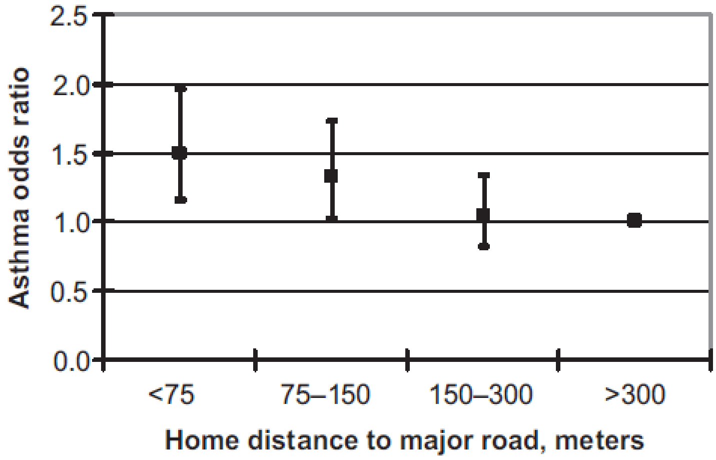


Figure 7: Traffic proximity and risk of asthma onset in CHS



4.6 Case Study 6: Short-term health impacts of diesel exhaust

Acute Inflammatory Responses in the Airways and Peripheral Blood After Short-Term Exposure to Diesel Exhaust in Healthy Human Volunteers (Salvi et al., 1997)	
Aim	To observe toxicity of diesel exhaust in healthy humans, hypothesizing that exposure to diesel exhaust might induce inflammatory and mediator responses in the airways and peripheral blood.
Background	Diesel engines generate up to 100 times more particles than similar-sized petrol engines where: • The World Health Organization estimates PM is responsible for over 500,000 premature deaths annually. • There is extensive evidence to suggest that exposure to increased levels of inhalable particulate pollutants is associated with increases in mortality and morbidity from cardiovascular and respiratory causes. • Due to the microscopic size of particles generated from diesel exhaust, they can remain airborne for long periods of time, and can deposit deeper into the lungs than larger-sized particles.
Methodology	To observe the toxicity of diesel exhaust, the study: • Recruited fifteen healthy non-smoking volunteers between the ages of 21 and 28. They had no history of asthma or respiratory illness. • Exposed the volunteers to air or diesel exhaust for 1 hour in an exposure chamber, during which they performed moderate exercise on a bicycle. • Generated diesel exhaust from an idling Volvo diesel engine, with concentration of PM comparable to PM_{10} levels seen in enclosed spaces such as ferry docks. • Took blood samples 6 hours after exposure to diesel exhaust.
Findings	The study found: • There was a marked cellular inflammatory response in volunteers, associated with an increase in a number of inflammatory mediators in the airway lining fluid.

4.7 Case Study 7: Long-term health impacts of diesel exhaust

Lung Cancer and Elemental Carbon Exposure in Trucking Industry Workers (Garshick et al., 2012)	
Aim	To undergo a retrospective cohort study to assess lung cancer mortality risk among U.S. truck industry workers
Background	Previous epidemiologic studies have reported a positive association between lung cancer risk and work in occupations with some degree of diesel exhaust exposure.
Methodology	To determine whether there is a causal link between lung cancer and diesel exhaust exposure, the following parameters were used: • Obtaining computerized work records for 58,326 unionised trucking industry employees in 1985 across four national trucking companies. • Obtaining date of death and cause-specific mortality from 1985 to 2000 from National Death Index using social security number, name and date of birth. • Including workers in the analysis if they worked for at least 1 year in one of the study companies. Job duties included long-haul drivers and dockworkers. • Estimating job duty's exposure to elemental carbon (EC), seen in $PM_{1.0}$, using a statistical model based on a national exposure assessment.
Findings	The study found: • The mean cumulative years of work was 21.6 years. • There is a wide range of EC exposure between duties. • Throughout 2000, there was 779 lung cancer cases out of 4,306 deaths. • Exposure to EC is positively associated with lung cancer mortality after adjusting for employment duration as well as race, census region and calendar year.

5 Limitations

The studies included within this paper are a desktop review of publicly available international literature and inform Infrastructure Victoria's Second Container Port Advice.

The studies considered in the international literature review demonstrate correlation, but not causation. These studies do not necessarily replicate the same operating and environmental conditions that exist around the Port of Melbourne.