Department of Science, Information Technology and Innovation

Western–Metropolitan Rail System Phase 2 Coal Dust Monitoring Program

Phase 2 monitoring report: February 2014 to December 2015

June 2016

Queensland Government

Prepared by

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Executive summary

In March 2013 the Queensland Resources Council engaged the then Department of Science, Information Technology, Innovation and the Arts (now the Department of Science, Information Technology and Innovation (DSITI)) as an independent third party to undertake a dust monitoring program along the Western–Metropolitan Rail System on behalf of the mining companies using and the service providers managing the network. The dust monitoring program was initiated in response to community concern regarding the impact of coal dust from coal haulage rail transport along the rail system.

The dust monitoring program was undertaken in two components:

1) Phase 1, undertaken between March and early July 2013, evaluated:
    a) the background particle levels at representative sites, followed by
    b) the effectiveness of additional voluntary dust mitigation measures implemented at one mine site, including coal wagon load profiling and veneering, to reduce coal loss during transport along the rail system.

and

2) Phase 2, undertaken since February 2014, assessed the ongoing effectiveness of coal dust mitigation measures, as detailed in the South West System Coal Dust Management Plan (CDMP), in reducing coal dust emissions following full implementation across all coal mines from December 2013.

Whilst the Phase 1 monitoring results, published in November 2013, indicated that coal haulage rail transport was compliant with air quality criteria prior to implementation of additional dust mitigation measures, including load profiling and veneering, mining companies and associated service providers voluntarily adopted the additional dust mitigation measures as outlined in the CDMP to further improve their overall environmental performance.

Phase 2 commenced in February 2014 and remains ongoing (currently funded through to March 2017). It involves continuous monitoring of PM_{10} (particles less than 10 micrometres in diameter), $PM_{2.5}$ (particles less than 2.5 micrometres in diameter), TSP (total suspended particles) and deposited dust (particles settling from the air) at the rail corridor boundary at Cannon Hill on the Metropolitan rail line. Monitoring of deposited dust is also conducted at the rail corridor boundary at Fairfield and Toowoomba. This report presents the monitoring results obtained by DSITI between February 2014 to December 2015 and an assessment of the effectiveness of the ongoing CDMP measures over this period. Monitoring results obtained after December 2015 will be presented at a later time.

The continuous PM_{10}, $PM_{2.5}$ and TSP concentrations at the Cannon Hill (North) monitoring site resulting from all particle emission sources, including coal haulage rail transport, predominantly complied with ambient air quality criteria for protection of human health and avoidance of amenity degradation. Very infrequent exceedences of 24-hour average criteria were recorded between February 2014 and December 2015 (not more than one day per year for each particle fraction), with none of these caused by rail transport or more specifically coal haulage. The PM_{10} 24-hour exceedance in 2015, and the TSP 24-hour exceedences in 2014 and 2015, were the result of dust from rail track maintenance works, while the $PM_{2.5}$ 24-hour exceedence in 2014 was due to smoke from vegetation fires in the South East Queensland region. The $PM_{2.5}$ annual guideline exceedence in 2014 was the result of multiple urban and natural $PM_{2.5}$ sources within the South East Queensland region.

Examination of the relationships between PM_{10}, $PM_{2.5}$ and TSP concentrations and wind direction indicates that rail transport emissions are only a minor contributor to overall airborne particle levels at the Cannon Hill monitoring site. Data analysis has identified the re-suspension of particles from the rail track ballast and dry ground within the rail corridor by the air turbulence generated by passing trains of all types, not just coal haulage, as the main impact from rail transport, not direct emissions from trains (such as exhaust emissions or particle loss from rail wagons).

Dust deposition rates from all sources at the three rail corridor monitoring locations were generally less than half of the dust nuisance assessment value of 120 mg/m^2/day recommended by the Department of Environment and Heritage Protection. The dust nuisance assessment value was only exceeded on two occasions at the Toowoomba (West) monitoring site, in November 2014 and November 2015. On both of these occasions coal haulage rail transport emissions could be ruled out on the basis of the absence of coal dust in the collected particles. Instead, higher than average levels of plant material in the deposited dust sample suggest that these exceedences were due to an annual vegetation-related event such as flowering.

The lack of a consistent positive correlation between deposited dust levels and winds from the direction of the rail corridor for both monitoring sites located on opposite sides of the rail corridor indicates that rail transport, including coal haulage, emissions are not a significant contributor to overall deposited dust levels adjacent to the rail corridor.

Soil and rock particles, at typical levels of between 70 and 90 per cent, were found to be the major particle type present in the deposited dust samples collected at the three rail corridor monitoring locations. Coal dust seldom exceeded ten per cent of total dust in the monthly deposited dust samples collected in 2014; less in the 2015 samples when coal dust rarely comprised more than five per cent of total dust. The most common type of black particles present in the deposited dust is black rubber dust, making up between five and ten per cent of most samples. The primary source of the black rubber dust would be tyre wear from moving vehicles.

During 2015, coal dust was rarely detected in deposited dust samples outside of the drier months from June to October, an observation that can be explained by the source of the coal particles being predominantly re-suspension of coal particles present in the rail track ballast and soil in the rail corridor as the ground dried out rather than direct loss from rail wagons.

While the coal deposition levels measured in Phase 1 were well below the dust nuisance assessment value, Phase 2 monitoring has demonstrated a very significant reduction in the mass of coal depositing from the air from levels initially measured in March and April 2013 before the CDMP measures were implemented. Across the rail system as a whole, the estimated average deposition rate of coal dust has fallen from a pre-CDMP level of 7 mg/m^2/day to 1 mg/m^2/day in 2014 and 2015, a reduction of 86 per cent. The reduction at individual monitoring locations has ranged from 67 per cent to 93 per cent. At the current estimated rail system average deposition rate of 1 mg/m^2/day, coal deposition is just 0.8 per cent of the DEHP dust nuisance assessment value of 120 mg/m^2/day.

Based on the Phase 2 monitoring results, implementation of the CDMP measures, including load profiling and veneering, has been and continues to be highly effective in reducing the loss of coal dust from loaded rail wagons during transport. Re-suspension of dust from the rail corridor by the air turbulence generated by passing trains of all types, not just coal haulage, has been identified as the primary air quality impact from rail transport.

Contents

List of tables

List of figures

Glossary of terms

AAQ NEPM	Commonwealth National Environment Protection (Ambient Air Quality) Measure
AS/NZS	Australian Standard/New Zealand Standard
Ash	The mass of the insoluble portion of particles deposited in a dust deposit gauge which remains after heating the sample to a temperature of 850 degrees Celsius for 30 minutes. This is an indication of the mineral content of the sample.
CDMP	Coal Dust Management Plan.
Combustible matter	The mass of the insoluble portion of particles deposited in a dust deposit gauge which is lost on heating the sample to a temperature of 850 degrees Celsius for 30 minutes. This is an indication of the amount of organic matter of the sample.
Deposited dust	Particles collected in a dust deposit gauge which pass through a one millimetre mesh sieve.
DEHP	Department of Environment and Heritage Protection.
DSITI	Department of Science, Information Technology and Innovation.
EPP Air	Queensland Environmental Protection (Air) Policy 2008.
Insoluble solids	The mass of the insoluble portion of particles deposited in a dust deposit gauge.
µg	Microgram (= one millionth of a gram).
$\mu g/m^3$	Micrograms per cubic metre. A measure of the mass of particles suspended in a unit volume of air.
µm	Micrometre (= one millionth of a metre).
m/s	Metres per second. A measure of wind speed.
mg	Milligram (= one thousandth of a gram).
$mg/m^2/day$	Milligrams per square metre per day. A measure of the average mass of particles settling on a unit area on a daily basis.
mm	Millimetre (= one thousandth of a metre).
NZ MfE	New Zealand Ministry for the Environment.
$PM_{2.5}$	Atmospheric suspended particles with aerodynamic diameter less than 2.5 µm.
PM_{10}	Atmospheric suspended particles with aerodynamic diameter less than 10 µm.
Pollution rose	A diagram representing the frequency distribution of an air pollutant in relation to wind direction on a polar coordinate map.
Soluble solids	The mass of the soluble portion of particles deposited in a deposit gauge.
TEOM™	Tapered Element Oscillating Microbalance instrument that measures particle concentrations on a continuous basis.
Total solids	The total mass of particles deposited in a dust deposit gauge (the sum of insoluble and soluble solids fractions).
TSP	Total suspended particles.
UQMP	University of Queensland Materials Performance laboratory.
Wind rose	A diagram representing the frequency distribution of wind speed and direction on a polar coordinate map. Wind direction is the direction the wind is blowing from.

Introduction

Approximately 7 million tonnes of coal are currently exported from the Port of Brisbane[1]. The export coal is transported to the Port of Brisbane from coal mines in the Clarence-Moreton and Surat Basins in southern Queensland via the Western–Metropolitan Rail System. This network is owned and managed by Queensland Rail, while the coal haulage (train) services are undertaken by Aurizon. The coal haulage starts just east of Miles, travels through Dalby, Toowoomba, Ipswich and the western and southern suburbs of Brisbane to the Port of Brisbane.

Coal is transported to the Port of Brisbane in uncovered rail wagons. This activity has caused some members of the community to raise concerns that uncovered loaded and unloaded rail wagons release significant coal dust, contributing to higher ambient airborne particle levels, impacts to human health and amenity nuisance.

In response, the Queensland Resources Council (QRC) engaged the then Department of Science, Information Technology, Innovation and the Arts (now the Department of Science, Information Technology and Innovation (DSITI)) to undertake a dust monitoring program along the Western–Metropolitan Rail System on behalf of the mining companies utilising, and service providers managing, the network.

This dust monitoring program has been undertaken in two components:

1) Phase 1, undertaken between March and early July 2013, evaluated
    a) background particle levels at representative sites, followed by
    b) the effectiveness of additional voluntary dust mitigation measures implemented at one mine site (which at the time accounted for around 60 per cent of total tonnage of coal transported), including coal wagon load profiling and veneering, to reduce coal loss during transport along the Western–Metropolitan Rail System.

       Load profiling involves re-shaping the loaded coal surface to create a low-profile, garden-bed shape to reduce the dust emissions during transport. Veneering involves spraying a biodegradable non-toxic binding agent onto the loaded coal surface at the time of loading. The veneering solution binds the top layer of the coal surface together forming a flexible layer that reduces coal dust lift-off during transit. These additional dust mitigation measures are documented in the South West System Coal Dust Management Plan (CDMP)[2].

and

2) Phase 2, undertaken since February 2014, assessed the effectiveness of the fully implemented CDMP mitigation measures across all coal mines from December 2013 in reducing coal dust emissions.

The results of Phase 1 were published in November 2013[3]. This report indicates that coal haulage rail transport was compliant with ambient air quality objectives prior to the implementation of the additional dust mitigation measures. The Phase 1 monitoring data did not show any statistically significant change in the concentrations of airborne particles less than 2.5 micrometres and 10 micrometres in diameter ($PM_{2.5}$ and PM_{10} respectively) at rail corridor monitoring sites following implementation of the additional dust mitigation measures. Regional urban particle emission

[1] based on trade statistics for 2014 and 2015 obtained from https://www.portbris.com.au/trade-logistics/trade-statistics.

[2] available from https://www.qrc.org.au/01_cms/details.asp?ID=3080.

[3] report available from http://www.ehp.qld.gov.au/management/coal-dust/monitoring.html.

sources were identified as being the major influence on $PM_{2.5}$ and PM_{10} concentrations at rail corridor monitoring sites rather than rail transport, including that from coal haulage rail transport emissions. However, a general trend towards decreased rates of dust settling from the air and lower levels of coal dust in the deposited dust samples was observed at the rail corridor monitoring sites following the implementation of load profiling and veneering of rail wagons, although it was noted that monitoring over a longer period than two months was needed to demonstrate that this apparent improvement was ongoing. This is one of the aims of Phase 2 of the monitoring program.

Nevertheless, all mining companies delivering coal to the Port of Brisbane voluntarily adopted the additional dust mitigation measures outlined in the CDMP by December 2013.

Phase 2 commenced in February 2014 and remains ongoing (currently funded through to March 2017). It involves continuous monitoring of $PM_{2.5}$, PM_{10} and total suspended particles (TSP) at Cannon Hill adjacent to the rail line used by coal trains. Deposited dust (particles settling from the air) levels are also monitoring adjacent to the rail line at Cannon Hill, Fairfield and Toowoomba. This report presents the Phase 2 monitoring results obtained by DSITI between February 2014 and December 2015 to assess the effectiveness of the fully implemented CDMP measures in reducing coal dust emissions. Results following this time will be presented at a later date.

Airborne particles

Airborne particles can be generated by many different processes, particularly in an urban context where a wide range of domestic, commercial, industrial and transport activities take place. While the size of the particles will depend on the particular process, in general combustion processes involving the burning of fuel (e.g. motor vehicle engines, industrial boilers, solid fuel heaters) will produce smaller particles (typically less than 2.5 micrometres in diameter) than mechanical processes such as earthworks, mining, construction activities, and wind erosion.

Particulate matter can have a variety of health and amenity degradation (dust nuisance) effects depending on the concentration, the size of particles and the exposure time. Both long (over years) and short term (over hours or days) particle exposure has been linked to health problems. Health effects associated with exposure to elevated airborne particle levels range from coughing, sneezing, wheezing and increased breathlessness to aggravation of cardiovascular and respiratory disease and premature mortality[4]. Potential amenity degradation effects of elevated dust levels include short term reduction in visibility, build-up of particulate matter on homes and soiling of washing. In general, particulate matter with an aerodynamic diameter greater than 10 micrometres (µm) tends to be associated with amenity degradation impacts, while particulate matter less than 10 µm (PM_{10}) is associated with health impacts.

While both PM_{10} and $PM_{2.5}$ size fractions have associations with adverse health outcomes, current understanding is that $PM_{2.5}$ appears to be more important than PM_{10} for explaining the health effects attributed to exposure to particles[5].

As health impacts primarily relate to the concentration of suspended particulate matter that is inhaled, air quality standards to protect human health are expressed as a concentration, i.e. the

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[4] National Environment Protection Council, *Draft Variation to the National Environment Protection (Ambient Air Quality) Measure Impact Statement*, July 2014, available from http://www.environment.gov.au/protection/nepc/nepms/ambient-air-quality/variation-2014/impact-statement.

[5] World Health Organization Regional Office for Europe, *Review of evidence on health aspects of air pollution – REVIHAAP project: final technical report*, 2013; available from http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report.

mass of particulate matter that is suspended per unit volume of air, usually measured in micrograms per cubic metre (µg/m³). Most amenity degradation impacts relate to the amount of particulate matter settling out on surfaces, hence guidelines for protection of amenity are expressed as the rate of deposition of particulate matter per unit surface area, usually measured in milligrams of dust accumulating over a square metre each day (mg/m²/day), averaged over a one month period.

The atmospheric lifetime of particulate matter, i.e. how long the particle is airborne, depends on the size of the particle. Larger (coarse) particulate matter tends to deposit quickly and in relatively close proximity to its point of emission whilst fine particulate matter may remain suspended in the atmosphere for many days and travel many hundreds of kilometres. It should be noted that whilst smaller particles have longer atmospheric lifetimes they also disperse as they travel and mix with cleaner air. This dispersion will reduce the overall concentration of the particles with increasing distance from the source of emission.

Particle emissions from rail transport

For rail transport in general, emissions of particles can be produced by wind erosion of loose soil and other material present in the rail corridor during the passage of trains (this may also occur in the absence of trains during strong winds) and engine emissions from diesel-powered locomotives.

In terms of the size of the particles associated with rail transport, particles produced by wind erosion would be expected to be predominantly larger than 2.5 µm in diameter, and often larger than 10 µm in diameter. Having originated from a combustion process, particles emitted from diesel locomotives would be expected to be predominantly less than 2.5 µm in diameter.

In relation to coal trains, particle emissions can also result from erosion of the coal surface of loaded wagons or residual coal in unloaded wagons during transit. In addition, coal leakage from the doors of wagons and coal deposited on sills, shear plates and bogies of wagons during loading can be deposited in the rail corridor, where it can be subsequently re-entrained into the air by wind erosion. The amount and rate of coal dust emitted from coal trains is variable and is dependent upon factors such as the surface area of coal exposed to air currents during transport, the shape or profile of load, the properties of the coal (dustiness, moisture content), the train type, speed, and vibration, the transport distance and route characteristics, and rainfall[6].

Coal dust particles lost from rail wagons would be most likely to be present as larger total suspended particles (TSP) and dust particles that settle from the air, but some will exist as PM_{10} particles.

It should be noted that the particle measurements recorded by the monitoring instruments sited next to the rail corridor will reflect total particle concentrations resulting from all the different particle emission sources impacting on the monitoring location. In an urban environment the number of contributing local and regional sources will be quite large, with particle emissions from rail transport making up only part of the overall level.

[6] Katestone Environmental, *Review of Dust from Coal Trains in Queensland*, in Queensland Resources Council, *Submission to the Federal Senate Standing Committee on Community Affairs Inquiry into the impacts on health of air quality in Australia*, Appendix A, March 2013, available at http://www.aph.gov.au/Parliamentary_Business/Committees/Senate_Committees?url= clac_ctte/air_quality/submissions.htm.

Ambient particle standards and guidelines

Current air quality standards or guidelines do not contain specific criteria for levels of coal dust in ambient air. In this report, assessment of possible health and amenity degradation impacts associated with the particle levels measured has been conducted by comparing the measured levels against recognised standards and guidelines developed for the total amount of particles of a particular size present in the air, regardless of source or composition. This means that the assessments presented in this report refer to particles present at the monitoring sites from all sources, not just coal trains.

There is an established national approach to setting air quality standards in Australia[7,8]. This process is established by the *National Environment Protection Council Act 1994 (Cth)* through National Environment Protection Measures (NEPMs). The aim of the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) is ambient air quality that allows for the adequate protection of human health and well-being. The Queensland Environment Protection (Air) Policy 2008 (EPP Air) adopted the Ambient Air Quality NEPM standards existing at the time as air quality objectives. On 4 February 2016, the AAQ NEPM was varied to include a PM_{10} annual average standard[9]. This standard is yet to be incorporated into the EPP Air.

Ambient PM_{10} concentrations have been compared with the EPP Air 24-hour air quality objective of 50 µg/m^3 and the AAQ NEPM annual standard of 25 µg/m^3. Ambient $PM_{2.5}$ concentrations have been compared with the EPP Air 24-hour and annual air quality objectives of 25 µg/m^3 and 8 µg/m^3 respectively. Longer-term ambient TSP concentrations have been compared against the EPP Air annual air quality objective of 90 µg/m^3.

For 24-hour average air quality criteria, calendar day average particle concentrations are generally used to assess compliance with air quality criteria[10]. This report adopts this approach when assessing compliance with 24-hour air quality criteria.

There are currently no ambient PM_{10}, $PM_{2.5}$ or TSP guidelines for protection of human health for exposure periods shorter than 24 hours. For this reason, DSITI is not in a position to provide any guidance on potential health impacts resulting from exposure to particles for periods less than 24 hours.

Regarding amenity degradation, the Department of Environment and Heritage Protection (DEHP) guideline document *Application requirements for activities with impacts to air*[11] (Air Impacts Guideline) lists two measures for assessing dust nuisance potential. Short-term (24-hour average) TSP concentrations are to be compared against the trigger levels provided in the New Zealand Ministry for the Environment (NZ MfE) document *Good practice guide for assessing and managing*

[7] National Environment Protection Council, *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement*, available from http://www.scew.gov.au/sites/www.scew.gov.au/files/resources/9947318f-af8c-0b24-d928-04e4d3a4b25c/files/aaq-impstat-aaq-nepm-revised-impact-statement-final-199806.pdf, 1998.

[8] National Environment Protection Council, *Methodology for setting air quality standards in Australia Part A*, available at http://www.scew.gov.au/sites/www.scew.gov.au/files/resources/458719dc-73eb-4cfd-a688-a36b32e80f6c/files/methodology-air-quality-standards-australia-parta.pdf, 2011, accessed 22 July 2013.

[9] For further information see http://www.nepc.gov.au/resource/variation-ambient-air-quality-nepm-%E2%80%93-particles-standards.

[10] An example of this is the Commonwealth National Environment Protection (Ambient Air Quality) Measure, available from https://www.comlaw.gov.au/Details/C2004H03935. For the purposes of assessing compliance with the standards and goals of this Measure, Schedule 2 defines an averaging period of 1 day as a calendar day average.

[11] Available from http://www.ehp.qld.gov.au/assets/documents/regulation/era-gl-air-impacts.pdf.

the environmental effects of dust emissions[12]. In this report, 24-hour TSP concentrations have been compared against the NZ MfE dust nuisance trigger level for sensitive areas of 80 µg/m^3.

The dust deposition rate – the amount of dust that settles out of the air over time – is also to be considered. Acceptable dust deposition rate criteria have generally been derived from subjective observations and investigation of dust levels and nuisance effects. The Air Impacts Guideline recommends a dust deposition limit of 120 milligrams per square metre per day, averaged over one month, as appropriate for assessing dust nuisance potential from dust settling out on surfaces.

Monitoring program design

The objectives of the Phase 2 monitoring program were to:

- assess seasonal changes in dust levels adjacent to the rail corridor; and
- assess the effectiveness of adoption of CDMP measures, including rail wagon load profiling and veneering, in reducing coal dust emissions.

To achieve these aims, the continuous monitoring component collected information on:

- PM_{10} and $PM_{2.5}$ concentrations – for assessment against criteria for protection of human health
- TSP – for assessment against longer-term (annual) criteria for protection of human health and short-term (24-hour) amenity-based (nuisance) criteria
- deposited dust – for assessment against amenity-based (nuisance) criteria
- particle composition of deposited dust – for assessment of the contribution of coal and other particle types to overall deposited dust levels
- meteorology (e.g. wind speed and direction) – to assist with identifying possible particle sources

The continuous PM_{10}, $PM_{2.5}$ and TSP and meteorology monitoring data was also used to assess the impact of train movements on particle concentrations.

Monitoring locations

A monitoring site was established in the Brisbane suburb of Cannon Hill to measure PM_{10}, $PM_{2.5}$ and TSP on a continuous basis. The location of the monitoring equipment on the rail corridor boundary downwind of prevailing winds was determined by DSITI to provide measurements representative of maximum particle exposure levels experienced by the surrounding community, whilst also meeting access and space requirements for establishment and maintenance of the equipment. For these reasons, one of the previous Phase 1 monitoring locations was not adopted for the location of the continuous monitoring equipment.

Deposited dust samplers were sited at Cannon Hill, Fairfield and Toowoomba. At each location, two samplers were deployed, one on each side of the rail corridor, to ensure any dust fallout resulting from rail transport was captured in at least one of the samplers. The location of the samplers on the rail corridor boundary would provide measurements representative of maximum dust deposition levels experienced by the surrounding community. Samplers at Fairfield remained consistent with the Phase 1 sites, whilst those at Cannon Hill were located approximately 4 km closer to the Port of Brisbane than the closest Phase 1 site (Coorparoo) and those at Toowoomba

[12] Available from http://www.mfe.govt.nz/publications/air/good-practice-guide-assessing-and-managing-environmental-effects-dust-emissions.

were located approximately 2 km closer to the Toowoomba CBD than the Willowburn site used in Phase 1.

Details of the individual Phase 2 monitoring sites and parameters measured are summarised in Table 1 and the equipment locations at each of the monitoring sites are shown in Figures 1 to 3.

Table 1. Details of Phase 2 Western–Metropolitan Rail System rail corridor air monitoring locations.

Monitoring site	Number of rail lines	Maximum train speed		Position relative to rail line	Distance from nearest rail track	Distance from furthest rail track	Measurement parameters
		Freight	Passenger				
Cannon Hill	3	60 km/h (both directions)	80 km/h (both directions)	North	6 metres	21 metres	Continuous PM_{10} Continuous $PM_{2.5}$ Continuous TSP Deposited dust Meteorology
				South	4 metres	18 metres	Deposited dust
Fairfield	3	60 km/h (both directions)	70 km/h (to City) 80 km/h (from City)[a]	East	3 metres	12 metres	Deposited dust
				West	6 metres	22 metres	Deposited dust
Toowoomba	2	60 km/h (both directions)	60 km/h (both directions)	East	18 metres	22 metres	Deposited dust
				West	8 metres	12 metres	Deposited dust

[a] express trains are permitted to travel at 100 km/h

It should be noted that non-express passenger trains at Cannon Hill and Fairfield would be travelling much slower than the maximum speeds listed in Table 1, as they would either be preparing to stop at, or accelerating away from, the adjoining station. As a result of restricted signals, track bends and priority for passenger services, the majority of freight services were likely to be travelling at speeds less than the maximum speeds indicated in Table 1.

The monitoring equipment at Cannon Hill is located in Queensland Rail compounds situated on either side of the rail corridor immediately to the west of the Cannon Hill Railway Station (Figure 1). The Cannon Hill sites are approximately 14 km from the Port of Brisbane and approximately 4 km closer to the Port than the easternmost site (Coorparoo) used in the Phase 1 monitoring. At Cannon Hill loaded coal trains use a separate rail line dedicated for freight services. The Cannon Hill (North) monitoring site (where the continuous particle monitoring equipment is sited) is located next to this dedicated freight rail line.

In close proximity to the Cannon Hill monitoring sites are three major road traffic corridors – Wynnum Road 300 m to the south, Lytton Road 600 m to the north-west/north and Creek Road 1 km to the east. The heavily-trafficked Gateway Motorway is also only about 2 km north-east of the monitoring site. All of these roads carry a high proportion of heavy vehicles. Emissions from vehicles travelling on these roads will contribute to particle levels, especially $PM_{2.5}$, measured at the monitoring site.

Other potential particle emission sources in the vicinity of the Cannon Hill monitoring sites are facilities located in the adjacent Southgate Corporate Park, Brisbane Airport and domestic activities taking place in the surrounding residential areas.

Continuous PM_{10}, $PM_{2.5}$, TSP and meteorological parameter monitoring commenced at the Cannon Hill (North) monitoring site on 1 February 2014. Deposited dust monitoring began at the Cannon Hill (North) and Cannon Hill (South) monitoring sites on 4 February 2014. DSITI staff established the monitoring site at Cannon Hill and are responsible for the ongoing operation and maintenance of the equipment and collection and validation of the monitoring data.

Figure 1. Monitoring equipment locations at Cannon Hill.

At Fairfield the two dust deposition samplers are located on either side of the rail corridor at the Fairfield Railway Station (Figure 2). Fairfield was one of the rail corridor sites used in the Phase 1 monitoring. At the Fairfield site loaded coal trains use a separate rail line dedicated for freight services. The Fairfield (West) deposited dust sampler is situated next to this freight rail line.

The Fairfield monitoring site was situated between two major road traffic corridors – Fairfield Road 300 m to the west and Ipswich Road 400 m to the east. The heavily-trafficked Pacific Motorway is also located 1 km to the east of the monitoring site. Emissions from vehicles travelling on these roads will contribute to particle levels, especially $PM_{2.5}$, measured at the monitoring site. Other potential particle emission sources in the vicinity of the Fairfield monitoring sites are an adjacent shopping centre and domestic activities taking place in the surrounding residential areas.

Deposited dust monitoring began at the Fairfield (East) and Fairfield (West) monitoring sites on 4 February 2014. DSITI staff deployed the samplers and are responsible for the ongoing sampling and validation of the monitoring data.

Following repeated vandalism of the sampler, measurement of deposited dust ceased at the Fairfield (East) site in November 2015. Data from both Fairfield sites prior to November 2015 demonstrated that deposited dust levels and composition was similar at both sites and Fairfield deposited dust results would not be compromised by sampling at the Fairfield (West) site only.

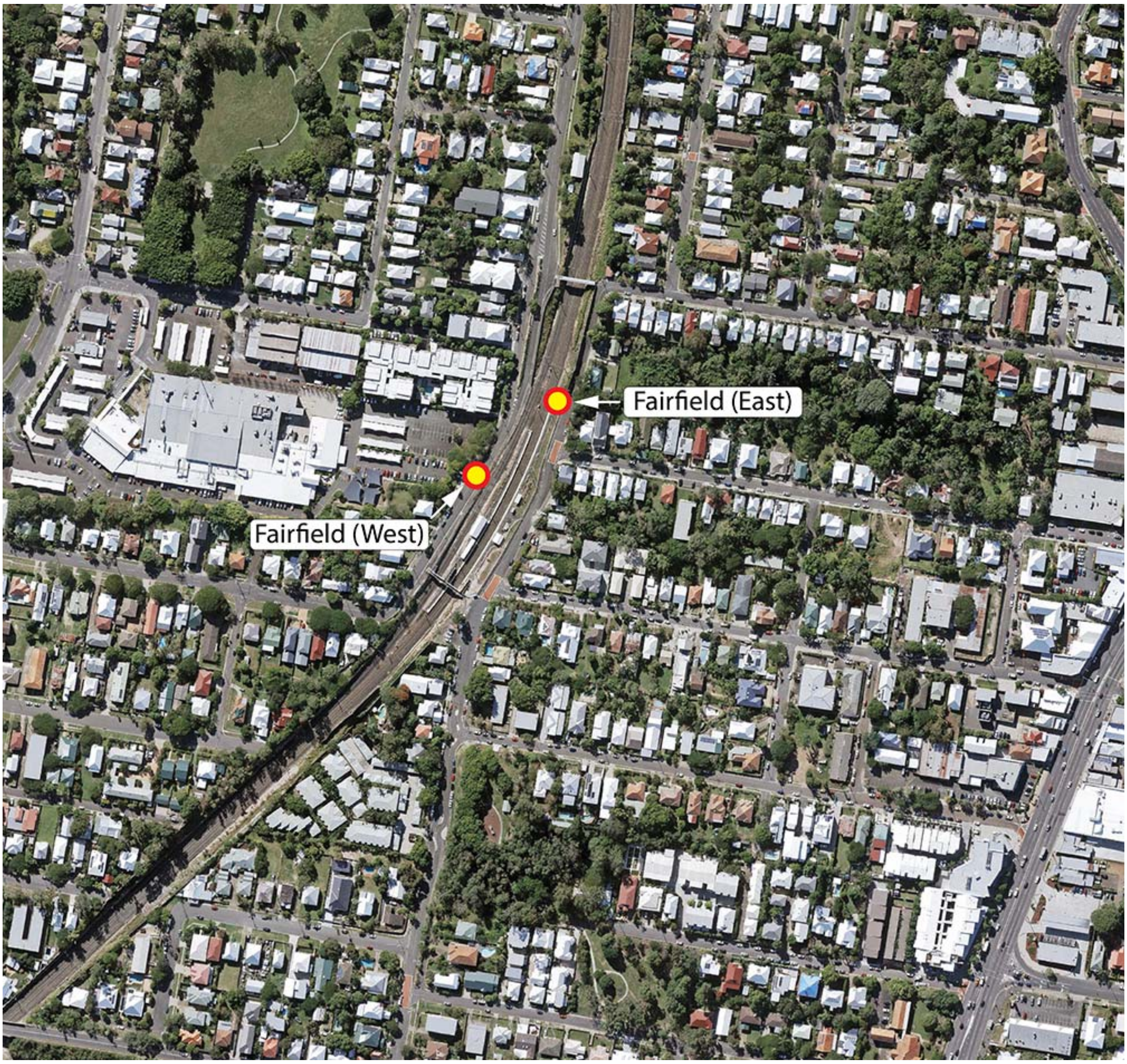


Figure 2. Monitoring equipment locations at Fairfield.

At Toowoomba the two dust deposition samplers are located on either side of the rail corridor in North Toowoomba just west of where the rail line used by coal trains crosses Gowrie Creek (Figure 3). Due to site access constraints, the two samplers were situated approximately 500 m apart. The location of the samplers was approximately 2 km closer to the Toowoomba CBD than the

Willowburn site used in Phase 1. At Toowoomba there are two rail lines in the rail corridor, however trains predominantly use the line on the western side of the corridor. The Toowoomba (West) deposited dust sampler is situated closest to this main line.

Major road traffic corridors are located within 500 m to 1 km of the two sampling sites, however traffic volumes on these roads are considerably less than the major traffic corridors in the vicinity of the Brisbane monitoring sites. Other particle sources in the vicinity of the monitoring sites that could contribute to the deposited dust collected include activities at nearby commercial premises (which include landscaping businesses) and windblown dust from exposed ground.

Figure 3. Monitoring equipment locations at Toowoomba.

Dust deposition monitoring began at the Toowoomba sites on 13 March 2014. DSITI staff deployed the dust deposition samplers in Toowoomba and are responsible for validation of the monitoring data. Staff from the DEHP Toowoomba office undertake the monthly sample collection.

Monitoring equipment

Continuous PM_{10} and $PM_{2.5}$ concentrations (averaged over five minute periods) are monitored at the Cannon Hill (North) site using a Model 1405DF dichotomous Tapered Element Oscillating Microbalance (TEOM™) instrument operated in accordance with the Australian/New Zealand Standard AS/NZS 3580.9.13:2013 *Method 9.13: Determination of suspended particulate matter—$PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance monitor*.

The dichotomous TEOM™ instrument operates by first drawing air through a size-selective inlet that excludes particles larger than PM_{10}. In the instrument's sampling system the air stream is split into two separate particle streams, one containing particles less than 2.5 µm in diameter ($PM_{2.5}$) and the other containing particles between 2.5 µm and 10 µm in diameter ($PM_{2.5\text{-}10}$). The two particle streams then pass through separate filters mounted on hollow glass tubes (tapered elements) vibrating at their natural frequencies (similar to how a tuning fork operates). Particle masses are then measured using the change in the oscillating frequency of each tube following particle deposition on the filters. The particle concentrations are calculated using the flow rates for each particle stream, with PM_{10} concentrations calculated as the sum of the simultaneous measurements from the $PM_{2.5}$ and $PM_{2.5\ 10}$ particle streams.

Continuous TSP concentrations (averaged over five minute periods) are monitored using a Model 1405 TEOM™ instrument. The TEOM™ instrument draws air through an inlet designed to sample total suspended particles at the flow rate of the instrument (16.7 L/min). The particle stream then passes through a filter mounted on a glass tube (tapered element) vibrating at its natural frequency. The change in the oscillating frequency of the glass tube following particle deposition on the filter is used to measure the particle mass, and the particle concentration is calculated using the flow rate for the particle stream. The TSP instrument is operated in accordance with the requirements of Australian Standard AS 3580.9.8—2008 *Method 9.8: Determination of suspended particulate matter—PM_{10} continuous direct mass method using a tapered element oscillating microbalance analyser*, with a TSP inlet fitted in place of a size-selective PM_{10} inlet.

Deposited dust levels are measured over monthly periods using a funnel and collection bottle (called a dust deposition gauge), which catches dust settling on the internal surface of the funnel. Following sampling, the dust is washed from the bottle and then filtered and weighed.

The dust deposition results are expressed as the weight of dust collected per unit of surface area per day, averaged over a standardised 30-day sampling period (e.g. mg/m^2/day averaged over a 30-day period). The deposited dust is further characterised as insoluble solids (the fraction of total particles deposited which are not water-soluble – these are the particles typically responsible for nuisance impacts), ash (the part of the insoluble dust fraction which remains after heating the sample to a temperature of 850 degrees Celsius for 30 minutes) and combustible matter (the part of the insoluble dust fraction which is lost on heating the sample to a temperature of 850 degrees Celsius for 30 minutes). Deposited dust is collected and analysed in accordance with the Australian/New Zealand Standard AS/NZS 3580.10.1:2003 *Method 10.1: Determination of particulate matter—Deposited Matter—Gravimetric method*.

Determining the types of particles present in the dust at the monitoring site is an important element of the monitoring program as this information assists in identifying likely sources of the particles. Sub-samples of the deposited dust are examined through a microscope and the proportions of different particles in each dust sample are measured based on the surface area coverage of each particle type. The particle composition analysis is conducted by the University of Queensland's Materials Performance laboratory (UQMP). The analysis method is able to distinguish a range of black-coloured particles (coal, soot and rubber dust), mineral dust particles (e.g. soil, rock, cement, glass), biological particles (e.g. insect and plants) and other general organic particles (e.g. wood, fibres and plastics). The method accuracy is in the order of ± 5 per cent. It should be noted that as the microscopic examination is based on surface area coverage and not particle mass, the proportions of the different particles (based on area) cannot be directly applied to generate particle concentration ratios (based on mass and volume) or particle deposition (based on mass). To convert from area-based coverage to particle concentration or mass values requires knowledge of the densities of the different particle types.

Wind speed and direction, relative humidity, temperature and rainfall measurements (averaged over five minute periods) are also recorded at Cannon Hill to assist with determining the contribution from different particle sources to PM_{10}, $PM_{2.5}$, TSP and deposited dust levels.

Results and discussion

Train movements

Train movement data for the Cannon Hill site during the reporting period was supplied by Queensland Rail and is summarised in Table 2.

Table 2. Summary of train movements at Cannon Hill during the period February 2014 to December 2015.

Train type	Statistic	Cannon Hill train movements
Coal (loaded)	Total	3143
	Daily average	10
	Daily range	0 to 14
Coal (empty)	Total	3144
	Daily average	10
	Daily range	0 to 14
Other non-coal freight	Total	1449
	Daily average	5
	Daily range	0 to 13
Passenger	Total	45648
	Daily average	143
	Daily range	0 to 184
Other train types	Total	532
	Daily average	2
	Daily range	0 to 4

On average, ten loaded and ten unloaded coal trains passed the Cannon Hill monitoring site each day during the reporting period. The maximum number of loaded and unloaded coal train movements on any one day was 14 and 13 respectively. Other non-coal freight rail services were less frequent, averaging five services per day and a maximum of 13 services on a single day. Cannon Hill experienced high electric passenger train service numbers, with an average of 143 services per day and a maximum daily total of 184.

With the closure of the Wilkie Creek Coal Mine north-west of Dalby in December 2013, the number of coal trains accessing the Port of Brisbane during the reporting period was less than during the Phase 1 monitoring period when there was an average of 13 loaded and 13 unloaded coal train movements per day. The average number of non-coal freight train movements is unchanged from the Phase 1 monitoring period. Passenger train movements have increased by 45 per cent from the Phase 1 monitoring period when the average number of daily services was 99.

All coal trains using the Western–Metropolitan rail systems consist of 41 wagons hauled by two diesel locomotives located at the front of the train. The maximum permitted speed for freight trains at the three rail corridor monitoring sites is 60 km/h (see Table 1), although restricted signals, track bends and priority for passenger services mean that these services are often travelling at lower speeds. Data on the actual speed of individual trains as they passed the Cannon Hill monitoring site was not available.

Meteorology

An important influence on rail corridor dust emissions is dust suppression due to heavy and persistent rainfall. This dust suppression would include a reduction in both the loss of coal particles from rail wagons during transport and the amount of surface dust present in the rail corridor being re-entrained during the passage of trains. Figures 4 compares the monthly rainfall totals measured between February 2014 and December 2015 at Bureau of Meteorology rainfall stations close to the three rail corridor monitoring sites with median rainfall totals over the years 1996 to 2015[13].

Figure 4 shows that rainfall over the period February to October 2014 was generally well below the long-term median value. Brisbane sites experienced rainfall totals above the long-term median value for much of the period from November 2014 to May 2015, followed by totals around the median values for the remainder of 2015. Apart from above-median totals in December 2014 and May 2015, rainfall totals in Toowoomba were similar to the long-term median values for the period November 2014 to December 2015.

The average or below average rainfall conditions for much of 2014 and the second half of 2015 mean that measured particle levels would not have been suppressed to any significant extent during these periods. Measurements during these periods will therefore provide information on particle exposures in the upper portion of the exposure range. While wet conditions experienced in Brisbane between November 2014 and May 2015 mean that ambient particle measurements over this period could under-represent typical levels expected for this time of year, monitoring results for early 2014 and late 2015 provide information on particle levels for the same periods of the year under drier conditions.

[13] Historical rainfall data for the Brisbane, Archerfield and Toowoomba Airport sites obtained from the Bureau of Meteorology Climate Data Online website, http://www.bom.gov.au/climate/data/.

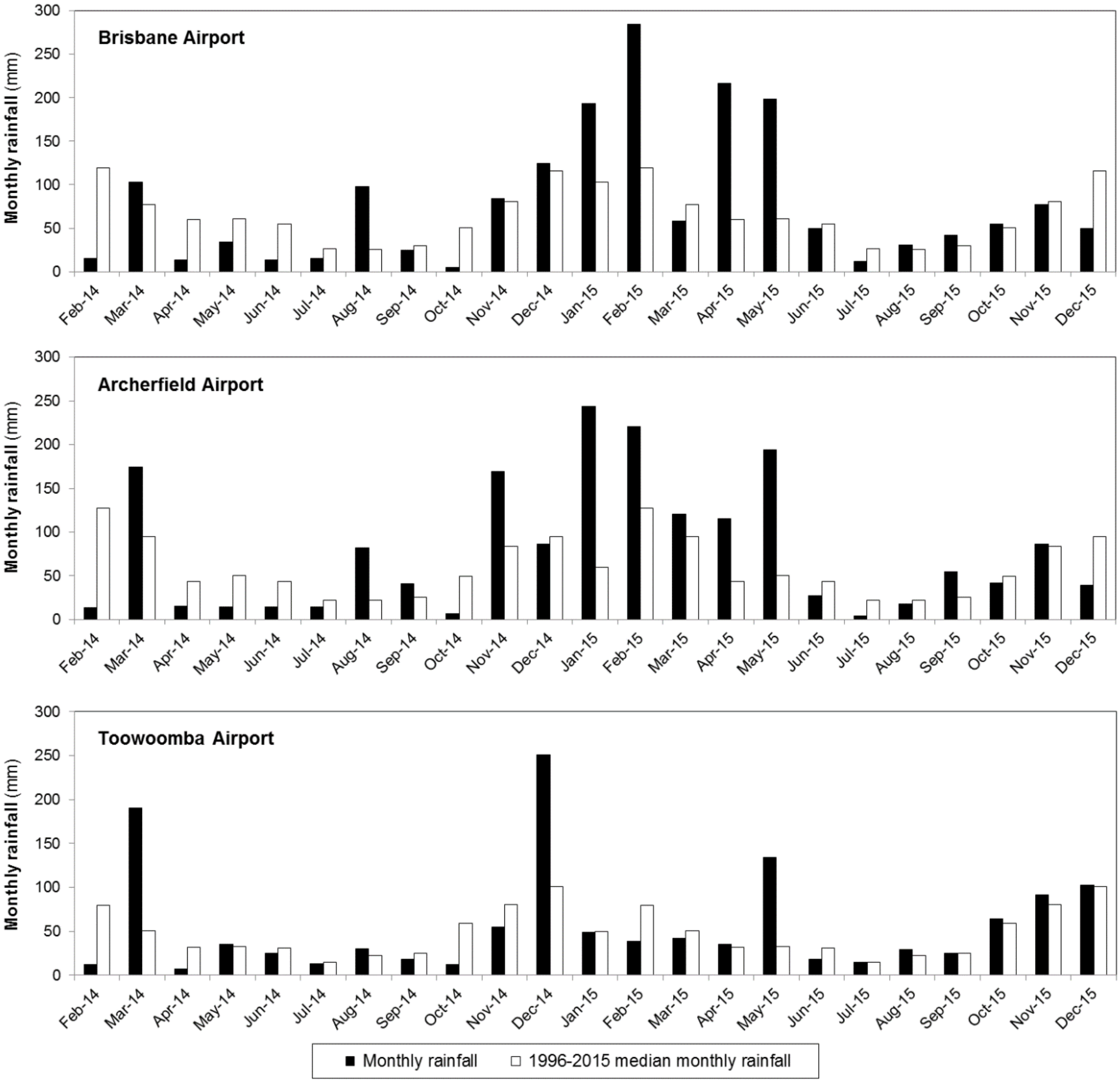


Figure 4. Monthly rainfall totals for Bureau of Meteorology stations in Brisbane and Toowoomba close to the rail corridor monitoring sites, February 2014 to December 2015.

Wind direction was another important factor in the measurement of dust impacts at the monitoring sites. Wind information was collected at Cannon Hill as part of this study. For the Fairfield and Toowoomba monitoring sites where on-site wind monitoring was not conducted, wind data from DSITI's ambient air monitoring sites at Rocklea and Jondaryan respectively have been used to provide indicative wind conditions. The wind direction ranges necessary for dust generated by train movements to impact the monitoring sites (i.e. winds blowing from the rail corridor towards the monitoring site), together with the proportion of winds within these ranges over the reporting period, are summarised in the 'rail corridor' columns in Table 3.

While particles generated by train movements could be measured at the monitoring site during winds from any direction within the 'rail corridor' ranges listed in Table 3, the potential for dust impacts would be greatest for winds coinciding with the rail line orientation at the monitoring location. In this situation, any particles generated by, or lost from, any part of the train would be more likely to be carried over the monitoring site and sampled. The wind ranges and proportions for winds blowing along the rail line orientation at each monitoring site over the reporting period are summarised in the 'rail lines' columns in Table 3. The analysis of possible relationships between particle levels and wind direction presented in this report has incorporated both the 'rail corridor' and 'rail lines' wind direction ranges.

Table 3. Wind conditions at the rail corridor monitoring sites, February 2014 to December 2015.

Monitoring site	Wind range for dust impacts (degrees)[a]		Proportion of winds within dust impact range (%)	
	Rail corridor	Rail lines	Rail corridor	Rail lines
Cannon Hill (North)	70 to 260	70 to 100, 240 to 260	68	25
Cannon Hill (South)	0 to 90, 250 to 360	60 to 90, 250 to 280	45	33
Fairfield (East)[b]	0 to 20, 200 to 360	0 to 20, 200 to 230	51	19
Fairfield (West)[b]	20 to 220	20 to 40, 180 to 220	59	23
Toowoomba (East)[c]	160 to 330	160 to 180, 310 to 330	29	5
Toowoomba (West)[c]	0 to 140, 310 to 360	110 to 140, 310 to 340	70	15

[a] North = 0 degrees and 360 degrees, east = 90 degrees, south = 180 degrees, west = 270 degrees

[b] Continuous wind measurements from DSITI's air quality monitoring site at Rocklea have been used to derive the summary wind information for the Fairfield sites

[c] Continuous wind measurements from DSITI's air quality monitoring site at Jondaryan have been used to derive the summary wind information for the Toowoomba sites

Figures 5 to 7 show the distribution of winds over the reporting period for each monitoring site as wind roses overlaid on a map of the monitoring site location. The wind roses show the frequency distribution for ten degree wind direction sectors. The length of each 'arm' shows the proportion of winds blowing from that direction, with the shading within each 'arm' showing the breakdown of wind speeds for that particular wind direction (the wind speed ranges are shown in the legend in the bottom left of the figures). The percentage of total winds is shown on the vertical scale above the legend.

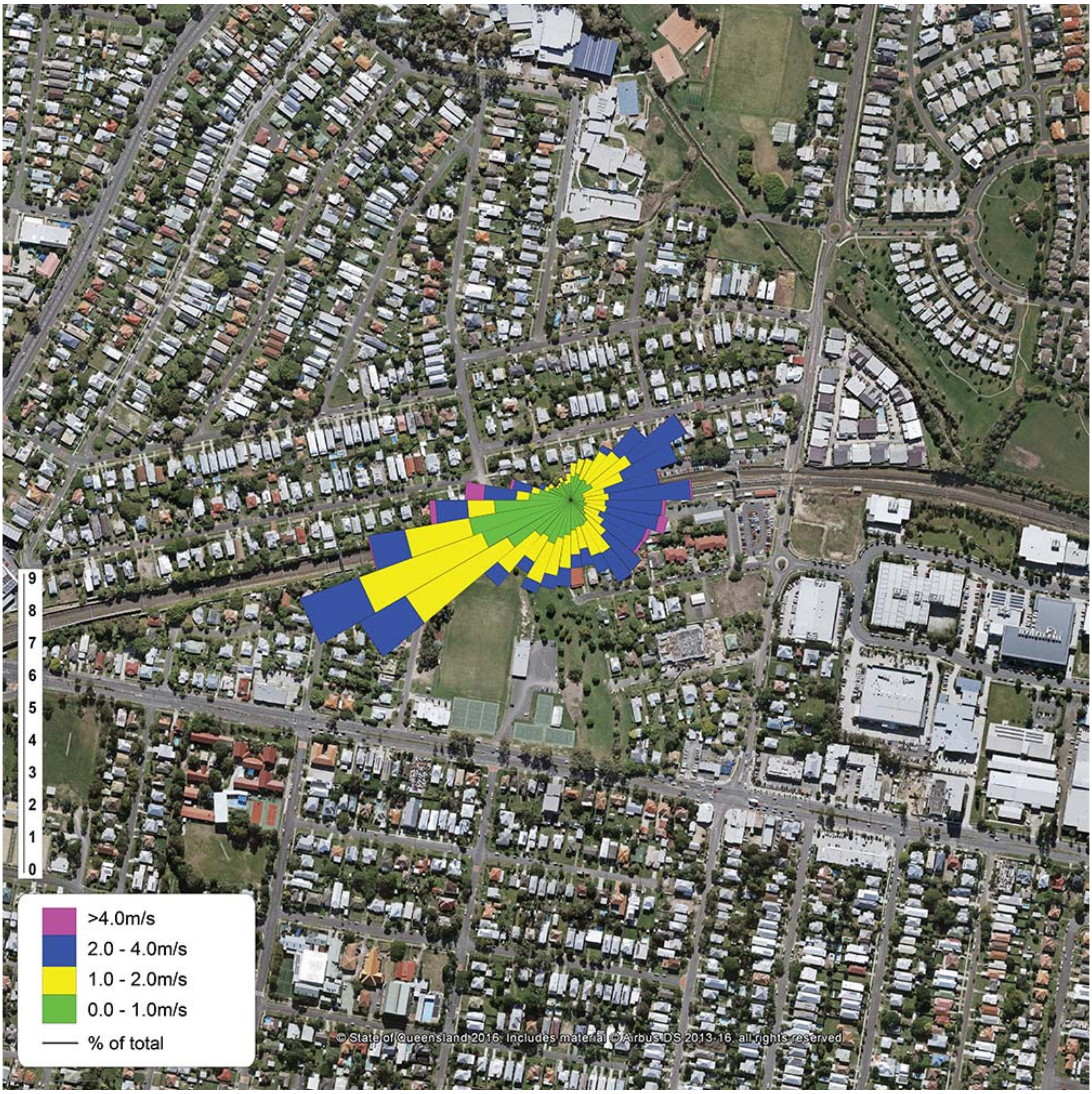


Figure 5. Cannon Hill wind rose, February 2014 to December 2015.

Figure 6. Fairfield wind rose, February 2014 to December 2015.

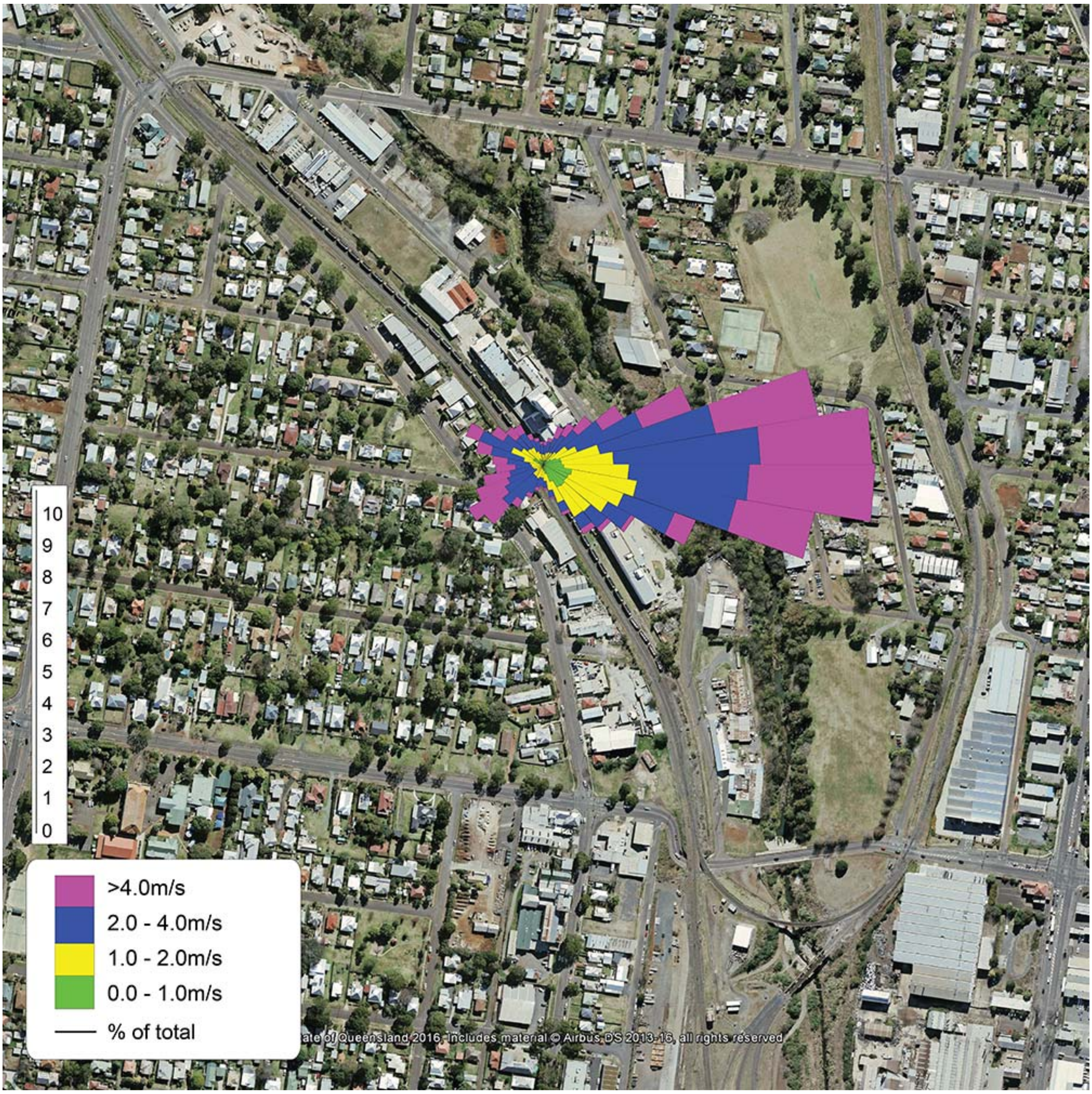


Figure 7. Toowoomba wind rose, February 2014 to December 2015.

Table 3 and Figure 5 show that more than two-thirds of all winds blew from the direction of the rail corridor to the Cannon Hill (North) monitoring site during the reporting period. On this basis, the continuous particle monitoring measurements obtained at this site will have adequately captured any impacts from rail transport emissions.

Wind conditions are less critical for the deposited dust measurements as siting of separate deposited dust samplers on opposite sides of the rail corridor means that as any dust generated by train movements would be expected to be captured in at least one of the samplers. Based on the above wind data, the Cannon Hill (North), Fairfield (West) and Toowoomba (West) deposited dust samplers would be expected to be most impacted by dust generated by rail transport. All of these sites are also located next to the rail line used by loaded coal trains. While the frequency of winds blowing towards the Cannon Hill (South), Fairfield (East) and Toowoomba (East) monitoring sites is lower, these samplers still provide important information on dust sources during less common winds and background contributions from sources outside the rail corridor during prevailing winds.

PM_{10}

Measurement summary

PM_{10} concentrations were measured at the Cannon Hill (North) site on a continuous basis using a Model 1405DF dichotomous Tapered Element Oscillating Microbalance (TEOM™) instrument operated in accordance with the Australian/New Zealand Standard AS/NZS 3580.9.13:2013.

Summary PM_{10} concentration data recorded at the Cannon Hill (North) monitoring site for the period from site establishment in February 2014 to December 2015 are provided in Table 4. It is important to note that the reported PM_{10} measurements will be the sum of contributions from all PM_{10} emission sources, such as motor vehicles and industry as well as rail transport, impacting on the Cannon Hill (North) site. In addition, coal haulage rail transport will represent only a proportion of the total PM_{10} originating from rail transport.

Table 4 shows the number of hourly and daily average samples, and average, maximum and percentile concentration values for the entire reporting period and for the individual 2014 and 2015 calendar years. Hourly percentile values have been included in Table 4 to show the distribution of hourly average concentrations. PM_{10} data availability over the entire reporting period was 92.6 per cent.

Table 4. PM_{10} concentrations at the Cannon Hill (North) monitoring site between 1 February 2014 and 31 December 2015

Number of samples		PM_{10} concentration (µg/m^3)									
Hourly	Daily[a]	Average	Maximum		Days >EPP Air objective[a]	Hourly average percentile values					
			Rolling 24-hour[a]	Calendar day[a]		99th	98th	95th	90th	75th	50th
1 February 2014 to 31 December 2015											
15530	640	15.7	63.4	62.4	1	45.0	39.4	31.3	25.8	19.4	14.2
1 February 2014 to 31 December 2014											
7107	292	16.9	44.2	43.4	0	48.9	42.4	34.4	28.5	21.5	15.3
1 January 2015 to 31 December 2015											
8423	348	14.7	63.4	62.4	1	40.8	35.4	27.7	23.4	18.0	13.4

[a] where data availability during the 24-hour period is at least 75 per cent.

The EPP Air 24-hour objective for PM_{10} is 50 µg/m^3, with this concentration not to be exceeded on more than 5 days in a 12 month period.

The AAQ NEPM standards for PM_{10} are an annual average of 25 µg/m^3 and a 24-hour average of 50 µg/m^3.

Table 4 indicates that there was an overall reduction in PM_{10} concentrations in 2015 when compared to 2014 levels. One contributing factor is likely to have been the below average rainfall experienced for much of 2014, which would have led to increased levels of windblown dust from dry ground in the area surrounding the monitoring site.

Compliance with standards and guidelines

The air quality objective for PM_{10} specified in the EPP Air is that 24-hour average concentrations do not exceed 50 µg/m^3 on more than five days each year. The AAQ NEPM standards for PM_{10} are an annual average concentration of 25 µg/m^3 and a maximum 24-hour average concentration of

50 µg/m³. When reporting compliance against the AAQ NEPM PM_{10} 24-hour average standard, monitoring data that has been determined as being directly associated with an exceptional event such as bushfire smoke or dust storm is excluded.

Consistent with the findings of the four-month Phase 1 monitoring (both prior to and following the commencement of load profiling and veneering of coal rail wagons), monitoring at Cannon Hill from February 2014 to December 2015 demonstrated that PM_{10} emissions from rail transport have not resulted in any exceedences of the EPP Air or AAQ NEPM PM_{10} criteria.

Annual average PM_{10} concentrations complied with the AAQ NEPM annual standard of 25 µg/m³ at the Cannon Hill (North) monitoring site over the reporting period. Annual average PM_{10} concentrations for the 2014 and 2015 calendar years were 16.9 µg/m³ and 14.7 µg/m³ respectively. The average PM_{10} concentration over the entire reporting period was 15.7 µg/m³.

Figure 8 displays the 24-hour average PM_{10} concentrations measured at the Cannon Hill (North) monitoring site on each day over the reporting period.

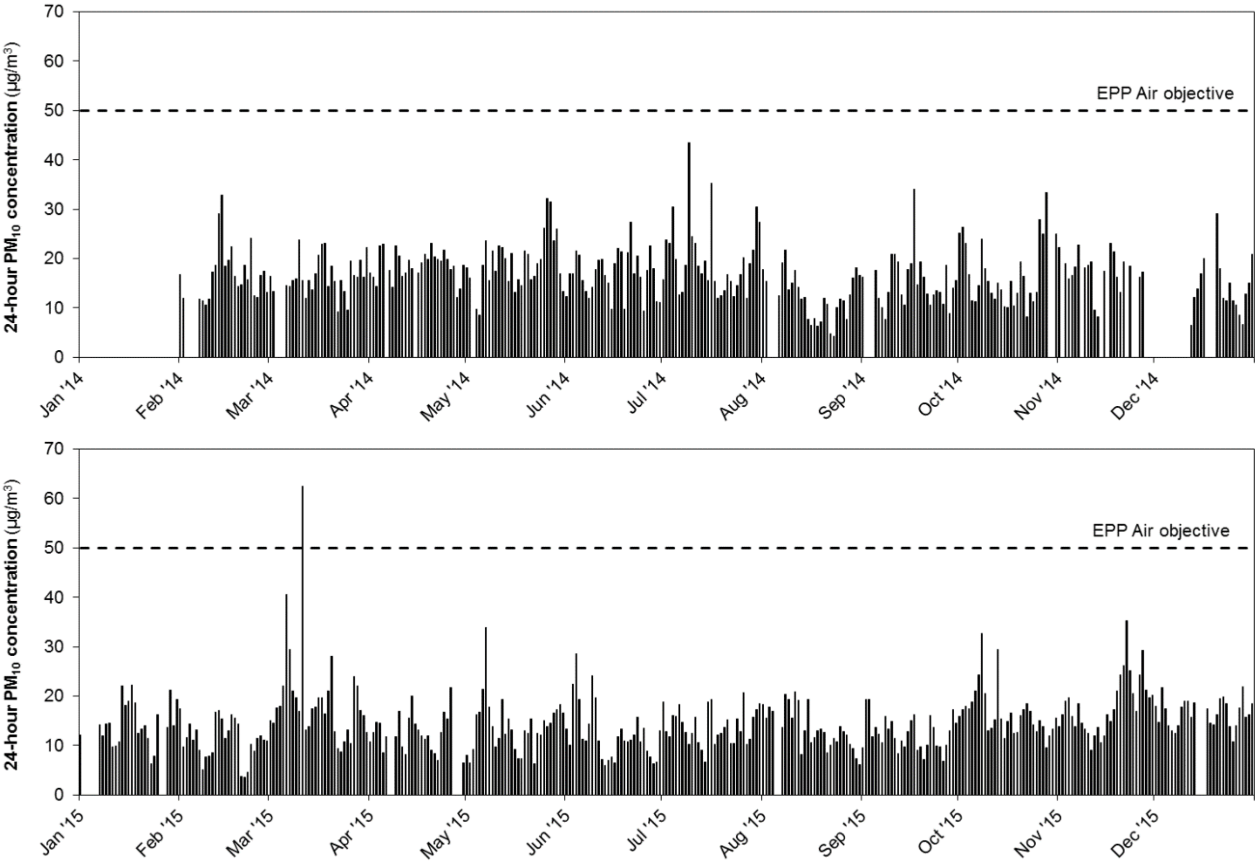


Figure 8. Daily average PM_{10} concentrations at the Cannon Hill (North) monitoring site between 1 February 2014 and 31 December 2015

PM_{10} concentrations exceeded the EPP Air 24-hour objective of 50 µg/m³ on only one day during the reporting period, on 11 March 2015 (see Figure 8), as a result of dust emissions generated by rail track reconditioning works conducted in close proximity to the monitoring site. This reconditioning work included clearing loose material from the track ballast. There were no train movements at Cannon Hill during the period on 11 March when the elevated PM_{10} measurements responsible for the 24-hour objective exceedence were recorded.

Figure 8 shows that daily average PM_{10} concentrations at the Cannon Hill (North) monitoring site over the reporting period typically ranged from 15 μg/m^3 to 30 μg/m^3; levels of 70 to 40 per cent below the EPP Air 24-hour air quality objective.

Rail transport contribution to PM_{10} levels

Assessment of the contribution from rail transport (of which coal haulage rail transport will only be a part) to overall PM_{10} levels measured at the Cannon Hill (North) monitoring site was undertaken by examining the relationship between PM_{10} concentrations and wind direction. As the PM_{10} measurements were the sum of contributions from all PM_{10} sources and monitoring was conducted at a single location only, it is not possible to quantitatively determine the contribution from rail transport. For this reason, only a qualitative assessment is possible.

The relationship between hourly PM_{10} concentrations and wind direction at the Cannon Hill (North) monitoring site is shown as a pollution rose overlaid on a map of the monitoring site in Figure 9. The length of each ‘arm’ in the pollution rose shows the fraction of total PM_{10} particles over the reporting period that was measured during winds from that particular ten degree direction sector. The shading within each ‘arm’ gives a breakdown of the relative contributions of one-hour PM_{10} particle concentrations within the four ranges (shown in the legend box in Figure 9) to the overall amount of PM_{10} associated with the particular wind direction sector. The percentage of total measured PM_{10} is shown by the scale above the legend box in the figure. The red lines on the pollution rose indicate the two wind direction ranges used for evaluation of PM_{10} impacts associated with winds blowing along the rail line. PM_{10} roses for the 2014 and 2015 calendar years are displayed in Figure 10.

Figure 9 shows that PM_{10} particles are associated with all wind directions, consistent with the large number of PM_{10} sources present in an urban context. During the reporting period approximately 68 per cent of total PM_{10} was associated with winds blowing from the direction of the rail corridor and approximately 27 per cent of total PM_{10} was associated with winds blowing along the rail lines when maximum impacts from rail transport emissions are expected to occur.

The PM_{10} pollution roses for the 2014 and 2015 calendar years are similar in shape (Figure 10), indicating that there were no major changes in PM_{10} sources over the reporting period. In 2015, there was a significant reduction in hourly PM_{10} concentrations greater than 50 μg/m^3 (the pink segment), and those remaining were largely associated with wind directions where there would have been no contribution from rail transport emissions. Given the low rainfall conditions during much of 2014, windblown dust from dry ground is likely to explain the higher incidence of hourly PM_{10} concentrations greater than 50 μg/m^3 across all wind directions in 2014.

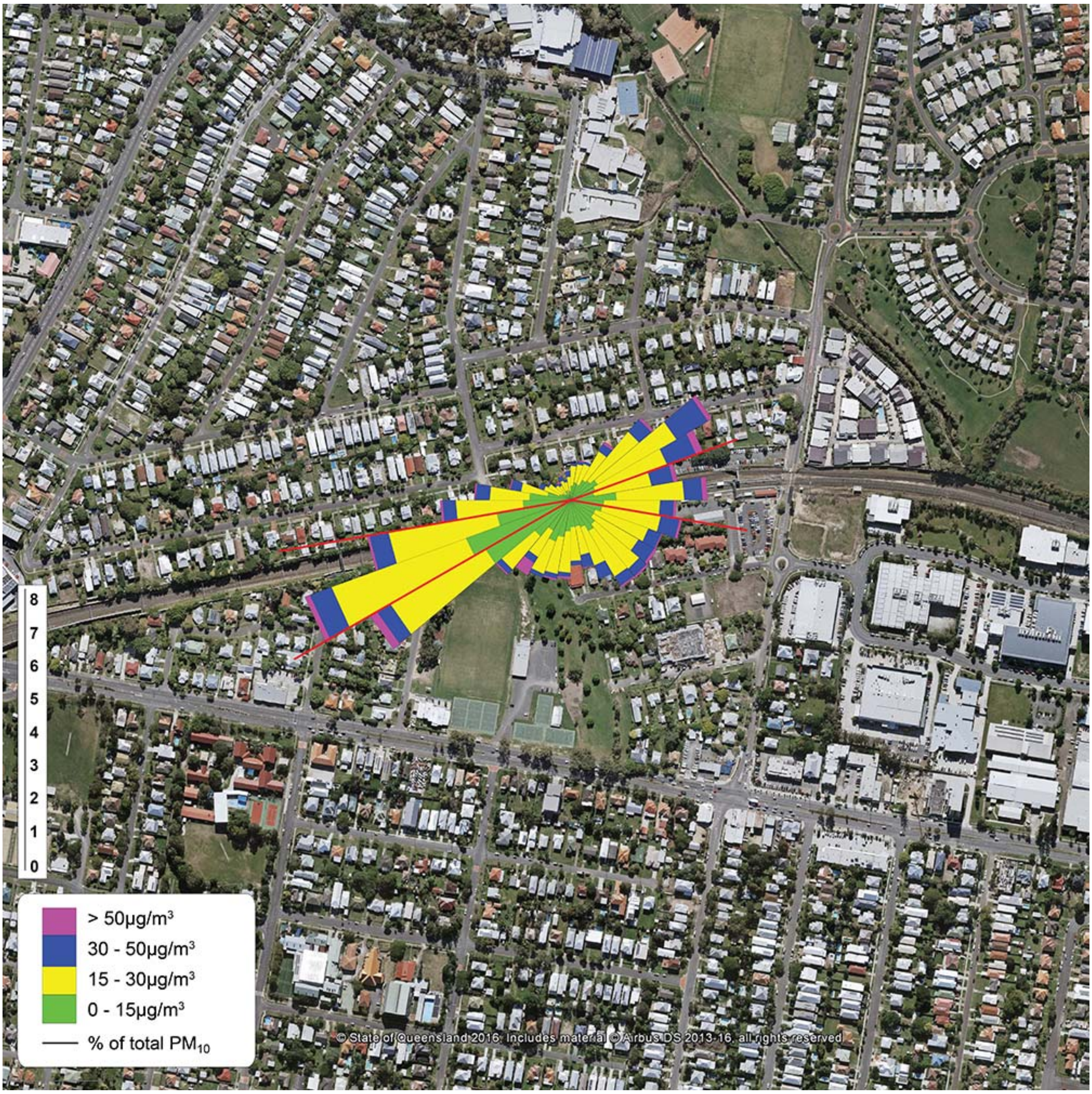


Figure 9. Relationship between hourly average PM_{10} concentrations and wind direction at the Cannon Hill (North) monitoring site during the period 1 February 2014 to 31 December 2015

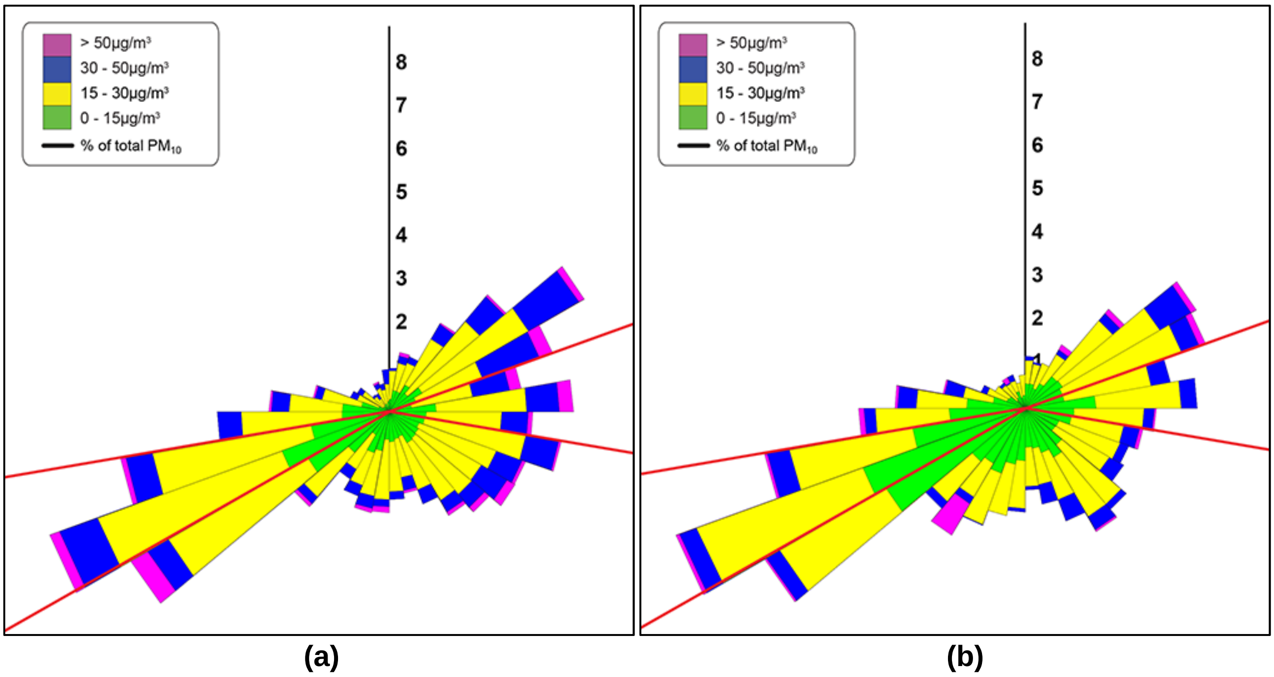


Figure 10. Relationship between hourly average PM_{10} concentrations and wind direction at the Cannon Hill (North) monitoring site during (a) 2014 and (b) 2015

To determine if PM_{10} emissions from rail transport were a significant contributor to overall PM_{10} levels at the monitoring site, average PM_{10} concentrations for the separate ten degree wind ranges were compared against the average PM_{10} concentration across all wind directions. If rail transport emissions were a significant contributor to overall PM_{10} levels, average PM_{10} concentrations for winds blowing from the rail corridor would be expected to be higher than the overall average PM_{10} concentration. This would especially apply to winds aligned with the rail line orientation as higher impacts would be expected under these conditions, as previously described. The result of this analysis is graphed in Figure 11.

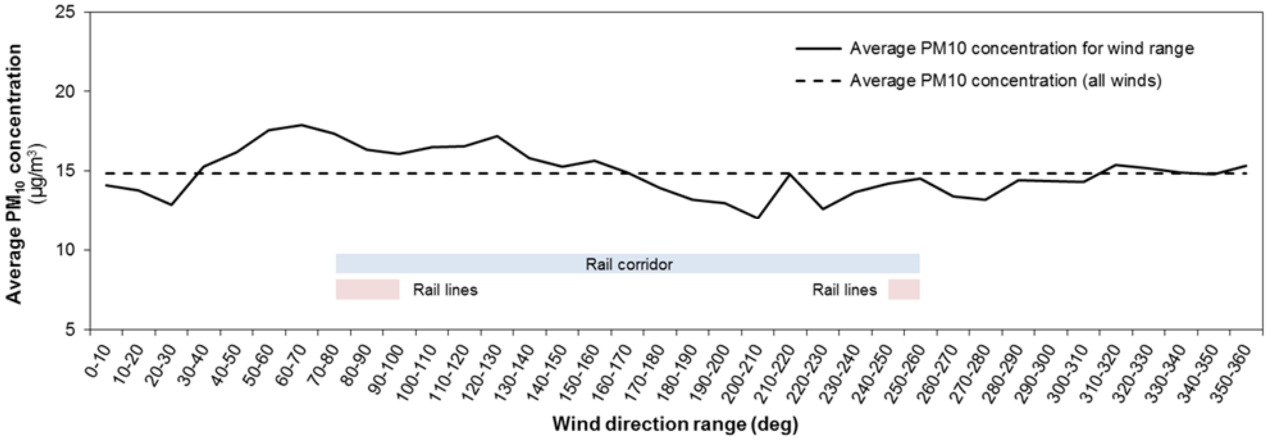


Figure 11. Comparison of average PM_{10} concentrations for 10 degree wind direction sectors against the average PM_{10} concentration for all wind directions at the Cannon Hill (North) monitoring site over the period 1 February 2014 to 31 December 2015

Figure 11 shows that average PM_{10} concentrations for individual wind sectors within the rail corridor impact range are not all higher than the overall average PM_{10} concentration as would be expected if rail transport emissions were a significant contributor to total PM_{10} exposure at the Cannon Hill (North) monitoring site. Wind directions where the PM_{10} concentration is markedly higher than the overall average are limited to between 40 degrees and 140 degrees. For part of this wind direction range, between 40 degrees and 70 degrees, rail corridor particle emissions would not contribute to the measured PM_{10} concentrations, indicating that other PM_{10} sources are responsible. Of particular note in terms of the contribution from rail transport is the fact that average PM_{10} concentrations for both wind direction ranges aligned with the rail line orientation at Cannon Hill are not both above the overall average PM_{10} concentration. In the absence of a corresponding PM_{10} concentration peak for the 240 to 260 degree wind sectors, the higher than average PM_{10} concentrations seen for the 70 to 100 degree wind sectors are considered to be due to PM_{10} sources other than rail transport emissions.

Major non-rail PM_{10} sources located on wind directions between 40 and 140 degrees include the Brisbane Airport, Brisbane River Mouth industries and Lytton Road and Gateway Motorway road corridors which carry significant heavy vehicle traffic. In coastal locations, onshore winds can also transport sea salt particles inland[14], and it is likely that there is a sea salt contribution to the elevated average PM_{10} concentrations observed at Cannon Hill for wind directions between 40 degrees and 140 degrees, as these are onshore winds.

This analysis points to emissions from rail transport, including coal haulage, making up only a minor fraction of total PM_{10} measured at the Cannon Hill (North) monitoring site over the reporting period.

PM_{10} levels during train movements

The continuous PM_{10} monitoring instrument at the Cannon Hill (North) monitoring site records five-minute averaged PM_{10} concentrations. Five-minute values recorded during winds blowing from the direction of the rail corridor have been analysed to assess the impact of train passing the monitoring site on PM_{10} concentrations at the rail corridor boundary.

The methodology used to assess the impact of the passage of different train types on PM_{10} levels involved comparing the frequency distribution of five-minute PM_{10} concentrations coinciding with the passage of a train during winds blowing from the direction of the rail corridor with the distribution during periods when there were no train movements across the entire reporting period. If train movements are consistently associated with elevated PM_{10} concentrations then one would expect to see a shift towards higher concentrations in the frequency distribution for measurements coinciding with train movements relative to measurements when there are no trains.

To minimise the impact of external factors on this analysis, periods when the cumulative rainfall in the preceding 24 hours exceeded 1 mm, when there were regional airborne PM_{10} episodes such as smoke from vegetation fires, or when atypical local dust episodes such as rail track maintenance work occurred, were excluded from the calculations. The analysis also excluded five-minute periods when more than one train movement occurred during the period as it was not possible to separate the individual train emission contributions.

The result of this analysis is graphed in Figure 12 for two wind scenarios, firstly for train movements during all winds blowing from the direction of the rail corridor, and secondly where wind directions are limited to the narrower rail line orientation direction ranges. The number of individual five-minute measurements making up the frequency distribution for each train type is shown in brackets in the legend box for each wind scenario.

[14] Monitoring by ANSTO has shown that sea salt particles can comprise up to 50 per cent of total $PM_{2.5}$ at coastal locations in New South Wales (*www.ansto.gov.au/ResearchHub/IER/Capabilities/ASP/ASPPublications/index.htm*).

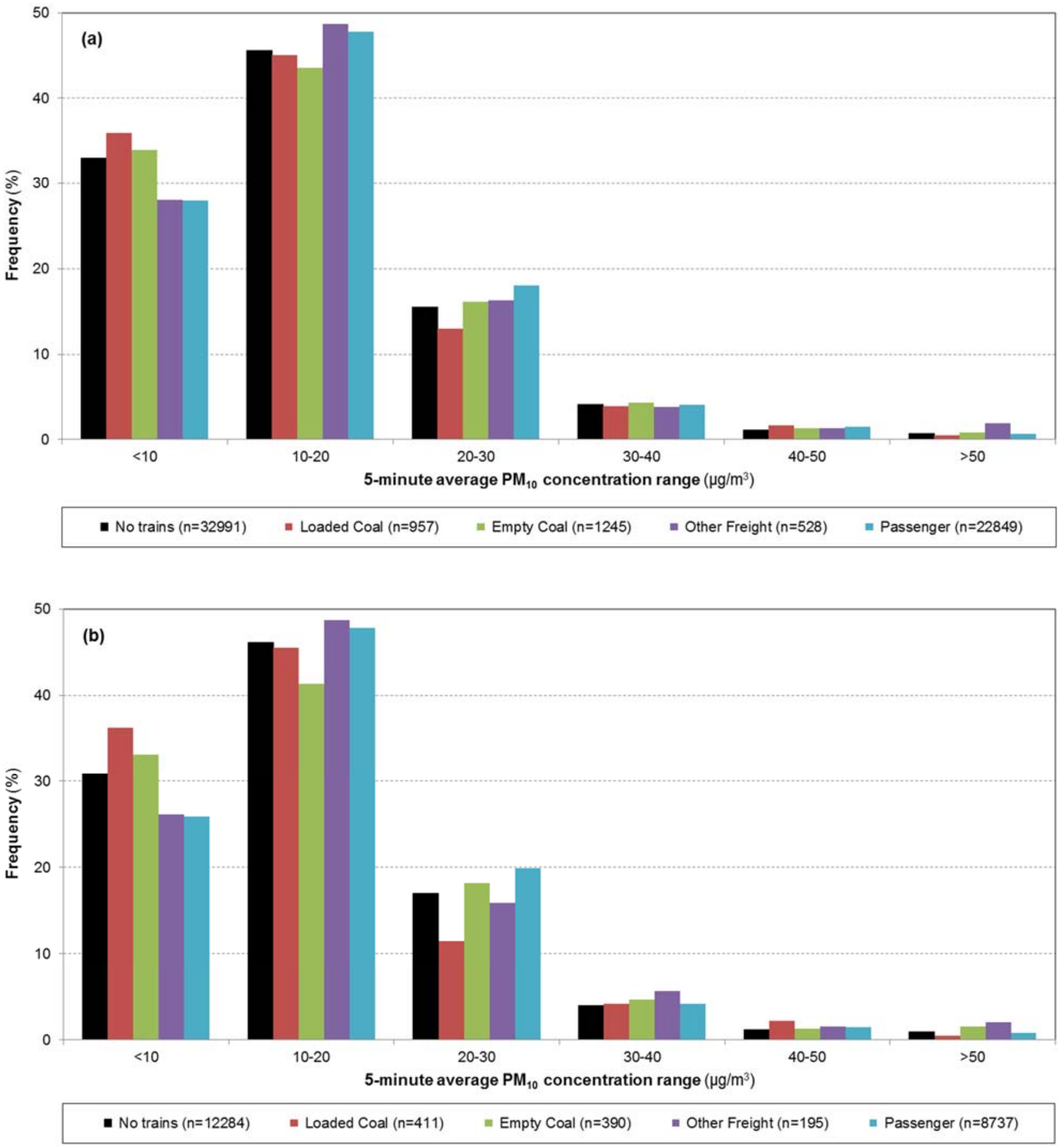


Figure 12. Relative frequency of 5-minute PM_{10} concentration measurements for different train types for (a) all winds from the direction of the rail corridor and (b) winds from the direction of the rail lines at the Cannon Hill (North) monitoring site from February 2014 to December 2015

This analysis shows that five-minute average PM_{10} concentrations coinciding with the passage of a train do not show any appreciable trend to higher concentrations relative to the baseline 'no train' concentration frequency distribution (the black column in Figure 12). There is also little difference between the frequency distribution for five-minute PM_{10} concentrations associated with winds coming from the direction of the rail lines and that for five-minute PM_{10} concentrations for all winds from the direction of the rail corridor.

With the exception of the lowest concentration range (five-minute average PM_{10} concentrations less than 10 µg/m^3), coal haulage rail transport impacts are not greater than the impacts from non-coal freight and passenger trains.

This analysis indicates that, as a whole, PM_{10} emissions from rail transport (including locomotive exhaust emissions, loss from wagons and airborne particles generated from surface dust by air turbulence as the train passes) are not resulting in higher PM_{10} concentrations at the Cannon Hill (North) monitoring site than non-rail sources such as motor vehicles. There is no evidence that coal loss from loaded or empty coal train wagons is a significant contributor to total PM_{10} exposure at the monitoring site.

$PM_{2.5}$

Measurement summary

$PM_{2.5}$ concentrations were measured at the Cannon Hill (North) site on a continuous basis using a Model 1405DF dichotomous Tapered Element Oscillating Microbalance (TEOM™) instrument operated in accordance with the Australian/New Zealand Standard AS/NZS 3580.9.13:2013.

Summary $PM_{2.5}$ concentration data recorded at the Cannon Hill (North) monitoring site for the period from site establishment in February 2014 to December 2015 are provided in Table 5. It is important to note that the reported $PM_{2.5}$ measurements will be the sum of contributions from all $PM_{2.5}$ emission sources, such as motor vehicles and industry as well as rail transport, impacting on the Cannon Hill (North) site. In addition, coal haulage rail transport will represent only a proportion of the total $PM_{2.5}$ originating from rail transport.

The number of hourly and daily average samples, and average, maximum and percentile concentration values are shown for the entire reporting period and for the individual calendar years. Hourly percentile values have been included in Table 5 to show the distribution of hourly average concentrations. Data availability over the entire reporting period was 92.6 per cent.

Table 5. $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site between 1 February 2014 and 31 December 2015

Number of samples		$PM_{2.5}$ concentration (µg/m^3)									
Hourly	Daily[a]	Average	Maximum		Days >EPP Air objective[a]	Hourly average percentile values					
			Rolling 24-hour[a]	Calendar day[a]		99th	98th	95th	90th	75th	50th
1 February 2014 to 31 December 2015											
15532	640	7.9	26.4	26.1	1	30.5	25.8	19.1	15.1	10.3	6.6
1 February 2014 to 31 December 2014											
7109	292	9.1	26.4	26.1	1	34.4	30.1	22.9	18.2	12.2	7.6
1 January 2015 to 31 December 2015											
8423	348	6.9	17.9	16.1	0	23.1	18.9	15.1	12.4	9.0	6.1

[a] where data availability during the 24-hour period is at least 75 per cent.
The EPP Air 24-hour objectives for $PM_{2.5}$ are an annual average of 8 µg/m^3 and a 24-hour average of 25 µg/m^3.

Table 5 indicates that there was an overall reduction in $PM_{2.5}$ concentrations in 2015 compared to those measured in 2014. As described for PM_{10}, lower levels of windblown dust in 2015 may have been a contributing factor. Another factor is likely to have been increased amounts of smoke particles in the South East Queensland region in 2014 as a result of a greater incidence of bush and grass fires during the dry conditions.

Compliance with standards and guidelines

The air quality objectives for $PM_{2.5}$ specified in the EPP Air are that annual average concentrations do not exceed 8 µg/m^3 and 24-hour average concentrations do not exceed 25 µg/m^3.

Consistent with the findings of the four-month Phase 1 monitoring (both prior to and following the commencement of load profiling and veneering of coal rail wagons), monitoring at Cannon Hill from February 2014 to December 2015 demonstrated that $PM_{2.5}$ emissions from rail transport have not resulted in any exceedences of the EPP Air $PM_{2.5}$ criteria.

Annual average $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site exceeded the EPP Air annual objective of 8 µg/m^3 in 2014, but complied with the annual objective in 2015. Annual average $PM_{2.5}$ concentrations for the 2014 and 2015 calendar years were 9.1 µg/m^3 and 6.9 µg/m^3 respectively. The average $PM_{2.5}$ concentration over the entire reporting period was 7.9 µg/m^3.

$PM_{2.5}$ concentrations measured at the Cannon Hill (North) monitoring site are the product of emissions from multiple transport, industry, commercial, domestic and natural sources. For this reason it is not possible to assign a specific cause to the exceedence of the EPP Air annual objective in 2014. Due to their small size, $PM_{2.5}$ particles can travel considerable distances from the point of emission (although concentrations will decrease with increasing distance). In both 2014 and 2015, 33 per cent of total $PM_{2.5}$ at the Cannon Hill monitoring site was associated with wind directions which precluded any contribution from the rail corridor. From analysis of the monitoring data (discussed later in this section) there does not appear to be any single $PM_{2.5}$ emission source dominating $PM_{2.5}$ levels at the Cannon Hill monitoring site.

Figure 13 displays the 24-hour average $PM_{2.5}$ concentrations measured at the Cannon Hill (North) monitoring site on each day over the reporting period.

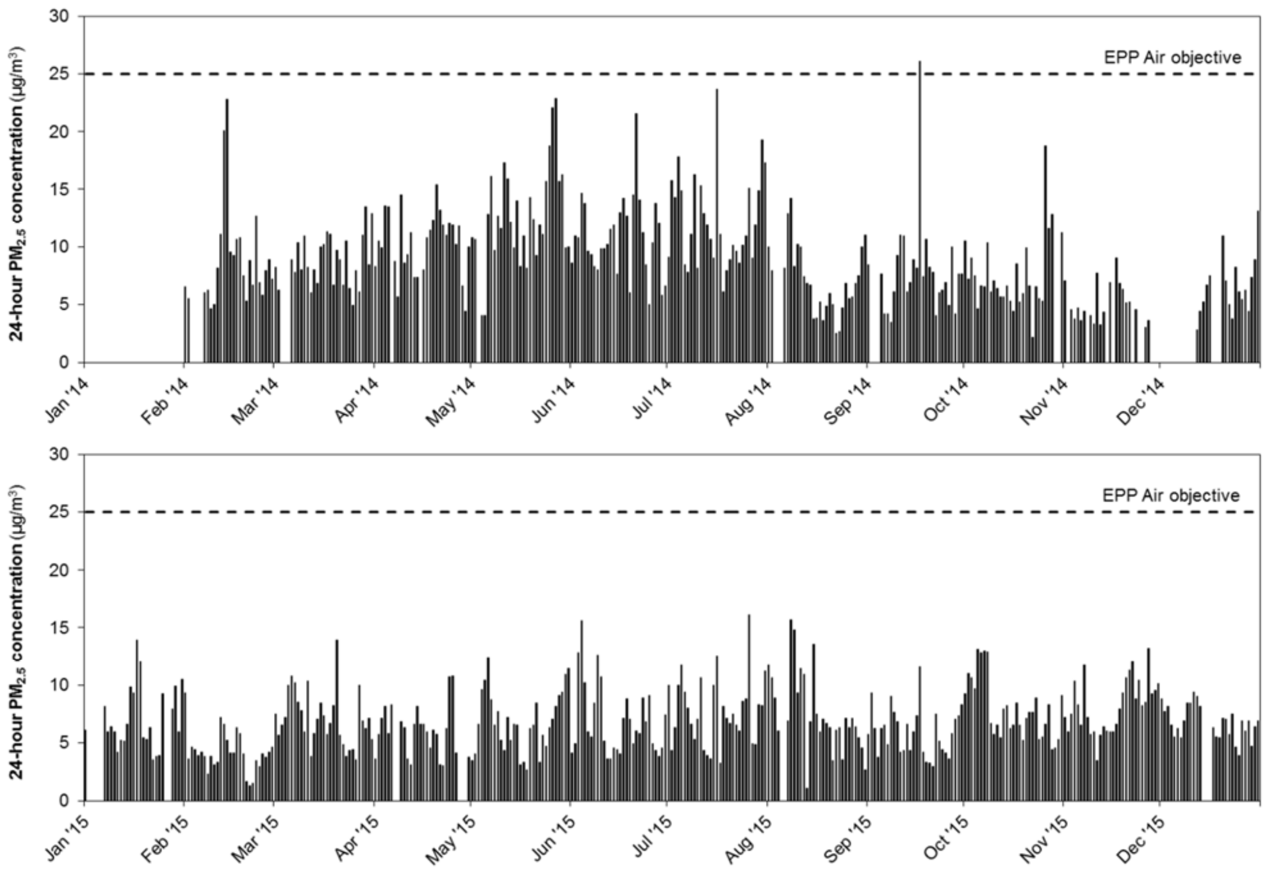


Figure 13. Daily average $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site between 1 February 2014 and 31 December 2015

Daily average $PM_{2.5}$ concentrations exceeded the EPP Air 24-hour objective of 25 µg/m^3 on only one day during the reporting period, 17 September 2014 (see Figure 13), as a result of extra $PM_{2.5}$ emissions from vegetation fires in the South East Queensland region adding to the levels already present from urban sources such as transport and industry.

Typical daily average $PM_{2.5}$ concentrations at the Cannon Hill monitoring site were in the range 5 µg/m^3 to 15 µg/m^3; levels of 80 to 40 per cent below the EPP Air 24-hour air quality objective.

Rail transport contribution to $PM_{2.5}$ levels

As for PM_{10}, assessment of the contribution from rail transport (of which coal haulage rail transport will only be a part) to overall $PM_{2.5}$ levels measured at the Cannon Hill (North) monitoring site was undertaken by examining the relationship between $PM_{2.5}$ concentrations and wind direction. As the $PM_{2.5}$ measurements were the sum of contributions from all $PM_{2.5}$ sources and monitoring was conducted at a single location only, it is not possible to quantitatively determine the contribution from rail transport. For this reason, only a qualitative assessment is possible.

The relationship between hourly $PM_{2.5}$ concentrations and wind direction at the Cannon Hill (North) monitoring site is shown as a pollution rose overlaid on a map of the monitoring site in Figure 14. The length of each ‘arm’ in the pollution rose shows the fraction of total $PM_{2.5}$ particles over the reporting period that was measured during winds from that particular ten degree direction sector. The shading within each ‘arm’ gives a breakdown of the relative contributions of one-hour $PM_{2.5}$ particle concentrations within the four ranges (shown in the legend box in Figure 14) to the overall amount of $PM_{2.5}$ associated with the particular wind direction sector. The percentage of total measured $PM_{2.5}$ is shown by the scale above the legend box in the figure. The red lines on the pollution rose indicate the two wind direction ranges used for evaluation of $PM_{2.5}$ impacts associated with winds blowing along the rail line. $PM_{2.5}$ roses for the 2014 and 2015 calendar years are displayed in Figure 15.

Figure 14. Relationship between hourly average $PM_{2.5}$ concentrations and wind direction at the Cannon Hill (North) monitoring site during the period 1 February 2014 to 31 December 2015

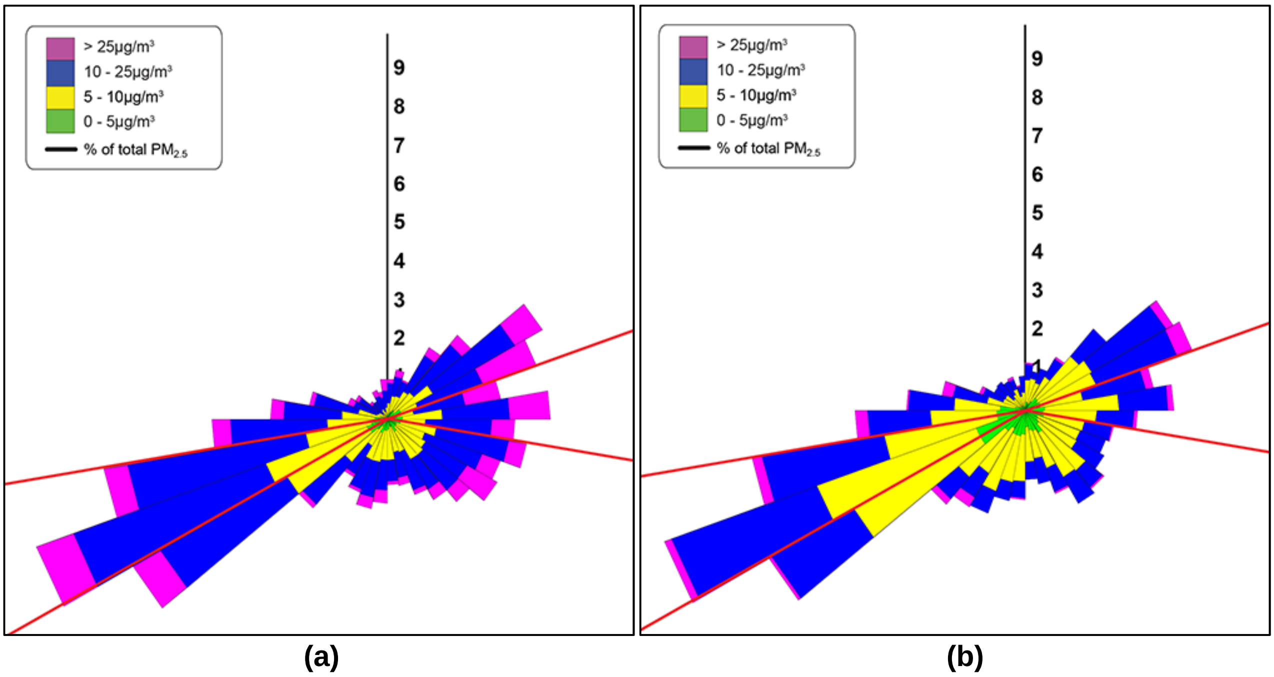


Figure 15. Relationship between hourly average $PM_{2.5}$ concentrations and wind direction at the Cannon Hill (North) monitoring site during (a) 2014 and (b) 2015

Figure 14 shows that $PM_{2.5}$ particles are associated with all wind directions which is consistent with the large number of $PM_{2.5}$ sources present in an urban context. During the reporting period approximately 67 per cent of total $PM_{2.5}$ was associated with winds blowing from the direction of the rail corridor and approximately 29 per cent of total $PM_{2.5}$ was associated with winds blowing along the rail lines when maximum impacts from rail transport emissions are expected to occur.

In 2015, there was a significant reduction in hourly $PM_{2.5}$ concentrations greater than 25 µg/m^3 (the pink segment) compared with 2014 (Figure 15). In 2015, elevated hourly $PM_{2.5}$ concentrations (i.e. greater than 25 µg/m^3) were spread more evenly across all wind direction sectors than observed for PM_{10}. Due to their small size, $PM_{2.5}$ particles can travel considerable distances from the point of emission, with the result that regional $PM_{2.5}$ sources will have more impact on levels at the Cannon Hill (North) monitoring site than for larger particle fractions such as PM_{10} and TSP. The higher incidence of hourly $PM_{2.5}$ concentrations greater than 25 µg/m^3 across all wind directions in 2014 reflects higher background smoke and windblown dust levels during the dry conditions.

To determine if $PM_{2.5}$ emissions from rail transport were a significant contributor to overall $PM_{2.5}$ levels at the monitoring site, the average $PM_{2.5}$ concentrations for the separate ten degree wind ranges were compared against the average $PM_{2.5}$ concentration across all wind directions. If rail transport emissions were a significant contributor to overall $PM_{2.5}$ levels then average $PM_{2.5}$ concentrations for winds blowing from the rail corridor would be expected to be higher than the overall average $PM_{2.5}$ concentration. This would especially apply to winds aligned with the rail line orientation as higher impacts would be expected under these conditions, as previously described. The result of this analysis is graphed in Figure 16.

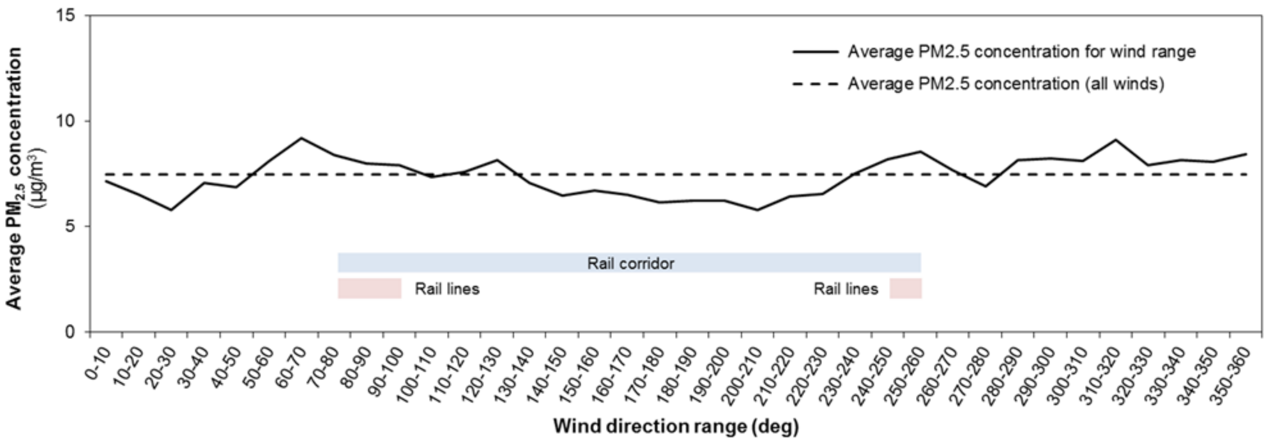


Figure 16. Comparison of average $PM_{2.5}$ concentrations for 10 degree wind direction sectors against the average $PM_{2.5}$ concentration for all wind directions at the Cannon Hill (North) monitoring site over the period 1 February 2014 to 31 December 2015

Figure 16 shows that average $PM_{2.5}$ concentrations associated with winds from the direction of the rail corridor are not consistently higher than the overall average $PM_{2.5}$ concentration as would be expected if rail transport emissions were a significant contributor to total $PM_{2.5}$ exposure at the Cannon Hill (North) monitoring site. Figure 16 shows that for all individual ten degree wind sectors there is little difference between the individual wind sector average $PM_{2.5}$ concentration and the overall average $PM_{2.5}$ concentration. This is consistent with the majority of $PM_{2.5}$ measured at the Cannon Hill (North) monitoring site being well mixed emissions from a range of regional urban and natural $PM_{2.5}$ sources rather than a specific local $PM_{2.5}$ source in the vicinity of the monitoring site. If anything, Figure 16 shows that for those wind directions where rail transport emissions could potentially contribute, $PM_{2.5}$ concentrations tended to be lower than the overall average $PM_{2.5}$ concentration.

This analysis points to $PM_{2.5}$ emissions from rail transport, including coal haulage, being only a very minor contributor to total $PM_{2.5}$ measured at the monitoring site over the reporting period. $PM_{2.5}$ impacts are dominated by regional urban and natural $PM_{2.5}$ emission sources.

$PM_{2.5}$ levels during train movements

The continuous $PM_{2.5}$ monitoring instrument at the Cannon Hill (North) monitoring site records five-minute averaged $PM_{2.5}$ concentrations. Five-minute values recorded during winds blowing from the direction of the rail corridor have been analysed to assess the impact of trains passing the monitoring site on $PM_{2.5}$ concentrations at the rail corridor boundary.

In the same way as for PM_{10}, the impact of the passage of different train types on $PM_{2.5}$ levels involved comparing the frequency distribution of five-minute $PM_{2.5}$ concentrations coinciding with the passage of a train during winds blowing from the direction of the rail corridor with the distribution during periods when there were no train movements across the entire reporting period. If train movements are consistently associated with elevated $PM_{2.5}$ concentrations then one would expect to see a shift towards higher concentrations in the frequency distribution for measurements coinciding with train movements relative to measurements when there are no trains.

To minimise the impact of external factors on this analysis, periods when the cumulative rainfall in the preceding 24 hours exceeded 1 mm, when there were regional airborne $PM_{2.5}$ episodes such as smoke from vegetation fires, or when atypical local dust episodes such as rail track maintenance work occurred, were excluded from the calculations. The analysis also excluded five-minute periods when more than one train movement occurred during the period as it was not possible to separate the individual train emission contributions.

The result of this analysis is graphed in Figure 17 for two wind scenarios, firstly for train movements during all winds blowing from the direction of the rail corridor, and secondly where wind directions are limited to the narrower rail line orientation direction ranges. The number of individual five-minute measurements making up the frequency distribution for each train type is shown in brackets in the legend box for each wind scenario.

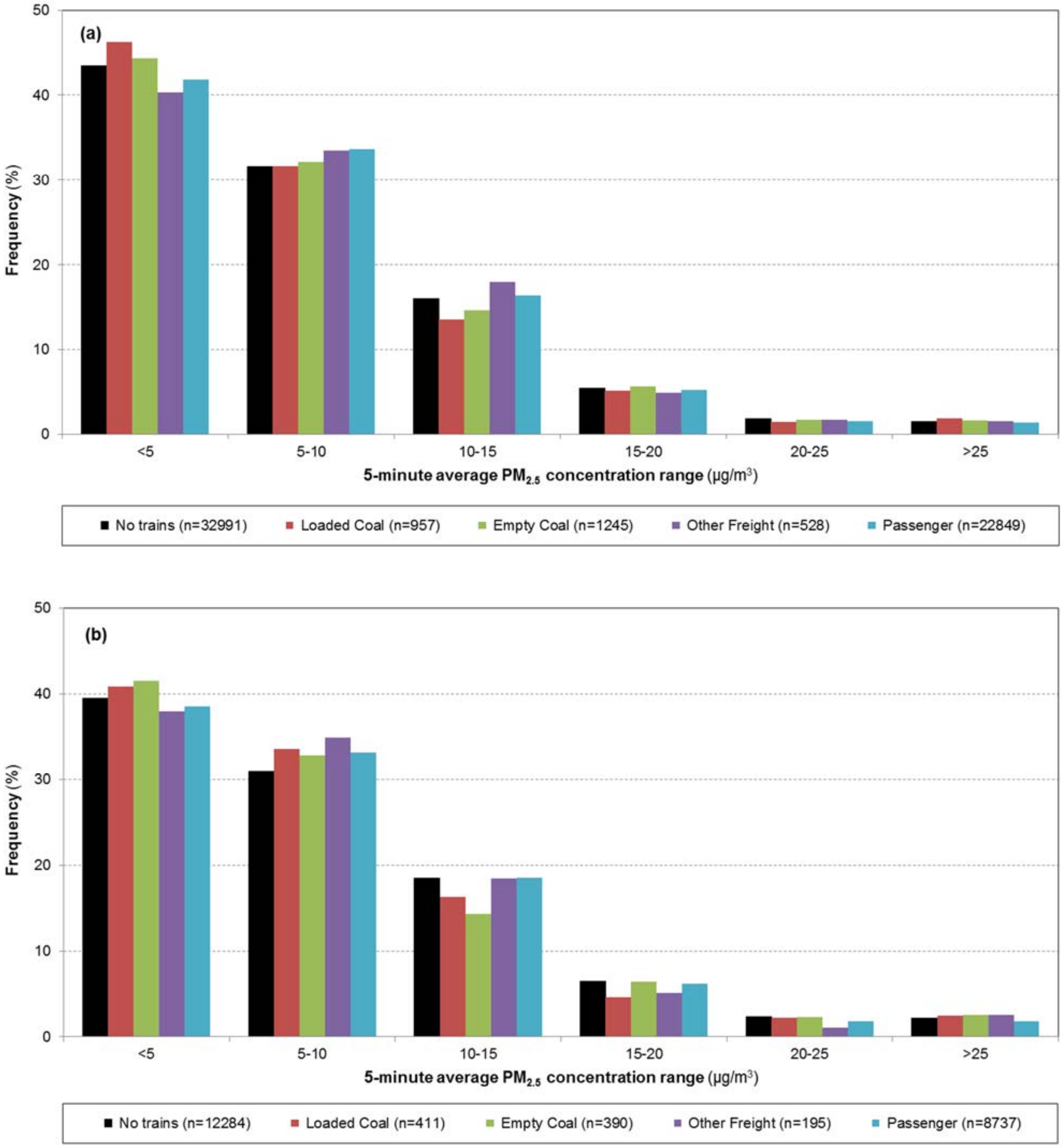


Figure 17. Relative frequency of 5-minute $PM_{2.5}$ concentration measurements for different train types for (a) all winds from the direction of the rail corridor and (b) winds from the direction of the rail lines at the Cannon Hill (North) monitoring site from February 2014 to December 2015

This analysis shows that five-minute average $PM_{2.5}$ concentrations coinciding with the passage of a train show very little change from the baseline ‘no train’ concentration frequency distribution (the black column in Figure 17), particularly for five-minute $PM_{2.5}$ concentrations greater than 10 μg/m^3. There is also little variation between the different train types, with coal haulage rail transport impacts approximating those of non-coal freight and passenger trains.

This analysis indicates that, as a whole, $PM_{2.5}$ emissions from rail transport (including locomotive exhaust emissions, loss from wagons and airborne particles generated from surface dust by air turbulence as the train passes) are not resulting in higher $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site than non-rail sources. There is no evidence that coal loss from loaded or empty coal train wagons is a significant contributor to total $PM_{2.5}$ exposure at the monitoring site. The analysis further supports the previous conclusion that $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site are dominated by $PM_{2.5}$ from regional urban and natural emission sources.

TSP

Measurement summary

TSP concentrations were measured at the Cannon Hill (North) site on a continuous basis using a Model 1405 Tapered Element Oscillating Microbalance (TEOM™) instrument operated in accordance with the Australian Standard AS 3580.9.8:2008.

Summary TSP concentration data recorded at the Cannon Hill (North) monitoring site for the period from site establishment in February 2014 to December 2015 are provided in Table 6. It is important to note that the reported TSP measurements will be the sum of contributions from all TSP emission sources, such as motor vehicles and industry as well as rail transport, impacting on the Cannon Hill (North) site. In addition, coal haulage rail transport will represent only a proportion of the total TSP originating from rail transport.

Table 6 shows the number of hourly and daily average samples, and average, maximum and percentile concentration values for the entire reporting period and for the individual 2014 and 2015 calendar years. Hourly percentile values have been included in Table 6 to show the distribution of hourly average concentrations. TSP data availability over the entire reporting period was 95.4 per cent.

Table 6 indicates that there was a slight reduction in TSP concentrations in 2015 compared to those measured in 2014. As for PM_{10}, it is likely that increased windblown dust from dry ground during the below average rainfall conditions existing for much of 2014 was responsible for the higher TSP concentrations in 2014.

Table 6. TSP concentrations at the Cannon Hill (North) monitoring site between 1 February 2014 and 31 December 2015

Number of samples		TSP concentration (µg/m³)									
Hourly	Daily[a]	Average	Maximum: Rolling 24-hour[a]	Maximum: Calendar day[a]	Days >NZ dust nuisance trigger level[a]	Hourly average percentile values: 99th	98th	95th	90th	75th	50th
1 February 2014 to 31 December 2015											
15999	666	23.8	146.2	145.9	2	73.9	61.9	47.2	38.9	28.6	20.7
1 February 2014 to 31 December 2014											
7735	323	24.4	140.2	138.0	1	74.0	61.9	47.7	39.6	29.1	21.2
1 January 2015 to 31 December 2015											
8264	343	23.3	146.2	145.9	1	73.9	61.8	46.9	38.1	28.1	20.2

[a] where data availability during the 24-hour period is at least 75 per cent.
The EPP Air annual average objective for TSP is 90 µg/m³.
The NZ MfE 24-hour TSP dust nuisance trigger level for sensitive areas is 80 µg/m³.

Compliance with standards and guidelines

The TSP air quality objective for protection of human health and wellbeing specified in the EPP Air is that annual average concentrations do not exceed 90 µg/m³.Monitoring at Cannon Hill from February 2014 to December 2015 demonstrated that TSP emissions from rail transport have not resulted in any exceedence of the EPP Air objective.

Annual average TSP concentrations complied with the EPP Air annual objective of 90 µg/m³ at the Cannon Hill (North) monitoring site over the reporting period. Annual average TSP concentrations for the 2014 and 2015 calendar years were 24.4 µg/m³ and 23.3 µg/m³ respectively. The average TSP concentration over the entire reporting period was 23.8 µg/m³.

To protect against amenity degradation (nuisance impacts) the DEHP Air Impacts Guideline specifies that 24-hour TSP concentrations should comply with the dust nuisance trigger levels set by the New Zealand Ministry for the Environment (NZ MfE)[15]. In assessing TSP concentrations at the Cannon Hill (North) monitoring site, the NZ MfE dust nuisance trigger level for sensitive areas of 80 µg/m³ has been used.

Monitoring at Cannon Hill over the period February 2014 to December 2015 has demonstrated that TSP emissions from rail transport have not resulted in any exceedences of the NZ MfE dust nuisance trigger level for sensitive areas.

Figure 18 displays the 24-hour average TSP concentrations measured at the Cannon Hill (North) monitoring site on each day over the reporting period.

[15] For TSP, the NZ MfE has set three dust nuisance trigger levels depending on the environment where the dust impacts are occurring. For sensitive areas (such as a residential development) 24-hour TSP concentrations should not exceed 80 µg/m³, for areas with moderate sensitivity 100 µg/m³, and for insensitive areas 120 µg/m³.

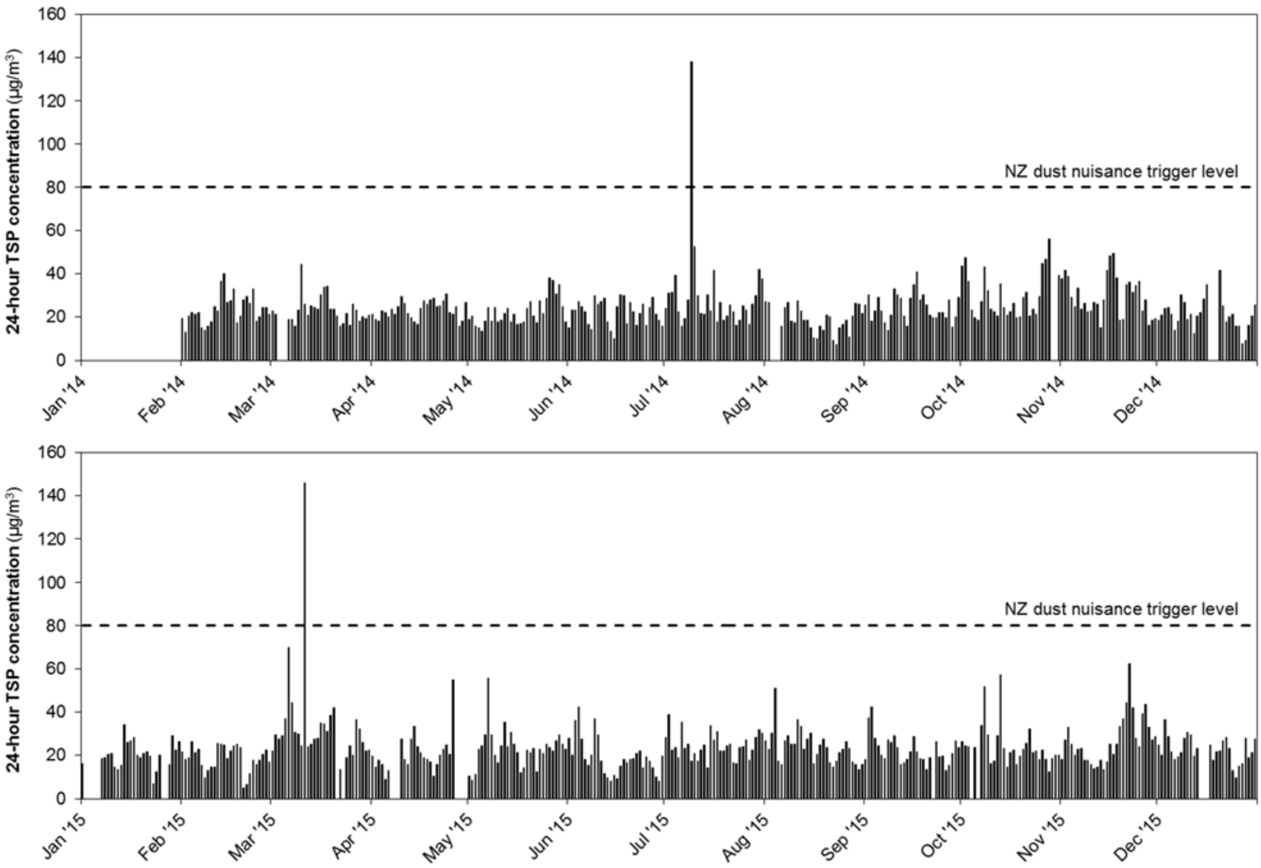


Figure 18. Daily average TSP concentrations at the Cannon Hill (North) monitoring site from 1 February 2014 to 31 December 2015

TSP concentrations exceeded the NZ MfE 24-hour dust nuisance trigger level of 80 µg/m^3 on only two days during the reporting period, on 9 July 2014 and 11 March 2015 (see Figure 18). On both occasions when the TSP dust nuisance trigger level was exceeded, dust generated by rail track maintenance work being carried out on the rail lines next to the monitoring site was responsible. The exceedence on 9 July 2014 was due to dust from emergency track repair works. Dust from rail track reconditioning work, including clearing loose material from the track ballast, led to the exceedence on 11 March 2015. On both days there were no train movements at Cannon Hill during the periods when the elevated TSP measurements responsible for the 24-hour trigger level exceedences were recorded.

Figure 18 shows that daily average TSP concentrations at the Cannon Hill (North) monitoring site over the reporting period typically ranged from 20 µg/m^3 to 40 µg/m^3; levels 75 to 50 per cent below the NZ MfE dust nuisance trigger level.

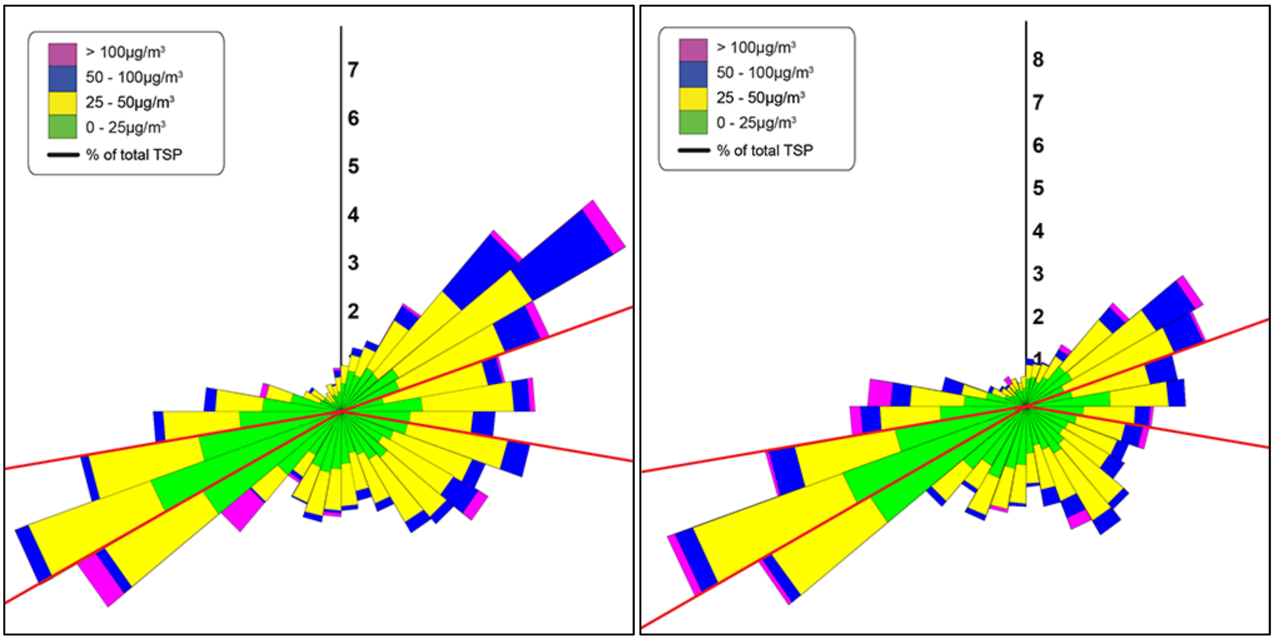
Rail transport contribution to TSP levels

Assessment of the contribution from rail transport (which coal haulage rail transport will only be a part) to overall TSP levels measured at the Cannon Hill (North) monitoring site was undertaken by examining the relationship between TSP concentrations and wind direction. As the TSP measurements were the sum of contributions from all TSP sources and monitoring was conducted at a single location only, it is not possible to quantitatively determine the contribution from rail transport. For this reason, only a qualitative assessment is possible.

The relationship between hourly TSP concentrations and wind direction at the Cannon Hill (North) monitoring site is shown as a pollution rose overlaid on a map of the monitoring site in Figure 19.

The length of each 'arm' in the pollution rose shows the fraction of total TSP particles over the reporting period that was measured during winds from that particular ten degree direction sector. The shading within each 'arm' gives a breakdown of the relative contributions of one-hour TSP particle concentrations within the four ranges (shown in the legend box in Figure 19) to the overall amount of TSP associated with the particular wind direction sector. The percentage of total measured TSP is shown by the scale above the legend box in the figure. The red lines on the pollution rose indicate the two wind direction ranges used for evaluation of TSP impacts associated with winds blowing along the rail line. TSP roses for the 2014 and 2015 calendar years are displayed in Figure 20.

Figure 19. Relationship between hourly average TSP concentrations and wind direction at the Cannon Hill (North) monitoring site during the period 1 February 2014 to 31 December 2015



(a) **(b)**

Figure 20. Relationship between hourly average TSP concentrations and wind direction at the Cannon Hill (North) monitoring site during (a) 2014 and (b) 2015

Figure 19 shows that TSP particles are associated with all wind directions, consistent with the large number of TSP sources present in an urban context. During the reporting period approximately 66 per cent of total TSP was associated with winds blowing from the direction of the rail corridor and approximately 25 per cent of total TSP was associated with winds blowing along the rail lines when maximum impacts from rail transport emissions are expected to occur.

Overall, hourly TSP concentrations were generally higher in 2014 than 2015 (see Figure 20). As identified for PM_{10}, greater amounts of windblown dust during the dry conditions in 2014 would have contributed to this situation. The decrease in TSP concentrations was most noticeable for north-easterly winds outside the rail corridor impact ranges, suggesting an additional localised source of TSP particles in this direction during the earlier part of the reporting period that decreased or ceased over time (such as dust from earthworks or housing construction). A specific source was not identified.

To determine if TSP emissions from rail transport were a significant contributor to overall TSP levels at the monitoring site, the average TSP concentrations for the separate ten degree wind sectors were compared against the average TSP concentration across all wind directions. If rail transport emissions were a significant contributor to overall TSP levels, average TSP concentrations for winds blowing from the rail corridor would be expected to be higher than the overall average TSP concentration. This would especially apply to winds aligned with the rail line orientation as higher impacts would be expected under these conditions, as previously described. The result of this analysis is graphed in Figure 21.

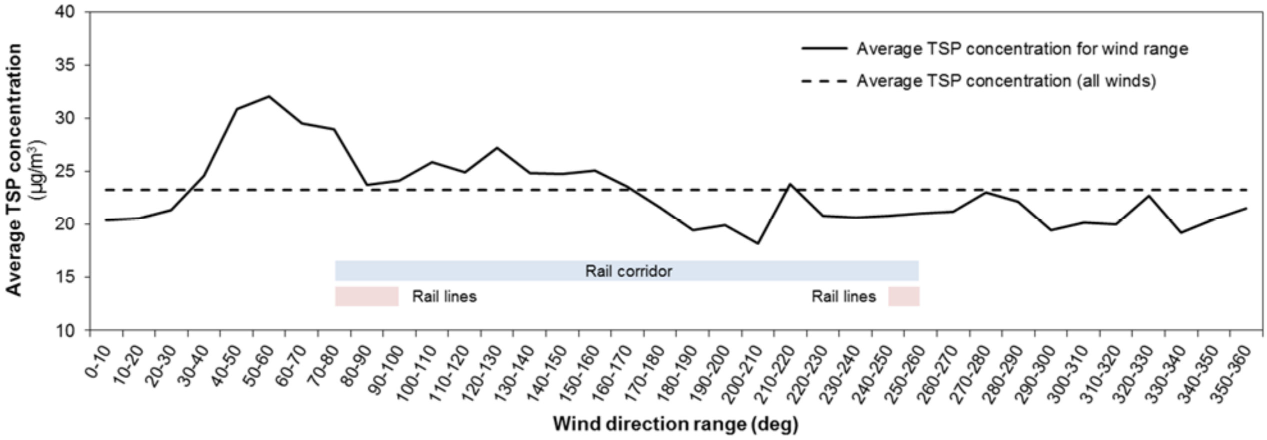


Figure 21. Comparison of average TSP concentrations for 10 degree wind direction sectors with the average TSP concentration for all wind directions at the Cannon Hill (North) monitoring site over the period 1 February 2014 to 31 December 2015

Figure 21 shows that average TSP concentrations associated with winds from the direction of the rail corridor are not consistently higher than the overall average TSP concentration as would be expected if rail transport emissions were a significant contributor to total TSP exposure at the Cannon Hill (North) monitoring site. Wind directions where the TSP concentration is markedly higher than the overall average are limited to between 40 degrees and 80 degrees, outside the range where rail corridor emissions would contribute. Of particular note in terms of the contribution from rail transport is the fact that average TSP concentrations for both wind direction ranges aligned with the rail line orientation at Cannon Hill are not both above the overall average TSP concentration. In the absence of a corresponding TSP concentration peak for the 240 to 260 degree wind sectors, the higher than average TSP concentrations seen for the 70 to 100 degree wind sectors are considered to be due to TSP sources other than rail transport emissions.

The individual wind sector TSP concentrations pattern relative to the overall average TSP concentration in Figure 21 is similar to that seen for PM_{10} in Figure 11, indicating that the same particle sources as described previously for PM_{10} are also likely to be contributing to the ambient TSP concentrations measured at Cannon Hill. The greater divergence seen for TSP compared to PM_{10} for wind directions between 40 degrees and 80 degrees most likely reflects the impact of the short-term localised earthworks or housing development source mentioned previously.

This analysis points to emissions from rail transport, including coal haulage rail transport, making up only a minor fraction of total TSP measured at the Cannon Hill (North) monitoring site over the reporting period.

TSP levels during train movements

The continuous TSP monitoring instrument at the Cannon Hill (North) monitoring site records five-minute averaged TSP concentrations. Five-minute values recorded during winds blowing from the direction of the rail corridor have been analysed to assess the impact of train passing the monitoring site on TSP concentrations at the rail corridor boundary.

In the same way as for PM_{10} and $PM_{2.5}$, the impact of the passage of different train types on TSP levels involved comparing the frequency distribution of five-minute TSP concentrations coinciding with the passage of a train during winds blowing from the direction of the rail corridor with the distribution during periods when there were no train movements across the entire reporting period. If train movements are consistently associated with elevated TSP concentrations, then one would expect to see a shift towards higher concentrations in the frequency distribution for measurements coinciding with train movements relative to measurements when there are no trains.

To minimise the impact of external factors on this analysis, periods when the cumulative rainfall in the preceding 24 hours exceeded 1 mm or when atypical local dust episodes such as rail track maintenance work occurred, were excluded from the calculations. The analysis also excluded five-minute periods when more than one train movement occurred during the period as it was not possible to separate the individual train emission contributions.

The result of this analysis is graphed in Figure 22 for two wind scenarios, firstly for train movements during all winds blowing from the direction of the rail corridor, and secondly where wind directions are limited to the narrower rail line orientation direction ranges. The number of individual five-minute measurements making up the frequency distribution for each train type is shown in brackets in the legend box for each wind scenario.

This analysis shows that five-minute average TSP concentrations coinciding with the passage of a train do show a trend to higher concentrations relative to the baseline ‘no train’ concentration frequency distribution (the black column in Figure 22), particularly for TSP concentrations up to 40 µg/m^3.

The greatest deviation from the baseline ‘no train’ distribution is seen for non-coal freight and passenger services. With passenger services being electric and therefore having no locomotive exhaust emissions, and minimal or no load particle loss from non-coal freight and passenger services, this observation indicates that the rail transport TSP emissions are largely unrelated to locomotive exhaust or coal loss. Re-suspension of particles from rail corridor surfaces by the air turbulence generated by the passing train, which is related to train speed and ground dryness and not the type of train, would explain this observation. There is no evidence that coal loss from loaded or empty coal train wagons is a significant contributor to TSP exposure at the monitoring site during the passing of a train.

Particles generated by air turbulence from a passing train will contain a significant proportion of particles greater than PM_{10} in size close to the source of emission. Given the close proximity of the Cannon Hill (North) monitoring site to the rail corridor, this would explain why the five-minute TSP measurements show a shift to higher concentrations while the five-minute PM_{10} and $PM_{2.5}$ measurements do not show a similar increase.

It needs to be noted that while this analysis indicates that train movements are associated with an increase in short-term TSP levels, the high proportion of time when there are no trains passing the monitoring site means that non-rail TSP sources still dominate overall TSP exposure at the monitoring site, as previously shown.

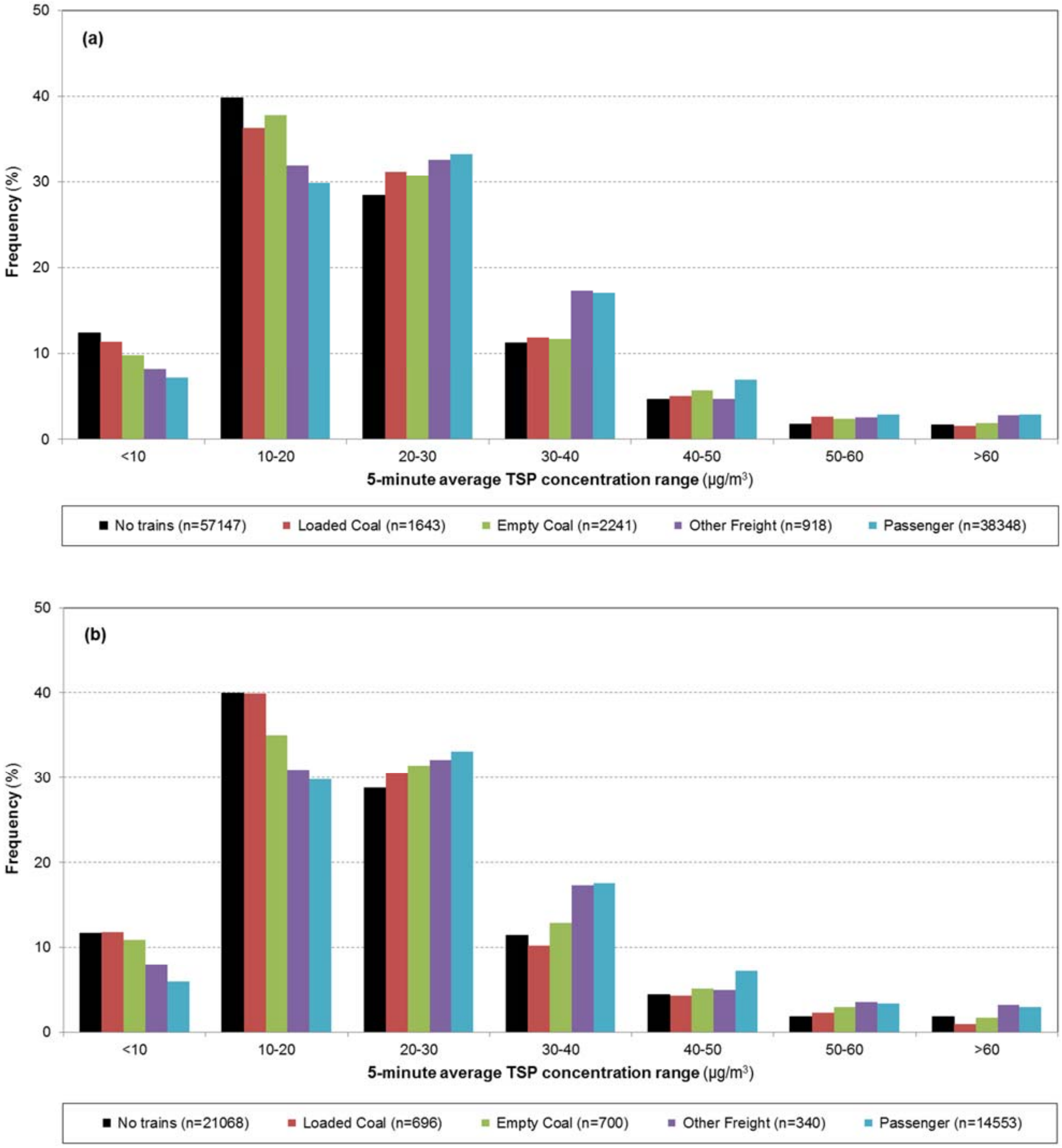


Figure 22. Relative frequency of 5-minute TSP concentration measurements for different train types for (a) all winds from the direction of the rail corridor and (b) winds from the direction of the rail lines at the Cannon Hill (North) monitoring site from February 2014 to December 2015

Deposited dust

Measurement summary

Deposited dust was measured over monthly periods at three locations along the rail corridor used to transport coal to the Port of Brisbane – Cannon Hill and Fairfield in Brisbane and Toowoomba – using dust deposition samplers operated in accordance with Australian/New Zealand Standard AS/NZS 3580.10.1:2003. At each location, sampling was conducted on each side of the rail corridor to ensure any rail corridor emissions are captured in at least one of the samplers for all wind directions[16].

Dust that settles from the air is made up almost entirely of particles 30 micrometres and greater in diameter[17]. It is important to note that the measured dust deposition values are the combined total of all dust emission sources in proximity to the monitoring site, not just dust emissions from rail transport. In addition, coal haulage rail transport will represent only a proportion of the total deposited dust originating from rail transport.

The dust deposition analysis method determines total, dissolved and insoluble deposited matter, with a further breakdown of the insoluble fraction into combustible (organic) matter and ash (mineral) content. Insoluble matter is the solid material collected by filtering the sample, while the dissolved matter is determined by evaporating some or all of the liquid filtrate. 'Combustible (organic) matter' is that portion of the insoluble matter lost on heating at a temperature of 850°C for 30 minutes and is an indication of the amount of organic matter in the dust. Any coal particles present in the insoluble deposited dust will be part of this organic matter fraction, along with other organic material such as plant fragments, insect material, plastic fragments, wood dust, soot and rubber dust. The ash content is an indication of the mineral content of the dust and is often primarily soil or rock particles.

Dust annoyance is primarily correlated with levels of the insoluble deposited matter fraction. Insoluble deposited matter results from the dust deposition sampling at the three Western–Metropolitan Rail System monitoring locations for the reporting period are summarised in Tables 7 to 9 and displayed graphically in Figures 23 to 28. Tables 7 to 9 also include the proportion of winds blowing from the direction of the rail corridor and rail line for each monthly sampling period.

In Figures 23 to 28 the contributions from combustible (organic) matter particles and ash (mineral) particles to the overall insoluble dust deposition rate are shown by the divisions on each column, and the proportion of winds blowing from the direction of the rail corridor during each sampling period is shown by the dotted line. Further details of the individual monthly dust deposition samples and analysis results can be found in Tables 17 to 22 in the Appendix to this report.

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[16] Repeated vandalism of the deposited dust sampler at the Fairfield (East) site has meant that no data is available for this site following August 2015. Sampling at this site was discontinued in November 2015.

[17] J.H. Fairweather, A.F. Sidlow and W.L. Faith, *Particle size distribution of settled dust*, Journal of the Air Pollution Control Association, 15:8, 345-347, 1965, available at http://dx.doi.org/10.1080/00022470.1965.10468389.

Table 7. Average daily dust deposition rates (mg/m^2/day) at the Cannon Hill (North) and Cannon Hill (South) monitoring sites from February 2014 to December 2015

Month	Dust deposition rate (mg/m^2/day)						Winds from direction of rail corridor (%)		Winds from direction of rail lines (%)		Rainfall (mm)
	Insoluble solids[a]		Ash (mineral)		Combustible (organic) matter						
	North	South	North	South	North	South	North	South	North	South	
February 2014	28	24	16	14	12	10	68	48	21	19	16
March 2014	34	29	16	15	17	14	75	44	26	25	122
April 2014	26	75	18	14	8	61	69	39	18	17	12
May 2014	16	14	9	8	7	6	71	38	25	23	13
June 2014	17	17	12	12	5	6	66	42	27	29	11
July 2014	32	32	21	21	12	11	59	51	28	31	10
August 2014	11	11	7	8	4	3	72	34	20	21	43
September 2014	19	20	14	15	5	5	63	49	23	24	18
October 2014	9	39	5	20	4	19	54	60	21	26	10
November 2014	67	83	46	46	20	37	44	73	21	26	68
December 2014	28	41	20	24	8	16	55	60	22	25	70
January 2015	18	29	7	13	11	17	77	39	25	22	169
February 2015	15	28	9	18	5	10	90	17	14	10	209
March 2015	14	13	10	7	4	6	72	42	24	21	241
April 2015	27	24	20	16	6	7	64	48	27	31	251
May 2015	39	9	17	8	22	1	65	44	28	30	3
June 2015	22	16	18	12	4	3	79	27	26	21	5
July 2015	24	27	17	19	7	9	58	50	25	30	7
August 2015	30	31	18	21	12	11	59	53	28	29	14
September 2015	35	42	21	23	13	19	67	43	24	22	48
October 2015	55	58	33	32	22	26	61	53	21	24	50
November 2015	32	40	23	29	10	11	59	51	16	17	44
December 2015	27	57	17	20	10	37	73	39	22	21	69

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m^2/day (averaged over a one month period) to minimise dust nuisance impacts.

Table 8. Average daily dust deposition rates ($mg/m^2/day$) at the Fairfield (East) and Fairfield (West) monitoring sites from February 2014 to December 2015

Month	Dust deposition rate ($mg/m^2/day$)						Winds from direction of rail corridor (%)		Winds from direction of rail lines (%)		Rainfall (mm)
	Insoluble solids[a]		Ash (mineral)		Combustible (organic) matter						
	East	West	East	West	East	West	East	West	East	West	
February 2014	33	26	20	13	13	13	27	81	15	22	18
March 2014	58	58	22	27	36	31	35	74	17	19	99
April 2014	18	24	13	18	5	5	54	58	21	27	12
May 2014	20	18	14	11	6	7	60	51	19	22	2
June 2014	16	16	13	10	3	8	73	37	18	20	8
July 2014	24	22	16	13	9	9	65	44	17	22	11
August 2014	17	24	13	14	4	10	64	47	20	22	51
September 2014	n.d.	24	n.d.	16	n.d.	9	n.d.	65	n.d.	22	10
October 2014	36	33	17	19	20	14	34	73	14	19	13
November 2014	83	90	56	52	26	38	22	81	12	21	82
December 2014	34	36	20	22	14	14	36	71	17	21	80
January 2015	23	16	11	7	12	9	40	69	19	21	141
February 2015	17	13	9	7	7	5	41	72	21	24	116
March 2015	15	12	8	4	7	8	42	68	18	20	137
April 2015	24	23	13	12	11	11	66	44	18	18	160
May 2015	n.d.	9	n.d.	8	n.d.	2	n.d.	36	n.d.	20	2
June 2015	10	14	10	12	0	2	68	44	22	22	2
July 2015	18	18	13	11	5	7	68	39	15	17	3
August 2015	6	21	4	12	1	9	62	46	16	19	14
September 2015	n.d.	26	n.d.	17	n.d.	9	n.d.	57	n.d.	22	52
October 2015	n.d.	49	n.d.	29	n.d.	21	n.d.	72	n.d.	20	67
November 2015	n.d.	19	n.d.	17	n.d.	3	n.d.	71	n.d.	21	65
December 2015	n.d.	30	n.d.	43	n.d.	17	n.d.	63	n.d.	18	66

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 $mg/m^2/day$ (averaged over a one month period) to minimise dust nuisance impacts.

Table 9. Average daily dust deposition rates (mg/m²/day) at the Toowoomba (East) and Toowoomba (West) monitoring sites from March 2014 to December 2015

Month	Dust deposition rate (mg/m²/day)						Winds from direction of rail corridor (%)		Winds from direction of rail lines (%)		Rainfall (mm)
	Insoluble solids[a]		Ash (mineral)		Combustible (organic) matter						
	East	West	East	West	East	West	East	West	East	West	
March 2014	112	42	77	28	35	13	14	84	5	13	185
April 2014	28	29	20	23	8	6	33	64	6	17	40
May 2014	23	25	13	18	10	7	17	79	5	18	3
June 2014	30	34	23	25	7	10	48	18	8	16	25
July 2014	26	44	20	36	7	9	52	46	8	15	14
August 2014	19	35	17	30	3	5	35	59	6	17	29
September 2014	23	24	16	19	7	5	39	63	7	14	18
October 2014	51	54	24	44	27	10	31	71	5	10	15
November 2014	46	136	30	77	15	58	24	80	7	11	56
December 2014	59	43	47	30	12	14	22	79	6	14	259
January 2015	33	43	23	23	10	20	25	73	6	14	38
February 2015	32	29	23	20	10	9	6	88	3	25	39
March 2015	53	59	26	34	27	25	26	75	5	13	66
April 2015	51	25	35	19	16	7	46	52	6	12	139
May 2015	19	29	16	25	3	4	53	46	7	17	7
June 2015	16	20	12	17	5	3	31	64	6	20	18
July 2015	39	45	32	36	7	9	48	51	7	15	15
August 2015	40	40	31	30	9	10	51	49	7	14	36
September 2015	36	92	28	69	8	23	31	69	7	15	19
October 2015	49	97	28	55	21	42	9	84	3	7	107
November 2015	45	185	27	64	18	121	14	88	4	10	60
December 2015	53	40	27	23	26	17	9	91	2	9	132

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.

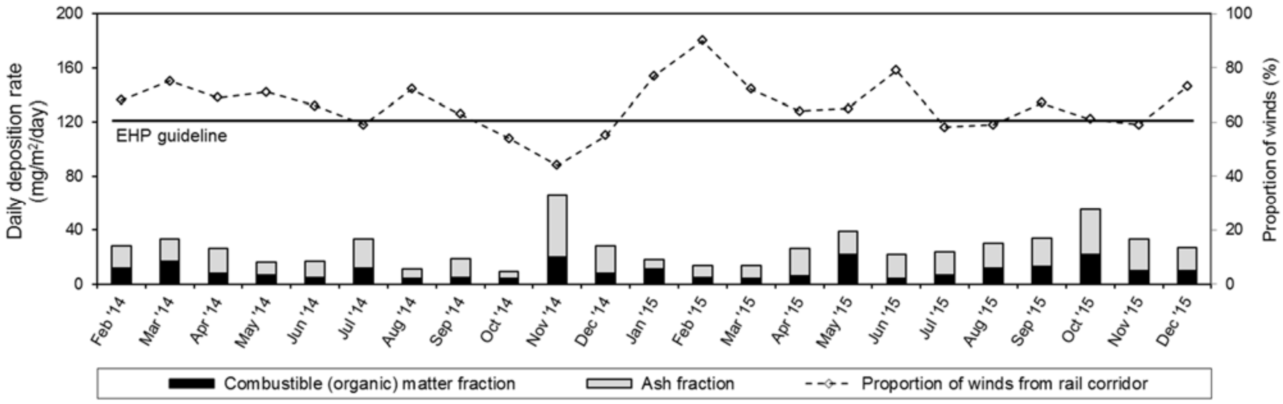

Figure 23. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Cannon Hill (North) monitoring site from February 2014 to December 2015

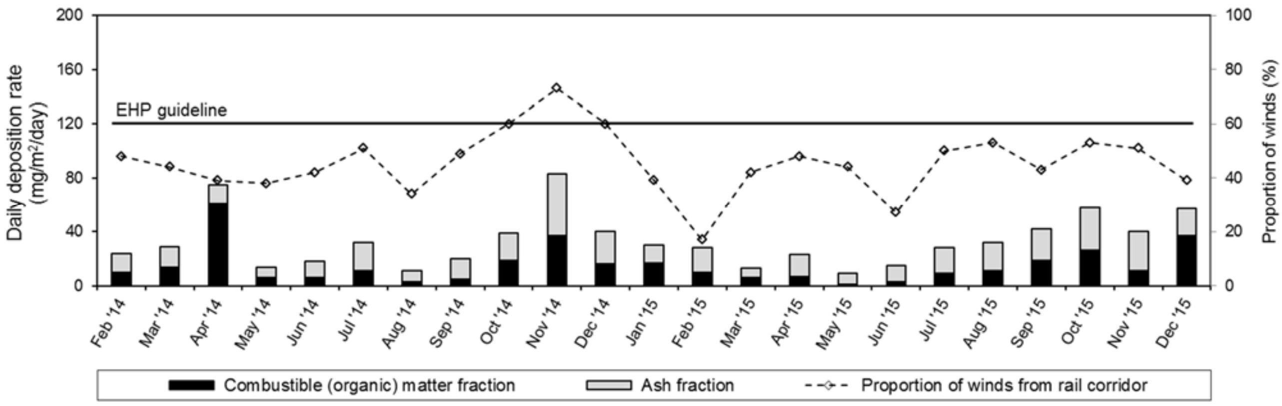

Figure 24. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Cannon Hill (South) monitoring site from February 2014 to December 2015

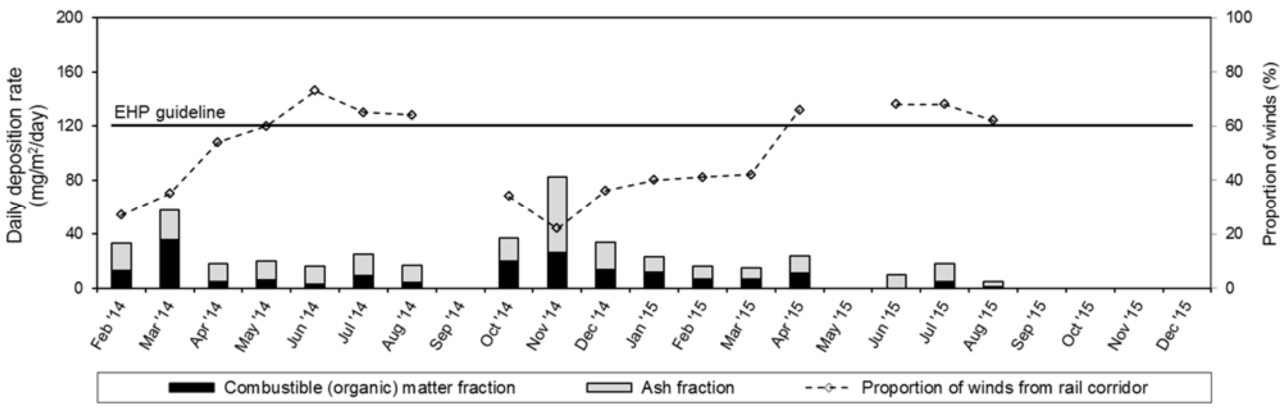

Figure 25. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Fairfield (East) monitoring site from February 2014 to December 2015

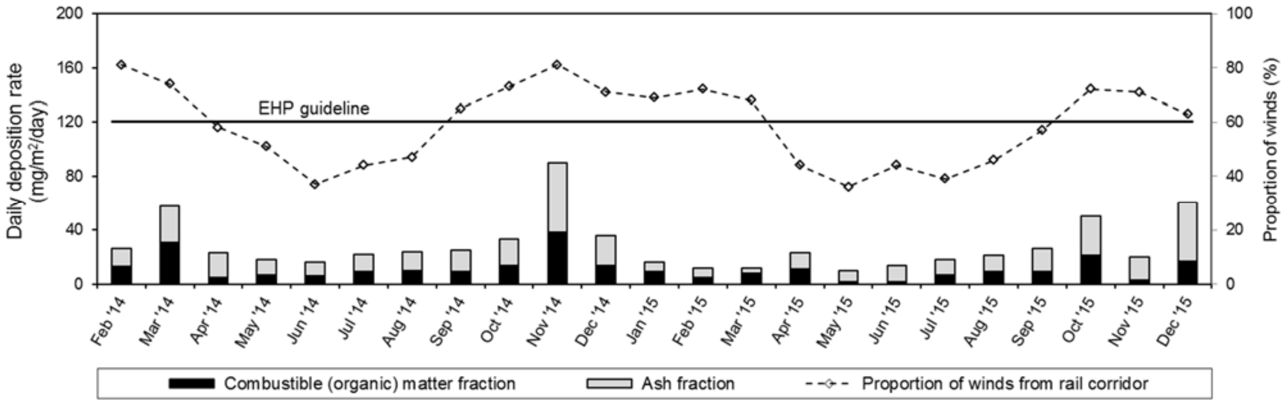

Figure 26. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Fairfield (West) monitoring site from February 2014 to December 2015

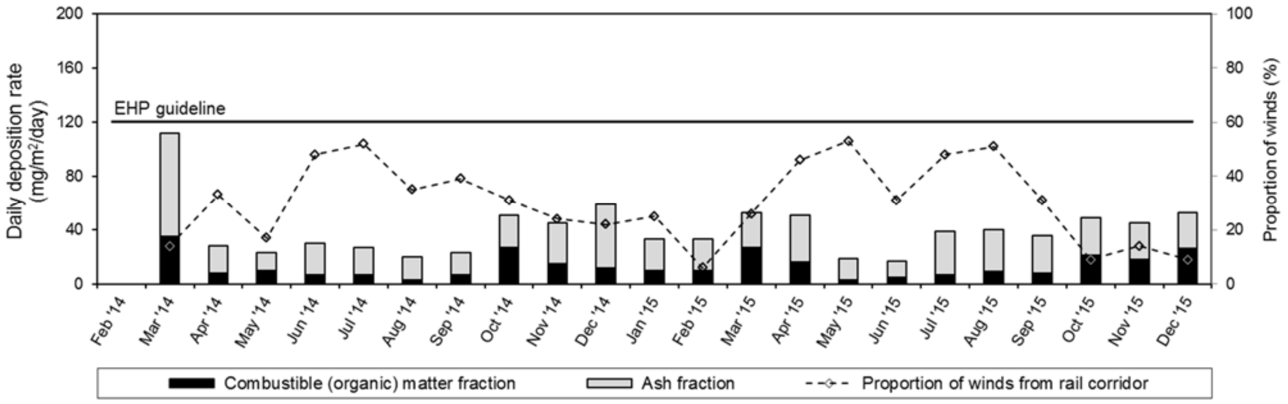

Figure 27. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Toowoomba (East) monitoring site from March 2014 to December 2015

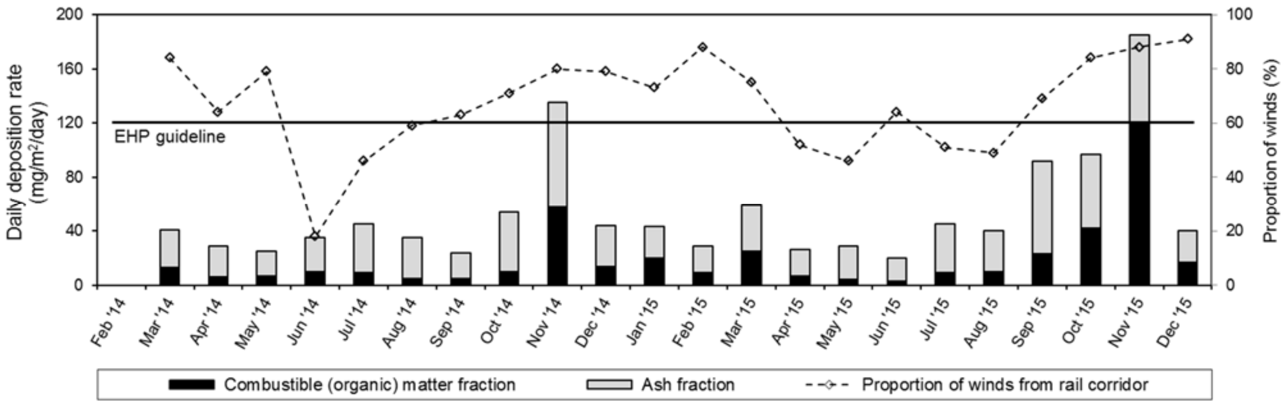

Figure 28. Insoluble dust deposition rates and proportion of winds blowing from the direction of the rail corridor at the Toowoomba (West) monitoring site from March 2014 to December 2015

In general, the deposited dust samples had higher mineral content than organic content which is consistent with soil and rock particles being the predominant particle type present at each monitoring site (and confirmed by the particle composition results discussed later in the report).

Compliance with standards and guidelines

As dust annoyance is correlated primarily with levels of the insoluble dust fraction, nuisance assessment guidelines are generally expressed in terms of insoluble dust deposition. While the level at which settled dust is considered a nuisance is quite subjective, in this report an insoluble dust deposition rate of 120 mg/m^2/day (averaged over one month) as specified in the Air Impacts Guideline issued by the DEHP[18] is used to assess whether insoluble deposited matter levels constitute a nuisance.

Consistent with the findings of the four-month Phase 1 monitoring (both prior to and following the commencement of load profiling and veneering of coal rail wagons), monitoring at the three rail corridor locations from February 2014 to December 2015 demonstrated that dust emissions from rail transport have not resulted in any exceedences of the DEHP dust nuisance criterion.

Figures 23 to 28 show that insoluble dust deposition levels at the rail corridor monitoring sites have complied with the DEHP dust nuisance assessment value of 120 mg/m^2/day at all sites, with the exception of the Toowoomba (West) site in November 2014 and November 2015. In both monthly periods when the dust nuisance guideline was exceeded at the Toowoomba (West) monitoring site, there was no coal detected in the deposited dust sample (see later section), indicating that loss of coal from rail wagons did not contribute to either of these exceedences. Both of these exceedences were associated with an elevated combustible matter content and microscope analysis (see later section) showed a higher than usual proportion of plant matter in these dust samples. This points to an annual vegetation-related event, such as flowering, being largely responsible for the elevated dust deposition during these two months.

Rail transport contribution to deposited dust levels

Assessment of the contribution from rail transport (of which coal haulage rail transport will only be a part) to overall deposited dust levels measured at the three rail corridor locations was undertaken by examining the relationship between the daily average insoluble solids deposition rate and the proportion of winds blowing from the direction of the rail corridor and rail line alignment at each monitoring site. If rail transport emissions were a significant contributor to overall deposited dust levels, a positive correlation between deposited dust levels and the proportion of winds from the direction of the rail corridor during the monthly sampling period would be expected at both monitoring sites on opposite sides of the rail corridor. A stronger correlation could exist for winds aligned with the rail line orientation as higher impacts would be expected under these conditions, as previously described. As the deposited dust measurements are the sum of contributions from all dust sources, it is not possible to quantitatively determine the contribution from rail transport.

To remove the potential effect of rainfall on deposited dust levels, relationships during only those months where less than 40mm of rain fell was also examined.

The relationship between the daily average insoluble solids deposition rate and the proportion of winds blowing from the direction of the rail corridor at each monitoring site is plotted as the dotted line in Figures 29(a) to 34(a). The corresponding relationships for only those months where less than 40mm of rain fell are shown by the solid line in Figures 29(a) to 34(a).

The relationship between the daily average dust deposition rate and the proportion of winds blowing from the direction of the rail lines for each monitoring site, again for all months (dotted line) and low rainfall months (solid line), is shown in Figures 29(b) to 34(b).

[18] http://www.ehp.qld.gov.au/assets/documents/regulation/era-gl-air-impacts.pdf.

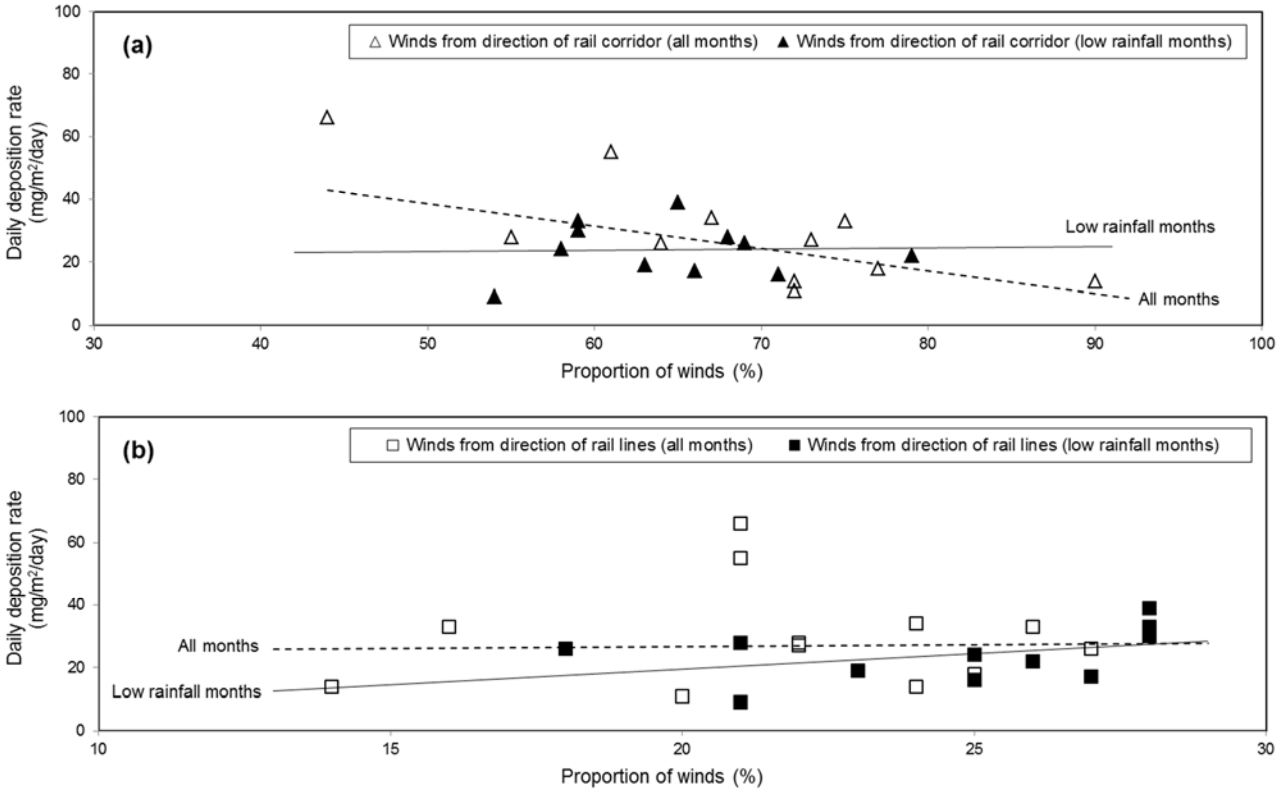

Figure 29. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Cannon Hill (North) monitoring site from February 2014 to December 2015

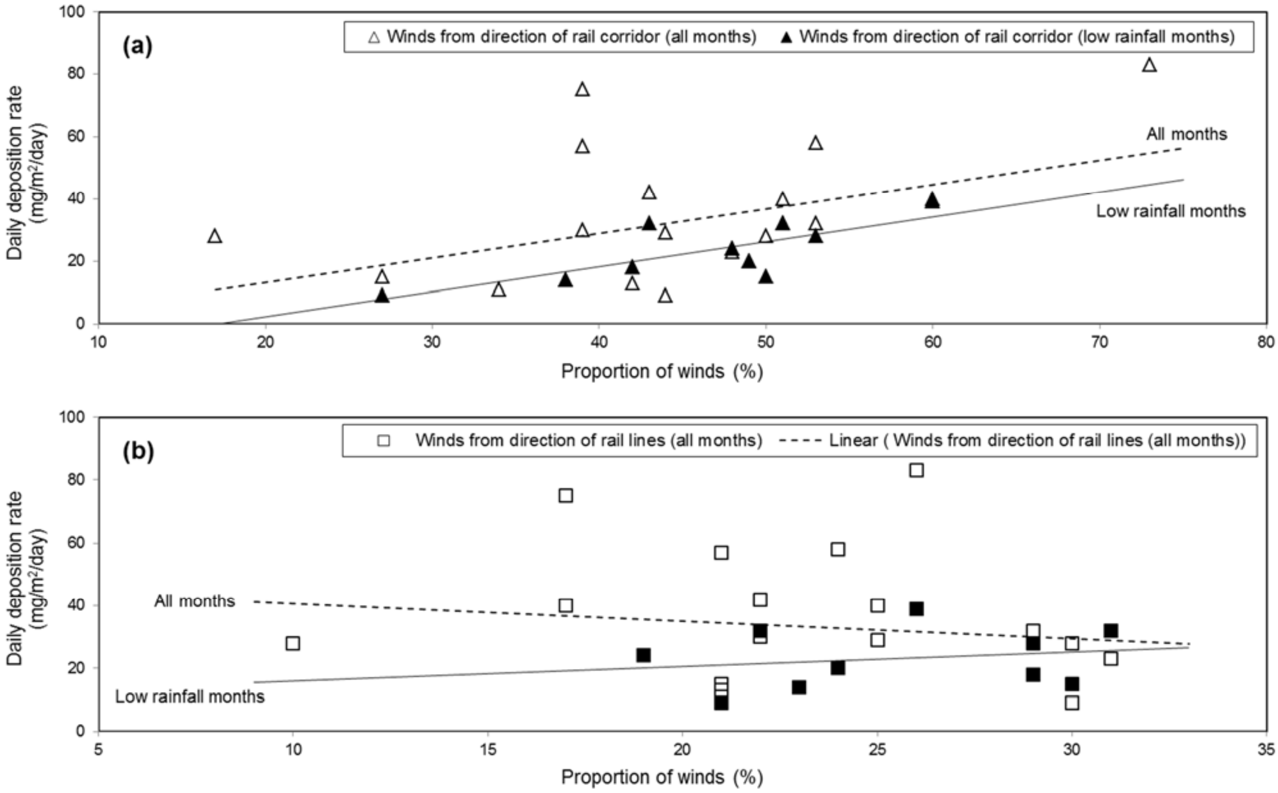

Figure 30. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Cannon Hill (South) monitoring site from February 2014 to December 2015

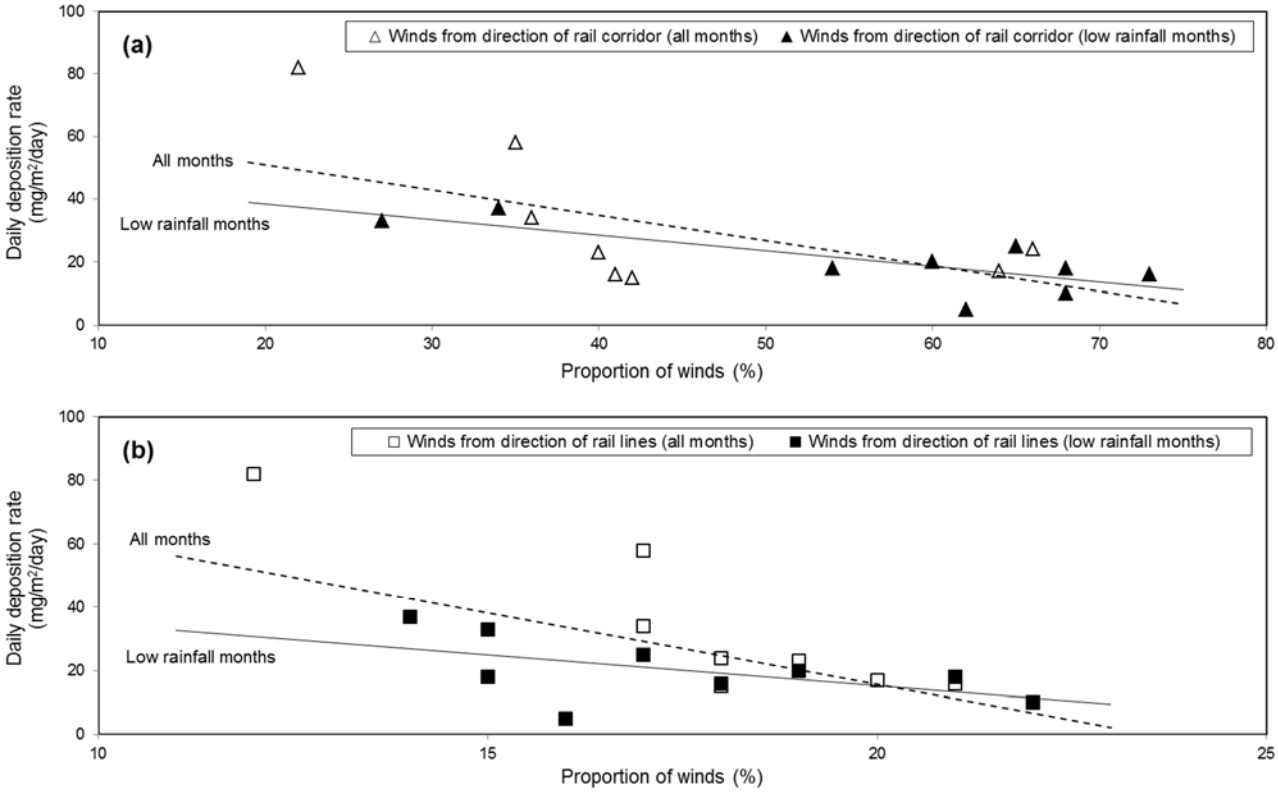

Figure 31. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Fairfield (East) monitoring site from February 2014 to August 2015

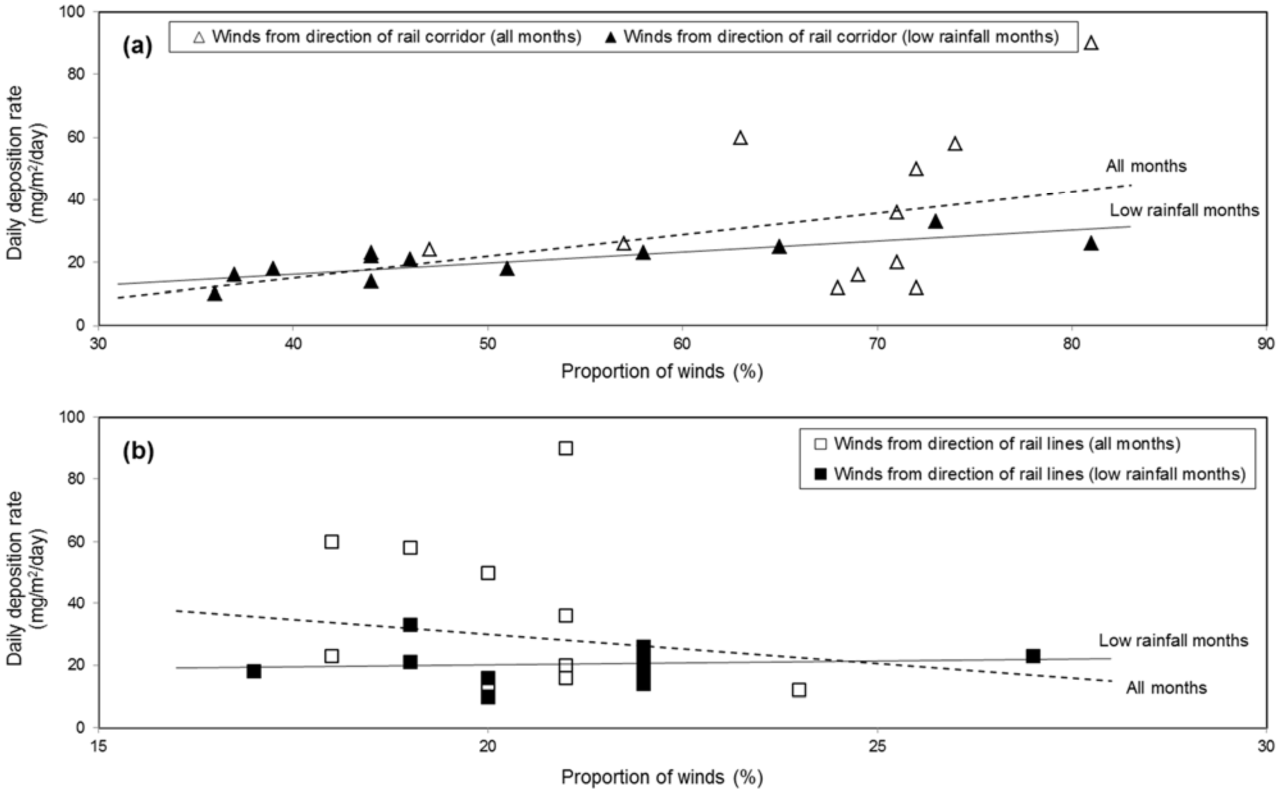

Figure 32. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Fairfield (West) monitoring site from February 2014 to December 2015

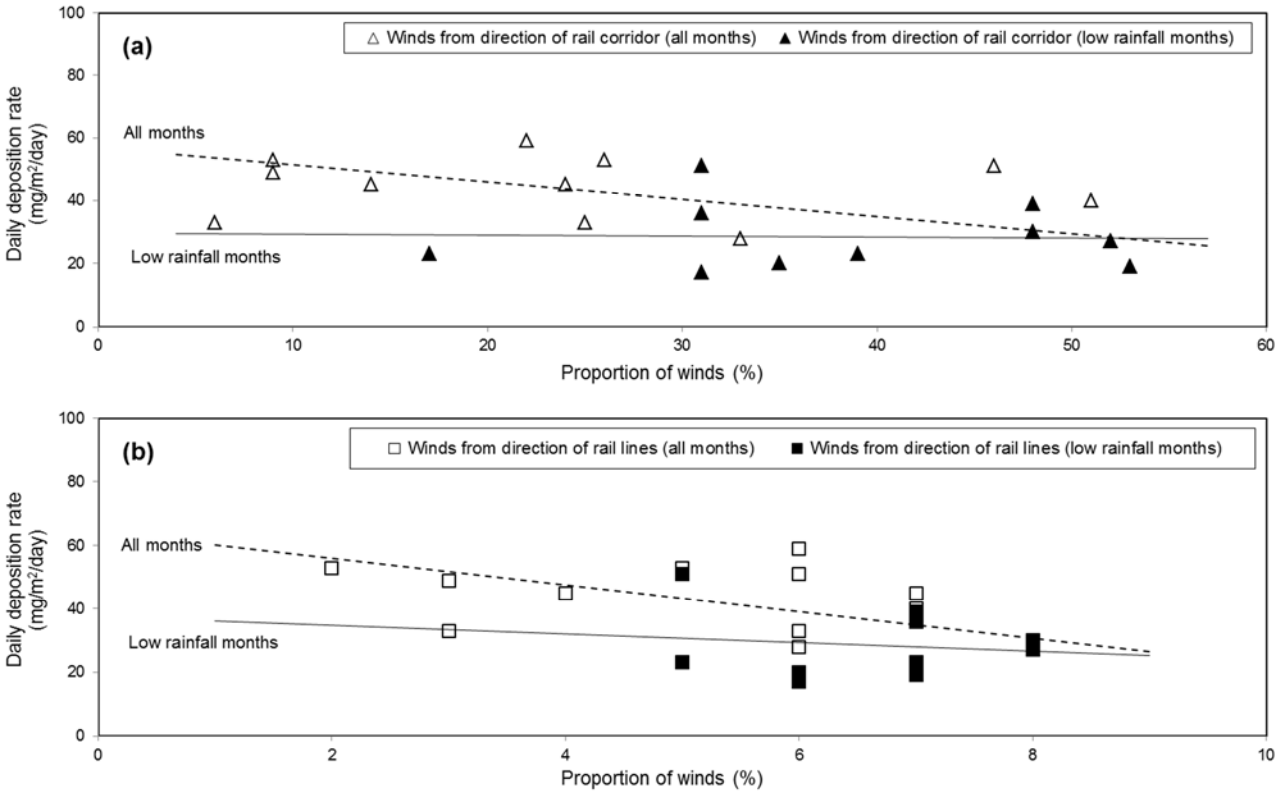

Figure 33. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Toowoomba (East) monitoring site from March 2014 to December 2015

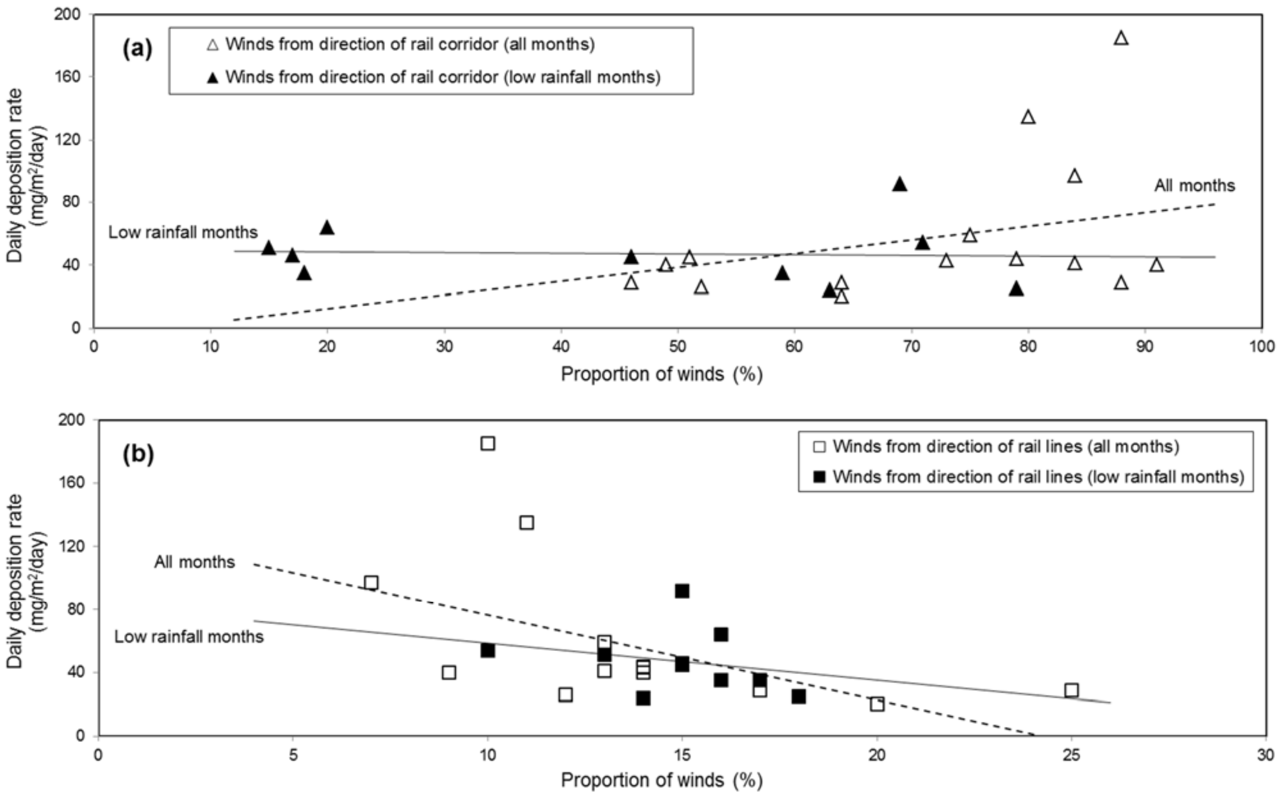

Figure 34. Relationship between average daily insoluble dust deposition rate and (a) the proportion of winds from the direction of the rail corridor and (b) the proportion of winds from the direction of the rail lines at the Toowoomba (West) monitoring site from March 2014 to December 2015

While there is a positive correlation between the daily average insoluble dust deposition rate and the proportion of winds from either the direction of the rail corridor or the direction of the rail lines during the monthly sampling periods at some individual monitoring sites, at none of the three rail corridor monitoring locations is a positive correlation seen at the two monitoring sites located on opposite sides of the rail corridor. This indicates that in those instances where a positive correlation is observed, dust deposition at the monitoring site is primarily influenced by particle source(s) outside the rail corridor.

Based on this analysis, it is concluded that any contribution from dust emissions originating from rail transport, of which only part will be from coal haulage rail transport, to overall deposited dust levels is minor in comparison to the amount of dust coming from non-rail sources.

Particle composition

The composition of the deposited dust samples has been used to identify the contributing particle sources, including coal dust. The deposited dust composition analysis involved taking a sub-sample from the dust deposition sampler, filtering this through a membrane filter and examining the insoluble particles retained on the filter under a microscope.

The particle composition analysis was conducted by the University of Queensland Materials Performance (UQMP) laboratory. The UQMP procedure can distinguish between a range of black-coloured particles (coal, soot and rubber dust), inorganic and mineral dust particles (e.g. soil, rock, cement, glass), particles of biological origin (e.g. insect and plant fragments) and other general organic particles (e.g. wood, fibres and plastics). The reported proportions of the different particles in each dust sample are based on the surface area coverage of each particle type on the membrane filter. The technique can resolve the surface area coverage of the different particle type to a typical accuracy of ± 5 per cent.

The results of the particle composition analysis for the monthly deposited dust samples collected at the rail corridor monitoring sites between February 2014 and December 2015 are summarised in Tables 10 to 12 and displayed graphically in Figures 35 to 40. In Figures 35 to 40 the proportions of the different particle types (coal dust, other black particles, inorganic and mineral particles and biological particles) are indicated by the divisions within each column, with the dust deposition rate and the proportion of winds blowing from the direction of the rail corridor during each sampling period overlaid as a solid line and a dotted line respectively. Details of the individual monthly dust deposition particle composition results can be found in Tables 23 to 40 in the Appendix to this report.

Table 10. Deposited dust particle composition analysis results for the Cannon Hill (North) and Cannon Hill (South) monitoring sites, February 2014 to December 2015

Month	Surface coverage (%)[a]									
	Coal dust		Other black particles		Inorganic and mineral		Biological		Other particle types	
	North	South	North	South	North	South	North	South	North	South
February 2014	trace	5	10	trace	90	95	trace	trace	trace	0
March 2014	trace	trace	trace	10	100	90	trace	trace	trace	trace
April 2014	10	trace	trace	trace	90	90	0	10	trace	0
May 2014	10	10	trace	5	90	85	trace	trace	trace	trace
June 2014	10	5	20	10	60	60	10	25	0	0
July 2014	10	5	5	10	65	45	20	40	0	0
August 2014	trace	trace	trace	trace	95	75	5	30	0	trace
September 2014	15	10	5	10	80	75	trace	5	0	0
October 2014	10	5	5	10	80	70	trace	10	trace	trace
November 2014	5	2	trace	trace	85	98	10	trace	0	0
December 2014	trace	trace	trace	0	95	85	trace	10	5	5
January 2015	5	trace	trace	10	90	90	trace	trace	5	trace
February 2015	trace	trace	10	10	70	80	20	10	0	trace
March 2015	5	trace	7	5	83	85	5	10	trace	trace
April 2015	trace	trace	5	20	75	60	20	20	trace	trace
May 2015	trace	trace	trace	10	75	80	25	10	0	0
June 2015	5	trace	15	10	70	55	10	35	trace	trace
July 2015	2	5	5	10	73	65	20	20	0	trace
August 2015	5	2	5	5	70	63	20	30	trace	0
September 2015	5	4	trace	trace	65	66	30	30	trace	0
October 2015	trace	5	2	10	78	70	20	15	0	0
November 2015	trace	trace	5	10	70	80	25	10	trace	trace
December 2015	trace	0	0	10	60	10	40	30	0	50

[a] the uncertainty in the measurement of surface coverage is typically ±5 per cent.

Table 11. Deposited dust particle composition analysis results for the Fairfield (East) and Fairfield (West) monitoring sites, February 2014 to December 2015

Month	Surface coverage (%)[a]									
	Coal dust		Other black particles		Inorganic and mineral		Biological		Other particle types	
	East	West	East	West	East	West	East	West	East	West
February 2014	0	0	trace	5	95	95	5	trace	trace	trace
March 2014	trace	0	trace	trace	100	90	trace	10	0	0
April 2014	0	10	trace	25	100	65	trace	trace	0	0
May 2014	trace	trace	15	20	85	80	trace	trace	0	trace
June 2014	10	trace	20	20	60	70	10	10	trace	trace
July 2014	20	trace	10	20	50	70	20	10	0	0
August 2014	trace	trace	10	10	90	90	trace	trace	0	0
September 2014	n.d.	0	n.d.	20	n.d.	75	n.d.	5	n.d.	trace
October 2014	trace	trace	trace	5	100	95	trace	trace	trace	trace
November 2014	2	5	trace	5	93	90	5	trace	trace	0
December 2014	trace	trace	7	trace	88	90	5	10	trace	trace
January 2015	0	0	trace	trace	100	100	trace	trace	trace	trace
February 2015	trace	0	15	5	65	65	20	30	0	0
March 2015	trace	trace	7	15	73	85	20	trace	trace	0
April 2015	trace	2	5	5	95	93	trace	trace	trace	0
May 2015	n.d.	0	n.d.	20	n.d.	60	n.d.	20	n.d.	0
June 2015	trace	0	5	15	60	65	30	20	trace	trace
July 2015	2	5	5	20	68	55	25	20	0	trace
August 2015	5	5	10	10	65	65	20	20	0	0
September 2015	n.d.	trace	n.d.	10	n.d.	65	n.d.	25	n.d.	0
October 2015	n.d.	trace	n.d.	trace	n.d.	85	n.d.	15	n.d.	0
November 2015	n.d.	15	n.d.	10	n.d.	65	n.d.	10	n.d.	0
December 2015	n.d.	0	n.d.	trace	n.d.	100	n.d.	trace	n.d.	trace

[a] the uncertainty in the measurement of surface coverage is typically ±5 per cent.

n.d. = no data (sampling equipment vandalised or sampling discontinued)

Table 12. Deposited dust particle composition analysis results for the Toowoomba (East) and Toowoomba (West) monitoring sites, March 2014 to December 2015

Month	Surface coverage (%)[a]									
	Coal dust		Other black particles		Inorganic and mineral		Biological		Other particle types	
	East	West	East	West	East	West	East	West	East	West
March 2014	trace	trace	trace	0	100	90	trace	10	trace	trace
April 2014	0	trace	10	10	90	85	trace	5	0	trace
May 2014	trace	trace	trace	10	100	90	trace	trace	0	0
June 2014	trace	trace	20	10	70	70	10	20	0	0
July 2014	0	trace	10	10	80	80	10	10	0	0
August 2014	20	10	trace	10	80	80	trace	trace	0	0
September 2014	trace	5	10	10	90	80	trace	5	0	0
October 2014	trace	5	trace	5	100	70	trace	20	0	trace
November 2014	5	0	5	0	60	50	30	50	0	trace
December 2014	5	trace	4	trace	91	100	trace	trace	0	trace
January 2015	0	5	trace	trace	90	85	10	trace	trace	10
February 2015	trace	0	5	5	95	85	trace	10	0	0
March 2015	5	2	5	5	80	79	10	14	trace	trace
April 2015	0	0	5	5	75	95	20	0	trace	trace
May 2015	0	0	25	10	65	80	10	10	0	0
June 2015	5	trace	10	20	55	70	30	10	trace	trace
July 2015	5	trace	20	5	50	75	25	20	0	trace
August 2015	2	trace	5	10	83	65	10	25	0	0
September 2015	0	5	trace	5	70	65	30	25	trace	0
October 2015	trace	0	0	5	65	60	35	35	0	0
November 2015	trace	trace	5	10	70	80	25	10	trace	trace
December 2015	trace	trace	0	0	50	80	50	20	0	0

[a] the uncertainty in the measurement of surface coverage is typically ±5 per cent.

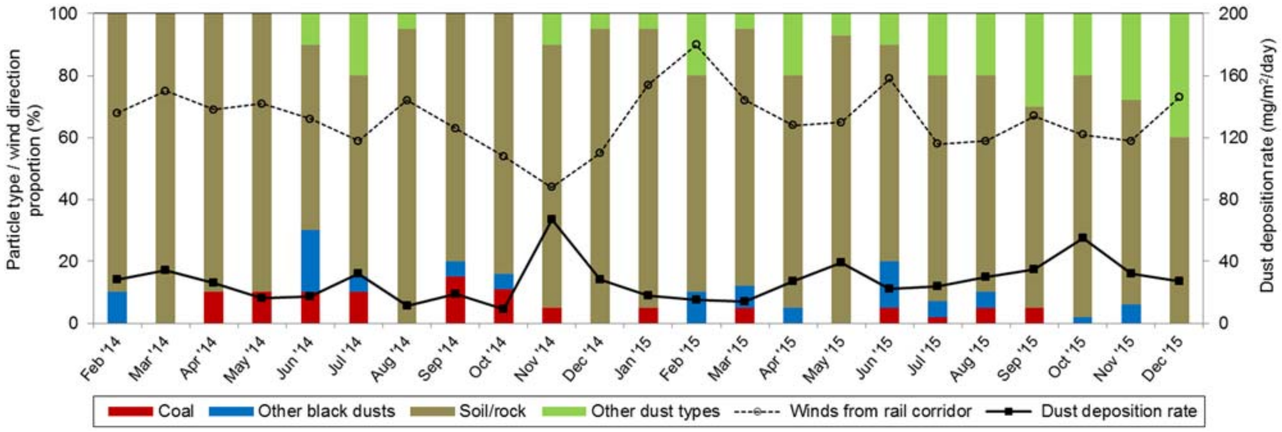

Figure 35. Deposited dust composition at the Cannon Hill (North) monitoring site from February 2014 to December 2015

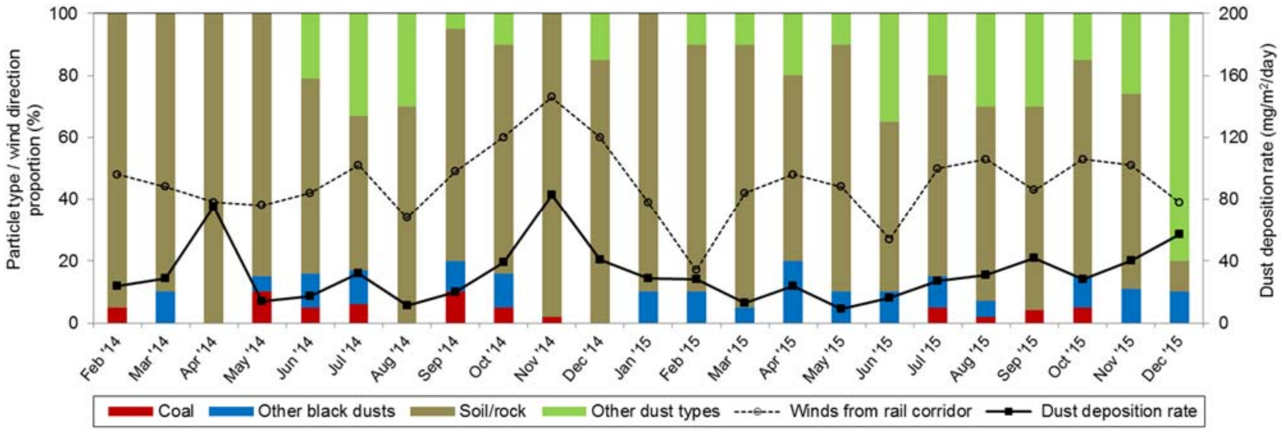

Figure 36. Deposited dust composition at the Cannon Hill (South) monitoring site from February 2014 to December 2015

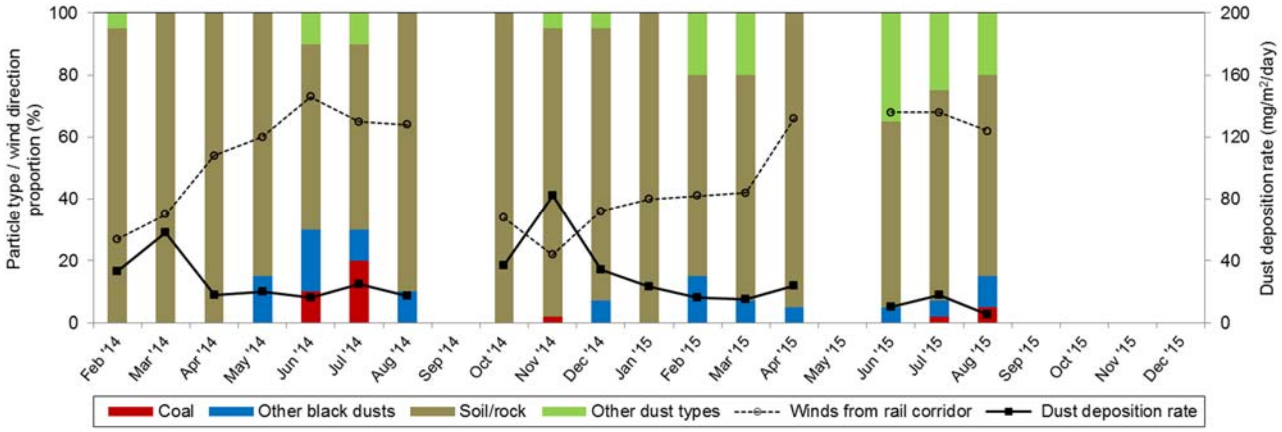

Figure 37. Deposited dust composition at the Fairfield (East) monitoring site from February 2014 to August 2015

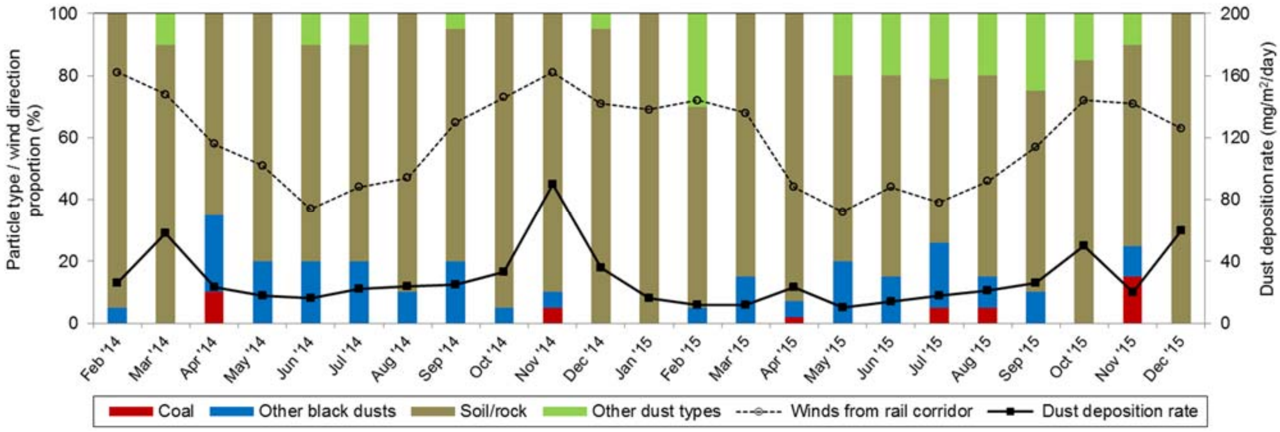

Figure 38. Deposited dust composition at the Fairfield (West) monitoring site from February 2014 to December 2015

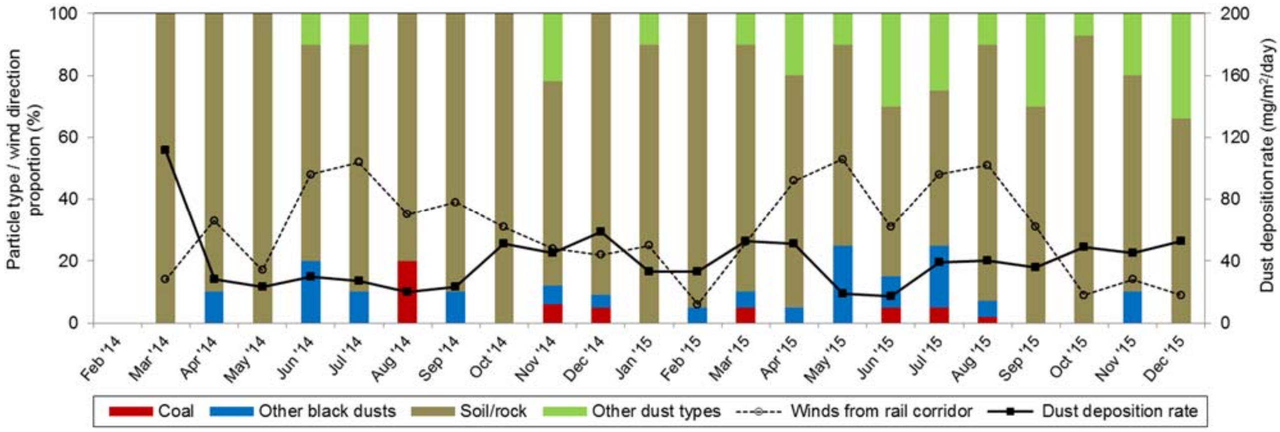

Figure 39. Deposited dust composition at the Toowoomba (East) monitoring site from March 2014 to December 2015

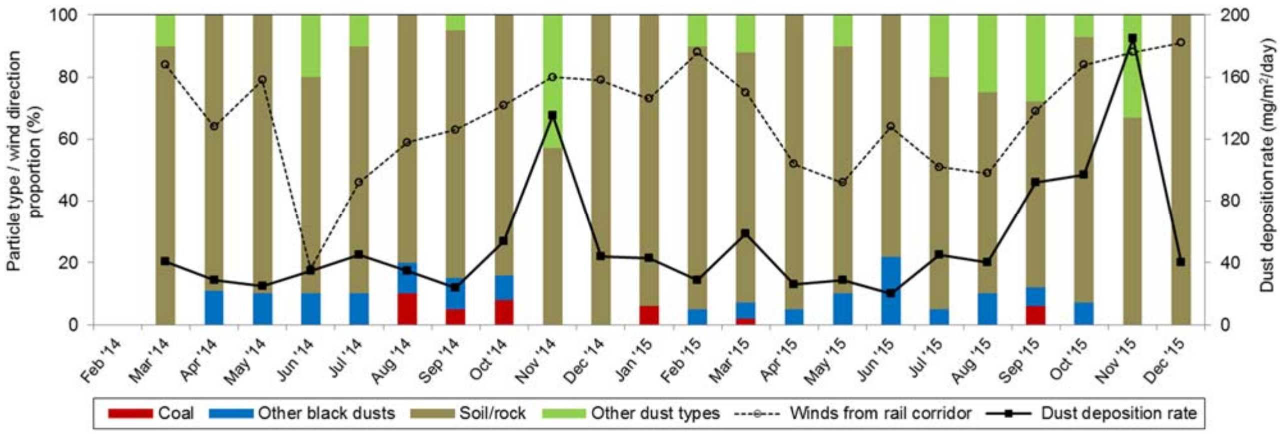

Figure 40. Deposited dust composition at the Toowoomba (West) monitoring site from March 2014 to December 2015

Soil and rock particles were by far the largest type of particles found in the deposited dust samples collected at the rail corridor monitoring sites. On a coverage basis, soil and rock dust made up between 50 and 85 per cent of all particle types.

The maximum coal dust coverage level in the monthly deposited dust samples was 20 per cent, found in only two samples, or 1.5 per cent, of total samples collected between February 2014 and December 2015. Across the 130 monthly deposited dust samples collected, 82 (or 63 per cent) contain no coal dust or only trace amounts. Overall, coal dust levels were lower in 2015 than in 2014, with coal dust coverage levels rarely exceeding 5 per cent in individual samples collected during 2015. Figures 35 to 40 show no obvious relationship between coal dust coverage and the proportion of winds blowing from the direction of the rail corridor during the sampling period.

Figures 35 to 40 also show no obvious relationship between the proportion of coal dust present in the deposited dust sample and the overall dust deposition rate. The conclusion drawn from this is that other dust sources have a greater influence on the amount of dust on a mass basis being deposited at the monitoring sites than any coal haulage rail transport emissions that may be occurring.

The particle composition results show that the most common type of black particles present in the deposited dust samples is black rubber dust, which frequently comprises 5 to 10 per cent by surface area of the monthly samples. In urban areas the primary source of black rubber dust will be vehicle tyre wear during driving. The black rubber dust will be collected by the samplers either as direct emissions from nearby roads or re-suspension of rubber dust present in the road corridor by passing traffic or strong winds.

During 2015, coal dust was rarely detected in the deposited dust samples outside of the drier months of the year (June to October). This observation can be explained by the origin of the coal particles in the dust deposition samples being primarily re-suspension of coal present in the track ballast and soil in the rail corridor when the ground dries out, rather than direct loss from coal haulage rail wagons, and supports the effectiveness of CDMP dust mitigation measures in reducing coal loss from rail wagons. Over time, ongoing effective measures to reduce coal loss from rail wagons would in turn minimise the amount of coal available in the rail corridor to be re-suspended by passing trains.

Coal deposition

As the particle composition analysis results are in terms of relative surface area coverage and not mass, the measured proportions cannot be directly applied to the overall dust deposition rate to give a mass deposition rate for individual particle types.

To gain an approximate measure of the mass of coal (and other particle types) being deposited at each monitoring site, typical densities for the different particle types were applied to the surface area proportions obtained from the microscope particle composition analysis.

For this exercise, those particle types which were artefacts of the sampling method and not present in the air environment (such as copper sludge formed from the copper sulfate algicide added to the sampler, and photosynthetic slime and fungi formed in the collection bottle solution during the sampling period) were excluded and the surface area coverage of the remaining ambient particle types which came from the ambient air were proportionally scaled up to achieve a total surface area coverage of 100 per cent.

Similar calculations were undertaken for the particle composition results obtained in the Phase 1 monitoring conducted between March and early July 2013 to provide a comparison with the Phase 2 monitoring results for those periods when load profiling and veneering was not undertaken or was not undertaken at all coal mines. For the Cannon Hill and Toowoomba locations which were not part of the Phase 1 study, sites at the closest Phase 1 monitoring locations (Coorparoo and Willowburn respectively) were used for this comparison.

The results of the particle mass deposition calculations[19] for the monthly deposited dust samples collected at the rail corridor monitoring sites in Phase 1, and in Phase 2 between February 2014 and December 2015, are summarised in Tables 13 to 15 and displayed graphically in Figures 41 to 46.

[19] The following densities were applied to the different particle types:

Particle type	Density (g/cm^3)	Reference
Coal	1.5	A.J. Mutton, *Queensland Coals: Physical and Chemical Properties, Colliery and Company Information*, 14th Edition, Department of Natural Resources and Mines Bureau of Mining and Petroleum, 2003, downloaded from https://www.dnrm.qld.gov.au/?a=267497.
Fly ash	2.4	Cement Australia, Safety Data Sheets for Fly Ash, http://www.cementaustralia.com.au/wps/wcm/connect/website/bulk/Bulk-Home/technical-product-information/#msds.
Insect material	0.7	Locust, dry value, *Density of Bulk Materials*, http://www.simetric.co.uk/si_materials.htm.
Paint	1.2	B. Müller and U. Poth, *Coatings Formulation*, Vincentz Network, 2011, downloaded from https://www.european-coatings.com/var/StorageVincentz/VN-Link/285_Leseprobe.pdf.
Plant material	0.3	Bark, wood refuse value, *Density of Some Common Materials*, The Engineering Toolbox http://www.engineeringtoolbox.com/density-materials-d_1652.html.
Plastic	1.2	Average of listed densities for common plastics on http://www.dotmar.com.au/density.html.
Soil / rock	2.1	J. Priddle, D. Lacey, B. Look and C. Gallage, *Residual Soil Properties of South East Queensland*, Australian Geomechanics Journal, 48(1), pp. 67-76, 2013, downloaded from http://eprints.qut.edu.au/59538/.
Soot	1.8	R.C. Flagan and J.H. Seinfeld, *Fundamentals of Air Pollution Engineering*, Prentice-Hall, 1988, p381, downloaded from http://authors.library.caltech.edu/25069/1/AirPollution88.pdf.
Tyre rubber	1.2	Geosyntec Consultants, *Guidance Manual For Engineering Uses of Scrap Tires*, Maryland Department of the Environment, 2008, accessed from http://www.mde.state.md.us/assets/document/Guidance_Manual_For_Scrap_Tires.pdf.

Table 13. Deposited dust particle type mass deposition results for the Coorparoo (North) and Coorparoo (South) monitoring sites, March to June 2013, and Cannon Hill (North) and Cannon Hill (South) monitoring sites, February 2014 to December 2015

Month	Insoluble dust deposition rate (mg/m²/day)		Particle type deposition rate (mg/m²/day)					
			Coal dust		Soil and rock dust		Other particle types	
	North	South	North	South	North	South	North	South
No CDMP measures – all mines (Coorparoo)								
March 2013	107	108	10	19	83	80	14	9
April 2013	106	109	0	18	97	82	9	14
CDMP measures at New Acland Mine only (Coorparoo)								
May 2013	24	27	4	5	19	19	2	4
June 2013	27	20	1	0	23	17	3	3
CDMP measures – all mines (Cannon Hill)								
February 2014	28	24	0	1	26	23	2	0
March 2014	34	29	0	0	34	27	0	2
April 2014	26	75	2	0	24	75	0	0
May 2014	16	14	1	1	15	13	0	0
June 2014	17	17	1	1	12	14	3	2
July 2014	32	32	3	2	27	25	2	5
August 2014	11	11	0	0	11	10	0	1
September 2014	19	20	2	2	16	17	1	2
October 2014	9	39	1	2	8	33	0	4
November 2014	67	83	3	1	63	82	2	0
December 2014	28	41	0	0	27	39	1	2
January 2015	18	29	1	0	17	27	1	2
February 2015	15	28	0	0	13	26	2	2
March 2015	14	13	1	0	13	12	1	1
April 2015	27	24	0	0	25	19	2	5
May 2015	39	9	0	0	38	8	1	1
June 2015	22	16	1	0	18	13	3	3
July 2015	24	27	0	1	22	23	2	3
August 2015	30	31	1	1	26	27	2	3
September 2015	35	42	2	2	30	38	3	2
October 2015	55	58	0	1	51	24	4	3
November 2015	32	40	0	0	27	28	5	12
December 2015	27	57	0	0	24	12	3	45

Table 14. Deposited dust particle type mass deposition results for the Fairfield (East) and Fairfield (West) monitoring sites, March to June 2013 and February 2014 to December 2015

Month	Insoluble dust deposition rate (mg/m^2/day)		Particle type deposition rate (mg/m^2/day)					
			Coal dust		Soil and rock dust		Other particle types	
	East	West	East	West	East	West	East	West
No CDMP measures – all mines								
March 2013	46	57	4	6	38	47	4	5
April 2013	18	112	2	10	15	84	2	18
CDMP measures at New Acland Mine only								
May 2013	20	27	2	1	16	24	3	2
June 2013	23	24	0	2	22	21	1	1
CDMP measures – all mines								
February 2014	33	26	0	0	33	25	0	1
March 2014	58	58	0	0	58	57	0	1
April 2014	18	24	0	2	18	17	0	4
May 2014	20	18	0	0	18	16	2	2
June 2014	16	16	1	0	12	14	3	2
July 2014	24	22	4	0	18	19	2	3
August 2014	17	24	0	0	16	23	1	1
September 2014	n.d.	24	n.d.	0	n.d.	21	n.d.	4
October 2014	36	33	0	0	37	32	0	1
November 2014	83	90	1	3	79	84	1	3
December 2014	34	36	0	0	31	36	3	0
January 2015	23	16	0	0	23	16	0	0
February 2015	17	13	0	0	14	11	2	1
March 2015	15	12	0	0	14	11	1	1
April 2015	24	23	0	0	23	22	1	1
May 2015	n.d.	9	n.d.	0	n.d.	8	n.d.	2
June 2015	10	14	0	0	9	12	1	2
July 2015	18	18	0	1	16	13	2	4
August 2015	6	21	0	1	4	17	1	3
September 2015	n.d.	26	n.d.	0	n.d.	22	n.d.	4
October 2015	n.d.	49	n.d.	0	n.d.	48	n.d.	2
November 2015	n.d.	19	n.d.	3	n.d.	16	n.d.	2
December 2015	n.d.	30	n.d.	0	n.d.	60	n.d.	0

Table 15. Deposited dust particle type mass deposition results for the Willowburn (East) and Willowburn (West) monitoring sites, April to May 2013, and Toowoomba (East) and Toowoomba (West) monitoring sites, March 2014 to December 2015

Month	Insoluble dust deposition rate (mg/m^2/day)		Particle type deposition rate (mg/m^2/day)					
			Coal dust		Soil and rock dust		Other particle types	
	East	West	East	West	East	West	East	West
No CDMP measures – all mines (Willowburn)								
April 2013	25	11	5	1	19	9	2	1
CDMP measures at New Acland Mine only (Willowburn)								
May 2013	33	14	0	1	25	12	8	1
CDMP measures – all mines (Toowoomba)								
March 2014	112	42	0	0	112	40	0	1
April 2014	28	29	0	0	26	27	2	2
May 2014	23	25	0	0	23	24	0	1
June 2014	30	34	0	0	25	31	5	4
July 2014	26	44	0	0	25	41	2	4
August 2014	19	35	3	3	17	30	0	2
September 2014	23	24	0	1	22	21	1	2
October 2014	51	54	0	3	51	48	0	3
November 2014	46	136	2	0	38	112	5	23
December 2014	59	43	2	0	55	44	2	0
January 2015	33	43	0	2	32	41	1	0
February 2015	32	29	0	0	32	28	1	1
March 2015	53	59	2	1	48	54	3	4
April 2015	51	25	0	0	46	25	5	1
May 2015	19	29	0	0	15	26	4	3
June 2015	16	20	1	0	13	17	3	3
July 2015	39	45	2	0	28	42	9	3
August 2015	40	40	1	0	37	35	2	5
September 2015	36	92	0	5	32	74	4	13
October 2015	49	97	0	0	48	90	1	7
November 2015	45	185	0	0	39	173	6	12
December 2015	53	40	0	0	47	40	6	0

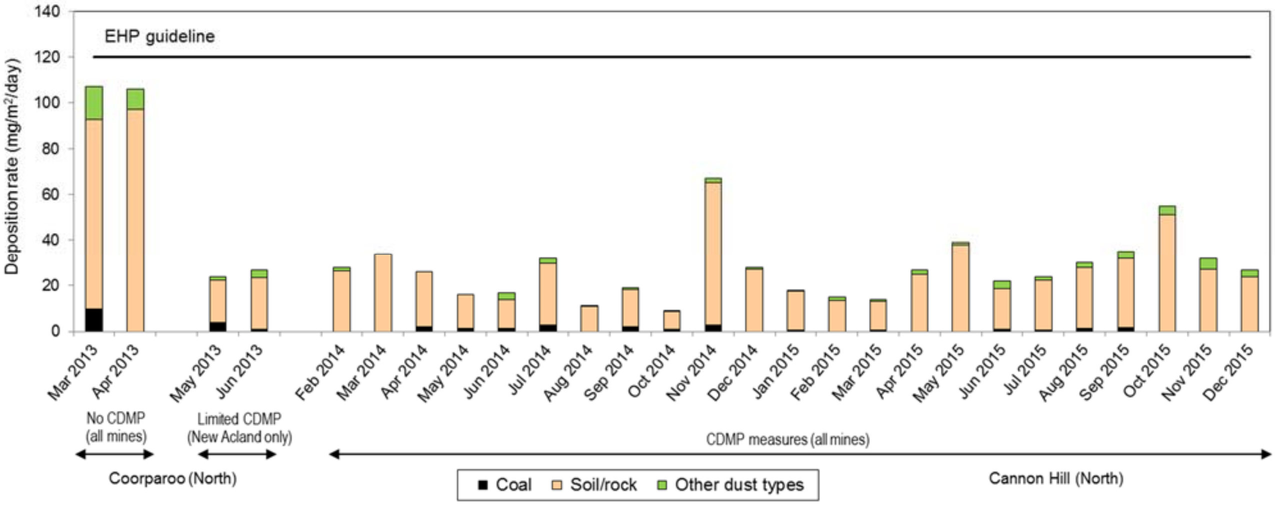

Figure 41. Deposition rates for different particle types at the Coorparoo (North) monitoring site, March to June 2013 and the Cannon Hill (North) monitoring site, February 2014 to December 2015

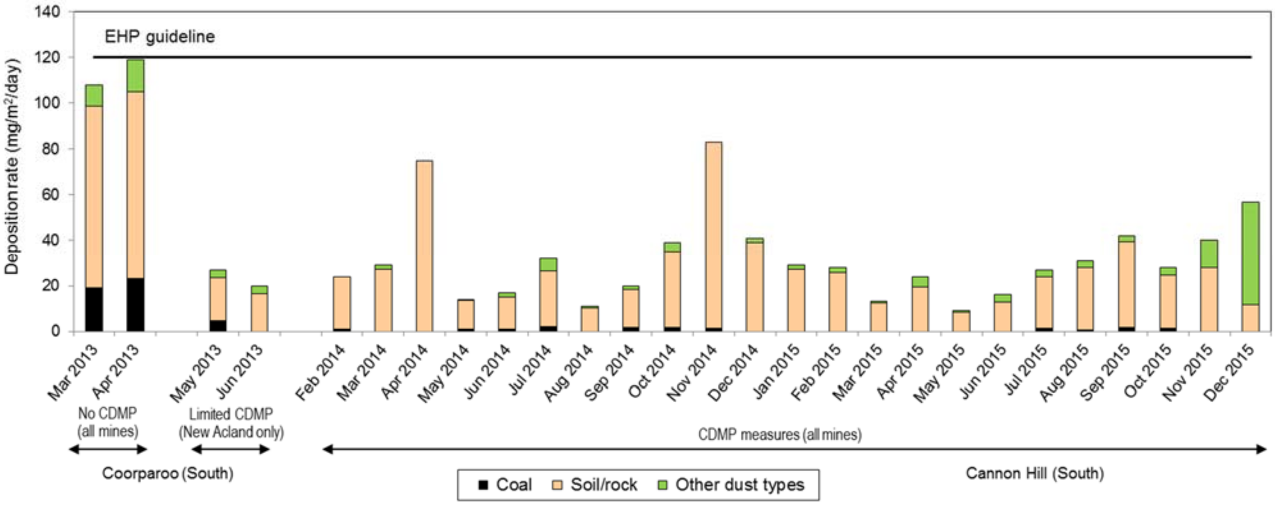

Figure 42. Deposition rates for different particle types at the Coorparoo (South) monitoring site, March to June 2013 and the Cannon Hill (South) monitoring site, February 2014 to December 2015

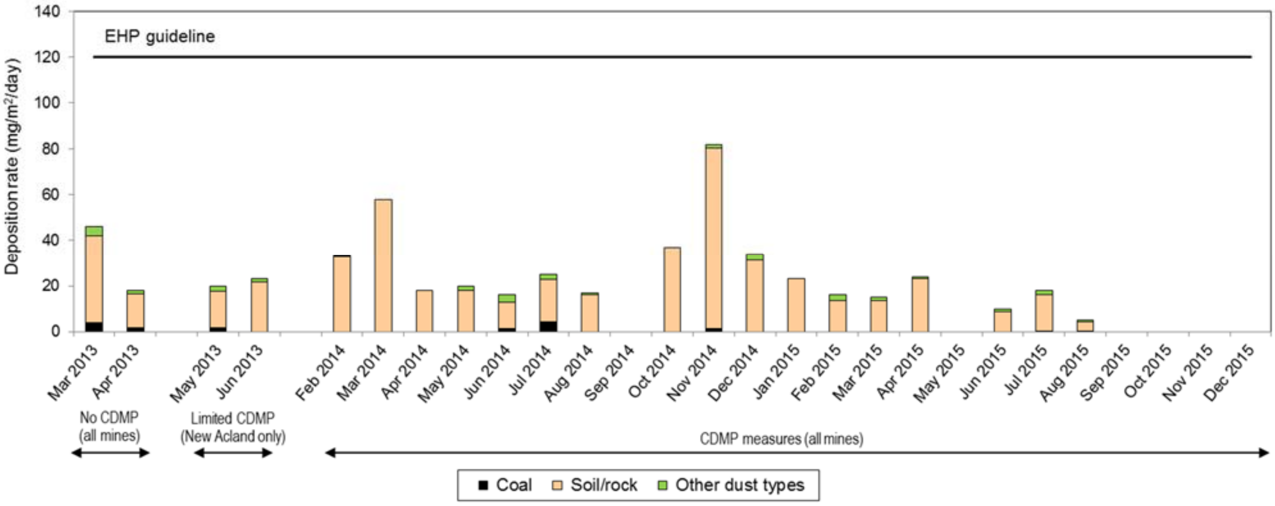

Figure 43. Deposition rates for different particle types at the Fairfield (East) monitoring site, March to June 2013 and February 2014 to December 2015

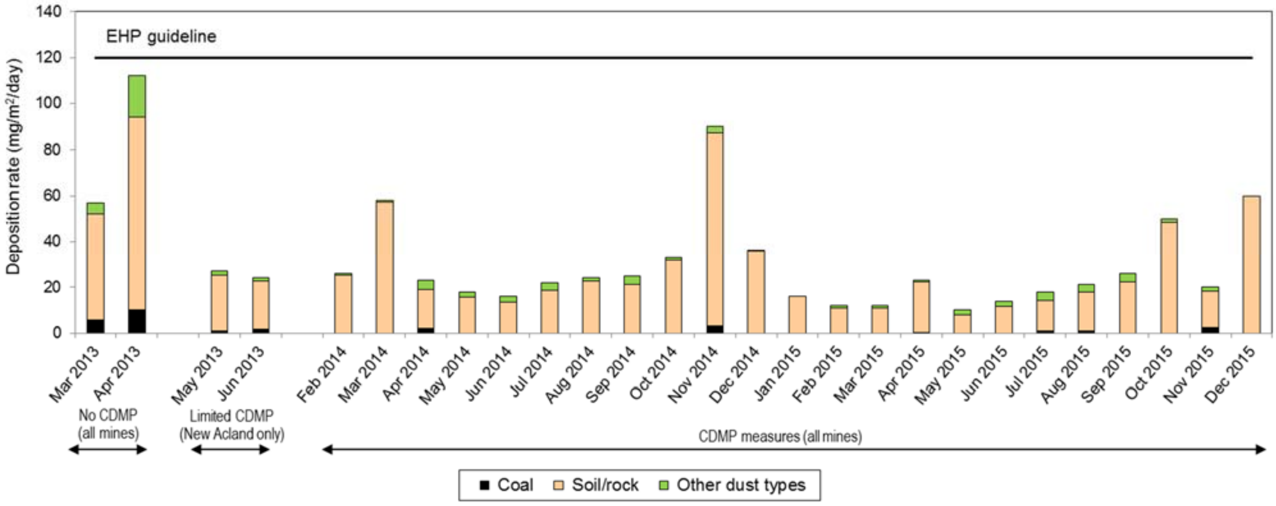

Figure 44. Deposition rates for different particle types at the Fairfield (West) monitoring site, March to June 2013 and February 2014 to December 2015

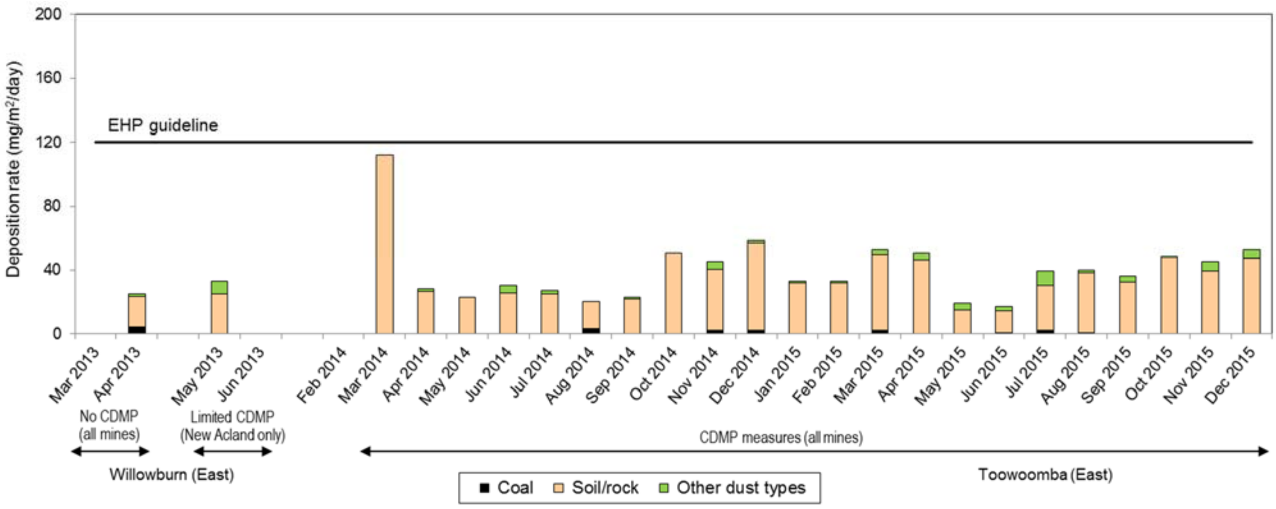

Figure 45. Deposition rates for different particle types at the Willowburn (East) monitoring site, April to May 2013 and the Toowoomba (East) monitoring site, March 2014 to December 2015

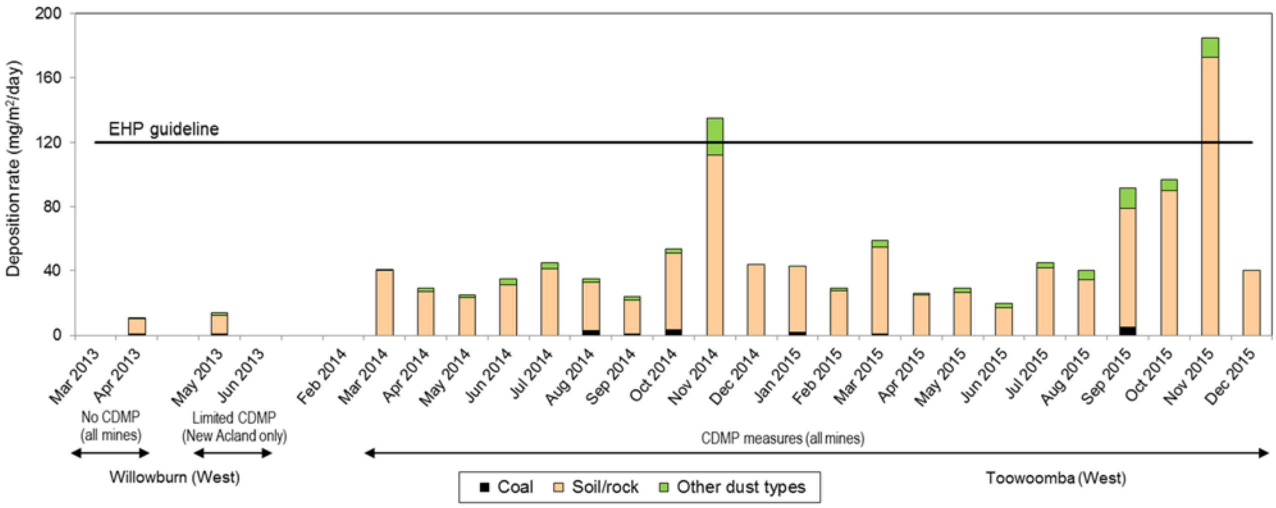

Figure 46. Deposition rates for different particle types at the Willowburn (West) monitoring site, April to May 2013 and the Toowoomba (West) monitoring site, March 2014 to December 2015

Soil and rock particles were by far the largest contributor to the insoluble dust mass deposition rate at the rail corridor monitoring sites. The mass of coal deposited at the monitoring sites is very low (rarely above 2 mg/m^2/day) and generally only measurable during drier periods of the year (June to October). As mentioned previously, this points to the presence of coal in the deposited dust samples coming from re-suspension of coal dust present in the track ballast and soil in the rail corridor during dry conditions rather than direct loss from coal trains using the rail corridor during the sampling period.

Effectiveness of the South West System Coal Dust Management Plan measures in mitigating loss of coal from rail wagons

The effectiveness of the CDMP measures in mitigating loss of coal from rail wagons was assessed by comparing the difference in average insoluble dust and coal deposition levels across the Western–Metropolitan Rail System before CDMP implementation in Phase 1 with those measured in Phase 2. As previously mentioned, the insoluble dust values are the combined sum from all dust sources, while the initial source of the coal will be coal haulage rail transport (although re-suspension of coal present in the rail corridor will contribute to measured levels). This approach assumes that the insoluble dust and coal deposition measurements obtained in March and April 2013 during Phase 1 are representative of typical levels before implementation of the CDMP measures.

The March and April 2013 insoluble dust and coal deposition rate values from Phase 1 listed in Tables 13 to 15 for both monitoring sites at each of the rail corridor locations were averaged to obtain a measure of average deposition rates before the CDMP was implemented. The same process was followed using all the Phase 2 values between February 2014 and December 2015 to obtain a measure of average deposition rates following full implementation of the CDMP. The average deposition rate values for each monitoring location were then averaged to obtain an estimate of insoluble dust and coal deposition rates across the rail system before the CDMP was implemented and following full implementation at all coal mines. The results are summarised in Table 16. The changes in deposition rates following implementation of the CDMP measures are also displayed graphically in Figure 47.

Table 16. Average deposition rates for insoluble dust and coal at Western–Metropolitan Rail System monitoring locations before and following implementation of the South West System Coal Dust Monitoring Plan measures

Monitoring location	Deposition rate (mg/m^2/day)			
	Insoluble dust[a]		Coal	
	Pre-CDMP	Post-CDMP	Pre-CDMP	Post-CDMP
Coorparoo / Cannon Hill	108	30	12	1
Fairfield	58	27	6	<1
Willowburn / Toowoomba	18	47	3	1
Rail system average	**61**	**35**	**7**	**1**

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m^2/day (averaged over a one month period) to minimise dust nuisance impacts.

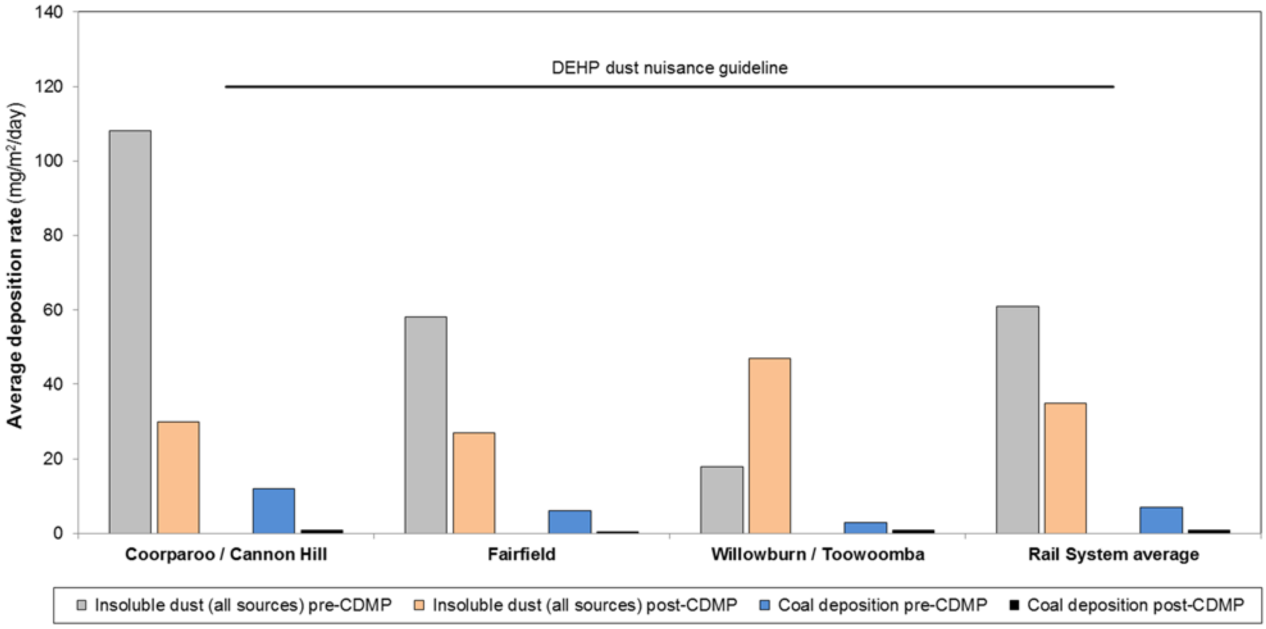

Figure 47. Average deposition rates for insoluble dust and coal at Western–Metropolitan Rail System monitoring locations before and following implementation of the South West System Coal Dust Monitoring Plan measures

Table 16 and Figure 47 show that the decrease in coal deposition levels following full implementation of the CDMP measures has been much greater than the corresponding decrease in insoluble dust deposition. As a result of the CDMP implementation, the estimated average deposition rate of coal dust across the rail system has reduced by 86 per cent from 7 mg/m^2/day to 1 mg/m^2/day. There has been a 92 per cent reduction at Cannon Hill (relative to Coorparoo Phase 1 levels), 93 per cent reduction at Fairfield, and 67 per cent reduction at Toowoomba (relative to Willowburn Phase 1 levels).

At the current estimated rail system average deposition rate of 1 mg/m^2/day, coal deposition is just 0.8 per cent of the DEHP dust nuisance guideline of 120 mg/m^2/day. Put another way, coal deposition complies with the DEHP guideline by more than 99 per cent.

These results show that the CDMP measures, which include load profiling and veneering of rail wagons, have been highly effective in reducing coal dust loss from rail wagons during transport.

Conclusions

Whilst the Phase 1 monitoring conducted between March and early July 2013 indicated that coal haulage rail transport was compliant with air quality criteria during this period, mining companies and associated service providers voluntarily adopted additional dust mitigation measures as outlined in the CDMP to further improve their overall environmental performance. As part of this, a second round of air monitoring was undertaken to assess the ongoing effectiveness of these dust mitigation measures. This report presents the results from the Phase 2 Western–Metropolitan Rail Systems coal dust monitoring program for the period February 2014 to December 2015.

Particle (PM_{10}, $PM_{2.5}$ and TSP) concentrations and deposited dust levels were monitored along the rail corridor at Cannon Hill, Fairfield and Toowoomba and compared with air quality criteria for both human health protection and degradation of amenity. Continuous PM_{10}, $PM_{2.5}$ and TSP concentrations at the Cannon Hill (North) monitoring site resulting from all particle emission sources, including coal haulage rail transport, predominantly complied with ambient air quality criteria for protection of human health. Very infrequent exceedences, as described below, were recorded with none of these caused by rail transport or, more specifically, coal haulage.

Annual average PM_{10} concentrations at the Cannon Hill (North) monitoring site from all sources, including coal haulage rail transport as a proportion of total emissions, complied with the AAQ NEPM annual standard over the entire reporting period. The 24-hour average PM_{10} concentrations complied with the EPP Air 24-hour objective during the reporting period, with the exception of one day in 2015 when rail track reconditioning work next to the monitoring site generated high dust levels. Typical 24-hour average PM_{10} concentrations at the Cannon Hill (North) monitoring site ranged from 15 µg/m^3 to 30 µg/m^3, or 70 to 40 per cent below the EPP Air objective. Overall, PM_{10} concentrations measured in 2015 were lower than for 2014.

Emissions from rail transport, including coal haulage, made up only a minor fraction of total PM_{10} measured at the Cannon Hill (North) monitoring site over the reporting period. Non-rail PM_{10} sources, including motor vehicles, industry and natural sources such as sea salt, were identified as the predominant contributors to total PM_{10}. At Cannon Hill, five-minute average PM_{10} concentrations coinciding with the passage of a train, including coal haulage, did not show any appreciable trend to higher concentrations when compared to levels measured when there were no train movements.

Annual average $PM_{2.5}$ concentrations from all sources, including coal haulage rail transport as a proportion of total emissions, exceeded the EPP Air annual objective at the Cannon Hill (North) monitoring site in 2014, but complied during 2015. A combination of $PM_{2.5}$ from multiple region-wide urban and natural $PM_{2.5}$ sources, and not rail transport or, more specifically, coal haulage, was determined to be the cause of the exceedence in 2014. Similarly, 24-hour $PM_{2.5}$ concentrations complied with the EPP Air 24-hour average objective during 2014 and 2015, with the exception of one day in 2014 when smoke from vegetation fires in the South East Queensland region added to existing $PM_{2.5}$ levels from urban sources. Typical 24-hour average $PM_{2.5}$ concentrations at the Cannon Hill (North) monitoring site over the reporting period ranged from 5 µg/m^3 to 15 µg/m^3, or 80 to 40 per cent below the EPP Air objective. Overall, $PM_{2.5}$ concentrations measured in 2015 were lower than for 2014.

Emissions from rail transport, including coal haulage, made up only a very minor fraction of total $PM_{2.5}$ measured at the Cannon Hill (North) monitoring site over the reporting period. The monitoring data indicates that $PM_{2.5}$ at Cannon Hill is dominated by well mixed emissions from a range of region-wide urban and natural sources, including motor vehicles, industry and vegetation burning. At Cannon Hill, five-minute average $PM_{2.5}$ concentrations coinciding with the passage of a train, including coal haulage, did not show any appreciable trend to higher concentrations when compared to levels measured when there were no train movements.

Annual average TSP concentrations at the Cannon Hill (North) monitoring site from all sources, including coal haulage rail transport as a proportion of total emissions, complied with the EPP Air annual objective for protection of human health during 2014 and 2015. The 24-hour average TSP concentrations complied with the NZ MfE dust nuisance trigger level value for sensitive areas over the same period, with the exception of two days (one in 2014 and one in 2015), both resulting from dust associated with rail track maintenance works next to the monitoring site when there were no trains using the rail corridor at Cannon Hill. Typical 24-hour average TSP concentrations at the Cannon Hill (North) monitoring site ranged from 20 $\mu g/m^3$ to 40 $\mu g/m^3$, or 75 to 50 per cent below the NZ MfE dust nuisance trigger value. Overall, TSP concentrations decreased slightly in 2015 compared to 2014 levels.

Emissions from rail transport, including coal haulage, made up only a minor fraction of total TSP measured at the Cannon Hill (North) monitoring site over the reporting period. Non-rail TSP sources, in particular windblown dust from earthworks and dry ground, were identified as the predominant contributors to total TSP. At Cannon Hill, five-minute average TSP concentrations coinciding with the passage of a train exhibited a trend towards higher concentrations when compared to levels measured when there were no train movements. This increase was most pronounced for electric passenger trains and least for loaded coal trains, indicating that the increased TSP levels were due to re-suspension of particles from the rail corridor surface by the air turbulence generated by the passing train rather than direct emissions from trains such as exhaust emissions or coal particle loss from rail wagons.

Dust deposition rates at all the rail corridor monitoring sites complied with the DEHP dust nuisance assessment value during 2014 and 2015, with the exception of the Toowoomba (West) monitoring site in November 2014 and November 2015. On both these occasions there was no coal detected in the deposited dust sample, indicating that coal trains did not contribute to either of these exceedences. Instead, both samples contained a higher than usual proportion of plant matter, suggesting that an annual vegetation-related event such as flowering was a factor. The lack of a consistent positive correlation between deposited dust levels and winds from the direction of the rail corridor for both monitoring sites located on opposite sides of the rail corridor indicates that rail transport, including coal haulage, emissions are not a significant contributor to overall deposited dust levels adjacent to the rail corridor. Typically dust deposition rates from all sources were less than half the DEHP dust nuisance assessment value at the rail corridor boundary.

Soil and rock particles were the major particle type present in the deposited dust samples collected at the three rail corridor monitoring locations, typically comprising 70 to 90 per cent of total coverage. Coal dust seldom exceeded ten per cent of total dust in the monthly deposited dust samples collected in 2014, while in the 2015 samples coal dust rarely comprised more than five per cent of total dust. The most common type of black particles present in the deposited dust samples was black rubber dust, primarily coming from vehicle tyre wear during driving. Black rubber dust was present at levels between five and 10 per cent in most monthly samples.

During 2015, coal dust was rarely detected in deposited dust samples outside of the drier months from June to October, an observation that can be explained by the source of the coal particles being predominantly re-suspension of coal particles present in the rail track ballast and soil in the rail corridor as the ground dried out rather than direct loss from rail wagons. This indicates that the implementation of the CDMP mitigation measures at all coal mines has contributed to an ongoing reduction in the amount of coal dust entering the rail corridor.

The mass of coal depositing from the air has fallen very significantly from the levels initially measured in March and April 2013 before the CDMP measures were implemented. Some improvement was observed in the period immediately following the implementation of load profiling and veneering at the New Acland Mine in May 2013. The results of the Phase 2 monitoring reported here show that following the implementation of the CDMP measures at all mines from December 2013 there has been continued significant improvement in the mass of coal depositing from the air. Across the rail system as a whole, the estimated average deposition rate of coal dust has fallen from a pre-CDMP level of 7 mg/m^2/day to 1 mg/m^2/day in 2014 and 2015, a reduction of 86 per cent. The reduction at individual monitoring locations has ranged from 67 per cent to 93 per cent. At the current estimated rail system average deposition rate of 1 mg/m^2/day, coal deposition is just 0.8 per cent of the DEHP dust nuisance assessment value of 120 mg/m^2/day.

Based on these results, implementation of the CDMP measures, including load profiling and veneering, have been and continue to be highly effective in reducing the loss of coal dust from loaded rail wagons during transport. Re-suspension of dust from the rail corridor by the air turbulence generated by passing trains of all types, not just coal haulage, has been identified as the primary air quality impact from rail transport.

Appendix

Table 17. Monthly deposited dust sampling results for the Cannon Hill (North) monitoring site from February 2014 to December 2015

Date deployed	Date collected	Days sampled	Deposition rate (mg/m²/day)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
04/02/14	03/03/14	27	58	28	16	12	30	62	16
03/03/14	04/04/14	32	48	34	16	17	14	68	122
04/04/14	02/05/14	28	40	26	18	8	14	67	12
02/05/04	03/06/14	31	31	16	9	7	15	69	13
03/06/14	04/07/14	31	37	17	12	5	20	65	11
04/07/14	04/08/14	31	44	32	21	12	12	57	10
04/08/14	04/09/14	31	25	11	7	4	14	72	43
04/09/14	03/10/14	29	46	19	14	5	27	59	16
03/10/14	04/11/14	32	17	9	5	4	8	48	10
04/11/14	28/11/14	24	102	67	46	20	35	36	68
28/11/14	06/01/15	38	36	28	20	8	8	48	70
06/01/15	04/02/15	29	19	18	7	11	1	71	169
04/02/15	05/03/15	29	23	15	9	5	8	88	209
05/03/15	02/04/15	28	25	14	10	4	11	67	241
02/04/15	04/05/15	32	35	27	20	6	8	62	251
04/05/15	04/06/15	31	80	39	17	22	41	63	3
04/06/15	06/07/15	32	49	22	18	4	27	78	5
06/07/15	05/08/15	30	43	24	17	7	19	56	7
05/08/15	07/09/15	33	45	30	18	12	25	56	14
07/09/15	06/10/15	29	73	35	21	13	38	64	48
06/10/15	05/11/15	30	74	55	33	22	19	55	50
05/11/15	07/12/15	32	61	32	23	10	29	56	44
07/12/15	06/01/16	30	77	27	17	10	50	68	69

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.

Table 18. Monthly deposited dust sampling results for the Cannon Hill (South) monitoring site from February 2014 to December 2015

Date deployed	Date collected	Days sampled	Deposition rate ($mg/m^2/day$)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
04/02/14	03/03/14	27	67	24	14	10	43	39	16
03/03/14	04/04/14	32	45	29	15	14	16	33	122
04/04/14	02/05/14	28	99	75	14	61	24	35	12
02/05/04	03/06/14	31	33	14	8	6	19	35	13
03/06/14	04/07/14	31	44	17	12	6	27	40	11
04/07/14	04/08/14	31	51	32	21	11	19	48	10
04/08/14	04/09/14	31	31	11	8	3	20	31	43
04/09/14	03/10/14	29	52	20	15	5	32	43	16
03/10/14	04/11/14	32	47	39	20	19	8	53	10
04/11/14	28/11/14	24	141	83	46	37	58	64	68
28/11/14	06/01/15	38	63	41	24	16	22	53	70
06/01/15	04/02/15	29	30	29	13	17	1	29	169
04/02/15	05/03/15	29	35	28	18	10	7	13	209
05/03/15	02/04/15	28	15	13	7	6	2	35	241
02/04/15	04/05/15	32	46	24	16	7	22	43	251
04/05/15	04/06/15	31	46	9	8	1	35	42	3
04/06/15	06/07/15	32	60	16	12	3	44	25	5
06/07/15	05/08/15	30	58	27	19	9	31	48	7
05/08/15	07/09/15	33	59	31	21	11	28	49	14
07/09/15	06/10/15	29	74	42	23	19	32	39	48
06/10/15	05/11/15	30	119	58	32	26	61	46	50
05/11/15	07/12/15	32	101	40	29	11	61	45	44
07/12/15	11/01/16	35	120	57	20	37	53	33	69

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 $mg/m^2/day$ (averaged over a one month period) to minimise dust nuisance impacts.

Table 19. Monthly deposited dust sampling results for the Fairfield (East) monitoring site from February 2014 to October 2015

Date deployed	Date collected	Days sampled	Deposition rate ($mg/m^2/day$)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
04/02/14	03/03/14	27	52	33	20	13	19	27	18
03/03/14	04/04/14	32	111	58	22	36	53	35	99
04/04/14	02/05/14	28	18	18	13	5	0	54	12
02/05/04	03/06/14	31	24	20	14	6	4	60	2
03/06/14	03/07/14	30	33	16	13	3	17	73	8
03/07/14	04/08/14	32	38	24	16	9	14	65	11
04/08/14	04/09/14	31	30	17	13	4	13	64	51
04/09/14	03/10/14	29	Invalid sample – sampling equipment vandalised						
03/10/14	04/11/14	32	39	36	17	20	3	34	13
04/11/14	28/11/14	24	109	83	56	26	26	22	82
28/11/14	06/01/15	38	34	34	20	14	0	36	80
06/01/15	04/02/15	29	27	23	11	12	4	40	141
04/02/15	05/03/15	29	19	17	9	7	2	41	116
05/03/15	02/04/15	28	33	15	8	7	18	42	137
02/04/15	04/05/15	32	42	24	13	11	18	66	160
04/05/15	04/06/15	31	Invalid sample – sampling equipment vandalised						
04/06/15	06/07/15	32	44	10	10	0	34	68	2
06/07/15	05/08/15	30	32	18	13	5	14	68	3
05/08/15	07/09/15	33	21	6	4	1	15	62	14
07/09/15	06/10/15	29	Invalid sample – sampling equipment vandalised						
06/10/15	05/11/15	30	Invalid sample – sampling equipment vandalised[b]						

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 $mg/m^2/day$ (averaged over a one month period) to minimise dust nuisance impacts.

[b] Due to repeated equipment vandalism, deposited dust sampling ceased at the Fairfield (East) site in November 2015.

Table 20. Monthly deposited dust sampling results for the Fairfield (West) monitoring site from February 2014 to December 2015

Date deployed	Date collected	Days sampled	Deposition rate (mg/m²/day)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
04/02/14	03/03/14	27	43	26	13	13	17	79	18
03/03/14	04/04/14	32	102	58	27	31	44	72	99
04/04/14	02/05/14	28	43	24	18	5	19	54	12
02/05/04	03/06/14	31	34	18	11	7	16	48	2
03/06/14	03/07/14	30	29	16	10	6	13	34	8
03/07/14	04/08/14	32	38	22	13	9	16	42	11
04/08/14	04/09/14	31	43	24	14	10	19	44	51
04/09/14	03/10/14	29	45	24	16	9	21	62	10
03/10/14	04/11/14	32	35	33	19	14	2	71	13
04/11/14	28/11/14	24	117	90	52	38	27	81	82
28/11/14	06/01/15	38	48	36	22	14	12	69	80
06/01/15	04/02/15	29	17	16	7	9	1	67	141
04/02/15	05/03/15	29	34	13	7	5	21	69	116
05/03/15	02/04/15	28	15	12	4	8	3	65	137
02/04/15	04/05/15	32	28	23	12	11	5	41	160
04/05/15	04/06/15	31	48	9	8	2	39	34	2
04/06/15	06/07/15	32	49	14	12	2	35	41	2
06/07/15	05/08/15	30	47	18	11	7	29	37	3
05/08/15	07/09/15	33	47	21	12	9	26	44	14
07/09/15	06/10/15	29	47	26	17	9	21	54	52
06/10/15	05/11/15	30	83	49	29	21	34	69	67
05/11/15	07/12/15	32	53	19	17	3	34	69	65
07/12/15	06/01/16	30	73	30	43	17	13	61	66

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.

Table 21. Monthly deposited dust sampling results for the Toowoomba (East) monitoring site from March 2014 to December 2015

Date deployed	Date collected	Days sampled	Deposition rate (mg/m²/day)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
13/03/14	04/04/14	22	131	112	77	35	19	14	185
04/04/14	05/05/14	31	319	28	20	8	291	33	40
05/05/04	02/06/14	28	41	23	13	10	18	17	3
02/06/14	02/07/14	30	50	30	23	7	20	48	25
02/07/14	04/08/14	33	36	26	20	7	10	52	14
04/08/14	01/09/14	27	35	19	17	3	16	35	29
01/09/14	07/10/14	36	39	23	16	7	16	39	18
07/10/14	05/11/14	29	61	51	24	27	10	31	15
05/11/14	03/12/14	28	87	46	30	15	41	24	56
03/12/14	06/01/15	33	98	59	47	12	39	22	259
06/01/15	03/02/15	28	62	33	23	10	29	25	38
03/02/15	04/03/15	29	38	32	23	10	6	6	39
04/03/15	08/04/15	35	85	53	26	27	32	26	66
08/04/15	06/05/15	28	76	51	35	16	25	46	139
06/05/15	02/06/15	27	41	19	16	3	22	53	7
02/06/15	09/07/15	37	33	16	12	5	17	31	18
09/07/15	04/08/15	26	40	39	32	7	1	48	15
04/08/15	03/09/15	30	70	40	31	9	30	51	36
03/09/15	06/10/15	33	57	36	28	8	21	31	19
06/10/15	06/11/15	31	60	49	28	21	11	9	107
06/11/15	02/12/15	26	89	45	27	18	44	14	60
02/12/15	07/01/16	36	87	53	27	26	33	9	132

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 mg/m²/day (averaged over a one month period) to minimise dust nuisance impacts.

Table 22. Monthly deposited dust sampling results for the Toowoomba (West) monitoring site from March 2014 to December 2015

Date deployed	Date collected	Days sampled	Deposition rate ($mg/m^2/day$)					Winds from rail corridor (%)	Rainfall (mm)
			Total solids	Insoluble solids[a]	Ash (mineral)	Combustible (organic) matter	Soluble solids		
13/03/14	04/04/14	22	44	42	28	13	2	83	185
04/04/14	05/05/14	31	163	29	23	6	134	62	40
05/05/04	02/06/14	28	39	25	18	7	14	77	3
02/06/14	02/07/14	30	49	34	25	10	15	46	25
02/07/14	04/08/14	33	50	44	36	9	6	45	14
04/08/14	01/09/14	27	54	35	30	5	19	57	29
01/09/14	07/10/14	36	35	24	19	5	11	62	18
07/10/14	05/11/14	29	65	54	44	10	11	70	15
05/11/14	03/12/14	28	179	136	77	58	43	79	56
03/12/14	06/01/15	33	47	43	30	14	4	79	259
06/01/15	03/02/15	28	85	43	23	20	42	72	38
03/02/15	04/03/15	29	67	29	20	9	38	86	39
04/03/15	08/04/15	35	84	59	34	25	25	74	66
08/04/15	06/05/15	28	95	25	19	7	70	51	139
06/05/15	02/06/15	27	48	29	25	4	19	44	7
02/06/15	09/07/15	37	64	20	17	3	44	62	18
09/07/15	04/08/15	26	74	45	36	9	30	50	15
04/08/15	03/09/15	30	74	40	30	10	34	48	36
03/09/15	06/10/15	33	124	92	69	23	32	67	19
06/10/15	06/11/15	31	109	97	55	42	12	93	107
06/11/15	02/12/15	26	265	185	64	121	80	88	60
02/12/15	07/01/16	36	60	40	23	17	20	91	132

[a] the DEHP Air Impacts Guideline recommends that the insoluble solids deposition rate not exceed 120 $mg/m^2/day$ (averaged over a one month period) to minimise dust nuisance impacts.

Table 23. Deposited dust particle composition analysis results for the Cannon Hill (North) site from February 2014 to September 2014

Sampling period	Sampling month							
	February 2014 (04/02/14 to 03/03/14)	**March 2014** (03/03/14 to 04/04/14)	**April 2014** (04/04/14 to 02/05/14)	**May 2014** (02/05/14 to 03/06/14)	**June 2014** (03/06/14 to 04/07/14)	**July 2014** (04/07/14 to 04/08/14)	**August 2014** (04/08/14 to 04/09/14)	**September 2014** (04/09/14 to 03/10/14)
Insoluble dust deposition rate (mg/m^2/day)	28	34	26	16	17	32	11	19
Winds from rail corridor (%)	62	68	37	39	65	57	72	59
Rainfall (mm)	16	122	12	13	11	10	43	16
Particle composition *(% projected area basis)*								
Black								
Coal	trace	trace	10	10	10	10	trace	15
Soot	trace	trace	trace	n.d.	10	trace	trace	trace
Black rubber dust	10	trace	trace	trace	10	5	n.d.	5
Inorganics and minerals								
Soil or rock dust	90	100	90	90	60	65	95	80
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	trace	trace	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	trace	trace	trace	trace	trace
Biological								
P/S slime and fungi	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	trace	n.d.	trace	trace	trace	n.d.	trace
Plant debris (general)	trace	trace	n.d.	trace	10	20	5	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	trace	trace	trace	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	trace	trace	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 24. Deposited dust particle composition analysis results for the Cannon Hill (North) site from October 2014 to May 2015

Sampling period	Sampling month							
	October 2014 (03/10/14 to 04/11/14)	**November 2014** (04/11/14 to 28/11/14)	**December 2014** (28/11/14 to 06/01/15)	**January 2015** (06/01/15 to 04/02/15)	**February 2015** (04/02/15 to 05/03/15)	**March 2015** (05/03/15 to 02/04/15)	**April 2015** (02/04/15 to 04/05/15)	**May 2015** (04/05/15 to 04/06/15)
Insoluble dust deposition rate (mg/m^2/day)	9	67	28	18	15	14	27	39
Winds from rail corridor (%)	48	36	48	71	88	67	62	63
Rainfall (mm)	10	68	70	169	209	241	251	3
Particle composition *(% projected area basis)*								
Black								
Coal	10	5	trace	5	trace	5	trace	trace
Soot	trace	trace	trace	n.d.	n.d.	2	trace	n.d.
Black rubber dust	5	trace	trace	trace	10	5	5	trace
Inorganics and minerals								
Soil or rock dust	80	85	95	90	70	83	75	70
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	5	trace	n.d.	n.d.	n.d.	n.d.	n.d.	5
Biological								
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20
Insect debris	trace	5	trace	n.d.	trace	trace	n.d.	5
Plant debris (general)	trace	5	trace	trace	20	5	20	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	n.d.	n.d.	n.d.	n.d.	trace	trace	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	trace	n.d.	trace	n.d.	n.d.
Plastic fragments	n.d.	n.d.	5	5	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 25. Deposited dust particle composition analysis results for the Cannon Hill (North) site from June 2015 to December 2015

Sampling period	Sampling month						
	June 2015 (04/06/15 to 06/07/15)	**July 2015** (06/07/15 to 05/08/15)	**August 2015** (05/08/15 to 07/09/15)	**September 2015** (07/09/15 to 06/10/15)	**October 2015** (06/10/15 to 05/11/15)	**November 2015** (05/11/15 to 07/12/15)	**December 2015** (07/12/15 to 06/01/16)
Dust deposition rate (mg/m^2/day)	22	24	30	35	55	32	27
Winds from rail corridor (%)	78	56	56	64	55	60	68
Rainfall (mm)	5	7	14	48	50	44	69
***Particle composition** (% projected area basis)*							
Black							
Coal	5	2	5	5	trace	trace	trace
Soot	10	n.d.	n.d.	trace	trace	n.d.	n.d.
Black rubber dust	5	5	5	trace	2	5	n.d.
Inorganics and minerals							
Soil or rock dust	80	73	70	65	78	60	60
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	n.d.	trace	10	trace
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	n.d.	trace	10	10	20	10
Plant debris (general)	10	20	20	20	10	5	30
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Paint	trace	n.d.	trace	n.d.	n.d.	trace	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 26. Deposited dust particle composition analysis results for the Cannon Hill (South) site from February 2014 to September 2014

Sampling period	Sampling month							
	February 2014 (04/02/14 to 03/03/14)	**March 2014** (03/03/14 to 04/04/14)	**April 2014** (04/04/14 to 02/05/14)	**May 2014** (02/05/14 to 03/06/14)	**June 2014** (03/06/14 to 04/07/14)	**July 2014** (04/07/14 to 04/08/14)	**August 2014** (04/08/14 to 04/09/14)	**September 2014** (04/09/14 to 03/10/14)
Insoluble dust deposition rate (mg/m^2/day)	24	29	75	14	17	32	11	20
Winds from rail corridor (%)	39	33	35	35	40	48	31	43
Rainfall (mm)	16	122	12	13	11	10	43	16
Particle composition *(% projected area basis)*								
Black								
Coal	5	trace	trace	10	5	5	trace	10
Soot	n.d.	n.d.	n.d.	trace	trace	trace	n.d.	trace
Black rubber dust	Trace	10	trace	5	10	10	trace	10
Inorganics and minerals								
Soil or rock dust	95	90	70	85	60	45	70	75
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	20	trace	trace	trace	trace	trace
Biological								
P/S slime and fungi	n.d.	n.d.	10	n.d.	5	10	n.d.	n.d.
Insect debris	trace	trace	trace	trace	trace	trace	n.d.	5
Plant debris (general)	trace	trace	trace	trace	20	30	30	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	trace	n.d.	n.d.	n.d.	n.d.	trace	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 27. Deposited dust particle composition analysis results for the Cannon Hill (South) site from October 2014 to May 2015

Sampling period	Sampling month							
	October 2014 (03/10/14 to 04/11/14)	**November 2014** (04/11/14 to 28/11/14)	**December 2014** (28/11/14 to 06/01/15)	**January 2015** (06/01/15 to 04/02/15)	**February 2015** (04/02/15 to 05/03/15)	**March 2015** (05/03/15 to 02/04/15)	**April 2015** (02/04/15 to 04/05/15)	**May 2015** (04/05/15 to 04/06/15)
Insoluble dust deposition rate ($mg/m^2/day$)	39	83	41	29	28	13	24	9
Winds from rail corridor (%)	53	64	53	29	13	35	43	42
Rainfall (mm)	10	68	70	169	209	241	251	3
Particle composition *(% projected area basis)*								
Black								
Coal	5	2	trace	trace	trace	trace	trace	trace
Soot	trace	trace	n.d.	n.d.	n.d.	trace	trace	trace
Black rubber dust	10	trace	n.d.	10	10	5	20	10
Inorganics and minerals								
Soil or rock dust	70	98	85	90	80	85	60	80
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	5	trace	n.d.	n.d.	n.d.	n.d.	n.d.	trace
Biological								
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	5	trace	trace	n.d.	trace	trace	n.d.	trace
Plant debris (general)	5	trace	10	trace	10	10	trace	10
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	n.d.	n.d.	n.d.	n.d.	trace	trace	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Plastic fragments	trace	n.d.	5	trace	n.d.	trace	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 28. Deposited dust particle composition analysis results for the Cannon Hill (South) site from June 2015 to December 2015

Sampling period	Sampling month						
	June 2015 (04/06/15 to 06/07/15)	**July 2015** (06/07/15 to 05/08/15)	**August 2015** (05/08/15 to 07/09/15)	**September 2015** (07/09/15 to 06/10/15)	**October 2015** (06/10/15 to 05/11/15)	**November 2015** (05/11/15 to 07/12/15)	**December 2015** (07/12/15 to 11/01/16)
Insoluble dust deposition rate (mg/m^2/day)	16	27	31	42	58	40	57
Winds from rail corridor (%)	25	48	49	39	46	45	33
Rainfall (mm)	5	7	14	48	50	44	69
Particle composition *(% projected area basis)*							
Black							
Coal	trace	5	2	4	5	trace	n.d.
Soot	5	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Black rubber dust	5	10	5	trace	10	10	10
Inorganics and minerals							
Soil or rock dust	55	65	63	66	70	60	10
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	15	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	n.d.	trace	5	trace
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	trace	n.d.
Insect debris	5	n.d.	trace	n.d.	10	trace	n.d.
Plant debris (general)	30	20	30	30	10	10	30
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	trace	n.d.	n.d.	n.d.	n.d.	trace	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	50
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 29. Deposited dust particle composition analysis results for the Fairfield (East) site from February 2014 to August 2014

Sampling period	Sampling month						
	February 2014 (04/02/14 to 03/03/14)	**March 2014** (03/03/14 to 04/04/14)	**April 2014** (04/04/14 to 02/05/14)	**May 2014** (02/05/14 to 03/06/14)	**June 2014** (03/06/14 to 04/07/14)	**July 2014** (04/07/14 to 04/08/14)	**August 2014** (04/08/14 to 04/09/14)
Insoluble dust deposition rate ($mg/m^2/day$)	33	58	18	20	16	24	17
Winds from rail corridor (%)	27	35	54	60	73	65	64
Rainfall (mm)	18	99	12	2	8	11	51
***Particle composition** (% projected area basis)*							
Black							
Coal	n.d.	trace	n.d.	trace	10	20	trace
Soot	n.d.	trace	n.d.	5	10	trace	n.d.
Black rubber dust	trace	n.d.	trace	10	10	10	10
Inorganics and minerals							
Soil or rock dust	95	100	100	85	60	60	90
Fly ash	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	trace	trace	trace	trace
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Insect debris	trace	n.d.	trace	n.d.	trace	trace	trace
Plant debris (general)	5	trace	trace	trace	10	20	trace
Plant debris (plant char)	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	trace	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 30. Deposited dust particle composition analysis results for the Fairfield (East) site from September 2014 to March 2015

Sampling period	Sampling month						
	September 2014 (04/09/14 to 03/10/14)	**October 2014** (03/10/14 to 04/11/14)	**November 2014** (04/11/14 to 28/11/14)	**December 2014** (28/11/14 to 06/01/15)	**January 2015** (06/01/15 to 04/02/15)	**February 2015** (04/02/15 to 05/03/15)	**March 2015** (05/03/15 to 02/04/15)
Insoluble dust deposition rate (mg/m^2/day)	Invalid sample (sampling equipment vandalised)	36	83	34	23	17	15
Winds from rail corridor (%)		34	22	36	40	41	42
Rainfall (mm)		13	82	80	141	116	137
Particle composition *(% projected area basis)*							
Black							
Coal	-	trace	2	trace	n.d.	trace	trace
Soot	-	trace	trace	5	n.d.	n.d.	2
Black rubber dust	-	trace	trace	2	trace	15	5
Inorganics and minerals							
Soil or rock dust	-	100	93	88	100	65	73
Fly ash	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	-	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Other mineral dust	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	-	trace	trace	n.d.	n.d.	trace	n.d.
Biological							
P/S slime and fungi	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	-	trace	5	5	trace	trace	n.d.
Plant debris (general)	-	trace	trace	trace	trace	20	20
Plant debris (plant char)	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	-	trace	n.d.	n.d.	n.d.	n.d.	trace
Starch	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	-	n.d.	trace	trace	trace	n.d.	n.d.
Red rubber dust	-	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 31. Deposited dust particle composition analysis results for the Fairfield (East) site from April 2015 to October 2015

Sampling period	Sampling month						
	April 2015 (02/04/15 to 04/05/15)	**May 2015** (04/05/15 to 04/06/15)	**June 2015** (04/06/15 to 06/07/15)	**July 2015** (06/07/15 to 05/08/15)	**August 2015** (05/08/15 to 07/09/15)	**September 2015** (07/09/15 to 06/10/15)	**October 2015** (06/10/15 to 29/10/15)
Insoluble dust deposition rate ($mg/m^2/day$)	24	Invalid sample (sampling equipment vandalised)	10	18	6	Invalid sample (sampling equipment vandalised)	Invalid sample (sampling equipment vandalised)
Winds from rail corridor (%)	66		68	68	62		
Rainfall (mm)	160		2	3	14		
***Particle composition** (% projected area basis)*							
Black							
Coal	trace	-	trace	2	5	-	-
Soot	trace	-	trace	n.d.	n.d.	-	-
Black rubber dust	5	-	5	5	10	-	-
Inorganics and minerals							
Soil or rock dust	95	-	60	68	65	-	-
Fly ash	n.d.	-	n.d.	n.d.	n.d.	-	-
Cement dust	n.d.	-	n.d.	n.d.	n.d.	-	-
Other mineral dust	n.d.	-	n.d.	n.d.	n.d.	-	-
Glass fragments	n.d.	-	n.d.	n.d.	n.d.	-	-
Copper sludge	n.d.	-	n.d.	trace	trace	-	-
Biological							
P/S slime and fungi	n.d.	-	n.d.	n.d.	n.d.	-	-
Insect debris	trace	-	trace	5	n.d.	-	-
Plant debris (general)	trace	-	30	20	20	-	-
Plant debris (plant char)	n.d.	-	n.d.	n.d.	trace	-	-
Plant debris (other)	n.d.	-	n.d.	n.d.	n.d.	-	-
General organic types							
Wood dust	n.d.	-	n.d.	n.d.	n.d.	-	-
Fibres (miscellaneous)	trace	-	trace	n.d.	n.d.	-	-
Starch	n.d.	-	n.d.	n.d.	n.d.	-	-
Paint	n.d.	-	5	n.d.	n.d.	-	-
Plastic fragments	n.d.	-	n.d.	n.d.	n.d.	-	-
Red rubber dust	n.d.	-	n.d.	n.d.	n.d.	-	-
n.d. = not detected							

Table 32. Deposited dust particle composition analysis results for the Fairfield (West) site from February 2014 to September 2014

Sampling period	Sampling month							
	February 2014 (04/02/14 to 03/03/14)	**March 2014** (03/03/14 to 04/04/14)	**April 2014** (04/04/14 to 02/05/14)	**May 2014** (02/05/14 to 03/06/14)	**June 2014** (03/06/14 to 04/07/14)	**July 2014** (04/07/14 to 04/08/14)	**August 2014** (04/08/14 to 04/09/14)	**September 2014** (04/09/14 to 03/10/14)
Insoluble dust deposition rate (mg/m^2/day)	26	58	24	18	16	22	24	24
Winds from rail corridor (%)	79	72	54	48	34	42	44	62
Rainfall (mm)	18	99	12	2	8	11	51	10
Particle composition *(% projected area basis)*								
Black								
Coal	n.d.	n.d.	10	trace	trace	trace	trace	n.d.
Soot	n.d.	n.d.	5	trace	trace	trace	n.d.	trace
Black rubber dust	5	trace	20	20	20	20	10	20
Inorganics and minerals								
Soil or rock dust	95	90	65	80	70	70	90	75
Fly ash	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	trace	trace	trace	trace	trace
Biological								
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	n.d.	trace	trace	n.d.	n.d.	trace	5
Plant debris (general)	trace	10	trace	trace	10	10	trace	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	trace
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 33. Deposited dust particle composition analysis results for the Fairfield (West) site from October 2014 to May 2015

Sampling period	Sampling month							
	October 2014 (03/10/14 to 04/11/14)	**November 2014** (04/11/14 to 28/11/14)	**December 2014** (28/11/14 to 06/01/15)	**January 2015** (06/01/15 to 04/02/15)	**February 2015** (04/02/15 to 05/03/15)	**March 2015** (05/03/15 to 02/04/15)	**April 2015** (02/04/15 to 04/05/15)	**May 2015** (04/05/15 to 04/06/15)
Insoluble dust deposition rate (mg/m^2/day)	33	90	36	16	13	12	23	9
Winds from rail corridor (%)	71	81	69	67	69	65	41	34
Rainfall (mm)	13	82	80	141	116	137	160	2
Particle composition *(% projected area basis)*								
Black								
Coal	trace	5	trace	n.d.	n.d.	trace	2	n.d.
Soot	trace	trace	trace	trace	trace	5	trace	trace
Black rubber dust	5	5	trace	n.d.	5	10	5	20
Inorganics and minerals								
Soil or rock dust	95	90	90	100	65	85	93	60
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	trace	trace	n.d.	n.d.	trace	n.d.	n.d.	trace
Biological								
P/S slime and fungi	n.d.	n.d.	5	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	trace	n.d.	trace	trace	trace	trace	trace
Plant debris (general)	trace	trace	5	trace	30	trace	trace	20
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	trace	trace	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 34. Deposited dust particle composition analysis results for the Fairfield (West) site from June 2015 to December 2015

Sampling period	Sampling month						
	June 2015 (04/06/15 to 06/07/15)	**July 2015** (06/07/15 to 05/08/15)	**August 2015** (05/08/15 to 07/09/15)	**September 2015** (07/09/15 to 06/10/15)	**October 2015** (06/10/15 to 05/11/15)	**November 2015** (05/11/15 to 07/12/15)	**December 2015** (07/12/15 to 11/01/16)
Insoluble dust deposition rate (mg/m^2/day)	14	18	21	26	49	19	30
Winds from rail corridor (%)	41	37	44	54	69	69	61
Rainfall (mm)	2	3	14	52	67	65	66
***Particle composition** (% projected area basis)*							
Black							
Coal	n.d.	5	5	trace	trace	15	n.d.
Soot	5	n.d.	n.d.	n.d.	trace	n.d.	n.d.
Black rubber dust	10	20	10	10	trace	10	trace
Inorganics and minerals							
Soil or rock dust	65	50	65	65	85	65	100
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	5	trace	n.d.	trace	trace	trace
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	n.d.	trace	20	5	5	trace	n.d.
Plant debris (general)	20	20	trace	20	10	10	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	trace
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 35. Deposited dust particle composition analysis results for the Toowoomba (East) site from March 2014 to September 2014

Sampling period	Sampling month						
	March 2014 (13/03/14 to 04/04/14)	**April 2014** (04/04/14 to 05/05/14)	**May 2014** (05/05/14 to 02/06/14)	**June 2014** (02/06/14 to 02/07/14)	**July 2014** (02/07/14 to 04/08/14)	**August 2014** (04/08/14 to 01/09/14)	**September 2014** (01/09/14 to 07/10/14)
Insoluble dust deposition rate (mg/m^2/day)	112	28	23	30	26	19	23
Winds from rail corridor (%)	14	33	17	48	52	35	39
Rainfall (mm)	185	40	3	25	14	29	18
Particle composition *(% projected area basis)*							
Black							
Coal	trace	n.d.	trace	trace	n.d.	20	trace
Soot	n.d.	trace	n.d.	trace	trace	n.d.	trace
Black rubber dust	trace	10	trace	20	10	trace	10
Inorganics and minerals							
Soil or rock dust	100	90	100	70	80	80	90
Fly ash	trace	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	trace	trace	trace	n.d.	n.d.	trace	trace
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	trace	trace	trace	trace	trace	trace
Plant debris (general)	trace	trace	trace	10	10	trace	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 36. Deposited dust particle composition analysis results for the Toowoomba (East) site from October 2014 to May 2015

Sampling period	Sampling month							
	October 2014 (07/10/14 to 05/11/14)	**November 2014** (05/11/14 to 03/12/14)	**December 2014** (03/12/14 to 06/01/15)	**January 2015** (06/01/15 to 03/02/15)	**February 2015** (03/02/15 to 04/03/15)	**March 2015** (04/03/15 to 08/04/15)	**April 2015** (08/04/15 to 06/05/15)	**May 2015** (06/05/15 to 02/06/15)
Insoluble dust deposition rate (mg/m^2/day)	51	46	59	33	32	53	51	19
Winds from rail corridor (%)	31	24	22	25	6	26	46	53
Rainfall (mm)	15	56	259	38	39	66	139	7
Particle composition *(% projected area basis)*								
Black								
Coal	trace	5	5	n.d.	trace	5	n.d.	n.d.
Soot	trace	trace	2	trace	trace	trace	trace	5
Black rubber dust	trace	5	2	trace	5	5	5	20
Inorganics and minerals								
Soil or rock dust	100	60	91	90	93	80	75	65
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	trace	trace	n.d.	n.d.	2	n.d.	n.d.	trace
Biological								
P/S slime and fungi	n.d.	10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	10	n.d.	10	trace	5	10	5
Plant debris (general)	trace	10	trace	n.d.	trace	5	10	5
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	n.d.	n.d.	n.d.	n.d.	trace	trace	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 37. Deposited dust particle composition analysis results for the Toowoomba (East) site from June 2015 to December 2015

Sampling period	Sampling month						
	June 2015 (02/06/15 to 09/07/15)	**July 2015** (09/07/15 to 04/08/15)	**August 2015** (04/08/15 to 03/09/15)	**September 2015** (03/09/15 to 06/10/15)	**October 2015** (06/10/15 to 06/11/15)	**November 2015** (06/11/15 to 02/12/15)	**December 2015** (02/12/15 to 07/01/16)
Insoluble dust deposition rate (mg/m^2/day)	16	39	40	36	49	45	53
Winds from rail corridor (%)	31	48	51	31	9	14	9
Rainfall (mm)	18	15	36	19	107	60	132
Particle composition *(% projected area basis)*							
Black							
Coal	5	5	2	n.d.	trace	trace	trace
Soot	5	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Black rubber dust	5	20	5	n.d.	n.d.	10	n.d.
Inorganics and minerals							
Soil or rock dust	55	50	83	70	65	70	40
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	trace	trace	trace	n.d.	trace	trace	10
Biological							
P/S slime and fungi	n.d.	n.d.	n.d.	n.d.	30	n.d.	30
Insect debris	trace	trace	n.d.	20	5	10	10
Plant debris (general)	30	25	10	10	trace	10	10
Plant debris (plant char)	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	trace	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 38. Deposited dust particle composition analysis results for the Toowoomba (West) site from March 2014 to September 2014

Sampling period	Sampling month						
	March 2014 (13/03/14 to 04/04/14)	**April 2014** (04/04/14 to 05/05/14)	**May 2014** (05/05/14 to 02/06/14)	**June 2014** (02/06/14 to 02/07/14)	**July 2014** (02/07/14 to 04/08/14)	**August 2014** (04/08/14 to 01/09/14)	**September 2014** (01/09/14 to 07/10/14)
Insoluble dust deposition rate (mg/m^2/day)	42	29	25	34	44	35	24
Winds from rail corridor (%)	83	62	77	46	45	67	62
Rainfall (mm)	185	40	3	25	14	29	18
***Particle composition** (% projected area basis)*							
Black							
Coal	trace	trace	trace	trace	trace	10	5
Soot	n.d.	trace	trace	trace	trace	n.d.	n.d.
Black rubber dust	n.d.	10	10	10	10	10	10
Inorganics and minerals							
Soil or rock dust	90	85	90	70	80	80	80
Fly ash	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	trace	trace	trace	trace	trace	trace	trace
Biological							
P/S slime and fungi	trace	5	n.d.	n.d.	n.d.	n.d.	n.d.
Insect debris	trace	trace	trace	trace	n.d.	trace	5
Plant debris (general)	10	trace	trace	20	10	trace	n.d.
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	trace	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							

Table 39. Deposited dust particle composition analysis results for the Toowoomba (West) site from October 2014 to May 2015

Sampling period	Sampling month							
	October 2014 (07/10/14 to 05/11/14)	**November 2014** (05/11/14 to 03/12/14)	**December 2014** (03/12/14 to 06/01/15)	**January 2015** (06/01/15 to 03/02/15)	**February 2015** (03/02/15 to 04/03/15)	**March 2015** (04/03/15 to 08/04/15)	**April 2015** (08/04/15 to 06/05/15)	**May 2015** (06/05/15 to 02/06/15)
Insoluble dust deposition rate (mg/m^2/day)	54	136	43	43	29	59	25	29
Winds from rail corridor (%)	70	79	79	72	86	74	51	44
Rainfall (mm)	15	56	259	38	39	66	139	7
Particle composition *(% projected area basis)*								
Black								
Coal	5	n.d.	trace	5	n.d.	2	n.d.	n.d.
Soot	trace	n.d.	trace	n.d.	n.d.	5	trace	trace
Black rubber dust	5	n.d.	trace	trace	5	trace	5	10
Inorganics and minerals								
Soil or rock dust	50	40	100	85	85	79	95	80
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	20	10	n.d.	n.d.	n.d.	n.d.	n.d.	trace
Biological								
P/S slime and fungi	20	20	n.d.	n.d.	n.d.	2	n.d.	n.d.
Insect debris	trace	20	trace	trace	trace	2	n.d.	5
Plant debris (general)	trace	10	trace	trace	10	10	n.d.	5
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types								
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	trace	trace	n.d.	10	n.d.	n.d.	trace	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	n.d.	n.d.	n.d.	n.d.	n.d.	trace	n.d.	n.d.
Plastic fragments	n.d.	n.d.	trace	n.d.	n.d.	n.d.	trace	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected								

Table 40. Deposited dust particle composition analysis results for the Toowoomba (West) site from June 2015 to December 2015

Sampling period	Sampling month						
	June 2015 (02/06/15 to 09/07/15)	**July 2015** (09/07/15 to 04/08/15)	**August 2015** (04/08/15 to 03/09/15)	**September 2015** (03/09/15 to 06/10/15)	**October 2015** (06/10/15 to 06/11/15)	**November 2015** (06/11/15 to 02/12/15)	**December 2015** (02/12/15 to 07/01/16)
Insoluble dust deposition rate (mg/m^2/day)	20	45	40	92	97	185	40
Winds from rail corridor (%)	62	50	48	67	93	88	91
Rainfall (mm)	18	15	36	19	107	60	132
***Particle composition** (% projected area basis)*							
Black							
Coal	trace	trace	trace	5	n.d.	trace	trace
Soot	trace	n.d.	n.d.	5	n.d.	n.d.	n.d.
Black rubber dust	20	5	10	trace	5	n.d.	n.d.
Inorganics and minerals							
Soil or rock dust	70	75	65	55	60	20	80
Fly ash	n.d.	n.d.	n.d.	n.d.	n.d.	trace	n.d.
Cement dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Other mineral dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Glass fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Copper sludge	n.d.	trace	trace	10	trace	30	trace
Biological							
P/S slime and fungi	10	n.d.	n.d.	n.d.	30	40	20
Insect debris	trace	n.d.	5	5	5	n.d.	trace
Plant debris (general)	trace	20	20	20	trace	10	trace
Plant debris (plant char)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Plant debris (other)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
General organic types							
Wood dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Fibres (miscellaneous)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Starch	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Paint	trace	trace	n.d.	n.d.	n.d.	n.d.	n.d.
Plastic fragments	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Red rubber dust	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
n.d. = not detected							