Inhalable Mine Dust Restriction Review

Final Report

School of Public Health
University of Illinois Chicago

13 April 2025

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UNIVERSITY OF ILLINOIS AT CHICAGO

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Executive Summary

The University of Illinois Chicago (UIC) School of Public Health was engaged by Coal Services Health (CSH) to undertake an independent review of the guidelines for returning workers with coal mine dust lung disease (CMDLD) and other lung diseases to work. The focus of this work is inhalable mine dust permissible exposure levels given difficulties the industry has had in complying with the current guidelines adopted from Queensland. The independent review was a recommendation of, and overseen by, a committee formed by CSH and representatives of the NSW coal industry.

The review team examined previously published research and scientific guidelines relating to measurement of inhalable dusts and smaller dust fractions, as well as the effects occupational exposures have on respiratory health. We note that non-respiratory health effects of these dusts were not included in the review. The review team was also provided with inhalable and respirable dust measurements for NSW and Queensland coal mines, and relevant health data for NSW coal mine workers to consider potential impacts of the approach to inhalable dust in NSW coal mines on the worker population. The following are the major points which arose from the review:

- Inhalable dust refers to all particle sizes which may be inhaled into the upper respiratory tract and beyond, including the smaller particle sizes comprising the respirable and thoracic fractions. Most of the literature on the health effects of dust has been focused on the respirable fraction given the ability of these particles to penetrate most deeply into the lung. There is a robust body of literature describing the respiratory health effects associated with elevated respirable coal mine dust and respirable crystalline silica dust levels.
- Most studies on lower respiratory disease from inhalable dust have been conducted on dusts not otherwise regulated (i.e. dusts with no specific exposure limits), and have not focused on coal mine dust. The most significant health outcome that has been associated with exposure to these “non-toxic” or low-toxicity inhalable dusts is the development of chronic bronchitis and chronic obstructive pulmonary disease (COPD). We did not include literature relating to upper respiratory tract effects such as chronic sinusitis.
- There are few studies investigating the health effects of inhalable coal mine dust as distinct from the respirable dust fraction. Further, there is no information on the respiratory health effects of elevated inhalable fraction of coal mine dust in cases where the respirable fraction is controlled.
- Our review focused on the documented respiratory effects of coal mine dust exposure and not other disorders such as lung cancer or allergy. More research is needed to better understand the effects of inhalable dust exposure on the development of these diseases as well as any systemic effects.
- The recommendations contained in the Workers’ Compensation Regulatory Services Queensland (WCRSQ) guidelines specify reduced levels of coal mine dust exposure for workers who have evidence of varying degrees of CMDLD and/or non-occupational lung

disease. The criteria for reduced dust exposure and enhanced surveillance are based on the degree of pulmonary function impairment in the forced expiratory volume in one second (FEV_1) or lung diffusing capacity for carbon monoxide (D_{LCO}), and/or the presence of pneumoconiosis on chest imaging. The reduced exposure limits for inhalable dust are the most stringent of the recommended restrictions for dust exposure in the WCRSQ guidelines, more stringent than those for respirable coal dust and respirable crystalline silica.

- Workplace wind speed is a crucial factor in determining inhalability of dust particles but has been largely overlooked by many researchers. Likely, this is due to the fact that few workplaces outside of mining are subject to high wind speed conditions. However, accounting for wind speed is critical for measurements of inhalable dust particularly in underground coal mines.
- The Institute of Occupational Medicine (IOM) dust sampler, which is employed for sampling in NSW coal mines, is a reliable tool for monitoring airborne particulate matter in the inhalable particle size range at typical workplace wind speeds (0.5-4 m/s). However, its performance as a "blunt sampler" leads to deviations from International Organisation for Standardisation (ISO) conventions for larger particles at high wind speeds (>4 m/s). The applicability of inhalable dust exposure measurements taken in conditions of high wind speeds may be subject to question, particularly when there is an abundance of particles >50 micrometres (µm) in aerodynamic diameter.
- Large particles in aerosol samples are particularly sensitive to external flow fields, making proper orientation critical for inhalable samplers. Vertical positioning of the sampler is crucial for obtaining unbiased results. If the sampler orientation deviates from the vertical position, it is susceptible to entraining larger particles that are falling from the mine roof or other overhead sources and may yield spurious results.
- A review of previously published research literature suggests marked variability in the ratios of inhalable dust to respirable dust in coal mines.
- Analysis of a limited sample of data from the NSW Health Surveillance Scheme for Coal Mine Workers showed very few workers would likely require reduced dust exposure limits for findings of abnormal chest x-rays identified by CSH readers. Less than 0.5% of workers in the sample had abnormal findings that would require further follow up with advanced imaging. Fewer than 10% of referrals for advanced imaging with high resolution CT (HRCT) were made due to chest x-rays demonstrating opacities consistent with pneumoconiosis. Of the 16 cases with HRCT results available for evaluation by the review team, fewer than one-third had findings that were thought likely related to occupational exposure. Of note, given the data provided and our mandate, it was beyond the scope of this project to perform a review the quality of surveillance and ILO classifications of chest images.
- Results of a sample of respiratory physiology test data showed a greater prevalence of impairment in open cut workers than in underground workers. Overall, 5.3% of spirometry studies reviewed had abnormal reductions in FEV_1, with two-thirds of abnormal cases occurring in open cut workers. Two-thirds of workers with more severe levels of FEV_1 impairment worked in open cut settings. Among a sample of workers

referred for complex lung function testing due to abnormal findings in the Scheme, only 3/207 (1.4%) had impairment of D_{LCO}, all of whom had mild impairment. Of these, all were open cut workers.

- Review of data from a sample of coal mine workers placed on dust restriction (n=62) revealed that two-thirds had been referred due to abnormal lung function. Thirty-one workers had been placed on “mild” dust restrictions, 26 on “moderate” restrictions, and 5 entirely excluded from dust exposure. Of those with a finalised evaluation, fewer than 20% were felt by the respiratory physician to have an occupational contribution to their lung disease.
- Based on review of a sample of workers referred for evaluation by respiratory physicians between 2022 and 2024, CSH has referred more workers for a respiratory physician evaluation since the time of the UIC Review of the NSW Health Surveillance Scheme for Coal Mine Workers.[1]

Recommendations

The following recommendations are of primary importance:

1) Based on the available scientific evidence, we are unable to recommend that reduced inhalable dust exposure limits be used as a criterion for returning coal mine workers with occupational or non-occupational lung disease to the workplace in NSW. However, we acknowledge that larger dust fractions (e.g., thoracic dust) have been predictive of chronic lung disease in some research studies in the non-coal mining sector. A review of the current scientific literature does not provide sufficient evidence to support the use of reduced inhalable mine dust exposure limits as an additional predictor of reduced risk of coal mine dust lung disease when respirable coal mine and crystalline silica dust are controlled as per existing guidelines. This should not be construed as a recommendation that inhalable dust sampling should be discontinued and that inhalable dust exposures should not be regulated.
2) Consider continuing to sample inhalable dust in areas where there is a predominance of dust particles not otherwise regulated such as alkaline dust from spraying cements, metals, or where there is the presence of particulate matter with local irritant or systemic toxicity.

Directions for Future Study and Continuing Education

1) Consider side-by-side sampling of respirable and inhalable dust to better understand the variability in the ratios of these particle fractions and the conditions which may contribute to this variability.

2) Consider research studies evaluating particle size distributions within total coal mine dust samples to provide datasets that may be used to evaluate the additional predictive value of various particle size fractions (e.g., the thoracic fraction) on respiratory health.
3) Research alternative methods (e.g., isokinetic sampling) for the collection of inhalable dust in underground mines to avoid confounding by large particles transported by high wind speeds.
4) In order to ensure appropriate referrals of workers for reduced dust exposure limits, consider additional ongoing quality assurance review of health surveillance.
    - Review by external B-readers of an appropriate sample of negative ILO-classified chest x-ray images (0/-, 0/0, 0/1) of long-tenured workers to evaluate the negative predictive value of the ILO classifications.
    - Review by external B-readers of all positively classified ILO chest x-ray images (1/0 or greater) with corresponding HRCT images to determine positive predictive value of the original ILO classifications.
    - External review of the quality of a sample of CSH internal and external spirometry and D_{LCO} testing by a respiratory panel, similar to the recent audit performed by RSHQ, "Early detection of occupational lung disease through ensuring quality spirometry"[2] as well as ongoing training and quality assurance of providers by a respiratory scientist.
    - Consider partnering with the Thoracic Society of Australia and New Zealand or the Lung Foundation of Australia to develop continuing education for respiratory physicians to improve the use of primary data in reaching diagnoses of occupational and non-occupational lung disease in this at-risk population of coal mine workers.

Introduction

Background

In 2021, investigators from the University of Illinois Chicago (UIC) School of Public Health had been engaged by the NSW Government (NSW Resources Regulator) to undertake an independent quality assurance review of the NSW Health Surveillance Scheme for Coal Mine Workers (the Scheme) as the result of a recommendation of, and with oversight by, the NSW Mine Safety Advisory Council. This was completed in February 2023. Recommendation 14 of this review was to ***"establish formal criteria to return workers with early CMDLD*** [coal mine dust lung disease] ***or other non-occupational lung diseases to work, or removal from exposure for those with more advanced disease."*** The only available guideline at the time was that used by Workers' Compensation Regulatory Services Queensland (WCRSQ), "Returning workers with mine dust lung diseases to the workplace."[3] This guideline had been developed by an expert committee of respiratory and occupational health physicians to provide recommendations for modifying dust exposures for affected workers, and included enhanced health surveillance and tiered recommendations for reduced exposure limits for respirable coal mine dust (RCD), respirable crystalline silica (RCS), and inhalable mine dust (IMD). The level of reduction in the exposure limits was determined by the degree of impairment in pre-bronchodilator forced expiratory volume in one second (FEV_1) values from spirometry, lung diffusing capacity for carbon monoxide (D_{LCO}), or the presence of abnormal chest imaging findings consistent with pneumoconiosis. These guidelines were to be applied to individuals with lung disease, regardless of the contribution of occupational and non-occupational exposures.

In NSW, Coal Services Health (CSH) initiated a plan to adapt the use of the WCRSQ guideline, but it became apparent that the WCRSQ guidelines on restrictions for exposure to inhalable dust were difficult for some mine operators to achieve, especially in underground mining operations. This had the unintended result that many mine workers with mild impairments might be excluded from return to work due to inhalable mine dust levels, despite a mine's ability to meet the reduced limits for RCD and RCS. In August 2024, Coal Services Pty Limited engaged UIC to review the impacts of the proposed inhalable mine dust restrictions.

Objective of the Review

The review team was tasked with reviewing the current WCSRQ guidelines for inhalable mine dust, the current sampling technologies and their strengths and limitations, current data on inhalable mine dust in surface and underground coal mine operations in NSW, the impact of inhalable mine dust restrictions on the population of NSW miners with lung disease, and the feasibility of current dust controls for inhalable mine dust to achieve exposure limits that would allow workers with coal mine dust lung disease to return to work.

Data Security

To protect the health-related information evaluated during the review, all records were de-identified. CSH accessed and extracted health data for this review from their records. These data were de-identified through redaction or encoding of identifiers including the name and address. The de-identified data were sent to UIC via password-protected cloud-based file transfer services. Access to the de-identified data was limited to the review team.

Coal Mining in New South Wales

Major coal deposits in NSW range in rank from bituminous metallurgical and thermal coals to sub-bituminous thermal coals. As of June 2024, there were 36 coal mines in operation in NSW, 19 open cut mines and 17 underground mines.[4] These 36 mines directly employed a total of 25,500 coal mine workers (source: Coal Services Pty Ltd). Data shows 14,750 workers in Hunter, 3,116 in Gunnedah, 3,585 in Western NSW, and 3,344 in Southern NSW.[5]

Respiratory Health Effects of Inhalable Dust

Inhalable dust refers to all particle sizes which may be inhaled into the upper respiratory tract and beyond, including the smaller particle sizes comprising the respirable and thoracic fractions. Most of the literature on the health effects of dust have been focused on the respirable fraction given the ability of these particles to penetrate most deeply into the lung. There is a robust body of literature describing the health effects associated with elevated respirable coal mine dust and respirable crystalline silica dust levels. The spectrum of disease associated with higher cumulative respirable dust exposure ranges from fibrotic lung diseases, including classic pneumoconiosis such as coal workers' pneumoconiosis and mixed-dust pneumoconiosis; dust-related diffuse fibrosis; obstructive lung diseases including chronic obstructive pulmonary disease (COPD), emphysema, chronic bronchitis; lung function impairment; and malignant respiratory disease. This vast body of literature clearly demonstrates the relationship between coal mine dust exposure and these diseases, identifying dose-response relationships where the total cumulative estimated dose of respirable coal mine dust has been compared to the development of disease outcomes. We will not review this body of evidence here but refer the readers to excellent review articles and chapters in medical textbooks on this subject.[6–13]

There is less information on the specific health effects of the larger particle size fractions of coal mine dust, including those in the thoracic dust fraction, and the larger particles that are measured in the inhalable dust fraction. As noted above, there is no literature demonstrating inhalable dust levels are a risk factor for mine dust lung disease independent of respirable dust levels.

Inhalable and Thoracic Coal Mine Dust Studies

There are few studies investigating the health effects of inhalable coal mine dust as distinct from the respirable dust fractions. The majority of studies in the medical literature on the health effects of inhalable dust relate to dusts not otherwise regulated or specified. However, one early study evaluated the health effects of "total" dust vs. respirable dust. This was published by Dr. A.J. Cowie et. al. for the Institute of Medicine and published in 1981.[14] The authors attempted to determine if the fraction of coal mine dust which contained larger particles would be a better indicator of risk of chronic bronchitis, utilizing data from the first 10 years of the Pneumoconiosis Field Research trial of the British National Coal Board. They measured particle sizes and numbers for a small number of dust samples, and then extrapolated this to other dust samples. They then used this to derive total dust and respirable dust concentrations and cumulative dust exposures for individual workers based on the job-exposure matrices of individual workers. The outcome measures were the FEV_1 on spirometry and respiratory symptoms of cough and phlegm, dyspnoea, and recent chest illness. Controlling for age, smoking, and physique, the investigators found that the association between "total" dust volume or mass concentrations and indicators of respiratory disease did not differ significantly from associations identified using the respirable mass concentrations.

The German Committee for the determination of occupational exposure limits evaluated the relationship between fine (respirable) dust and total dust and the development of chronic bronchitis in mines.[15] They noted:

> *"It is conspicuous that the relationship between fine dust and total dust in mining is on average 1:7 whereas it lies in the range 1:3 to 1:4 in the other industries. Forced ventilation in mines results in underground wind speeds of 5 m/s and more, which have the effect that even large particles (> 15 µm) remain in suspension for long distances from the source of dust and so are included in the dust measured. Although some of these large particles do get inspired, they are deposited almost entirely in the upper airways and cannot reach the bronchial region. Total dust is therefore not as suitable for the determination of the chronic bronchitis risk as fine dust which is much more closely related to the dust fraction which is deposited in the tracheobronchial region. This conclusion has also been confirmed in more recent studies on the deposition of dusts in various regions of the respiratory tract."*[16]

Studies of Health Effects of Inhalable Dust Outside of Coal Mining

The majority of studies on inhalable dust have been conducted on dusts not otherwise regulated to have specific exposure limits. The most significant health outcome associated with exposure to "non-toxic" or low-toxicity inhalable dusts is the development of chronic bronchitis and chronic obstructive pulmonary disease (COPD). These dusts include amorphous silica, silicon, silicon carbide, pulverized fuel ash, limestone, gypsum, graphite, aluminium oxide, titanium dioxide, polyvinyl chloride, other mineral dusts with low crystalline silica content, and organic dusts free of harmful bacteria.[17]

There is no doubt that dusts that are not specifically regulated may contribute to the development of lung disease, and that these occur in varying proportions in coal mine dust. The US National Institute for Occupational Safety and Health (NIOSH) "Criteria for a Recommended Standard: Occupational Exposure to Respirable Coal Mine Dust" reviewed data on *respirable* particulate from test toner which produced lung fibrosis and chronic inflammation in rats.[18] Cullen et al. evaluated low-toxicity dusts including TiO_2 and $BaSO_4$ also in the respirable size range and found inflammation and fibrosis in rats exposed to photocopier toner.[19] These studies did not use the inhalable fraction of these dusts to show significant health effects.

Nordby et al.[20] studied a cohort of cement dust-exposed workers and found a significant relationship between high thoracic dust (which includes respirable dust) exposure and airflow limitation as measured by reduced FEV_1. Higher dust exposures were also associated with higher odds ratios of respiratory symptoms. In a follow-up study, they noted that levels of cement dust in the thoracic particle range were also associated with longitudinal lung function decline in their cohort.[21] In a companion study, they measured the ratios of respirable/thoracic, total/thoracic, and inhalable/thoracic fractions to estimate the levels associated with a significant effect on lung function.[22] These studies did not attempt to separate out the predictive value or relative contribution of these different fractions to the development of respiratory disease.

A study of Greek cement production workers showed a high prevalence of reduced FEV_1 and respiratory symptoms.[23] The authors took only 14 samples of total dust and 22 samples of respirable dust, apparently at the time of the study, finding one total dust sample exceed the Greek threshold limit level for total dust; there was no estimation of cumulative dust exposures. The authors concluded that workers the elevated prevalence of reduced FEV_1 and respiratory symptoms occurred “despite” total and inhalable dust levels below occupational exposure limits. They did not compare the predictive value of respirable dust exposure vs. inhalable or total dust exposure.

A study of longshoremen and dock workers evaluated their exposure to coal and coke dusts as well as smaller amounts of phosphate ore, alumina, sulphur, and vermiculite. The authors focused mainly on respirable dust but also had a smaller sample of inhalable particle size ranges. They found that reductions in lung function did not really differ at median inhalable dust levels when compared to median respirable dust levels.[24]

Gardiner et al. studied the respiratory health effects of carbon black exposure using inhalable dust measurements as their main exposure variable. They found significant associations between current and cumulative exposure to increasing levels of inhalable carbon black dust and respiratory symptoms and impaired lung function as measured by spirometric variables.[25] This study also did not assess the relative contributions of respirable vs. inhalable dust. Rather, the authors used cumulative inhalable dust as the exposure variable and found a relationship between carbon black exposure and obstructive impairment.

Franzinelli et al.[26] studied lung function impairment in pyrite (iron sulphide) miners in Tuscany, Italy. They sampled simultaneously for inhalable and respirable dust, and calculated quartz content. They also measured diesel exhaust exposure as calculated from carbon monoxide, nitrogen dioxide, and sulphur dioxide levels. This was done for three different exposure groups and a control group. They used spirometry, diffusion capacity for carbon monoxide, lung volume measurements, and presence of chronic bronchitis symptoms as their outcome measures. They found quartz content to range from 1.6% to 1.8% of total respirable dust. The most exposed workers had an average exposure of 1.04 mg/m^3 of inhalable dust and 0.60 mg/m^3 of respirable dust with an average of 1.5% quartz in both size fraction groups. Unfortunately, the authors did not analyse the predictive value of measuring inhalable versus respirable dust in relation to any of their health outcome measures.

Lotz et al.[27] studied potash miners exposed to salt dusts, nitrogen oxides, and diesel exhaust. Their outcome measures were also chest symptoms and spirometric measures of lung function. They found a relationship between exposure and chronic bronchitis symptoms in only one mine and did not isolate the effects of the component exposures.

Meijer et al.[28] studied inhaled dust and fumes in rubber workers. They found a decrease in lung function as demonstrated by reductions in the ratio of FEV_1 to the forced vital capacity (FVC), maximal mid-expiratory flow, and maximal expiratory flow at 50% of FVC were associated with 10 years of exposure to an average of 2.0 mg/m^3 inhalable dust. They also did not separately analyse the effects of inhalable versus respirable dust.

Abramson et al.[29] studied aluminium smelter workers, investigating inhalable dust as well as sulphur dioxide and fluoride exposure. They found that sulphur dioxide and, less strongly, fluoride were associated with symptoms and physiologic features of asthma. Inhalable dust and benzene soluble fraction were associated with symptoms and bronchial hyper-responsiveness. They did not measure respirable dust to determine any separate predictive value of this particle size fraction and noted that levels of all the assessed exposures were highly correlated.

Inhalable Dust Definitions and Sampling Conventions

Range of Dust Particulate Sizes

The size of particles in the air typically ranges from a few nanometres (nm) to >100 micrometres (µm) in diameter. When we breathe, these particles can enter the respiratory system, with a path that begins in the upper airway when air is inspired through the nose and mouth. The respiratory system functions like a multi-stage filter, capturing particles through three main mechanisms: inertial impaction, where larger particles are trapped in the upper airways because they cannot follow the changing direction of airflow; sedimentation, where particles settle in the lungs over time due to gravity; and diffusion, where very fine particles move into the alveolar region due to their small size and high surface area-to-volume ratio.

In occupational health, it is common practice to divide the respiratory system into three regions to help assess how deeply particles of different sizes can travel without being captured. These regions are as follows (See **Figure 1**):

1. **Upper airway (depth 1) – Inhalable fraction:** These are particles that enter through the nose and mouth. The particles may deposit in the nose, mouth and throat, but also include the fractions of smaller particles that may penetrate beyond the upper airway.
2. **Lower airways (depth 2) – Thoracic fraction:** This refers to particles that can penetrate past the glottis separating the upper airway from the lower airway. The particles may deposit in the trachea, bronchi, and bronchioles, but also includes the fraction of smaller particles that may penetrate beyond.
3. **Alveoli (depth 3) – Respirable fraction:** These particles are small enough to penetrate into the deepest, gas exchanging region of the lung, including terminal bronchioles and alveoli.

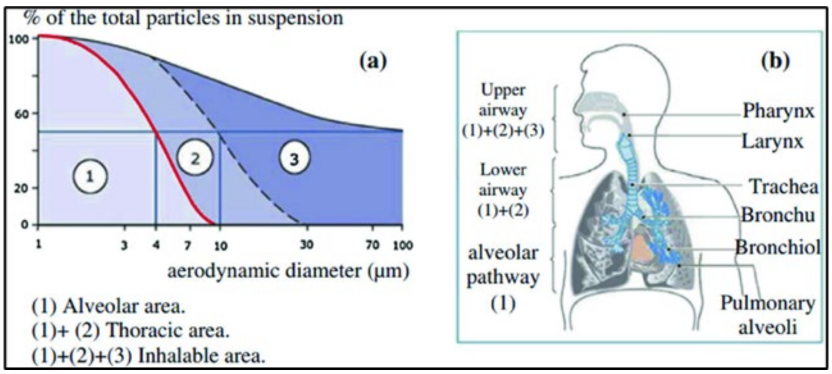

Figure 1 – (a) Sampling efficiency of the inhalable, thoracic and respirable conventions by particle aerodynamic diameter as percentages of total airborne particles in suspension. (b) Illustration of the human respiratory tract and idealised model of penetration by particle size fraction. [12]

ISO Report No. 7708:1995,[30] titled "Air quality - Particle size fraction definitions for health-related sampling," defines sampling conventions for measuring the mass concentration of particles in these three size fractions. These conventions are used to assess the potential health effects of airborne particles in the workplace and ambient environment. However, the conventions are approximations of respiratory tract behaviour, and the following assumptions should be noted:

- The inhalable fraction represents all particles suspended in air and as such should be viewed as a complex mixture of the three fractions which changes over time and distance from the source. An inhalable fraction of a given overall mass consisting of predominantly fine particles would contain a larger dose of particles capable of entering the lung than an equivalent inhalable fraction mass consisting of coarse particles.
- The inhalable fraction depends on the subject's minute ventilation (volume of air breathed per minute); use of oral, nasal, or oronasal breathing; and the speed and direction of the air movement surrounding the subject. The values given in the inhalable convention are based on average inspiratory flow rates and wind directions. It is noteworthy that the inhalable convention underestimates the fraction of larger particles at

higher wind speeds, such as when a subject faces into the wind with resulting higher inspiratory flow rates.

- Each size convention only approximates the particles penetrating (reaching) that region, not the fraction of particles depositing there. The size conventions do not account for the particles exiting the respiratory tract with exhalation.
- It should also be noted that there is considerable variation by age, sex, biological health status and among individuals in lung dust deposition in humans.[31]

Target performance for dust sampling instruments

Inhalable Convention

The **inhalable convention** specifies the target performance for sampling instruments when the inhalable fraction is the focus. The mathematical equation for the inhalable convention is:

Equation 1:

$$\mathbf{I(d_{ae}) = 0.5\,(1 + e^{-0.06d_{ae}})\ \text{for}\ 0 < d_{ae} < 100\ \mu m}$$

where:
$I(d_{ae})$ = sampling efficiency of inhaled particles as a function of aerodynamic particle diameter (d_{ae}) in µm.

It is important to note that the above equation is only valid when the wind speed (U) is less than 4 m/s. In addition, the aerodynamic diameter (d_{ae}) used in the equation is not the same as the actual diameter of a particle. The actual diameter refers to the physical size of the particle, measured directly as its longest dimension. In contrast, the aerodynamic diameter is a derived value that accounts for the particle's behaviour in air. It is defined as the diameter of a hypothetical spherical particle with the same density as water (1 g/cm^3) that would settle at the same rate as the actual particle.

From this equation, we can see that the sampling efficiency $I(d_{ae})$ is close to 1 for small particles, meaning nearly all small particles will be collected by the sampling instrument. As the particle size increases, sampling efficiency decreases. For particles around 100 µm in aerodynamic diameter, only about half would be expected to be captured by the sampling instrument. Therefore, the particle diameter corresponding to 50% sampling efficiency (D_{50}) for the inhalable dust is about 100 µm.

In underground mining situations the inhalability of larger particles increases as air speed increases. As noted above, the ISO inhalable convention only holds for speeds < 4 m/s. The inhalability of a 100-µm particle increases exponentially as speed increases (**Figure 2**).[32] For example, particles with aerodynamic diameter of 100 µm would be three times more "inhalable" at an air speed of 9 m/s compared to 1 m/s. Of great interest is the fact that, at high wind speeds, inhalable fractions greater than 1.0 may occur due to the inertial impaction of large particles in the air flowing past the nose and mouth.[33] This is consistent with the "blunt sampler" theory of Vincent et al. (1990).[34]

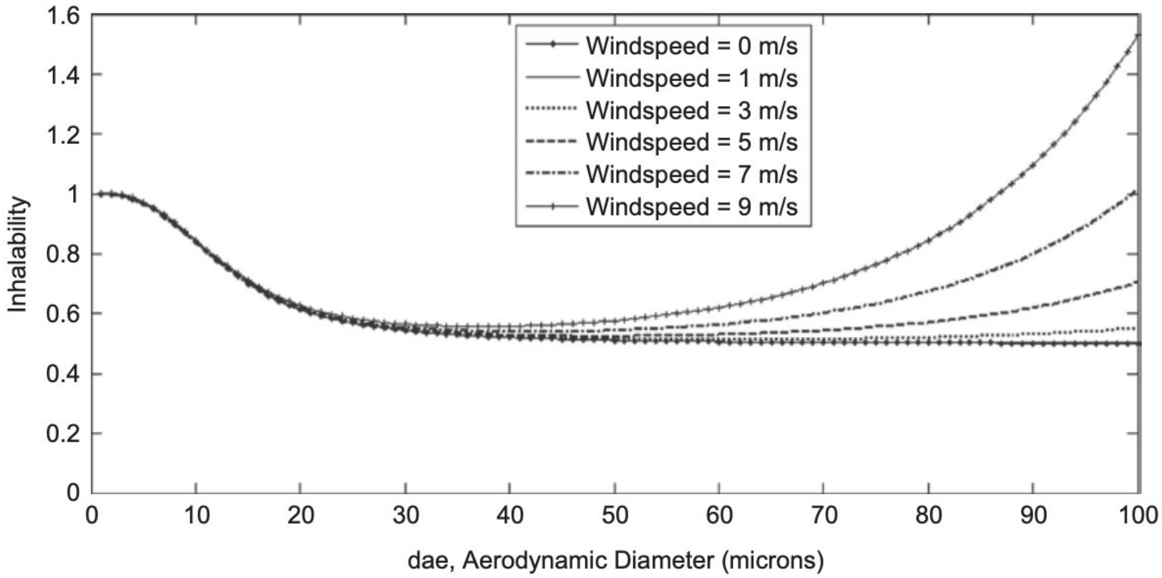

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Figure 2: Inhalability as a function of wind speed and aerodynamic diameter based on International Commission on Radiological Protection recommendations.[32]

Wind speed is therefore a crucial factor in determining inhalability but has been largely overlooked by many researchers.[35,36] Likely, this is due to the fact that few workplaces are subject to high wind speed conditions. However, this is critical for measurements of inhalable dust particularly in underground coal mines. For higher wind speeds, Vincent et al. (1990)[33] suggested a modification of **Equation 1** with the addition of a term to account for wind speed:

Equation 2:

$$\mathbf{I(d_{ae}) = 0.5\ (1 + e^{-0.06dae}) + 10^{-5}\ U^{-2.75}\ e^{0.055dae} \text{ for } 0 < d_{ae} < 100\ \mu m}$$

where:

$I(d_{ae})$ = sampling efficiency of inhalable particles as a function of aerodynamic particle diameter

U = wind speed in m/s

d_{ae} = aerodynamic particle diameter in µm

Thoracic Convention

The **thoracic convention** refers to a target specification for sampling instruments when the thoracic fraction is of interest. The mathematical equation for thoracic convention is:

Equation 3

$$\mathbf{T(d_{ae}) = I(d_{ae})[1-F(x)]}$$

where:

$T(d_{ae})$ = sampling efficiency of thoracic particles as a function of aerodynamic particle diameter

$x = \ln(d/11.64\ \mu m)/\ln(1.5)$

F(x) = the cumulative lognormal function for particles with a median diameter of 11.64 µm and geometric standard deviation of 1.5

From **Equation 3**, we can see that the sampling efficiency $T(d_{ae})$ is close to 1 for small particles, meaning nearly all small particles will be collected by the sampling instrument. As the particle size increases, $T(d_{ae})$ decreases. The D_{50} for thoracic dust is about 10 µm. Particles with an aerodynamic diameter greater than 25-30 µm will not be collected.

Respirable Convention

The **respirable convention** refers to a target specification for sampling instruments when the respirable fraction is of interest. The mathematical equation for respirable convention is:

Equation 4

$$\mathbf{R(d_{ae}) = I(d_{ae})[1-F(x)]}$$

where:
$R(d_{ae})$ = sampling efficiency of respirable particles as a function of aerodynamic particle diameter

$x = \ln(d/4.25\ \mu m)/\ln(1.5)$

F(x) = the cumulative lognormal function for particles with a median diameter of 4.25 µm and geometric standard deviation of 1.5

From **Equation 4**, we can see that the D_{50} for the respirable dust is about 4 µm. Particles with an aerodynamic diameter greater than 10 µm will not be collected.

Global Occupational Exposure Limits for Inhalable Dust

The US Occupational Safety and Health Administration (OSHA) has a permissible exposure limit of 15 mg/m^3 for "total" dust and 5 mg/m^3 for respirable dust.[37] Total dust includes all dust present in the atmosphere without regard to particle size, and not just the inhalable fraction, although total dust and inhalable dust are closely related. This limit is for "non-toxic" dusts known as dust particulates not otherwise regulated (PNOR) in the US. This includes all inert or nuisance dusts, whether mineral, inorganic, and not listed specifically in the OSHA limits for air contaminants. The American Conference of Government and Industrial Hygienists (ACGIH) recommends that there be a threshold limit value (TLV) of 3 mg/m^3 for respirable particles and 10 mg/m^3 for inhalable (not total) dust particles. This applies to insoluble particles of low toxicity for which no other TLV has been established,[37] and does not apply to, for example, coal mine dust or crystalline silica.

The UK Health Executive's Control of Substances Hazardous to Health has a 10 mg/m^3 standard for inhalable dust and 4 mg/m^3 for respirable dust not otherwise specified (NOS) (the same as PNOR in the US).[38] In 2011, authors from the Institute of Occupational Medicine (IOM) in Edinburgh, UK recommended that the permissible exposure limit for non-toxic inhalable dusts be lowered to 5 mg/m^3 based on their review of the literature, with many of the reviewed studies having been done at their institution.

The German Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area (MAK-Commission) set a new threshold (MAK-Value) for inert dusts, 4 mg/m^3 for inhalable dust and 1.5 mg/m^3 for respirable dust, in 1997.[15,39] This applies to dusts which do not have other threshold values or mixtures of dusts for which one of the components has a specific threshold value, and cement and coal dust are specifically excluded in this limit. They specifically noted the difficulties encountered when sampling inhalable dust in mines:

> *"Dispersed coarse particles can be present in airborne dust especially where wind speeds are high, for example, in mines. They then have a large effect on the gravimetrically determined concentration values without a corresponding effect on the human organism.* ***In certain situations where the particle size distributions have been shown to be displaced towards large particles, the use of the general threshold limit value for inhalable dust can be dispensed with.*** *However, the general threshold limit value for respirable dust must still be observed in these situations."* (Emphasis added. Reference German MAK Volume 12 Page 240).

Exposure Limits for Coal Mine Dust in Australia

There is no specific WES for inhalable coal dust, rather only a WES for respirable coal dust. There is a WES for inhalable dust NOS of 10 mg/m^3.[40] This is the exposure standard that is used by the NSW Resources Regulator[41] and Queensland regulators[42] for the control of inhalable dust in the workplace. The Australian Institute of Occupational Hygienists' "Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants" recommends that "Where no specific exposure standard has been assigned and the substance is both of inherently low toxicity and free from toxic impurities, exposure to dusts should be maintained below 10 mg/m^3, measured as inhalable dust "…as an 8-hour time-weighted average.[43] Of interest, the standards for inhalable dust NOS are not usually applied to industries where the dust is composed of substances which have separate regulations such as for coal and silica dusts. To our knowledge, a similar general inhalable dust exposure limit has not been applied to coal mine or silica-containing dusts outside of Australia.

The risk of CMDLD is related to cumulative coal mine dust exposure. Therefore, limits on workplace exposure play a critical role in the prevention of CMDLD. Per the NSW *Work Health and Safety (Mines) Regulation 2014*, mine operators are, as far as is reasonably practicable, to minimise the exposures of mine workers to dust. The WES for respirable coal dust in New South Wales was 2.5 mg/m^3 until 1 February 2021, when it was decreased to 1.5 mg/m^3.[44] The Australian (Safe Work Australia) WES for respirable coal dust containing less than 5% quartz was 3 mg/m^3 until 1 October 2022,[45] when it was decreased to 1.5 mg/m^3.[46] SafeWork Australia and NSW have the same WES for respirable crystalline silica of 0.05 mg/m³ which took effect 1 July 2020.[47] The goal of these exposure limits is to prevent the occurrence of pneumoconiosis and other CMDLD.

While there is a robust body of literature regarding the respiratory health effects of respirable coal mine and silica dust, there is less information on the health effects of inhalable dust in coal mining. There is no information on the health effects of elevated inhalable fraction of coal dust in cases where the respirable fraction is controlled.

The recommendations contained in the WCRSQ guidelines note reduced levels of exposure for workers who have evidence of varying degrees of CMDLD and/or non-occupational lung disease. The criteria for reduced dust exposure and enhanced surveillance are based on the degree of impairment in the FEV_1 or D_{LCO}, and/or the presence of pneumoconiosis on chest imaging. (See **Figure 3**). For example, the guideline recommends a reduction in inhalable mine dust from the WES of 10 mg/m^3 to 2.5 mg/m^3 for mild respiratory physiologic impairment or radiographic finding of early CMDLD, and a level of 1.25 mg/m^3 for more severe physiologic impairment or more advanced radiographic disease. However, it is noted that the degree of reduction in exposure limits differs substantially between the types of dust that are monitored. In the higher tier of reduced exposure limits, applied to workers with milder lung disease, there is a reduction in the exposure limit for inhalable mine dust to 25% of the WES, whereas the reduction for RCD is to 66% of the WES (from 1.5 mg/m^3 to 1 mg/m^3) and 50% of the WES for RCS (from 0.050 to 0.025 mg/m^3). For the lower tier of reduced exposure limits for workers with more severe lung disease, the exposure limit for inhalable mine dust is reduced to 12.5% of the WES (10 mg/m^3 to 1.25 mg/m^3), while exposure limits are reduced to 33% for RCD (1.5 mg/m^3 to 0.5 mg/m^3) and the same 50% reduction for RCS is used. Thus, the reduced exposure limits for inhalable dust were the most stringent of the recommended restrictions for dust exposure in the WCRSQ guidelines. (See **Table 2**)

Spirometry FEV_1 values (Pre-Bronchodilation % Predicted)	DLCO values (% predicted)	Restrictions (Time weighted average)	Enhanced medical surveillance recommendations
Rapid decline in FEV_1 defined as >15 per cent fall in reference value even if FEV_1 > LLN		<1mg/m³ RCD <0.025mg/m³ RCS <2.5mg/m³ IMD	Annual Respiratory Review CLFS Quarterly dust monitoring data and review of work tasks
> 70 per cent & <LLN (Mild)	>60 per cent & <LLN (Mild)	<1mg/m³ RCD <0.025mg/m³ RCS <2.5mg/m³ IMD	Annual Respiratory Review* CLFS Quarterly dust monitoring data and review of work tasks
60 – 69 per cent (Moderate)	40 – 60 per cent (Moderate)	<0.5mg/m³ RCD <0.025mg/m³ RCS <1.25mg/m³ IMD	Annual Respiratory Review* CLFS Quarterly dust monitoring data and review of work tasks
50-59 per cent (Moderately severe)	<40 per cent (Severe)	Case by case: usually exclude from dust exposure	Annual Respiratory Review* CLFS Quarterly dust monitoring data and review of work tasks (if applicable)
35-49 per cent (Severe)		Usually not fit for work Exclude from dust exposure	Annual Respiratory Review* CLFS Quarterly dust monitoring data and review of work tasks (if applicable)

ILO CXR Classification	HRCT ICOERD Classifications	Restrictions	Enhanced medical surveillance recommendations
≥1/0 & < 2/1 Or 1/0, 1/1 & 1/2	≥1 through 7	<0.5mg/m³ RCD <0.025mg/m³ RCS <2.5mg/m³ IMD	Annual respiratory review HRCT thorax CLFS Dust monitoring data and review of work tasks
2/1	8-9	<0.5mg/m³RCD <0.025mg/m³ RCS <1.25mg/m³ IMD	Annual respiratory review HRCT thorax CLFS Dust monitoring data and review of work tasks
≥2/2 and Category A, B, C PMF	≥10 and Category A, B, C PMF	Case by case: usually exclude dust	Annual respiratory review HRCT thorax CLFS* Dust monitoring data and review of work tasks (if applicable)

Figure 3 – Enhanced medical surveillance recommendations for different lung function impairment subgroups as per WCRSQ guidelines.[3] Abbreviations: FEV_1, forced expiratory volume in one second; D_{LCO}, lung diffusing capacity for carbon monoxide; LLN, lower limit of normal; RCD, respirable coal mine dust; RCS, respirable crystalline silica; IMD, inhalable mine dust; CLFS, complex lung function study; PMF, progressive massive fibrosis; HRCT, high-resolution CT scan; ICOERD, International Classification of High-resolution Computed Tomography for Occupational and Environmental Respiratory Diseases.

Table 1 - WCRSQ Recommended Reductions in WES

Contaminant	WES*	Reduced Standard for Mild Impairment	% Reduction from WES	Reduced Standard for Moderate Impairment	% Reduction from WES
RCD†	1.5mg/m³	1.0 mg/m³	33%	0.5 mg/m³	66%
RCS‡	0.05 mg/m³	0.025 mg/m³	50%	0.025 mg/m³	50%
IMD§	10 mg/m³	2.5 mg/m³	75%	1.25 mg/m³	87.5%

**Workplace Exposure Standard*
†Respirable coal dust (containing <5% quartz)
‡Respirable crystalline silica
§Inhalable mine dust

Current Sampling Methodology – Strengths and Limitations

Institute of Occupational Medicine (IOM) Inhalable Sampler

The IOM inhalable sampler, used by Coal Services and Resources Safety and Health Queensland (RSHQ), is one of the most widely used devices for personal air sampling of inhalable aerosols in workplace environments. Developed in the mid-1980s by researchers at the Institute of Occupational Medicine in Edinburgh, Scotland,[48] the sampler was specifically designed to capture airborne particles that correspond to the ISO inhalable convention by representing an average orientation under mouth breathing conditions. Accordingly, the sampler performs at wind speeds consistent with the ISO convention.

The IOM sampler incorporates a 25-mm filter housed inside a reusable cassette. The sampler has a 15-mm circular inlet with a lip that protrudes 1.5 mm outwards. The purpose of the lip is to minimize the potential for particles deposited on the outer surfaces of the inlet to be carried into the sampler. Since the aperture of the inlet is 15 mm, large particles (>100 µm) may be projected into the inlet due to inertia or fall into the inlet under the influence of gravity.[49]

Over the years, several studies[48,50–52] have characterized the performance of the IOM inhalable sampler under various conditions. These studies demonstrated that the IOM sampler closely follows the inhalable convention curve, particularly at workplaces where wind speeds range from 0.5-4 m/s (See **Figure 4**). At very low wind speeds (below 0.2 m/s), Aizenberg et al.[50] noted that the sampler tended to oversample at all sizes compared to the inhalable convention (See **Figure 5**). In contrast, at wind speeds >4 m/s, Kenny et al.[52] showed the IOM sampler oversampled larger particles compared to the inhalable convention (see **Figure 2**).

In an evaluation of potential sources of error from large particles in inhalable dust measurement Lidén and Kenny[53] noted that the inhalable convention assumes exposure from a steady stream of particles produced at a point remote to the sampling. In reality, workers can be exposed to non-uniform concentrations of particles generated close to the point of sampling and entrained in air currents or jets. Larger particles contained within such situations may be moving under their own momentum when they enter a sampler or human. In a simple theoretical model, the authors revealed 1000-µm particles generated close to a worker with speeds >5 m/s could be projected 75-150 cm, easily entering a sampler inlet. Thus, sampling devices with large unshielded inlets, such as the IOM sampler, are prone to particles entering inlets under their own momentum, and only a small number of these very large particles are needed to bias the mass concentration.

A number of other sampling devices are available which have been tested to the inhalable convention alongside the IOM sampler in low (<0.2 m/s) wind speeds and “typical” wind speeds (0.5, 1.0, 4.0 m/s).[54,55] Inhalable samplers currently commercially available include the GSP Conical Inhalable Sampler (CIS) sampler, Button Sampler and 7-Hole sampler are all clamed to meet the ISO convention, however all differ in their performance relative to different wind speeds and particle sizes.

Kenny et al. ranked eight (8) different inhalable samplers in order of precision at 3 wind speeds and the most precise samplers were the CIS and PERSPEC samplers, with the IOM sampler being ranked 6th, 7th, and 5th for wind speeds of 0.5, 1 and 4 m/s respectively and the 7-Hole sampler ranked 8th, 8th, and 6th respectively.[52] The performance of the Button sampler against the ISO convention was examined by Witschger and demonstrated good agreement across six particle fractions ranging from 6.9 to 76.9µm MMAD.[56] Gorner evaluated the Button sampler reporting a level of performance "only slightly inferior to those for the IOM".[57] Its applicability for underground coal mine use is however compromised by the use of aluminium in its construction.

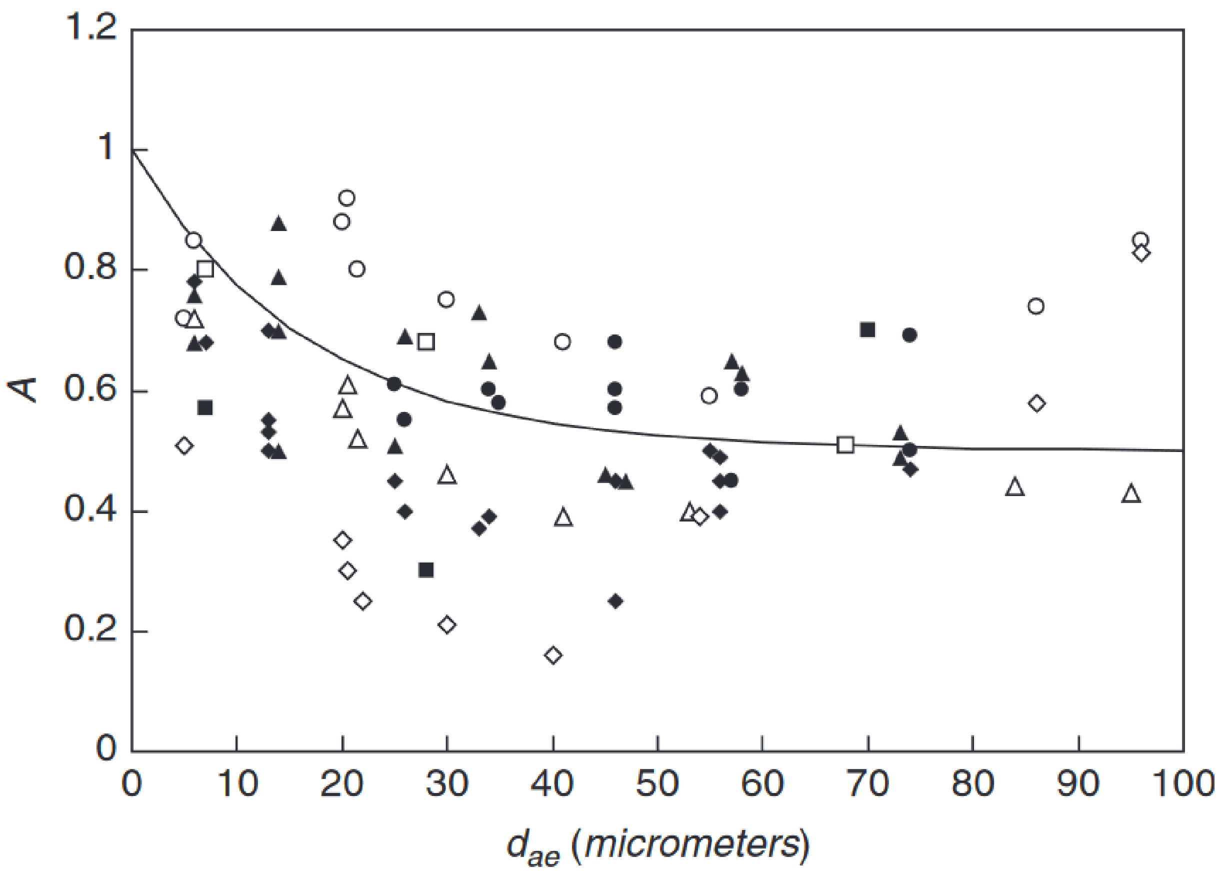


Figure 4 – Performance of the 2 Lpm IOM personal inhalable aerosol sampler in terms of aspiration efficiency (A) as a function of particle aerodynamic diameter (d_{ae}) for various wind speeds, results from wind tunnel studies in a number of laboratories (Mark and Vincent:[58] ● 0.5 m/s, ▲ 1 m/s, ◆ 2.6 m/s; Kenny et al.,[52]: ○ 0.5 m/s, △ 1 m/s, ◇ 4 m/s; Aizenbergetal.,[50]: □ 0.5 m/s, ■ 2 m/s)[59]

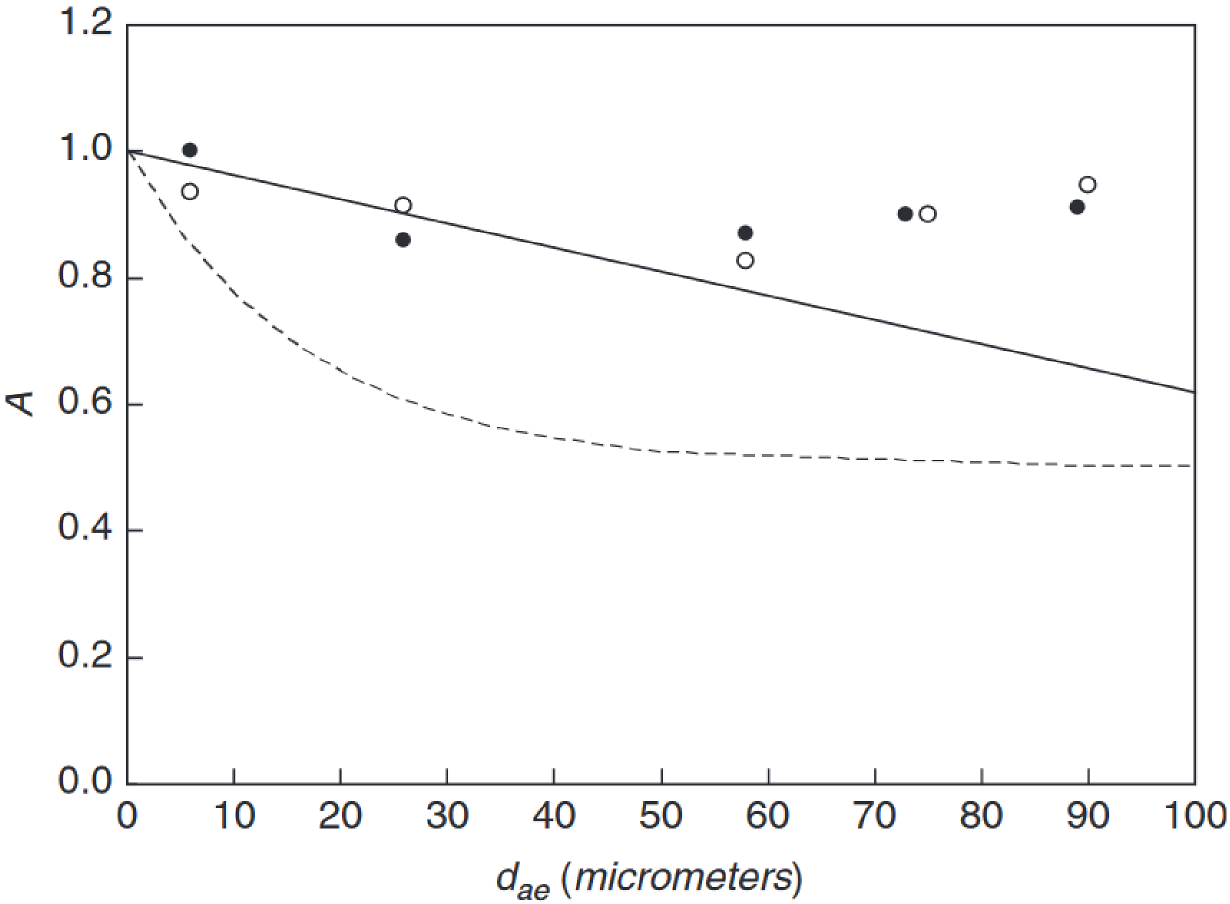


Figure 5 - Performance of the 2Lpm IOM inhalable aerosol sampler in calm air in terms of aspiration efficiency (A) as a function of particle aerodynamic diameter (d_{ae}), used both as a personal sampler and as a static sampler (Kenny et al., 1999: ○ IOM sampler as a personal sampler, ● IOM sampler as a static sampler; dashed line, inhalability curve; solid line, suggested inhalability curve for calm air)[59]

The default sampling flow rate for the IOM device is 2 L/min, and limited data exists on its performance at alternative flow rates. The only relevant study, conducted by Zhou and Cheng in 2009,[60] examined the effect of increasing the sampling flow rate from 2 L/min to 10.6 L/min to determine if the sampler's performance would remain consistent. Using a wind tunnel, they evaluated the sampling efficiency across different particle sizes, wind speeds, and wind directions. The study found that at a low wind speed of 0.56 m/s, the IOM sampler maintained its original collection efficiency when operated at the higher flow rate. The researchers concluded that the IOM sampler could be used at a higher flow rate of 10.6 L/min, with sampling efficiency similar to, but slightly lower than, that at the 2.0 L/min flow rate.

The NIOSH Manual of Analytical Methods, in the chapter "Factors Affecting Aerosol Sampling,"[61] notes that large particles in aerosol samples are particularly sensitive to external flow fields, making proper orientation critical for inhalable samplers. During testing, it is essential to mount the sampler on a person (or a mannequin in laboratory simulations) and position it vertically relative to the ground. This arrangement is crucial for obtaining unbiased results. If the sampler orientation deviates from the vertical position, it may be susceptible to entraining larger particles that are falling from the ceiling and may yield spurious results. The flow field near the sampler's inlet differs significantly when the sampler is mounted on a person (or mannequin) compared to when it is freestanding.

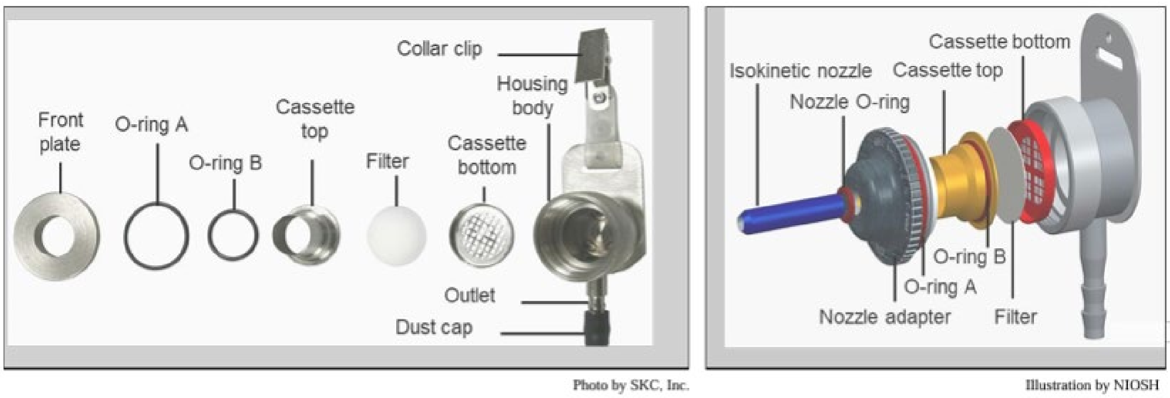


Figure 6.2. Photo (left) illustrating components of standard stainless steel IOM sampler. Illustration (right) showing the nozzle adapter and isokinetic nozzle designed by NIOSH.

Figure 6 - Photo of IOM Sampler Components, (from https://www.cdc.gov/niosh/docs/2021-119/default.html).

In the US, inhalable dust in coal mines is not regulated separately from respirable dust, but the IOM sampler is used by NIOSH for research purposes.[62] NIOSH uses the stainless steel version of the IOM sampler known for its stable mass in varying humidity conditions to collect coarse coal dust (particle size <70 µm). To improve sampling accuracy, NIOSH modified the sampler by adding a specialised nozzle (See **Figure 6**) for isokinetic sampling, rather than using the original open-face design. Isokinetic sampling ensures that the sampler's inlet velocity matches the airstream velocity, minimizing errors caused by particle inertia in uneven airstreams. In both laboratory and mine settings, NIOSH measured air velocity and selected the appropriate isokinetic nozzles for use with the IOM samplers.

In summary, the IOM sampler is a reliable tool for monitoring airborne particulate matter in the inhalable particle size range at typical workplace wind speeds (0.5-4 m/s). Under those conditions, sample collection closely follows the ISO inhalable convention curve, ensuring accurate data on inhalable dust exposure. However, its performance as a “blunt sampler” leads to deviations from ISO conventions for larger particles at high wind speeds (>4 m/s; see **Figure 2**) and bias from projected large particles. The utility of inhalable dust exposure measurements taken in conditions of high wind speeds is subject to question, particularly when there is an abundance of particles >50 µm in aerodynamic diameter.

Conclusion

Accurate and reliable dust samplers should conform to the sampling conventions described above. The results of sampling must consider the conditions in the workplace including wind speed, orientation of the sampler relative to the air stream, and any effects of dust falling into the sampling region. Sampling results may therefore not reflect the actual dust inhaled by workers.

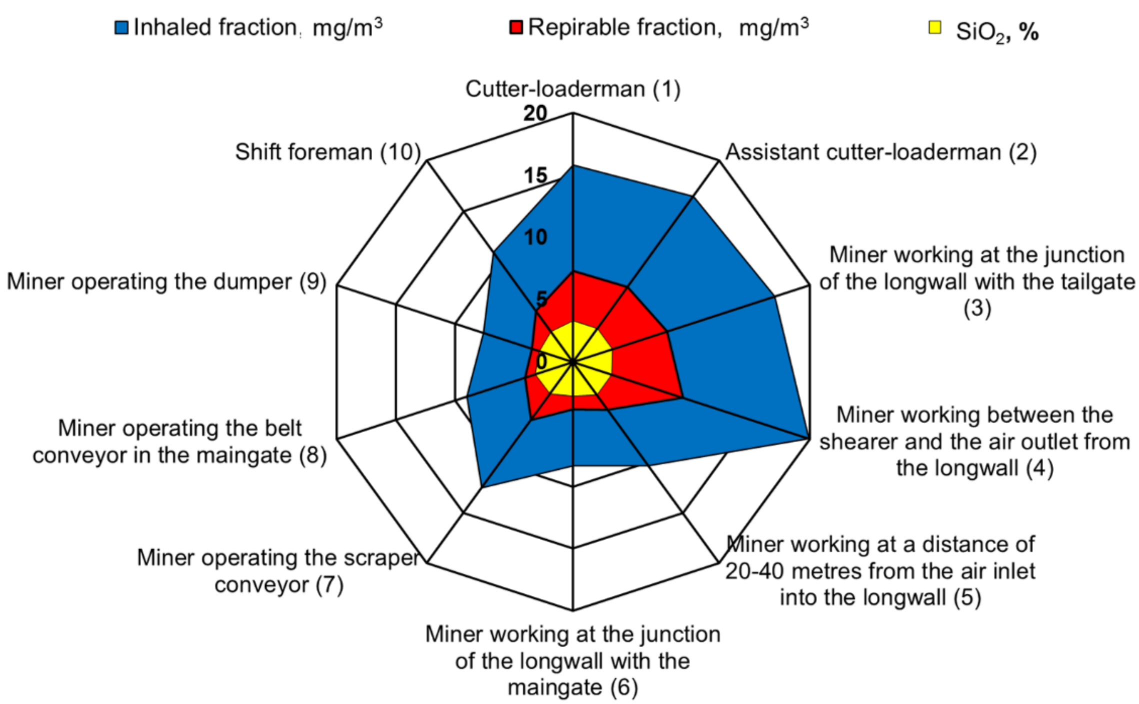
Review of Distribution of Dust Particle Size Fractions

Literature Review

Brodny et al.[63]

Brodny et al.[63] studied particle size fractions for longwall coal mines in Poland using a CIP-10-type personal dust sampler. They calculated the inhaled fraction, respirable fraction, and % SiO_2 for various occupations in the mine (See **Figure 7**). The ratio of inhaled dust to respirable dust mass concentration was, on average, consistent across occupations, ranging from 2.15 to 2.31. They did not evaluate the dust levels in relationship to any health outcomes.

Figure 7 - The average concentration of inhaled and respirable dust and the content of crystalline silica in various workstations from Brodny et al.[63]



Dodgson et al.[64]

Dodgson and colleagues at the IOM studied the characteristics of airborne dust in UK coal mines, examining the chemical constituents, mineral content, carbon content, and particle size distributions. They also evaluated a number of sampling and analytic devices. The investigators noted a wide range of ratios between total dust and respirable dust, which they felt was related to the coarseness of the airborne dust and the air velocity.

Potts et al.[65]

Investigations using Anderson 298 personal eight-stage impactors identified median particle sizes at various locations in three longwall and three continuous mining sections. The mass median aerodynamic particle (MMAD) sizes ranged from 7.5 to over 21 µm and the authors calculated ratios of thoracic dust to respirable dust to examine the differences in particle size distributions. The ratios were found to vary considerably from 1.5 to 6.7, leading the authors to postulate that compliance with the respirable dust standard may not equally limit the thoracic dust exposure of all mine workers.

Mark et al. [66]

This document reported on a study to examine the variability of exposure among British coal miners at three collieries using advancing or retreating longwall mining methods. Exposures to inspirable (inhalable) dust and its sub-fractions were examined using the IOM personal dust sampler along with an eight-stage cascade impactor to determine sub-fractions. A total of 94 personal inspirable dust measurements were collected with concentrations among all occupational groups at each colliery >10 mg/m^3, with some groups >100 mg/m^3. Mean inspirable to respirable dust mass ratios from personal samples in different work locations are summarised in **Table 3**.

Table 2 – Inspirable to respirable ratios from Mark et al.[66]

Colliery	Range of Mean Personal Inspirable – Respirable Ratio
Q	7.6 - 24.3
Y	5.7 – 16.8
F	6.8 – 16.3

The authors examined the relationships between particle sub-fractions and noted that the slopes of lines of best fit are significantly different for each group within a colliery, indicating each group is exposed to a different particle size distribution. However, the variability of exposure to sub-fractions was similar to variability in inspirable dust, indicating the overall particle size distribution for each group remains largely constant within collieries. There were significant differences between collieries for the thoracic and inspirable fractions, but non-significant differences for the thoracic and alveolar sub-fractions. Overall, the authors found, "*There is in general a linear relationship between a mineworker's exposure to a given deposition subfraction of inspirable dust (e.g., thoracic, tracheobronchial, respirable, and alveolar) and his exposure to inspirable dust. The slope of the relationship for each particular subfraction is not constant but depends upon the nature of the job and the working conditions of the mineworker*."

This study was undertaken as part of the development of the IOM inhalable dust sampler and found a high correlation between the various sub-fraction concentrations, although this varied across job groups. Of greatest relevance for the current review, the authors concluded that respirable dust estimates should be equally predictive of obstructive lung disease as other fractions.

Burkhart et al.[67]

Burkhart and colleagues also studied particle size distributions using cascade impactors in underground coal mines, finding that the particle size distribution relationships appeared reproducible for different areas of the mines in the 10 mines studied. They showed a wide range of particle distributions with a primary size mode of 17-20 µm, with a secondary size mode of 5-8 µm for all areas except the continuous miner and the feeder/breaker (See **Figure 8**). There was no health data collected in this study and therefore no attempt to relate exposures of one particle size distribution to health outcomes. The relationship between various particle size distribution groups appeared relatively constant in each area.

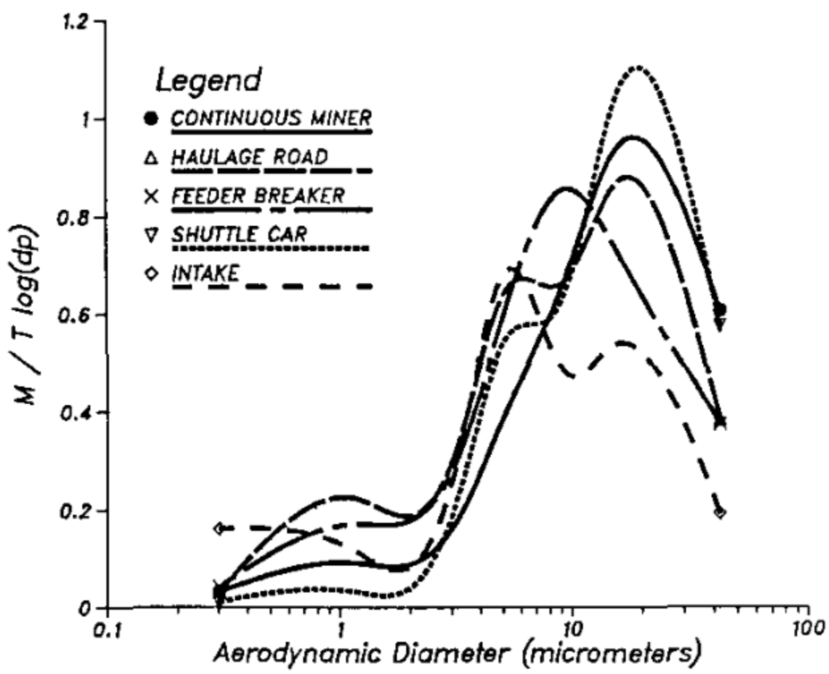


Figure 8 - Relative mass frequency distribution. A spline procedure was used to show the trend in the histogram data. From Burkhart et al. [67]

Seixas et al.[68]

In 1995, Seixas and colleagues published a study of the variability of particle size in four US underground coal mines, examining the ratio of tracheobronchial (thoracic) dust fraction to the respirable dust fraction. This was used to estimate the relative contribution of these dust fractions to the development of obstructive lung disease.[69] The authors sought to determine if there was an additional effect of the larger particles on more proximal levels of the tracheobronchial tree and therefore an important contributor to the development of chronic bronchitis. Using eight-stage personal cascade impactors to obtain a total of 180 samples, the authors noted, "*The results suggest that although the tracheobronchial dust fraction may contribute to the development of obstructive lung diseases, occupation-specific tracheobronchial dust fractions are not likely to produce stronger exposure-response estimates than the historically collected respirable dust concentrations*."

The authors discounted findings by Potts et al., who had suggested that controlling respirable dust might not effectively represent control of inhalable dust given the large variability they found in the ratio of inhaled to respirable dusts.[65] Seixas et al. felt the earlier study to be poorly representative of the conditions miners might face due to artifacts presented by sampler locations. They noted, "*The results suggest that there is little difference between these fractions across the job groups considered (range 2.0 to 3.4) and support the current authors' observation that there is little substantial difference in the particle size distributions between coal mining job categories, at least in the thoracic and respirable particle size range*."

The authors concluded, *"...that occupation-specific tracheo-bronchial dust exposures would be highly correlated with historically collected respirable exposures, and exposure-response analyses using the two measures would be similar*."

Current Data on the Relationship Between Particle Size Fractions in Australian Coal Mines.

(Note: A complete table of statistical analysis of exposures by contaminant and SEG is provided in Appendix B. Full Data Tables for NSW and QLD Inhalable Dust Exposures.)

Individual and site de-identified results of personal sampling for inhalable dust, respirable dust and respirable crystalline silica conducted under Order 42 for the time period 1 July 2021 to 30 June 2024 were provided by CSH. Individual and site de-identified results of personal sampling for inhalable dust, respirable dust and respirable crystalline silica provided to RSHQ by mine sites arising from statutory (Recognised Standard 14 (RS14)) and risk-based sampling for the time period from 1 January 2021 to 30 September 2024 were also obtained. Inhalable dust results are submitted to RSHQ in an annual basis, and, accordingly, only results from January 2021 to December 2023 were available.

Both data sets were curated with void results removed and any results missing data removed from the analysis. The data from each state was combined into three data packages representing inhalable, respirable and respirable crystalline silica with the addition of variables indicating mine type (surface/underground) and state.

It should be noted that the reporting terminology used in each state with respect to crystalline silica species is slightly different and may represent slight differences in analytical methods.

Respirable crystalline silica is a combination of the three most common polymorphs of crystalline silica; quartz, cristobalite and tridymite. The presence of tridymite and cristobalite is considered to be rare in mining applications. CSH measure quartz and report this as respirable quartz. Mine operators in Qld can employ a variety of methods to measure quartz but may or may not determine the presence of other polymorphs. RSHQ report respirable quartz with or without other polymorphs as respirable crystalline silica. For the purposes of this report, the review team treat respirable quartz measurements as equivalent to RCS.

Descriptive analysis was performed on each package using Tool 3 of the web-based Expostats application.[70] Expostats is a Bayesian calculator which performs statistical analysis on occupational hygiene data. Tool 3 assesses the effect of categorical values, in this case similar exposure groups (SEGs), to evaluate the differences in underlying distributions between SEGs. Geometric mean, geometric standard deviation, 95th percentile, arithmetic mean, and exceedance fraction were calculated to determine exposure distributions. The Bayesian equivalent of confidence limits, 90% credible intervals, were also calculated. These are the interval within which there is a 90% probability that the true value is contained. Exceedance fractions, the probability of exceeding a limit, were calculated for each state, SEG, and contaminant combination using the various exposure limit reductions outlined in the WCRSQ guidelines (See **Table 2**).

A Bayesian approach was selected to account for the high proportion of censored (<LOR) results in some of the data sets and also because of the differences in reporting thresholds between states and within some data sets, e.g. differences in reporting significant figures depending on the use of a 5-place or 6-place microbalance.

Summary data from the descriptive analysis was imported into StataNow/BE 18.5 for the evaluation of the ratios of inhalable dust to respirable dust.[71]

NSW Coal Mine Data

Data from 18,452 dust samples were provided by CSH, of which 464 were noted as void and removed from analysis. The final NSW data set consisted of 17 988 individual results. A breakdown of these by type and year is provided in **Table 4.**

Table 3 - NSW CSH Order 42 Final Data Set

Contaminant Name	Year				
	2021	2022	2023	2024	Total
Inhalable Dust	579	1172	1109	505	3365
Respirable Coal Dust	1295	2427	2440	1160	7322
Respirable Quartz	1295	2420	2432	1154	7301
Total	3169	6019	5981	2819	17988

Void reasons are shown in **Table 5**, with a clearly significant contributor being the presence of dust particles of an abnormal size. Of the void samples, nearly 50% were classified under the "Dust Particle Size" criterion. This criterion applies when a filter contains multiple particles with a physical diameter greater than 200 µm, or a single particle with physical diameter greater than 300 µm.

Table 4: Void Samples

Void Sample Reason	Frequency	Percent
<80% shift Length	19	4.09
Damaged Sampling Head	3	0.65
Dust Particle Size	226	48.71
Filter Damage	45	9.70
Flow Rate Variance	6	1.29
Hose Disconnected	26	5.60
Lab non-conformance	3	0.65
Sample Duration <5hrs	18	3.88
Sample Head Contact with Material	30	6.47
Sampler Removed by Worker	32	6.90
Sampling Pump Malfunction	56	12.07

The selection of 200 µm or 300 µm physical diameter particles as criteria for voiding inhalable dust samples appears to be arbitrary. The aerodynamic diameter determines whether a particle can be captured by the IOM sampler, not its physical diameter. The aerodynamic diameter best describes how particles behave in the air and their ability to be inhaled and captured by the sampler, regardless of their physical size. Unlike the thoracic and respirable conventions, the inhalable convention does not provide clear information on the aerodynamic diameter at which a sampler would achieve (near) zero collection efficiency.

While we can assume that particles larger than 100 µm in aerodynamic diameter would have a collection efficiency below 50%, 300 µm particles may still fall within the category of inhalable dust and could be captured by the inhalable sampler without representing evidence of improper sampling. However, the relative abundance of these larger particles will have a strong influence on the overall mass of particles collected on a filter.

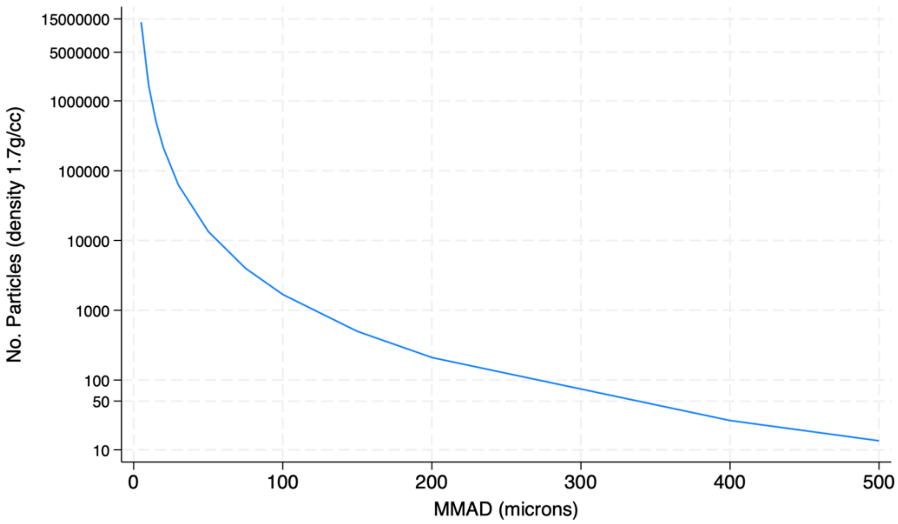


Figure 9 – Number of particles making up the same mass by MMAD

As illustrated in **Figure 9**, for the same overall mass, the number of particles (of density 1.7 g/cm^3) decreases exponentially as the MMAD increases. For example, 499 310 particles of 15 µm MMAD have the same mass as 210 particles of 200 µm MMAD, and just 26 particles of 400 µm MMAD.

Inhalable Dust Data

Inhalable dust concentrations for SEGs combined across all mines indicate that underground SEGs have the highest average (AM $UCL_{1,90}$) exposures and represent nine of the top ten exposed SEGs. **Table 6** shows inhalable dust results from the top ten SEGs where n≥10 with the exceedance fraction (EF) highlighted red showing SEGs where >5% of all exposures in the population are greater than the WES or modified WES. Exceedance fractions from ≥0.5% to 5% are highlighted yellow whist EF <0.5% are highlighted green. The EF can also be read as the probability of any individual sample being in excess of the WES or modified WES, assuming an equal distribution across all SEG/site combinations.

Table 5: Selected NSW CSH SEGs Inhalable Dust Exposures (SEGS where n ≥ 10).

CSH SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2.5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
CU07 Ventilation device installers	136	4.2 [3.7-4.9]	4.8	12 [10-15]	14	7.7% [5.2-11]	26% [21-32]	56% [50-62]	83% [78-87]
CP03 CHPP Laboratory	13	2.1 [1.2-4.9]	3.9	7.1 [3.7-19]	14	2.5% [0.31-11]	9% [2.4-24]	24% [11-41]	46% [29-64]
CU15 Stone Driveage	11	2.5 [1.7-4.7]	3.9	6.8 [4.1-16]	12	1.7% [0.12-10]	10% [2.6-27]	34% [17-54]	67% [47-83]
CU06 Outbye construction/infrastructure	123	2.9 [2.5-3.5]	3.3	8.9 [7.3-11]	11	3.9% [2.3-6.3]	15% [11-19]	37% [31-43]	65% [59-70]
CU01.1 Longwall Production (Uni Di)	450	2.9 [2.8-3.1]	3.1	7.3 [6.8-8]	7.9	1.9% [1.3-2.6]	13% [11-16]	45% [41-48]	80% [77-82]
CU16 Secondary support	23	2.2 [1.6-3.3]	3	6.2 [4.1-11]	9.4	1.4% [0.23-5.8]	8% [3-18]	27% [16-40]	57% [43-70]
CU02.1 Development - Cont mining and bolting	562	2.9 [2.7-3]	3	6.9 [6.4-7.4]	7.3	1.4% [1-2]	12% [10-14]	44% [41-47]	81% [79-83]
CU02.2 Development - Place change	86	2.5 [2.2-3]	2.9	6.6 [5.4-8.2]	7.8	1.4% [0.56-3]	10% [6.4-15]	36% [29-43]	71% [64-78]
CU04 Outbye supplies	54	2.3 [1.9-3]	2.8	6.5 [5-9]	8.3	1.5% [0.5-4]	9.1% [5-15]	30% [23-39]	62% [53-71]
CU01.2 Longwall Production (Bi Di)	559	2.5 [2.4-2.6]	2.6	5.8 [5.5-6.2]	6.2	0.62% [0.41-0.92]	8% [6.6-9.6]	38% [35-41]	78% [76-81]

It should be noted that the increase in the EF as the WES or modified WES is progressively halved is not linear. Rather, owing to the lognormal nature of exposure distributions, the EF increases in a non-linear fashion. This is illustrated in **Figure 10** where the numbers of exceedances in 1000 randomly selected workers in SEG CU02.1 Development - Cont mining and bolting are shown compared to four levels of WES or modified WES.

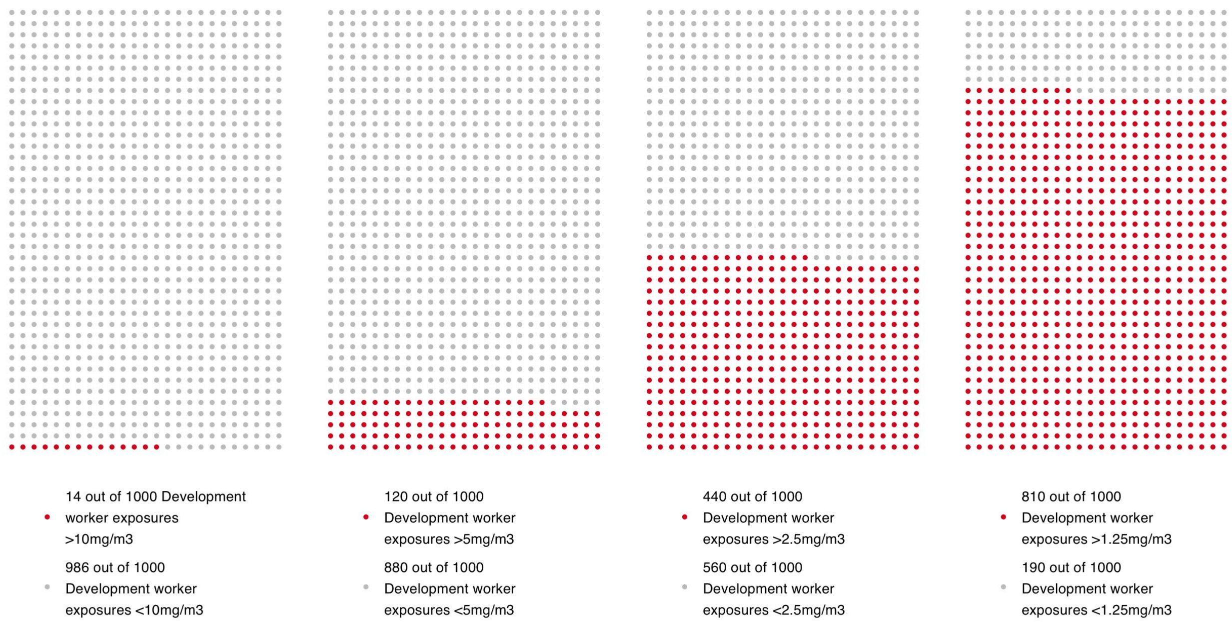


Figure 10: Inhalable Dust exposures for 1000 randomly selected NSW continuous mining development workers (SEG CU02.1) comparing numbers of exceedances over WES and modified WES.

Respirable Dust Data

Respirable dust exposures in NSW display a much lower proportion of potential exceedances, but underground SEGs represent nine of the ten highest average (AM $UCL_{1,90}$) exposed SEGs. **Table 7** contains the top ten SEGs where n≥10. Surprisingly, despite the collection of large numbers of samples in production SEGs, a total of seventeen SEGs contained sample numbers less than 10 limiting the overall assessment. It is clear however, that across-the-board current exposure control efforts are managing to limit worker exposure to respirable coal dusts to levels well below the current WES.

The presence of quartz in respirable coal dust samples at concentrations >5% potentially renders the current SWA WES for coal dust (respirable) irrelevant, or at least misleading, as there is currently no guidance in Australia on dealing with samples containing >5% quartz.

Table 6: Selected NSW CSH SEG Respirable Dust Exposures (SEGs where n ≥ 10)

CSH SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
CU01.2 Longwall Production (Bi Di)	1226	0.43 [0.42-0.44]	0.44	0.92 [0.88-0.96]	0.95	0.59% [0.45-0.77]	3.6% [3.1-4.3]	29% [27-31]
CU07 Ventilation device installers	11	0.3 [0.22-0.49]	0.43	0.73 [0.48-1.5]	1.2	0.36% [0.0066-4.8]	1.8% [0.12-11]	14% [4.2-32]
CU01.1 Longwall Production (Uni Di)	787	0.37 [0.36-0.38]	0.38	0.73 [0.7-0.76]	0.76	0.089% [0.054-0.14]	1.1% [0.81-1.5]	19% [17-21]
CU17 Gas drainage	12	0.28 [0.21-0.41]	0.37	0.61 [0.43-1.1]	0.93	0.075% [0.00041-2.1]	0.67% [0.02-6.2]	9.6% [2.4-26]
CP03 CHPP Laboratory	14	0.21 [0.14-0.35]	0.31	0.56 [0.35-1.2]	0.96	0.23% [0.0053-3]	0.94% [0.061-6.1]	6.7% [1.6-19]
CU02.3 Development - Pillar Extraction	145	0.28 [0.26-0.31]	0.31	0.66 [0.58-0.76]	0.73	0.16% [0.055-0.43]	1.1% [0.51-2.1]	11% [8.2-15]
CU02.2 Development - Place change	419	0.28 [0.27-0.3]	0.29	0.64 [0.59-0.69]	0.68	0.11% [0.058-0.21]	0.84% [0.54-1.3]	11% [8.7-13]
CU15 Stone Driveage	56	0.26 [0.22-0.3]	0.29	0.59 [0.48-0.74]	0.7	0.077% [0.0097-0.42]	0.6% [0.15-1.9]	8.2% [4.4-14]
CU02.1 Development - Cont mining and bolting	3069	0.28 [0.28-0.29]	0.28	0.58 [0.56-0.59]	0.59	0.025% [0.019-0.034]	0.35% [0.29-0.42]	8.6% [7.9-9.2]
CU16 Secondary support	17	0.18 [0.14-0.26]	0.24	0.44 [0.31-0.76]	0.65	0.031% [0.00031-0.82]	0.23% [0.0082-2.5]	3.4% [0.62-12]

The comparison to exceedances of the respirable coal dust WES or levels of modified WES to 1000 randomly selected workers in SEG CU02.1 Development - Cont mining and bolting are shown in **Figure 11** where a difference in the proportion of exceedances to inhalable dust (**Figure 10**) is clearly seen.

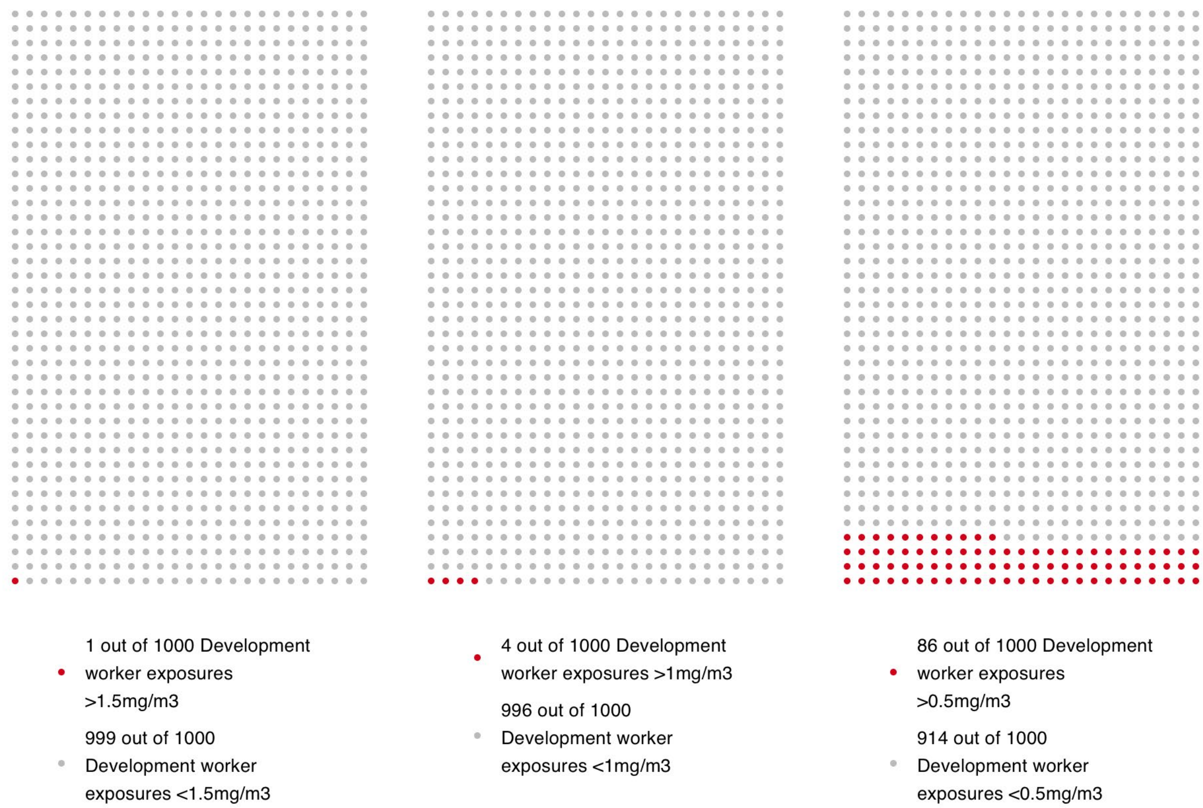


Figure 11: Respirable Dust exposures for 1000 randomly selected NSW continuous mining development workers (SEG CU02.1) comparing numbers of exceedances over WES and modified WES

Respirable Quartz Data

The respirable quartz exposure data is less influenced by SEG location. A number of surface mining SEGs are represented in the top ten average (AM $UCL_{1,90}$) as shown in **Table** 8. In this analysis the influence of exposure variability (GSD, not shown) contributes to the AM $UCL_{1,90}$ and other measures such as the AM and EF provide additional context. CS06 Field Maintenance and CS07 Blast Crew SEGs represent the highest surface mining SEGs exposed to RCS (0.021 mg/m^3 and 0.020 mg/m^3 AM $UCL_{1,90}$, respectively). Whilst exposures to respirable dust are generally well controlled (compared to current exposure standards), the relatively higher level of respirable crystalline silica in the dust represents increased health risks.

Table 7: Selected NSW CSH SEGs Respirable Quartz Exposures (SEGS where n ≥ 10)

CSH SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
CP03 CHPP Laboratory	14	0.028 [0.02-0.042]	0.038	0.068 [0.046-0.12]	0.11	11% [3.7-26]	42% [26-60]
CU17 Gas drainage	12	0.02 [0.013-0.044]	0.035	0.059 [0.034-0.16]	0.12	7.1% [1.4-22]	24% [11-43]
CU01.2 Longwall Production (Bi Di)	1225	0.032 [0.032-0.033]	0.033	0.07 [0.068-0.073]	0.073	15% [14-16]	57% [55-59]
CU02.3 Development - Pillar Extraction	144	0.026 [0.024-0.03]	0.029	0.066 [0.057-0.078]	0.075	11% [7.5-14]	39% [34-45]
CU08 ERZ Controllers (Outbye Deputies)	38	0.022 [0.017-0.031]	0.029	0.064 [0.046-0.1]	0.089	8.7% [4-16]	29% [20-39]
CU01.1 Longwall Production (Uni Di)	782	0.024 [0.023-0.025]	0.025	0.058 [0.055-0.062]	0.061	7.7% [6.5-9]	34% [32-37]
CU07 Ventilation device installers	11	0.016 [0.011-0.03]	0.025	0.042 [0.026-0.1]	0.078	2.9% [0.22-15]	17% [5.5-36]
CU02.2 Development - Place change	419	0.022 [0.02-0.023]	0.023	0.054 [0.049-0.059]	0.058	6.1% [4.7-7.7]	29% [26-32]
CS06 Field Maintenance	17	0.013 [0.0088-0.025]	0.021	0.039 [0.024-0.09]	0.071	2.8% [0.33-11]	12% [4.3-26]
CS07 Blast Crew	197	0.018 [0.017-0.02]	0.020	0.043 [0.039-0.05]	0.048	3.1% [2-4.9]	21% [17-25]

Queensland Coal Mine Data

A total of 65 761 valid results covering inhalable dust, respirable dust and respirable crystalline silica exposures across underground and surface coal mines were provided by the Coal Inspectorate of RSHQ. These results were combined into separate data sets by contaminant and then curated to select sample data matching the time period of samples provided by CSH (1 July 2021- 30 June 2024) resulting in a final analysis set consisting of 53 905 valid results. A summary of sample numbers by year and type is shown in **Table 9.**

Table 8: RSHQ final data set

Contaminant Name	Year				
	2021	2022	2023	2024	Total
Inhalable Dust	855	1461	2134	-	4450
Respirable Coal Dust	3280	8026	9043	4364	24 713
Respirable Crystalline Silica	3281	8031	9042	4388	24 742
Total	7416	17 518	20 219	8752	53 905

Inhalable Dust Data

Inhalable dust concentrations for SEGs combined across all mines indicate that underground SEGs have the highest average (AM $UCL_{1,90}$) exposures and represent eight (8) of the top ten (10) exposed SEGs. **Table 10** shows inhalable dust results from the top ten SEGs where n ≥ 10 samples with the exceedance fraction (EF) highlighted red showing SEGs where > 5% of all exposures in the population are greater than the WES or modified WES. Exceedance fractions from ≥ 0.5% to 5% are highlighted yellow whilst EF < 0.5% are highlighted green. The EF can also be read as the probability of any individual sample being in excess of the WES or modified WES, assuming an equal distribution across all SEG/site combinations.

Table 9: Selected QLD RSHQ SEG Inhalable Dust Exposures (SEGS where n ≥ 10)

RSHQ SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2.5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
QCU001 Longwall Production	131	7.3 [5.9-9.4]	8.8	26 [20-34]	32	19% [15-24]	39% [33-44]	61% [56-67]	81% [76-85]
QCU002 Development Production	203	5.3 [4.7-6]	5.8	16 [13-19]	18	12% [9.5-16]	34% [30-39]	63% [59-68]	86% [83-89]
QCU007 VCD Installer	107	4.8 [4-6]	5.7	15 [12-20]	19	11% [7.5-15]	29% [24-35]	55% [48-61]	78% [73-83]
QCU019 Production Support/Bullgang	211	4.7 [4.1-5.5]	5.3	15 [13-18]	17	11% [8-14]	28% [24-33]	54% [50-59]	78% [75-82]
QCU016 Secondary Support	118	3.5 [3-4.3]	4.1	11 [8.8-14]	13	6% [3.7-9.1]	20% [15-25]	45% [39-51]	72% [66-77]
QCU006 Outbye Construction/ Infrastructure	201	3.5 [3-4.2]	4	12 [9.8-15]	14	6.8% [4.8-9.2]	19% [16-23]	40% [35-44]	64% [59-68]
QCU008 ERZ Controller	162	3.4 [2.9-4.2]	4	12 [9.4-15]	14	6.5% [4.4-9.3]	18% [15-23]	39% [34-44]	63% [58-68]
QCU005 Longwall Moves	103	3.1 [2.7-3.7]	3.5	8.3 [7-10]	9.7	2.9% [1.6-5.3]	16% [12-21]	46% [40-53]	79% [73-84]
QCS025 Mobile/Bypass Crushing (Coal)	13	1.7 [0.94-4.4]	3.4	5.9 [3-17]	13	1.9% [0.19-9.3]	6.6% [1.5-19]	18% [7.1-35]	36% [21-54]
QCP005 Belt Splicers	13	1.9 [1.3-3.6]	3	5.5 [3.3-12]	9.9	1% [0.066-7]	6.3% [1.4-19]	23% [10-41]	52% [34-69]

Respirable Dust Data

Respirable dust exposures in Queensland display a much lower proportion of potential exceedances. Two of the highest average (AM $UCL_{1,90}$) exposed SEGs are boilermakers, but the nature of their exposures makes it highly likely that the causative agent is welding fume rather than mineral dusts. Excluding these workers, the remainder are still dominated by underground work groups in nine (9) of the top ten (10). **Table 11** has the top ten SEGs where n ≥ 10.

Table 10: Selected QLD RSHQ SEG Respirable Dust Exposures (SEGS where n ≥ 10)

RSHQ SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
QCU012 Boilermaker (Surface)	34	0.54 [0.28-1.4]	1.1	2 [1.1-4.9]	3.9	7.1% [3-14]	11% [5.5-19]	20% [12-31]
QCU001 Longwall Production	1,119	0.62 [0.59-0.65]	0.64	1.7 [1.6-1.8]	1.8	6.8% [5.9-7.8]	16% [14-17]	43% [41-45]
QCS005 Boilermaker	75	0.43 [0.33-0.62]	0.57	1.5 [1.1-2.3]	2.1	5.1% [2.7-9]	9.7% [5.9-15]	23% [17-30]
QCU007 VCD Installer	308	0.42 [0.38-0.47]	0.46	1.2 [1.1-1.4]	1.3	3% [2.1-4.2]	7.7% [5.9-9.8]	26% [23-30]
QCU008 ERZ Controller	555	0.35 [0.33-0.37]	0.37	0.94 [0.87-1]	1	1.3% [0.93-1.8]	4.3% [3.4-5.4]	20% [18-22]
QCU020 Returns	21	0.28 [0.2-0.42]	0.37	0.75 [0.51-1.3]	1.1	0.64% [0.06-3.8]	2.3% [0.43-8.2]	13% [5.3-25]
QCU002 Development Production	1,431	0.35 [0.34-0.37]	0.36	0.88 [0.84-0.92]	0.91	0.79% [0.62-0.99]	3.3% [2.8-3.9]	20% [19-21]
QCU015 Stone Drivage	191	0.29 [0.27-0.31]	0.31	0.65 [0.58-0.73]	0.71	0.12% [0.044-0.3]	0.91% [0.46-1.6]	11% [8.5-14]
QCU019 Production Support/Bullgang	619	0.3 [0.29-0.32]	0.31	0.75 [0.7-0.81]	0.8	0.44% [0.28-0.65]	2% [1.5-2.7]	14% [12-16]
QCU005 Longwall Moves	429	0.28 [0.26-0.29]	0.29	0.66 [0.61-0.71]	0.7	0.18% [0.098-0.31]	1.1% [0.73-1.6]	11% [9.1-13]

Respirable Quartz Data

In a manner similar to NSW, the respirable quartz exposure data is less influenced by SEG location. Six (6) surface mining SEGs are represented in the top ten average (AM $UCL_{1,90}$) SEGs shown in **Table** 12 from SEGs where n ≥ 10. In this analysis the influence of exposure variability (GSD, not shown) contributes to the AM $UCL_{1,90}$ and other measures such as the AM and EF provide additional context. Rather than larger production SEGs, the highest exposed SEGs in Qld are represented by smaller services SEGs or those involved in more itinerant work.

Table 11: Selected QLD RSHQ SEG Respirable Quartz Exposures (SEGs where n ≥ 10)

RSHQ SEG	n	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
QCU015 Stone Drivage	191	0.014 [0.011-0.019]	0.017	0.053 [0.041-0.072]	0.067	5.5% [3.6-7.9]	13% [10-17]
QCS009 Exploration Drillers	290	0.012 [0.0096-0.015]	0.014	0.044 [0.035-0.057]	0.054	4.2% [2.9-5.9]	11% [8.3-13]
QCS031 Industrial Cleaners	178	0.011 [0.009-0.016]	0.014	0.043 [0.033-0.06]	0.055	4% [2.5-6.3]	10% [7.5-14]
QCS032 Groundskeeping	87	0.01 [0.0073-0.015]	0.014	0.037 [0.026-0.059]	0.052	3.1% [1.3-6.1]	8.7% [5.3-13]
QCS026 Civil Construction	430	0.01 [0.0082-0.013]	0.013	0.04 [0.032-0.051]	0.048	3.8% [2.7-5.1]	8.4% [6.7-10]
QCU001 Longwall Production	1,118	0.012 [0.01-0.013]	0.013	0.045 [0.04-0.052]	0.05	4.4% [3.6-5.2]	10% [8.9-11]
QCU020 Returns	21	0.0049 [0.0025-0.021]	0.013	0.017 [0.0085-0.058]	0.041	0.94% [0.049-5.7]	2.9% [0.46-11]
QCU024 Drilling Other	97	0.0058 [0.0035-0.015]	0.011	0.021 [0.013-0.041]	0.035	1.8% [0.64-4.2]	4.1% [2-7.5]
QCS025 Mobile/Bypass Crushing (Coal)	42	0.0069 [0.0048-0.012]	0.01	0.024 [0.015-0.045]	0.038	1.2% [0.22-4.3]	4.6% [1.6-10]
QCS030 Domestic Cleaners	405	0.0091 [0.0082-0.01]	0.01	0.03 [0.026-0.035]	0.033	1.6% [1.1-2.5]	6.9% [5.4-8.7]

Ratio of Inhalable Dust to Respirable Dust

The ratio between the geometric mean inhalable dust exposures and geometric mean respirable dust exposures were statistically significantly greater in NSW than in Qld (Mann Whitney U Test p=0.002 between the two states). However, there was a difference in the distribution of SEGs in the data sets both states, which may introduce some error in the comparison test.

When displayed graphically in **Figure 12**, the differences between states and mine types are evident. What can be inferred is that dust exposures in NSW tend to be from coal mine dusts which have a larger inhalable to respirable dust ratio, this represents a marginally coarser particle size distribution (larger mass median particle size) and underground SEGs generally have the coarsest particle size distributions, and greater variance as evidenced by the higher interquartile range noted in **Table 13**. This property of dust exposures in some underground SEGs may be influenced by large particle bias as the difference between the geometric mean (GM) ratio and 95%ile ratio in underground SEGs compared to surface SEGs is substantially different.

The implications of this property of dust exposures in NSW are that the equivalence between an inhalable dust measurement and respirable dust measurement is not the same between the states even in similar SEG and mine types. The application of the same exposure limit for inhalable dust would result in different exposures to the number and size of dust particles between jurisdictions.

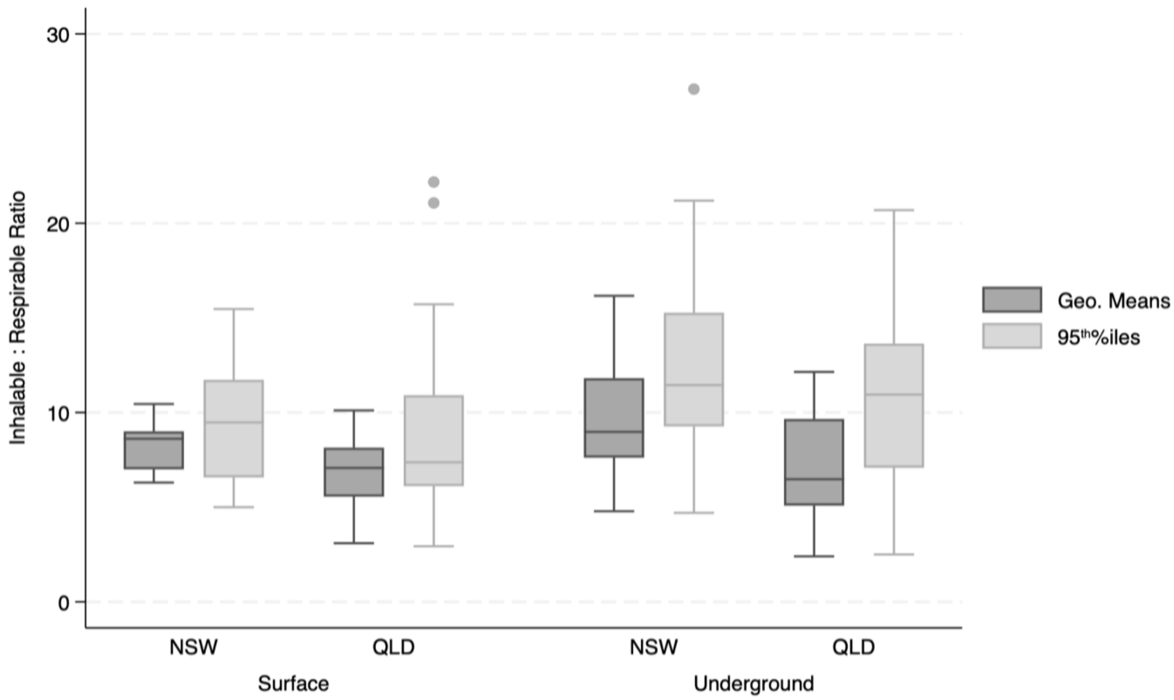


Figure 12: Boxplot of Inhalable to Respirable Ratios in SEGs by Mine type and Jurisdiction. Dark grey boxes are the ratio of the geometric means, the light grey boxes are the ratio of the 95th percentiles.

Table 12: Inhalable to Respirable ratio statistics (SEGs where n ≥ 10).

	SEGs with Inhalable results n ≥ 10	Median Ratio (Interquartile Range)	
		GM Inhalable : GM Respirable	95th%ile Inhalable : 95th%ile Respirable
NSW			
Surface	13	8.6 (2)	9.5 (5.2)
Underground	12	9 (4.2)	11(6)
Overall	*25*	*8.8 (3)*	*10 (4.7)*
QLD			
Surface	37	7.1 (2.6)	7.4 (4.8)
Underground	23	6.5 (4.6)	11 (6.6)
Overall	*60*	*7 (2.9)*	*8 (5.9)*
NSW + QLD			
Surface	50	7.2 (3)	7.6 (5.1)
Underground	35	7.8 (4.9)	11 (6.7)
Total	*85*	*7.3 (3.3)*	*8.5 (5.9)*

This property does appear to have some relationship with overall mass concentration as reflected by absolute inhalable dust levels. There appears to be a consistent increase in the ratio of GM respirable to GM inhalable along with the ratio of their 95% upper limits as the inhalable dust concentration increases, (see. **Figure 13**). At lower inhalable dust levels, <1 mg/m^3 the ratio is typically less than 1:10, whereas as inhalable dust levels increase the ratio is >1:10.

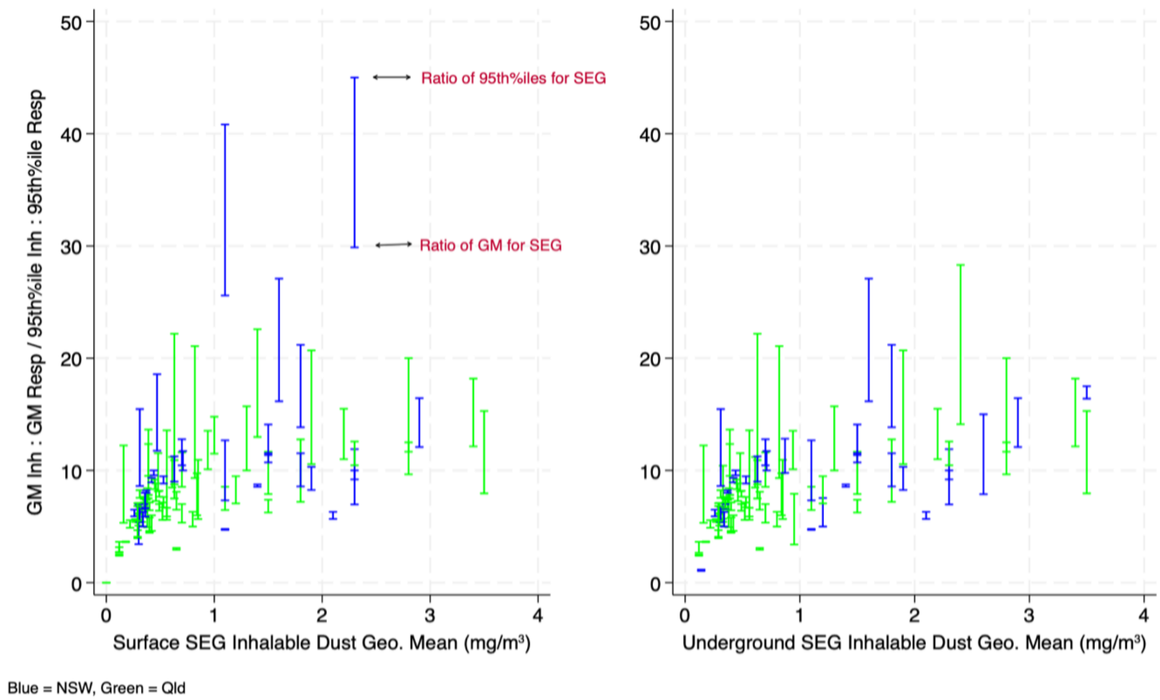


*Figure **13**: Surface and Underground SEG ratios of inhalable dust to respirable dust. The upper limits of the bars are the ratio of the 95th percentiles whilst the lower limits of the bars are the ratio of the geometric means for individual SEGs. Blue bars are from NSW SEGs where n ≥ 10 samples/SEG, green bars are from Qld SEGs where n ≥ 10 samples/SEG.*

A direct comparison between selected SEGs with the large numbers of samples reveals significant differences in the ratios of inhalable dust to respirable dust between Qld and NSW SEGs (**Table** 14). This finding is in keeping with that reported by Mark[66] that different groups of workers within a mine (SEGs) have different ratios, indicating each group is exposed to a different particle size distribution with significant differences between mines.

Table 13 – Inhalable to Respirable Ratios given as ratios of SEG Geometric Means and SEG 95th percentiles for Queensland and NSW SEGs

NSW SEG QLD SEG	*n* Inhalable samples NSW/QLD	Ratio of GM Inhalable/ Respirable		Ratio of 95th%ile Inhalable/ Respirable	
		NSW	QLD	NSW	QLD
CU02.1 Development - Cont mining and bolting QCU002 Development Production	562/203	9.2	12.1	11.9	18.2
CU01.2 Longwall Production (Bi Di) QCU001 Longwall Production	559/131	5.7	7.9	6.3	5.3
CU01.1 Longwall Production (Uni Di) QCU001 Longwall Production	450/131	7.0	7.9	10	15.3
CU06 Outbye construction/infrastructure QCU006 Outbye Construction/ Infrastructure	123/201	13.8	19.5	21.2	20.7
CS07 Blast Crew QCS007 Blast Crew	166/244	10.4	8.5	12.8	11.2
CS10 Blast Hole Drillers QCS010 Blast Hole Drillers	115/115	8.8	6.5	9.5	7.4
CP01 CHPP production QCP001 CHPP Production	214/242	9.0	8.5	11.2	11.6

Simulation Study Results for Inhalable/Respirable Ratios

The review team conducted a simulation study to better understand how the inhalable/respirable ratio changes with respect to dust size distribution. In occupational health, the lognormal distribution is commonly used to characterize the size distribution of airborne particles. The distribution is defined by two key parameters: the MMAD (also known as mass median diameter, or MMD) and the geometric standard deviation (GSD). The MMAD represents the central point of the particle size distribution, while the GSD indicates the variability of particle size diameters.

If the size distribution profile of airborne total dust is known, various sampling conventions (e.g., Equations. 1-4) can be applied to estimate the ratio of mass concentration for different dust fractions (e.g., respirable and inhalable). This ratio predicts the relationship between two sample results, assuming they were placed side by side and monitoring the same environment. **Figure 14** below shows the predicted ratios of dust mass concentration for inhalable to respirable (left) and thoracic to respirable (right) in relation to particle MMAD and GSD.

There is limited data on the actual particle size distribution of total coal mine dust. Studies suggest that the MMAD of total coal dust ranges from 10 to 35 µm, but the GSD was not reported.[72,73] Summary data reported by Lidén[53] contained coal mine particle size distributions from personal sampling between 15-40 µm MMAD and GSD from 2 to 5. Using the simulation study data and assuming the median particle GSD to be 2.8,[74] the predicted inhalable-to-respirable ratios would range from 4 to 20, while the thoracic-to-respirable ratios would range from 2 to 5. The implication from this data is that a respirable coal mine dust sample showing a concentration of 1 mg/m³ could be associated with an expected simultaneous sample showing a concentration between 4 and 20 mg/m³, and the simultaneous thoracic sample to be between 2 and 5 mg/m³. This illustrates the difficulties in attempting to impose an inhalable dust exposure limit that would be appropriate for a specific reduction in respirable dust.

	GSD					
MMD (µm)	2	2.4	2.8	3.2	3.6	4
2	1.19	1.25	1.28	1.31	1.33	1.35
4	1.80	1.78	1.77	1.75	1.74	1.72
6	2.75	2.49	2.34	2.23	2.15	2.09
8	4.11	3.38	3.00	2.75	2.59	2.46
10	5.99	4.47	3.74	3.31	3.03	2.83
12	8.50	5.76	4.57	3.91	3.49	3.20
14	11.79	7.29	5.48	4.54	3.96	3.58
16	16.04	9.07	6.49	5.21	4.45	3.95
18	21.43	11.13	7.60	5.91	4.95	4.34
20	28.19	13.49	8.79	6.65	5.47	4.72
22	36.56	16.16	10.09	7.43	5.99	5.11
24	46.82	19.18	11.48	8.24	6.54	5.51
26	59.27	22.56	12.97	9.09	7.09	5.91
28	74.24	26.33	14.56	9.97	7.66	6.31
30	92.10	30.50	16.26	10.88	8.24	6.72
32	113.24	35.10	18.06	11.83	8.83	7.13
34	138.09	40.16	19.97	12.81	9.43	7.54
36	167.10	45.69	21.99	13.83	10.05	7.96
38	200.77	51.73	24.11	14.87	10.67	8.38
40	239.62	58.28	26.35	15.96	11.31	8.81
42	284.21	65.37	28.69	17.07	11.96	9.24
44	335.14	73.03	31.15	18.22	12.62	9.67
46	393.04	81.28	33.72	19.39	13.29	10.10
48	458.55	90.13	36.41	20.61	13.97	10.54
50	532.40	99.62	39.21	21.85	14.66	10.99

	GSD					
MMD (µm)	2	2.4	2.8	3.2	3.6	4
2	1.18	1.21	1.23	1.24	1.24	1.24
4	1.66	1.59	1.53	1.49	1.46	1.43
6	2.26	1.98	1.82	1.71	1.64	1.59
8	2.96	2.38	2.09	1.92	1.80	1.72
10	3.72	2.79	2.35	2.11	1.95	1.84
12	4.55	3.19	2.60	2.28	2.08	1.95
14	5.44	3.59	2.84	2.45	2.21	2.04
16	6.37	4.00	3.08	2.60	2.32	2.14
18	7.36	4.40	3.30	2.76	2.43	2.22
20	8.39	4.80	3.52	2.90	2.54	2.31
22	9.46	5.21	3.74	3.04	2.64	2.38
24	10.58	5.61	3.95	3.18	2.74	2.46
26	11.73	6.01	4.16	3.31	2.83	2.53
28	12.93	6.42	4.36	3.43	2.92	2.60
30	14.16	6.82	4.57	3.56	3.01	2.66
32	15.42	7.22	4.76	3.68	3.09	2.73
34	16.73	7.62	4.96	3.80	3.17	2.79
36	18.06	8.03	5.15	3.91	3.25	2.85
38	19.43	8.43	5.34	4.03	3.33	2.91
40	20.83	8.83	5.53	4.14	3.41	2.96
42	22.27	9.23	5.71	4.25	3.48	3.02
44	23.73	9.64	5.90	4.36	3.55	3.07
46	25.22	10.04	6.08	4.46	3.62	3.12
48	26.75	10.44	6.26	4.57	3.69	3.17
50	28.30	10.85	6.44	4.67	3.76	3.22

Figure 14 – The ratios of dust mass concentration for inhalable to respirable (left) and thoracic to respirable (right) in relation to mass median aerodynamic diameter (MMAD, also known as mass median diameter or MMD) and geometric standard deviation (GSD).

Particle Dosimetry Modelling

The Multiple-Path Particle Dosimetry Model (MPPD)[75] was applied to estimate lung deposition fractions which only refers to dust which deposits and stays in a particular region of the lung, as opposed to the particle size fractions which may penetrate into that region but may be exhaled without biologic effect. These are divided into extrathoracic (above the glottis and corresponding to a portion of inhalable dust), tracheobronchial (corresponding to a portion of thoracic dust) and alveolar (corresponding to a portion of respirable dust) fractions of two different particle size distributions sampled isokinetically from a longwall face.[76]

To calculate the deposition of the dust particles in various regions of the respiratory tract the MPPD model requires inputs for the dust aerosol specifically: concentration, individual particle density, particle diameter (count median, mass median or MMAD), the GSD and whether a correction is to be made for inhalability.

Physiological inputs that relate to breathing must also be specified. These include initial lung volume at the start of the breath, which is termed functional residual capacity (FRC); the volume of air inhaled; the inspiratory fraction of the breathing cycle; and the route of breathing (nasal, oral, oronasal). In addition, the user must specify an airway morphometry model to be used and the volume of the upper respiratory tract. The model parameters are described in **Table 15**.

Table 14: Combinations of variable parameters used in MPPD Model

Variables	Parameter
Lung morphometry model	Human/Stochastic
FRC volume mL	3500
Head volume mL	50
Breathing route	Normal Augmenter
Tidal volume mL	700
Breaths per minute	16
Inspiratory fraction	0.3
Pause fraction	0
Dust concentration mg/m^3	5
Particle density (g/cc)	1.7
Particle size distribution	Specific MMAD, GSD

The results of a simple modelling exercise of two particle size distributions from a longwall are shown in **Table 16** and demonstrate that only a small fraction of the mass concentration of dust in air is deposited in the lungs. This was true for fine, but especially true for coarse particle sizes. Of significance, the total deposition fraction of a dust cloud containing "coarse particles" was only 42% of the total mass concentration of all particles in the air. Only 0.2% of the particles in that dust cloud were deposited below the glottis, and that portion was very likely those fine particles that are already being sampled by respirable dust monitoring. In a dust cloud containing a "fine particle" size distribution, only 0.8% of the particles in that dust cloud were deposited below the glottis. Inhalable dust sampling would therefore not likely contribute further to an evaluation of exposure risk in this setting. This data underscores another difficulty in using sampled inhalable dust results as an indicator or predictor of respiratory health outcomes.

Table 15: Results of MPPD Model for 2 different particle size distributions from a longwall face[76]

Lung Region	Deposition Fraction: Fine Particle Size Distribution MMAD 14.6µm GSD 2.09	Deposition Fraction: Coarse Particle Size Distribution MMAD 35.4µm GSD 2.42
Head	0.7196	0.4191
Tracheobronchial	0.0083	0.0018
Alveolar	0.0081	0.0022
Total	0.7360	0.4232

Summary

The body of evidence reviewed here suggests that the use of the inhalable dust fraction for coal mining dusts is likely complicated by the variations in the sampler performance at different wind speeds and high potential for contamination by large particles which either enter the IOM sampler under inertial or gravitational effects. These particles are less likely to have toxic effects when absorbed systemically or at local deposition sites in the head and neck.

Dust Control Technologies

In 2021, NIOSH released the *Best Practices for Dust Control in Coal Mining, Second Edition*[77], a comprehensive guide outlining engineering controls designed to help reduce worker exposure to respirable coal and silica dust. The handbook covers a range of controls, from well-established industry standards to newer, still-evolving solutions. Its goal is to highlight the best practices for controlling respirable dust levels in both underground and surface coal mining operations. The document is free to download. We have reviewed some emerging dust control technologies mentioned in the report for reference (see Appendix A. Dust Control Technologies**)**.

Current Data on Prevalence of CMDLD in NSW

Chest Imaging

Chest imaging is one of the most important tests used in the medical surveillance of coal mine workers. These images are classified using the International Labour Office[78] (ILO) system (see **Table 17**), according to the protocols developed by CSH.[79]

Table 16 - ILO Classification of small opacities (less than or equal to 10 mm in diameter)

ILO Major Profusion Category	ILO Minor Profusion Category	Classification of pneumoconiosis
Category 0	0/-	Negative
	0/0	
	0/1	
Category 1	1/0	Small Opacity Disease
	1/1	
	1/2	
Category 2	2/1	
	2/2	
	2/3	
Category 3	3/2	
	3/3	
	3/+	

The CSH Clinical Pathway Guidelines for chest imaging indicate that workers who have a chest radiograph classified as having small opacity profusion 1/0 or greater by the ILO system undergo further testing, including high resolution CT scanning (HRCT), see **Figure 15**. If the HRCT is positive for a respiratory abnormality the worker is then referred to a respiratory physician. The results of this evaluation are reviewed by the CSH Clinical Investigation Team (CIT) or a multi-disciplinary team to determine if the worker has a coal mine dust lung disease, and, if so, whether the worker should be considered for return to work under the reduced exposure guidelines and enhanced medical surveillance. These workers might not be allowed to return to work if it was believed that the mine could not meet the requirements for reduced exposure levels. A review of a sample of chest imaging results was performed to determine how many workers might be affected by this process.

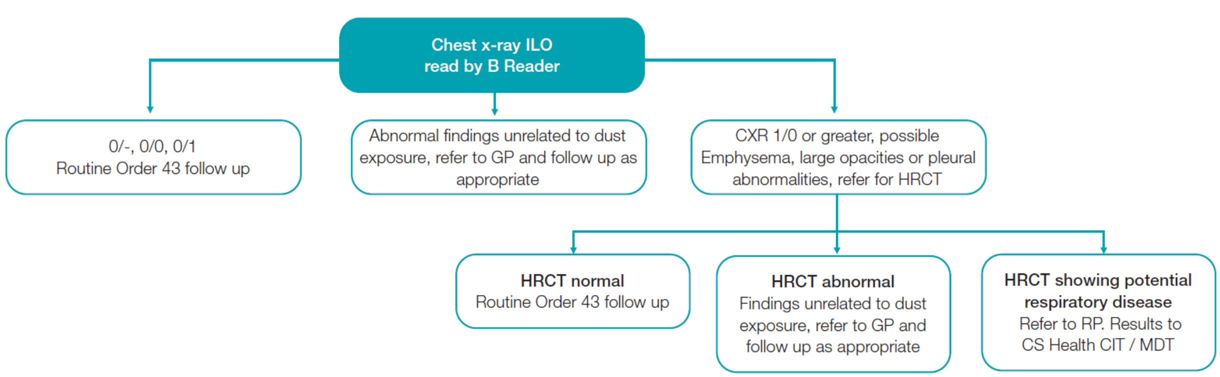


Figure 15 - CSH Pathway for Chest Imaging

Chest X-ray

The review team analysed de-identified chest imaging ILO classifications provided by CSH for chest x-rays performed from 1 January 2022 through 30 December 2023. We received the miner's date of birth, date of exam, ILO classification, and the CSH outcome for each study. We were not provided with demographic information, work history or smoking history in this data set. After removing duplicates, there was a total of 31 905 results for examination. The mean age at the time of the CXR was 38 years with a range of 15 to 78 years. The outcome variables determined by CSH are shown in **Table 18**. The ILO classifications are shown in **Table 19.** There were only 114 miners with abnormal CXRs (0.36%), or and only 12 with small opacity profusion greater than ILO major category 1 (note that miners with a 0/1 classification, considered negative by ILO, were excluded). Unfortunately, we do not have the HRCT data on these 114 workers to determine if the CXR classification was confirmed by HRCT. CSH chest x-ray outcome classifications are shown in **Table 20.** There were 139 images that were determined to be "Significantly Abnormal" which would require further evaluation, and these workers could potentially be subject to dust restrictions if CMDLD were confirmed. There were 25 miners whose images were classified as "Significantly Abnormal," but who did not have a positive ILO classification of 1/0 or greater. This is likely due to the finding of emphysema, which is a CMDLD that could have a normal ILO classification. It is possible that errors in coding may also account for a subset of the "Significantly Abnormal" classifications.

Table 17 - CSH Outcome Variables, January 2022-December 2023

CSH Outcome Variable	Interpretation
Normal	Negative ILO and no other findings
Routine Abnormal	Negative ILO but some other non-work-related finding
Significantly Abnormal	Positive ILO or another sign of CMDLD on CXR

Table 18 - ILO Classifications from chest x-rays, January 2022-December 2023

ILO profusion	Number	Percent
0/0	31 613	99.08
0/1	178	0.56
1/0	64	0.20
1/1	30	0.09
1/2	8	0.03
2/1	6	0.02
2/2	2	0.01
2/3	1	0.0003
3/2	1	0.0003
3/3	1	0.0003
3/+	1	0.0003
Total	31 905	100

Table 19 - CSH Outcomes, January 2022-December 2023

CSH Outcome	Number	Percent
Normal	30 031	94.13
Routine Abnormal	1735	5.44
Significantly Abnormal	139	0.44
Total	31 905	100

High-Resolution CT Scanning

We obtained a de-identified list of 425 HRCT scans that were performed from January 2022 through December 2022 and July 2023 through December 2024. Out of this list, 252 corresponded to chest x-ray data described in the sample above. The vast majority of HRCTs were taken for subjects with normal ILO classifications (86%) (See **Table 21**) and normal CSH chest x-ray outcome classifications (75%), (See **Table 22**). This is likely a reflection of the HRCTs ordered for evaluation of workers with abnormal physiologic testing only. We reviewed the de-identified reports on a subset of 15 HRCTs that were randomly selected by CSH. Of the three that were positive on ILO classifications of CXRs, all three were confirmed to have parenchymal abnormalities on HRCT. The abnormalities on two of these HRCTs were thought to be non-occupational in aetiology, and the remaining one possibly occupationally related. Of the two studies that were associated with ILO category 0/1 (borderline negative) for pneumoconiosis, the HRCT in one demonstrated minimal lower lobe scarring which was thought possibly related to occupation. Of the 11 studies associated with normal ILO classifications, 5 were normal, 3 had findings consistent with obstructive lung disease, and 2 had non-occupational findings that could have contributed to a restrictive impairment.

Table 20 - CXR ILO Findings Associated with HRCTs, January-December 2022 and July 2023-December 2024

Associated CXR ILO Classification	Number	Percent
Normal	217	86.1
ILO 0/1	12	4.7
ILO 1/0 or Greater	23	9.1
Total	252	100

Table 21 - CSH CXR Outcomes Associated with HRCTs, January-December 2022 and July 2023-December 2024

Associated CXR CSH Outcome	Number	Percent
Normal	188	74.6
Routine Abnormal	46	18.2
Significantly Abnormal	18	7.1
Total	252	100

Conclusions from Chest Imaging

The imaging surveillance of coal mine workers by CSH demonstrates a very small number of workers with findings consistent with radiographic CMDLD. Review of the small sample of those referred for advanced imaging with HRCT showed 1 of 3 with nodular opacities on CXR that were likely occupational, 1 of 2 of the borderline cases with occupationally related lung disease, and 3 of 11 of the cases associated with normal CXR showed findings consistent with obstructive lung disease which may be occupationally related.

As reflected by this sample of chest imaging findings, relatively few workers would be referred for reduced dust exposure limits and enhanced medical surveillance.

Physiology

Spirometry

Spirometry, which assesses the "bellows" function of the lungs through measurement of volumes of air on maximal forceful exhalation, is a required test in the NSW Health Surveillance Scheme for Coal Mine Workers (see **Figure 16)**. Early detection of spirometric abnormalities or evidence of accelerated decline in lung function provides an opportunity to intervene on a coal mine worker's subsequent dust exposure, with the aim of limiting subsequent health effects from CMDLD. As substantial loss of lung function can occur before a worker experiences exertional limitation, respiratory screening with physiologic testing such as spirometry plays a critical role in the prevention or limitation of future respiratory morbidity. Workers with abnormal findings are referred for further testing including complex lung function and HRCT and if positive sent to a respiratory physician. These results are also reviewed by the CIT or a multi-disciplinary team to determine if the worker has a CMDLD, and, if so, should be considered for reduced dust exposures and enhanced medical surveillance. These workers might not be allowed to return to work if it was believed that the mine could not meet the requirements for reduced exposure levels. A review of a spirometry results was performed to determine how many workers might be affected by this process.

The prevalence of abnormal spirometry pre- and post-enactment of recommendations from the 2023 UIC Review was evaluated using de-identified spirometry data from two separate periods, June-August 2022 and June-August 2024. Demographic data included age, smoking status, gender, height, weight, race/ethnicity, and work setting. Spirometry data included measured, predicted, per cent predicted, and lower limit of normal values for FEV_1, FVC, and FEV_1/FVC.

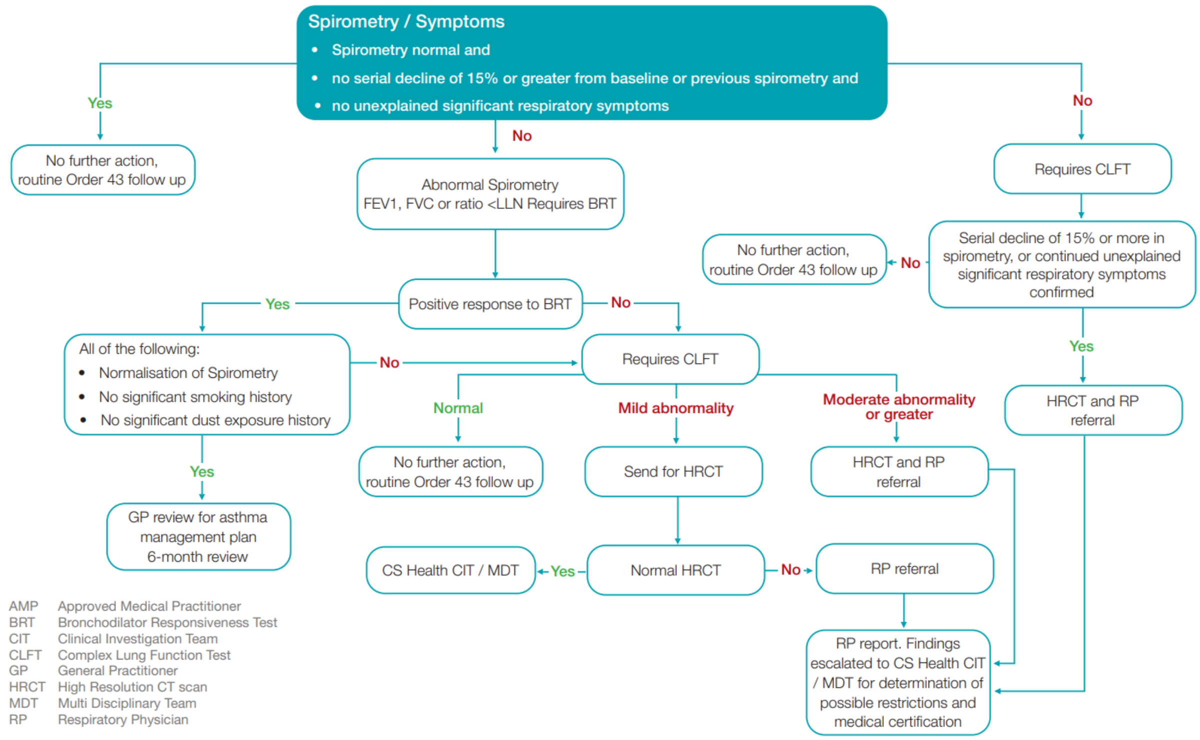


Figure 16 - CSH Pathway for Spirometry/Symptoms

The characteristics of the coal mine workers in the 2022 and 2024 samples were similar (**Table 23**). A slightly higher rate of never smoking status was observed in the 2024 sample (64.7% vs. 61.2%). The percentage of coal mine workers reported to be working in an open cut setting was somewhat higher in the 2024 sample (56.9% vs. 49.9%), with lower percentage working underground (26.7% vs. 30.4%).

Table 22 - Demographic Data on Miners with Spirometry Data, June-August 2022 and June-August 2024.

	Jun-Aug 2022 (n = 1537)	Jun-Aug 2024 (n = 2101)	Total (N = 3638)
Age, mean (SD)	41.6 (10.9)	41.4 (10.9)	41.5 (10.9)
Height, mean (SD)	177.4 (7.3)	177.2 (7.8)	177.3 (7.6)
Weight, mean (SD)	94.0 (17.3)	94.8 (17.6)	94.4 (17.5)
Gender, n (%)			
Male	1409 (91.7%)	1878 (89.4%)	3287 (90.4%)
Female	128 (8.3%)	223 (10.6%)	351 (9.6%)
Race/Ethnicity, n (%)			
Caucasian	1370 (89.1%)	1846 (87.9%)	3216 (88.4%)
ATSI	43 (2.8%)	70 (3.3%)	113 (3.1%)
Aboriginal	14 (0.9%)	10 (0.5%)	24 (0.7%)
Other/Not Specified	110 (7.2%)	0 (0.0%)	110 (3.0%)

Smoking Status, n (%)			
Never	941 (61.2%)	1359 (64.7%)	2300 (63.2%)
Former	392 (25.5%)	543 (25.8%)	935 (25.7%)
Current	204 (13.3%)	199 (9.5%)	403 (11.1%)
Work Setting, n (%)			
Open Cut	767 (49.9%)	1196 (56.9%)	1963 (54.0%)
Underground	467 (30.4%)	560 (26.7%)	1027 (28.2%)
Underground (Surface)	42 (2.7%)	77 (3.7%)	119 (3.3%)
CHPP	92 (6.0%)	113 (5.4%)	205 (5.6%)
Non-Mining	3 (0.2%)	1 (0.0%)	4 (0.1%)
Unspecified	166 (10.8%)	154 (7.3%)	320 (8.8%)

Abbreviations: SD – standard deviation; ATSI – Aboriginal and Torres Strait islander; CHPP – coal handling and preparation plant

The spirometry data between the 2022 and 2024 samples were also similar (**Table 24**). There were no substantial differences between the two groups in mean FEV1, FVC, or FEV1/FVC. Rates of abnormally low FEV1, FVC, and FEV1/FVC were similar as well.

Table 23 - Spirometry Data, June-August 2022 and June-August 2024.

	2022 (n = 1537)	2024 (n = 2101)	Total (N = 3638)
FEV_1, mean (SD)	4.06 (0.77)	3.95 (0.75)	3.99 (0.76)
FEV_1 % predicted, mean (SD)	99.6 (13.2)	97.4 (12.4)	98.3 (12.8)
FEV_1 < LLN, n (%)	77 (5.0%)	118 (5.6%)	195 (5.4%)
FVC, mean (SD)	5.21 (0.93)	5.10 (0.92)	5.15 (0.93)
FVC % predicted, mean (SD)	102.7 (12.6)	101.3 (12.1)	101.9 (12.3)
FVC < LLN, n (%)	30 (2.0%)	49 (2.3%)	79 (2.2%)
FEV_1/FVC, mean (%)	78.1 (6.0)	77.5 (6.3)	77.7 (6.2)
FEV_1/FVC < LLN, n (%)	117 (7.6%)	188 (8.9%)	305 (8.4%)

Abbreviations: FEV1 – forced expiratory volume in one second; FVC – forced vital capacity; SD – standard deviation; LLN – lower limit of normal.

Given the similarities in the spirometry data between the 2022 and 2024 samples, these data were combined for subsequent analysis. The review team focused on FEV_1, the most important spirometric measure of impairment, and is used to determine the need for reduced dust exposure limits. Of the 3638 spirometry studies, 6 (0.2%) were excluded due to invalid results. Of the remaining 3632 studies, 193 (5.3%) had FEV_1 values below the lower limit of normal (**Table 25**), as determined by CSH. Most of the cases (125/193, 64.8%) were observed in open cut workers. Open cut workers had higher rates of abnormally low FEV_1 compared to underground workers (6.4% vs. 3.6%). Although underground workers working on the surface had a higher rate of abnormally low FEV_1 than open cut workers (6.7% vs. 6.4%), it should be noted that the number of cases identified as surface workers at underground mines is small (n = 8 for the whole sample).

Table 24 - Work Settings of Miners with Abnormal Spirometry, June-August 2022 and June-August 2024.

Work setting	Number of workers (percent)	Number with abnormal FEV_1	Percentage of workers in that setting with abnormal FEV_1
CHPP	205 (5.6%)	10	4.9%
Non-Mining	4 (0.1%)	0	0.0%
Open Cut	1963 (54.0%)	125	6.4%
Underground	1027 (28.2%)	37	3.6%
Underground (Surface)	119 (3.3%)	8	6.7%
Unspecified	320 (8.8%)	13	4.1%
Total	3632	193	5.3%

The review team also evaluated the data on abnormally low FEV_1 by a widely used and accepted severity rating system,[80] and by work setting (see **Table 26**). Of the 193 cases with abnormally low FEV_1, 148 (76.7%) had mild impairment (≥ 70% predicted), with open cut and underground miners comprising most of these cases (62.8% and 22.3%, respectively). Open cut workers comprised the largest proportion of workers with abnormally low FEV_1 in the more severe impairment categories (32/45, 71.1%).

Table 25 - Severity of FEV_1 Impairment by Work Setting, June-August 2022 and June-August 2024.

Work setting	Mild (≥ 70% pred)	Moderate (60-69% pred)	Moderately severe (50-59% pred)	Severe (<50% pred)	Total
CHPP	8 (5.4%)	1 (3.3%)	1 (7.7%)	0 (0.0%)	10 (5.2%)
Open Cut	93 (62.8%)	24 (80.0%)	7 (53.8%)	1 (50.0%)	125 (64.8%)
Underground	33 (22.3%)	2 (6.7%)	2 (15.4%)	0 (0.0%)	37 (19.2%)
Underground (Surface)	7 (4.7%)	0 (0.0%)	1 (7.7%)	0 (0.0%)	8 (4.1%)
Unspecified	7 (4.7%)	3 (10.0%)	2 (15.4%)	1 (50.0%)	13 (6.7%)
Total	148	30	13	2	193

Lung Diffusing Capacity for Carbon Monoxide

Lung diffusing capacity for carbon monoxide (D_{LCO}) measures the gas exchange capacity of the lung and is used for further evaluation of workers with abnormal spirometry, chest imaging, or respiratory symptoms. Of note, this test is only used to evaluate workers with abnormal screening tests and the results from analysis of this group of workers are not representative of the larger population of coal mine workers. D_{LCO} measurements for 209 coal mine workers tested between February-June 2024 were reviewed. Two studies were excluded due to missing information. Of the remaining 207 cases, 3 (1.4%) had abnormally low D_{LCO}. All 3 individuals with abnormal D_{LCO} had measurements that were 70% predicted or higher, consistent with mild diffusion impairment. Two of the 3 had moderate reduction in FEV_1, while the third had an FEV_1 measurement in the normal range. All 3 worked in an open cut setting, aged upper 50s to low 60s.

Cases of Mine Workers Affected by Inhalable Mine Dust Guidelines

Workers Referred for Dust Restrictions

The review team evaluated de-identified data on workers who had been placed on dust restrictions during the period February-May 2024 (see **Table 27**). Of the 62 workers, the large majority (79%) were employed by contracting agencies. Forty-nine (79%) worked in open cut mines, and the remaining 13 (21%) worked underground. The majority (68%) had been referred for further evaluation due to abnormal lung function test results. Half of the workers had been placed on “mild” restrictions (<1.0 mg/m^3 respirable coal mine dust, <0.25 mg/m^3 respirable crystalline silica, and 2.5 mg/m^3 inhalable mine dust), and 42% on “moderate” restrictions (<0.5 mg/m^3 respirable coal mine dust, <0.25 mg/m^3 respirable crystalline silica, and 1.25 mg/m^3 inhalable mine dust); 5 workers were excluded from dust exposure.

Table 26 - Workers referred for dust restrictions, February-May 2024.

	Number (%)
Employment	
Mining company	13 (21.0%)
Contractor	49 (79.0%)
Work setting	
Open Cut/Surface	49 (79.0%)
Underground	13 (21.0%)
Reason for referral	
Abnormal lung function only	42 (67.7%)
Abnormal radiology only	9 (14.5%)
Both abnormal lung function and radiology	7 (11.3%)
Unspecified	4 (6.5%)
Dust restrictions	
Mild	31 (50.0%)
Moderate	26 (41.9%)
Excluded from dust exposure	5 (8.1%)
Diagnosis	
Mine dust lung disease	2 (3.2%)
Non-occupational lung disease	15 (24.2%)
Both occupational and non-occupational lung disease	2 (3.2%)
Other abnormality	1 (1.6%)
No significant abnormality	2 (3.2%)
Diagnosis unconfirmed or unspecified	40 (64.5%)

Most (65%) workers did not have a confirmed or specified diagnosis as of November 2024, and in many cases respiratory physician assessment was pending. Of the remaining 22 workers, 15 (68%) were deemed to have non-occupational lung disease, while only 4 (18%) were found to have lung disease due at least in part to occupational exposures.

Workers Referred for Respiratory Physician Evaluation

The review team was provided with de-identified data from 265 workers who had been referred for respiratory physician evaluation from January 2022 to June 2024, encompassing periods before and after the time of the UIC Review (see **Table 28**).

Table 27 – Workers referred for respiratory physician evaluation, January 2022-June 2024.

	2022 (n = 37)	2023 (n = 89)	2024 (n = 139)*	Total (N = 264)
Work setting				
Surface/Open Cut	22 (61.1%)	65 (73.0%)	87 (62.6%)	174 (65.9%)
Underground	11 (30.6%)	15 (16.9%)	36 (25.9%)	62 (23.5%)
CHPP	3 (8.3%)	9 (10.1%)	14 (10.1%)	26 (9.8%)
Other	0 (0.0%)	0 (0.0%)	2 (1.4%)	2 (0.8%)
Employer Field				
Mine operator	25 (67.6%)	44 (49.4%)	65 (46.8%)	134 (50.6%)
Contractor	11 (29.7%)	41 (46.1%)	64 (46.0%)	116 (43.8%)
Other/mixed employment	0 (0.0%)	2 (2.2%)	4 (2.9%)	6 (2.3%)
Non-mining	0 (0.0%)	0 (0.0%)	4 (2.9%)	4 (1.5%)
Unspecified	1 (2.7%)	2 (2.2%)	2 (1.4%)	5 (1.9%)
Years in industry				
< 10 years	7 (18.9%)	18 (20.2%)	41 (29.5%)	66 (24.9%)
10 - 20 years	16 (43.2%)	36 (40.4%)	59 (42.4%)	111 (41.9%)
20 - 30 years	4 (10.8%)	17 (19.1%)	24 (17.3%)	45 (17.0%)
> 30 years	10 (27.0%)	18 (20.2%)	15 (10.8%)	43 (16.2%)
Smoking status				
Non-smoker	9 (24.3%)	24 (27.0%)	49 (35.5%)	82 (31.1%)
Ex-smoker	6 (16.2%)	25 (28.1%)	39 (28.3%)	70 (26.5%)
Smoker	22 (59.5%)	40 (44.9%)	50 (36.2%)	112 (42.4%)
Referral trigger				
Abnormal lung function	17 (45.9%)	67 (75.3%)	85 (61.2%)	169 (63.8%)
Abnormal radiology	16 (43.2%)	13 (14.6%)	20 (14.4%)	49 (18.5%)
Abnormal radiology and lung function	3 (8.1%)	5 (5.6%)	27 (19.4%)	35 (13.2%)
Abnormal symptoms	1 (2.7%)	0 (0.0%)	2 (1.4%)	3 (1.1%)
Other health issue	0 (0.0%)	4 (4.5%)	5 (3.6%)	9 (3.4%)
Diagnosis				
Mine dust lung disease	3 (8.1%)	5 (5.6%)	4 (2.9%)	12 (4.5%)
Lung disease (other) occupational	0 (0.0%)	2 (2.2%)	0 (0.0%)	2 (0.8%)
Lung condition - non-occupational	5 (13.5%)	16 (18.0%)	13 (9.4%)	34 (12.8%)
Lung disease - non-occupational	13 (35.1%)	23 (25.8%)	18 (12.9%)	54 (20.4%)

Lung disease (other) - occupational and non-occupational attributions	1 (2.7%)	1 (1.1%)	6 (4.3%)	8 (3.0%)
Other abnormality or condition	3 (8.1%)	8 (9.0%)	0 (0.0%)	11 (4.2%)
No significant abnormality	9 (24.3%)	17 (19.1%)	7 (5.0%)	33 (12.5%)
Diagnosis unconfirmed	3 (8.1%)	17 (19.1%)	91 (65.5%)	111 (41.9%)

*2024 data are through June 2024.

Far more coal mine workers were referred for respiratory physician evaluation after the time of the UIC Review than in the year prior to the Review. For example, in the first six months of 2024, 139 workers were referred for evaluation, compared to 37 workers during all of 2022. When adjusted to exclude cases in which a diagnosis was not yet confirmed, annual rates of diagnosis of mine dust lung disease alone by respiratory physicians were unchanged (**Table 29**). However, in 2024 workers were diagnosed with lung disease due to a combination of occupational and non-occupational causes at a higher rate than in 2022 or 2023.

Table 28 - Confirmed diagnoses of workers evaluated by a respiratory physician, January 2022-June 2024.

	2022 (n = 34)	2023 (n = 72)	2024 (n = 48)*	Total (n = 154)
Diagnosis				
Mine dust lung disease	3 (8.8%)	5 (6.9%)	4 (8.3%)	12 (7.8%)
Lung disease (other) occupational	0 (0.0%)	2 (2.8%)	0 (0.0%)	2 (1.3%)
Lung condition - non-occupational	5 (14.7%)	16 (22.2%)	13 (27.1%)	34 (22.1%)
Lung disease - non-occupational	13 (38.2%)	23 (31.9%)	18 (37.5%)	54 (35.1%)
Lung disease (other) - occupational and non-occupational attributions	1 (2.9%)	1 (1.4%)	6 (12.5%)	8 (5.2%)
Other abnormality or condition	3 (8.8%)	8 (11.1%)	0 (0.0%)	11 (7.1%)
No significant abnormality	9 (26.5%)	17 (23.6%)	7 (14.6%)	33 (21.4%)

*2024 data are through June 2024.

Abbreviations

ACGIH	American Conference of Government and Industrial Hygienists
AM $UCL_{1,90}$	Arithmetic mean upper confidence limit (single-sided, 90^{th} percentile)
ATS	American Thoracic Society
cfm	Cubic feet per minute
CHPP	Coal handling and preparation plant
CI	Credible interval
CIS	Conical Inhalable Sampler
CIT	Clinical Investigation Team (Coal Services Health)
CLFS	Complex lung function study
CMDLD	Coal mine dust lung disease
COPD	Chronic obstructive pulmonary disease
CSH	Coal Services Health
D_{LCO}	Lung diffusing capacity for carbon monoxide
EF	Exceedance fraction
FEV_1	Forced expiratory volume in one second
FRC	Functional residual capacity
FVC	Forced vital capacity
GM	Geometric mean
gpm	Gallons per minute
GSD	Geometric standard deviation
HRCT	High resolution computed tomographic scan
ICOERD	International Classification of High-resolution Computed Tomography for Occupational and Environmental Respiratory Diseases
ILO	International Labour Office
IMD	Inhalable mine dust
IOM	Institute of Occupational Medicine (UK)
ISO	International Organisation for Standardisation
LLN	Lower limit of normal
LOR	Limit of reporting
MMAD	Mass median aerodynamic diameter
MMD	Mass median diameter
MPPD	Multiple Path Particle Dosimetry Model
MSAC	Mine Safety Advisory Council
NIOSH	National Institute for Occupational Safety and Health (US)
NOS	Not otherwise specified
NSW	New South Wales
OSHA	Occupational Safety and Health Administration (US)
PMF	Progressive massive fibrosis
PNOR	Particulates not otherwise regulated

psi	Pounds per square inch
Qld	Queensland
RCD	Respirable coal mine dust
RCS	Respirable crystalline silica
RSHQ	Resources Safety and Health Queensland
SD	Standard deviation
SEG	Similar exposure groups
SWA	Safe Work Australia
TLV	Threshold limit value
UG	Underground
UIC	University of Illinois Chicago
UK	United Kingdom
US	United States
WCRSQ	Workers' Compensation Regulatory Services Queensland
WES	Workplace exposure standard

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Appendix A. Dust Control Technologies

Emerging Dust Control Technologies for Longwall Mining

- **Fan-Powered Shearer Scrubber**

Fan-powered flooded bed scrubbers reduce respirable dust on continuous mining machines but have limited success on longwall shearers due to lower airflow capture and space constraints. Arya et al. (2018)[81] integrated a scrubber into a shearer, achieving up to 74% dust reduction in the walkway and 57% in the return. This shows potential for effective dust control, though further design modifications are needed for full integration into shearers.

- **Underside Shield Sprays**

Klima et al.[82] tested underside shield sprays on longwall shearers to extend the reach of headgate splitter arm sprays and reduce dust exposure to operators. The most effective configuration, using 75° spray angle, 4.5-foot distance, and 200-psi pressure, achieved over 95% dust reduction at upwind and centreline locations and 70% reduction at the ranging arm motor. These results suggest that underside sprays can significantly control dust upwind of the headgate drum, but further testing in real mining conditions is needed.

- **Foam**

Research in underground coal operations has shown that foam provides better respirable dust control than plain water, thanks to its lower surface tension, larger contact area with dust, and reduced water usage[83]. However, generating quality foam requires compressed air, adding complexity and operational challenges. The cost of equipment, maintenance, and chemical additives has limited foam adoption in the industry. Additionally, potential health effects from chemical additives and their impact on preparation plant functions must be evaluated before use [84].

Emerging Dust Control Technologies for Continuous Mining

- **Self-Cleaning Nozzles**

Klima et al.[85] conducted laboratory tests to compare the performance of two differently sized hollow cone Repair King nozzles with similarly sized hollow cone nozzles from Spraying Systems Co. and Steinen-Hahn, both commonly used in underground coal mines. Results showed that while the self-cleaning nozzles had similar water flow rates and airflow induction as the other nozzles, their airborne dust capture efficiency was approximately 25% lower.

- **Dry Scrubber**

Organiscak et al.[86] developed a mobile dry scrubber to reduce dust exposure for roof bolter operators by filtering return air from the continuous miner. Laboratory tests showed the dry scrubber achieved over 95% respirable dust removal efficiency at various airflows. Underground testing on two super sections using blowing face ventilation found that, when operating between 2,700 and 4,900 cfm, the dry scrubber reduced respirable dust by 50% at the face.

- **Wet Collector Box**
Reed et al.[87] evaluated a modified wet collector box as an alternative to traditional dry vacuum dust collection systems on roof bolters. The modification included removing the internal cyclone, adding a water spray (0.5–2.0 gpm at 100 psi), and installing a drain valve to wet and flush dust, reducing airborne exposure during cleanout. Underground testing compared dust levels between the wet and dry collector boxes. Results showed the wet collector box reduced operator dust exposure during cleanout by 80% and overall shift exposure by 25%. Additionally, quartz content in dust samples dropped from 7.4% with the dry collector to undetectable levels with the wet system.

- **Shuttle Car Canopy Air Curtain**
Reed et al.[88] adapted the canopy air curtain, previously used to reduce dust exposure for roof bolter operators, for haulage car operators. In collaboration with Marshall University and J.H. Fletcher & Co., NIOSH designed, installed, and tested the system on a ram car in an underground coal mine. Laboratory and in-mine testing measured respirable dust levels using various samplers. With the canopy air curtain providing over 300 cfm of airflow, results showed a 65% dust reduction while loading behind the continuous miner, with reductions of 18%, 36%, and 24% during tramming, unloading, and returning, respectively.

Approaches for Reducing Float Coal Dust Deposition

Float coal dust consists of fine coal particles smaller than 75 µm that becomes airborne during mining and transport before settling on mine surfaces. It poses a significant safety hazard as it can be easily re-entrained into the air by a pressure wave from a methane explosion, potentially fuelling a more extensive coal dust explosion. Owing to its particle size range float dust measurement and control has parallels with inhalable dust measurement and control. Some approaches for reducing float coal dust deposition:

- **Return Entry Flooded Bed Scrubber**
Patts et al. (2016)[89] evaluated a flooded bed scrubber installed between ventilation tubing and an auxiliary fan in a return entry to improve dust control. The scrubber, equipped with a stainless-steel filter panel and 12 water sprays, effectively removed airborne dust before discharge. Testing showed reductions of 92.5% for airborne float coal dust, 85.5% for respirable dust, and 84.2% for deposited dust.

- **Water Sprays**
Beck et al. (2018)[90] studied the effectiveness of water sprays in capturing airborne float coal dust in a controlled test area. Seven spray types were tested at varying pressures and orientations. The full cone spray at 160 psi, directed into the airstream, achieved the highest dust reduction at 40.1%. Most sprays performed better at higher pressures, and wider spray angles improved dust capture. The hydraulic atomizing spray, while using 45% less water than the full cone spray, showed the highest dust reduction per gallon, making it a viable option where water supply is limited.

- **Water Curtain on Longwall**

Seaman et al. (2020)[91] investigated the effectiveness of water curtains in reducing float coal dust on a longwall face. Testing in the full-scale longwall dust gallery showed that a water curtain with 21 full cone sprays at 160 psi reduced float dust by 49% and respirable dust by 33%. As the number of sprays was reduced, dust reductions dropped significantly. When two water curtains were used simultaneously, float dust was reduced by 56% and respirable dust by 43%, though the dust reduction per gallon of water decreased. Separating the curtains did not provide significant benefits. These results suggest that water curtains can effectively reduce float dust entering the return entry.

- **Conveyor Belt Transfer Controls**

Beck et al. [92] evaluated the effectiveness of water and water with wetting agent in reducing dust at an underground coal conveyor belt transfer point. Four water sprays were installed to cover the coal stream, operated at 35–40 psi, adding moisture of 0.24%–0.29% by weight. A chemical injection pump added wetting agent at 0.2% concentration. Testing showed that water-only sprays reduced airborne float dust by 32.3% and respirable dust by 28.3%. When the wetting agent was added, float dust reductions increased to 49.5%, and respirable dust reductions reached 46.4%.%.%.

Appendix B. Full Data Tables for NSW and QLD Inhalable Dust Exposures

NSW CSH SEGs Inhalable Dust Exposures.

CSH SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2. 5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
CP01 CHPP production	213	0.63 [0.57-0.7]	2.4 [2.3-2.6]	0.93 [0.83-1.1]	1	2.7 [2.3-3.2]	3.1	0.089% [0.033-0.21]	0.96% [0.52-1.7]	5.9% [4.2-8.2]	22% [18-26]
CP02 CHPP Maintenance	189	0.71 [0.63-0.79]	2.6 [2.4-2.9]	1.1 [0.98-1.3]	1.3	3.4 [2.9-4.1]	4	0.29% [0.13-0.62]	2.1% [1.2-3.4]	9.4% [7-12]	28% [23-32]
CP03 CHPP Laboratory	13	1.1 [0.64-1.9]	3.1 [2.3-4.9]	2.1 [1.2-4.9]	3.9	7.1 [3.7-19]	14	2.5% [0.31-11]	9% [2.4-24]	24% [11-41]	46% [29-64]
CP04 CHPP HME	44	0.37 [0.3-0.46]	2.4 [2.1-2.9]	0.55 [0.43-0.73]	0.68	1.6 [1.2-2.3]	2.1	0.0084% [0.00035-0.11]	0.15% [0.018-0.81]	1.5% [0.42-4.2]	8.2% [4.1-15]
CP06 CHPP Other	43	0.34 [0.28-0.41]	2 [1.8-2.4]	0.44 [0.36-0.55]	0.52	1.1 [0.86-1.5]	1.4	0.00012% [9.4e-07-0.0056]	0.0087% [0.00034-0.11]	0.26% [0.039-1.2]	3.4% [1.3-7.8]
CP07 ROM HME	5	0.36 [0.21-0.61]	1.9 [1.5-3.3]	0.44 [0.28-0.98]	0.77	1 [0.59-3.1]	2.3	1.2e-05% [0-0.38]	0.0024% [6.9e-10-2.2]	0.14% [2.5e-05-8.4]	2.5% [0.036-22]
CP08 CHPP Shutdown Maintenance	1	0.8 [0.13-5.2]	2.3 [1.4-11]	1.1 [0.32-33]	9.5	2.8 [0.81-100]	31	0.094% [0-34]	0.93% [1.2e-08-50]	6.6% [0.00072-69]	26% [0.67-86]
CS01 Pre-strip and overburden removal	185	0.31 [0.29-0.33]	1.8 [1.7-1.9]	0.37 [0.34-0.4]	0.39	0.81 [0.73-0.91]	0.89	2e-07% [6.9e-09-3.9e-06]	0.00012% [1.3e-05-0.00084]	0.02% [0.0054-0.065]	0.88% [0.45-1.6]
CS02 Coal Removal	64	0.35 [0.31-0.39]	1.8 [1.7-2]	0.41 [0.37-0.48]	0.46	0.92 [0.77-1.1]	1.1	6.2e-07% [2.5e-09-6.5e-05]	0.00032% [8.8e-06-0.0062]	0.042% [0.0052-0.24]	1.5% [0.54-3.6]
CS03 Open Cut Inspection Services	2	0.3 [0.12-0.72]	1.8 [1.2-4.9]	0.35 [0.19-1.6]	0.93	0.72 [0.36-5.6]	2.9	2.3e-08% [0-2]	2.8e-05% [0-6.4]	0.0083% [0-15]	0.48% [4.6e-11-31]
CS04 Road Maintenance	54	0.26 [0.23-0.29]	1.7 [1.6-1.9]	0.3 [0.27-0.35]	0.34	0.65 [0.54-0.8]	0.76	2.9e-09% [9.8e-13-1.9e-06]	5.4e-06% [2.6e-08-0.00043]	0.0024% [8.5e-05-0.033]	0.24% [0.043-0.96]
CS06 Field Maintenance	19	0.42 [0.31-0.55]	2.1 [1.8-2.7]	0.54 [0.41-0.79]	0.72	1.4 [0.96-2.3]	2	0.00066% [8.1e-07-0.075]	0.033% [0.00047-0.71]	0.69% [0.058-4.3]	6.6% [1.9-17]
CS07 Blast Crew	166	0.7	2.1	0.91	0.99	2.3	2.6	0.012%	0.33%	3.9%	21%

CSH SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 10 mg/m³ [90% CI]	EF 5 mg/m³ [90% CI]	EF 2. 5 mg/m³ [90% CI]	EF 1.25 mg/m³ [90% CI]
		[0.64-0.77]	[1.9-2.2]	[0.82-1]		[2-2.7]		[0.0028-0.044]	[0.14-0.73]	[2.5-6]	[17-26]
CS10 Blast Hole Drillers	115	0.53 [0.47-0.6]	2.1 [1.9-2.3]	0.7 [0.62-0.8]	0.78	1.8 [1.5-2.2]	2.1	0.0037% [0.00049-0.023]	0.12% [0.035-0.38]	1.8% [0.9-3.5]	12% [8.8-17]
CS14 Workshop	20	0.31 [0.21-0.44]	2.6 [2.1-3.5]	0.49 [0.34-0.81]	0.71	1.5 [0.94-2.8]	2.4	0.014% [0.00014-0.36]	0.18% [0.008-1.7]	1.4% [0.2-6.2]	7% [2.3-17]
CS15 Service Crew	2	1.1 [0.35-3.6]	2.3 [1.5-6.9]	1.6 [0.65-13]	6	4 [1.6-43]	21	0.29% [4.5e-07-23]	2.9% [0.0024-40]	15% [0.51-62]	44% [9.1-85]
CS16 Tyre Fitters	2	0.75 [0.3-1.8]	1.8 [1.2-5]	0.88 [0.47-4.3]	2.4	1.8 [0.9-15]	7.4	0.00029% [0-8.6]	0.04% [0-21]	1.4% [1.7e-07-39]	16% [0.25-65]
CS18 Dozer Push	3	0.36 [0.21-0.62]	1.6 [1.2-3.2]	0.4 [0.27-0.96]	0.71	0.73 [0.45-2.9]	1.9	6e-12% [0-0.3]	1.9e-07% [0-1.7]	0.00081% [0-7.2]	0.25% [3.4e-09-21]
CS20 Open Cut Other	22	0.44 [0.34-0.57]	2 [1.8-2.5]	0.56 [0.44-0.79]	0.72	1.4 [1-2.2]	2	0.00052% [9.6e-07-0.05]	0.03% [0.00054-0.56]	0.69% [0.07-3.8]	6.8% [2.3-16]
CS22 Pump Crew	1	2.3 [0.37-14]	2.3 [1.3-10]	3.3 [0.95-90]	26	8.1 [2.4-270]	85	2.9% [5.9e-06-60]	14% [0.047-78]	45% [3.8-94]	80% [17-100]
CS25 Mobile / Bypass Crushing (Coal)	3	0.47 [0.23-0.96]	1.9 [1.4-4.1]	0.58 [0.33-1.9]	1.2	1.3 [0.67-6.4]	3.8	3.6e-05% [0-2.3]	0.0061% [1.9e-12-7.4]	0.34% [2.7e-06-19]	5.2% [0.039-40]
CS28 Rehabilitation	4	0.21 [0.11-0.38]	1.9 [1.4-3.7]	0.26 [0.16-0.67]	0.49	0.58 [0.32-2.2]	1.5	7.7e-08% [0-0.21]	3.3e-05% [0-1]	0.0054% [2.8e-10-4.5]	0.26% [2.8e-05-13]
CU01.1 Longwall Production (Uni Di)	450	2.3 [2.1-2.4]	2 [2-2.1]	2.9 [2.8-3.1]	3.1	7.3 [6.8-8]	7.9	1.9% [1.3-2.6]	13% [11-16]	45% [41-48]	80% [77-82]
CU01.2 Longwall Production (Bi Di)	559	2.1 [2-2.1]	1.9 [1.8-1.9]	2.5 [2.4-2.6]	2.6	5.8 [5.5-6.2]	6.2	0.62% [0.41-0.92]	8% [6.6-9.6]	38% [35-41]	78% [76-81]
CU02.1 Development - Cont mining and bolting	562	2.3 [2.2-2.4]	2 [1.9-2]	2.9 [2.7-3]	3	6.9 [6.4-7.4]	7.3	1.4% [1-2]	12% [10-14]	44% [41-47]	81% [79-83]
CU02.2 Development - Place change	86	1.9 [1.7-2.2]	2.1 [1.9-2.4]	2.5 [2.2-3]	2.9	6.6 [5.4-8.2]	7.8	1.4% [0.56-3]	10% [6.4-15]	36% [29-43]	71% [64-78]
CU02.3 Development - Pillar Extraction	26	1.1 [0.94-1.4]	1.8 [1.6-2.2]	1.4 [1.1-1.7]	1.6	3.1 [2.4-4.4]	4	0.014% [0.00026-0.29]	0.69% [0.084-3.4]	9.5% [3.9-19]	44% [32-57]
CU03 Underground Maintenance	105	1.5 [1.3-1.7]	2.3 [2.1-2.6]	2.1 [1.8-2.5]	2.4	5.8 [4.8-7.3]	6.9	1.1% [0.47-2.4]	7.1% [4.5-11]	26% [21-32]	57% [51-63]
CU04 Outbye supplies	54	1.6	2.3	2.3	2.8	6.5	8.3	1.5%	9.1%	30%	62%

CSH SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 10 mg/m³ [90% CI]	EF 5 mg/m³ [90% CI]	EF 2. 5 mg/m³ [90% CI]	EF 1.25 mg/m³ [90% CI]
		[1.3-2]	[2.1-2.7]	[1.9-3]		[5-9]		[0.5-4]	[5-15]	[23-39]	[53-71]
CU05 Longwall moves	2	3.5 [1.3-9.8]	2 [1.3-5.5]	4.4 [2.1-27]	14	10 [4.5-92]	45	5.1% [0.0051-49]	28% [2.9-75]	70% [24-97]	95% [51-100]
CU06 Outbye construction / infrastructure	123	1.8 [1.6-2.1]	2.6 [2.4-2.9]	2.9 [2.5-3.5]	3.3	8.9 [7.3-11]	11	3.9% [2.3-6.3]	15% [11-19]	37% [31-43]	65% [59-70]
CU07 Ventilation device installers	136	2.9 [2.5-3.2]	2.4 [2.2-2.6]	4.2 [3.7-4.9]	4.8	12 [10-15]	14	7.7% [5.2-11]	26% [21-32]	56% [50-62]	83% [78-87]
CU08 ERZ Controllers (Outbye Deputies)	34	1.4 [1.2-1.7]	1.9 [1.7-2.2]	1.8 [1.5-2.2]	2.1	4.1 [3.2-5.7]	5.3	0.13% [0.01-0.9]	2.5% [0.72-6.9]	19% [11-29]	58% [46-68]
CU09 Surface Maintenance	2	0.14 [0.047-0.41]	2.1 [1.4-6.3]	0.19 [0.085-1.3]	0.63	0.44 [0.19-4.4]	2.1	2.3e-07% [0-1.7]	3.7e-05% [0-4.5]	0.0034% [0-9.8]	0.12% [1.3e-09-20]
CU15 Stone Driveage	11	1.8 [1.2-2.7]	2.3 [1.8-3.4]	2.5 [1.7-4.7]	3.9	6.8 [4.1-16]	12	1.7% [0.12-10]	10% [2.6-27]	34% [17-54]	67% [47-83]
CU16 Secondary support	23	1.5 [1.1-2]	2.4 [2-3.2]	2.2 [1.6-3.3]	3	6.2 [4.1-11]	9.4	1.4% [0.23-5.8]	8% [3-18]	27% [16-40]	57% [43-70]
CU17 Gas drainage	8	1.2 [0.68-2]	2.3 [1.8-3.8]	1.7 [1-3.7]	2.9	4.6 [2.5-13]	9.5	0.5% [0.0056-7.3]	3.9% [0.35-19]	18% [5.2-40]	47% [25-69]
CU18 Shift co-ordinator / mgmt	9	0.87 [0.44-1.7]	3.2 [2.3-5.9]	1.8 [0.89-5.6]	4	5.9 [2.7-21]	15	1.8% [0.1-12]	6.7% [1.1-23]	18% [6.1-39]	38% [19-60]
CU19 Production Support (Bullgang)	4	2.6 [0.87-8]	3.3 [2.1-8.5]	5.5 [2.1-42]	22	18 [6.2-140]	79	13% [1.5-44]	29% [7.9-63]	52% [22-81]	74% [41-94]

NSW CSH SEG Respirable Dust Exposures

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m³ [90% CI]	EF 1 mg/m³ [90% CI]	EF 0.5 mg/m³ [90% CI]
CP01 CHPP production	242	0.07 [0.065-0.076]	2.1 [2-2.3]	0.093 [0.085-0.1]	0.1	0.24 [0.22-0.28]	0.27	0.0024% [0.00056-0.009]	0.021% [0.0068-0.058]	0.45% [0.23-0.84]
CP02 CHPP Maintenance	176	0.071 [0.064-0.08]	2.3 [2.2-2.5]	0.1 [0.091-0.12]	0.11	0.29 [0.25-0.34]	0.33	0.018% [0.0045-0.06]	0.097% [0.034-0.25]	1.1% [0.58-2]
CP03 CHPP Laboratory	14	0.15 [0.1-0.21]	2.3 [1.8-3.2]	0.21 [0.14-0.35]	0.31	0.56 [0.35-1.2]	0.96	0.23% [0.0053-3]	0.94% [0.061-6.1]	6.7% [1.6-19]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
CP04 CHPP HME	40	0.045 [0.036-0.058]	2.5 [2.1-3]	0.068 [0.052-0.093]	0.086	0.2 [0.14-0.3]	0.27	0.0048% [0.00013-0.08]	0.028% [0.0017-0.26]	0.37% [0.059-1.6]
CP06 CHPP Other	48	0.053 [0.044-0.066]	2.3 [2.1-2.8]	0.077 [0.062-0.1]	0.094	0.22 [0.16-0.31]	0.28	0.0043% [0.00016-0.058]	0.027% [0.0021-0.22]	0.42% [0.082-1.6]
CP07 ROM HME	6	0.045 [0.025-0.083]	2.3 [1.7-4.2]	0.064 [0.037-0.17]	0.12	0.17 [0.09-0.59]	0.41	0.00094% [1.5e-09-0.98]	0.007% [1.3e-07-2]	0.16% [0.00016-6.1]
CS01 Pre-strip and overburden removal	169	0.046 [0.042-0.05]	2.1 [2-2.3]	0.06 [0.054-0.067]	0.066	0.15 [0.13-0.18]	0.17	0.00012% [1.1e-05-0.00092]	0.0015% [0.00023-0.0078]	0.06% [0.019-0.17]
CS02 Coal Removal	68	0.05 [0.044-0.056]	1.9 [1.7-2.1]	0.061 [0.053-0.07]	0.068	0.14 [0.12-0.17]	0.16	3.1e-06% [2.5e-08-0.00017]	9.1e-05% [2e-06-0.0023]	0.012% [0.0011-0.088]
CS03 Open Cut Inspection Services	2	0.043 [0.011-0.17]	2.7 [1.7-9.5]	0.072 [0.024-1]	0.39	0.21 [0.064-3.2]	1.4	0.017% [1.3e-10-10]	0.063% [2.3e-08-14]	0.59% [3.2e-05-26]
CS04 Road Maintenance	69	0.04 [0.035-0.045]	1.9 [1.7-2.1]	0.048 [0.042-0.056]	0.054	0.11 [0.093-0.14]	0.13	2.9e-07% [1.3e-09-2.8e-05]	1.2e-05% [1.4e-07-0.00047]	0.0025% [0.00015-0.026]
CS06 Field Maintenance	17	0.047 [0.035-0.063]	2 [1.7-2.6]	0.06 [0.045-0.088]	0.08	0.15 [0.1-0.25]	0.22	3.3e-05% [3.4e-09-0.018]	0.00058% [3.9e-07-0.086]	0.033% [0.00034-0.81]
CS07 Blast Crew	197	0.067 [0.063-0.072]	1.8 [1.8-1.9]	0.081 [0.075-0.088]	0.086	0.18 [0.17-0.21]	0.2	1.7e-05% [1.5e-06-0.00016]	0.00047% [7e-05-0.0026]	0.05% [0.016-0.13]
CS08 Tech Services	2	0.042 [0.014-0.12]	2.1 [1.4-6.2]	0.056 [0.025-0.37]	0.18	0.13 [0.056-1.3]	0.62	3.8e-05% [0-4.2]	0.00049% [0-6.9]	0.03% [2e-12-16]
CS10 Blast Hole Drillers	108	0.06 [0.054-0.067]	2 [1.9-2.2]	0.077 [0.068-0.087]	0.085	0.19 [0.16-0.23]	0.22	0.00017% [1e-05-0.002]	0.0025% [0.00027-0.017]	0.11% [0.03-0.36]
CS12 Warehousing	1	0.1 [0.017-0.6]	2.3 [1.3-10]	0.14 [0.04-3.8]	1.1	0.35 [0.1-11]	3.7	0.034% [0-28]	0.23% [5e-13-40]	1.9% [9.6e-07-56]
CS14 Workshop	18	0.036	1.8 [1.6-2.3]	0.043	0.054	0.096	0.14	4e-08%	2.2e-06% [3.9e-11-0.0039]	0.00073%

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m³ [90% CI]	EF 1 mg/m³ [90% CI]	EF 0.5 mg/m³ [90% CI]
		[0.028-0.045]		[0.034-0.058]		[0.071-0.15]		[5.6e-14-0.00041]		[6.3e-07-0.095]
CS15 Service Crew	4	0.043 [0.026-0.071]	1.7 [1.3-3.1]	0.049 [0.032-0.11]	0.082	0.098 [0.06-0.32]	0.22	2.2e-10% [0-0.11]	3.9e-08% [0-0.29]	8.7e-05% [0-1.9]
CS18 Dozer Push	6	0.045 [0.03-0.069]	1.7 [1.4-2.7]	0.053 [0.037-0.096]	0.08	0.11 [0.071-0.27]	0.21	1.6e-08% [0-0.032]	1.2e-06% [0-0.13]	0.00087% [1.9e-10-1.3]
CS20 Open Cut Other	17	0.046 [0.034-0.061]	2 [1.7-2.6]	0.058 [0.044-0.085]	0.077	0.14 [0.1-0.24]	0.21	2.5e-05% [2.6e-09-0.015]	5e-04% [3.1e-07-0.079]	0.029% [0.00025-0.79]
CS22 Pump Crew	8	0.077 [0.055-0.11]	1.7 [1.4-2.3]	0.088 [0.066-0.13]	0.12	0.18 [0.12-0.34]	0.29	2.9e-07% [0-0.031]	3.2e-05% [3.3e-12-0.19]	0.014% [1.7e-06-1.9]
CS24 Quarrying / Stone Crushing	5	0.04 [0.027-0.06]	1.6 [1.3-2.6]	0.045 [0.032-0.081]	0.067	0.086 [0.057-0.22]	0.17	1.8e-12% [0-0.0093]	5.2e-10% [0-0.04]	3.5e-06% [0-0.51]
CS25 Mobile / Bypass Crushing (Coal)	7	0.04 [0.032-0.051]	1.4 [1.2-1.9]	0.043 [0.035-0.058]	0.053	0.07 [0.054-0.12]	0.1	0% [0-7.1e-07]	0% [0-1.5e-05]	1e-11% [0-0.004]
CU01.1 Longwall Production (Uni Di)	787	0.33 [0.32-0.34]	1.6 [1.6-1.7]	0.37 [0.36-0.38]	0.38	0.73 [0.7-0.76]	0.76	0.089% [0.054-0.14]	1.1% [0.81-1.5]	19% [17-21]
CU01.2 Longwall Production (Bi Di)	1226	0.37 [0.36-0.38]	1.8 [1.7-1.8]	0.43 [0.42-0.44]	0.44	0.92 [0.88-0.96]	0.95	0.59% [0.45-0.77]	3.6% [3.1-4.3]	29% [27-31]
CU02.1 Development - Cont mining and bolting	3069	0.25 [0.24-0.25]	1.7 [1.7-1.7]	0.28 [0.28-0.29]	0.28	0.58 [0.56-0.59]	0.59	0.025% [0.019-0.034]	0.35% [0.29-0.42]	8.6% [7.9-9.2]
CU02.2 Development - Place change	419	0.23 [0.22-0.25]	1.8 [1.8-1.9]	0.28 [0.27-0.3]	0.29	0.64 [0.59-0.69]	0.68	0.11% [0.058-0.21]	0.84% [0.54-1.3]	11% [8.7-13]
CU02.3 Development - Pillar Extraction	145	0.23 [0.21-0.25]	1.9 [1.8-2]	0.28 [0.26-0.31]	0.31	0.66 [0.58-0.76]	0.73	0.16% [0.055-0.43]	1.1% [0.51-2.1]	11% [8.2-15]
CU03 Underground Maintenance	134	0.13 [0.12-0.15]	2.3 [2.1-2.5]	0.18 [0.16-0.21]	0.21	0.51 [0.43-0.62]	0.59	0.16% [0.05-0.42]	0.68% [0.29-1.4]	5.2% [3.3-7.9]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
CU04 Outbye supplies	47	0.099 [0.087-0.11]	1.7 [1.6-1.9]	0.11 [0.1-0.13]	0.13	0.24 [0.2-0.3]	0.28	2e-05% [1e-07-0.0014]	0.00083% [1.7e-05-0.019]	0.13% [0.016-0.68]
CU05 Longwall moves	5	0.2 [0.11-0.35]	2 [1.5-3.6]	0.25 [0.15-0.62]	0.46	0.61 [0.34-2]	1.4	0.17% [5.1e-05-8.4]	0.91% [0.0036-15]	8.7% [0.7-35]
CU06 Outbye construction / infrastructure	112	0.13 [0.12-0.14]	2.1 [1.9-2.2]	0.17 [0.15-0.19]	0.19	0.42 [0.36-0.51]	0.49	0.033% [0.0067-0.13]	0.22% [0.069-0.62]	3% [1.6-5.2]
CU07 Ventilation device installers	11	0.24 [0.17-0.34]	2 [1.6-2.8]	0.3 [0.22-0.49]	0.43	0.73 [0.48-1.5]	1.2	0.36% [0.0066-4.8]	1.8% [0.12-11]	14% [4.2-32]
CU08 ERZ Controllers (Outbye Deputies)	38	0.16 [0.13-0.19]	2 [1.8-2.3]	0.2 [0.16-0.25]	0.23	0.48 [0.37-0.66]	0.61	0.043% [0.0026-0.4]	0.31% [0.042-1.5]	4.3% [1.6-9.6]
CU09 Surface Maintenance	1	0.12 [0.019-0.83]	2.3 [1.4-11]	0.17 [0.048-5.7]	1.5	0.43 [0.12-17]	4.9	0.1% [0-36]	0.38% [6.4e-12-43]	3% [1.8e-05-61]
CU11 Belt Splicers	2	0.11 [0.038-0.32]	2 [1.4-6.2]	0.14 [0.067-0.99]	0.48	0.33 [0.14-3.5]	1.6	0.0084% [0-13]	0.069% [5.8e-11-19]	1.3% [2.5e-05-35]
CU15 Stone Driveage	56	0.21 [0.19-0.24]	1.9 [1.7-2.1]	0.26 [0.22-0.3]	0.29	0.59 [0.48-0.74]	0.7	0.077% [0.0097-0.42]	0.6% [0.15-1.9]	8.2% [4.4-14]
CU16 Secondary support	17	0.14 [0.11-0.19]	2 [1.7-2.6]	0.18 [0.14-0.26]	0.24	0.44 [0.31-0.76]	0.65	0.031% [0.00031-0.82]	0.23% [0.0082-2.5]	3.4% [0.62-12]
CU17 Gas drainage	12	0.23 [0.18-0.32]	1.8 [1.5-2.4]	0.28 [0.21-0.41]	0.37	0.61 [0.43-1.1]	0.93	0.075% [0.00041-2.1]	0.67% [0.02-6.2]	9.6% [2.4-26]
CU18 Shift co-ordinator / mgmt	9	0.089 [0.05-0.16]	2.8 [2-4.7]	0.15 [0.084-0.39]	0.29	0.47 [0.24-1.4]	1.1	0.26% [0.0023-4.7]	0.8% [0.022-8.2]	4.2% [0.45-18]
CU19 Production Support (Bullgang)	1	0.33 [0.056-2]	2.3 [1.3-10]	0.47 [0.13-13]	3.6	1.1 [0.34-38]	12	2.3% [2.4e-06-58]	7.4% [0.0016-70]	28% [0.81-88]
CU20 Returns	1	0.24	2.3 [1.3-11]	0.34	2.7	0.84 [0.24-27]	8.8	0.95% [6.2e-09-49]	3.1% [1.5e-05-61]	16% [0.083-80]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
		[0.038-1.4]		[0.094-9.4]						
CU21 Surface other	3	0.11 [0.062-0.2]	1.6 [1.2-3.3]	0.13 [0.081-0.31]	0.23	0.24 [0.14-0.96]	0.62	1.6e-06% [0-2]	0.00013% [0-5]	0.066% [1.4e-11-15]
CU22 Underground other	3	0.2 [0.069-0.55]	2.6 [1.7-6.8]	0.31 [0.13-1.9]	1	0.9 [0.34-6.8]	3.7	1.4% [0.0027-24]	3.9% [0.043-34]	16% [1.4-53]

NSW CSH SEGs Respirable Quartz Exposures

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
CP01 CHPP production	242	0.0091 [0.0083-0.0099]	1.9 [1.7-2]	0.011 [0.01-0.012]	0.012	0.025 [0.023-0.029]	0.028	0.31% [0.12-0.71]	5.2% [3.6-7.3]
CP02 CHPP Maintenance	176	0.0089 [0.0081-0.0097]	1.7 [1.6-1.9]	0.01 [0.0096-0.011]	0.011	0.022 [0.02-0.025]	0.024	0.075% [0.017-0.26]	2.9% [1.6-4.7]
CP03 CHPP Laboratory	14	0.022 [0.016-0.03]	2 [1.7-2.7]	0.028 [0.02-0.042]	0.038	0.068 [0.046-0.12]	0.11	11% [3.7-26]	42% [26-60]
CP04 CHPP HME	40	0.008 [0.006-0.0095]	1.7 [1.5-2.3]	0.0093 [0.0077-0.011]	0.011	0.02 [0.016-0.027]	0.025	0.044% [0.00068-0.76]	1.9% [0.36-6.1]
CP06 CHPP Other	48	0.0072 [0.0051-0.0092]	2.2 [1.8-3]	0.0098 [0.0078-0.012]	0.012	0.025 [0.019-0.038]	0.034	0.57% [0.067-2.7]	5.1% [2-11]
CP07 ROM HME	6	0.0084 [0.0046-0.011]	1.5 [1.1-2.8]	0.0091 [0.0062-0.014]	0.012	0.015 [0.011-0.038]	0.028	6.5e-05% [0-2.5]	0.17% [3.3e-11-12]
CS01 Pre-strip and overburden removal	169	0.01 [0.0092-0.011]	1.9 [1.8-2.1]	0.012 [0.011-0.014]	0.013	0.029 [0.026-0.034]	0.032	0.63% [0.26-1.4]	7.9% [5.4-11]
CS02 Coal Removal	68	0.011 [0.0094-0.012]	1.8 [1.6-2]	0.013 [0.011-0.014]	0.014	0.027 [0.023-0.033]	0.032	0.3% [0.053-1.2]	6.5% [3.4-11]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
CS03 Open Cut Inspection Services	2	0.0092 [0.00075-0.037]	2.9 [1.6-16]	0.016 [0.0039-0.36]	0.11	0.046 [0.012-0.87]	0.34	4.2% [0.015-42]	15% [0.63-61]
CS04 Road Maintenance	69	0.0094 [0.0083-0.01]	1.7 [1.5-1.9]	0.011 [0.0096-0.012]	0.012	0.022 [0.019-0.026]	0.025	0.048% [0.0042-0.33]	2.6% [1-5.8]
CS06 Field Maintenance	17	0.0086 [0.0047-0.013]	2.5 [1.9-4.6]	0.013 [0.0088-0.025]	0.021	0.039 [0.024-0.09]	0.071	2.8% [0.33-11]	12% [4.3-26]
CS07 Blast Crew	197	0.015 [0.014-0.016]	1.9 [1.8-2.1]	0.018 [0.017-0.02]	0.02	0.043 [0.039-0.05]	0.048	3.1% [2-4.9]	21% [17-25]
CS08 Tech Services	2	0.0067 [0.00092-0.021]	2.3 [1.3-11]	0.0096 [0.0029-0.11]	0.04	0.023 [0.0079-0.32]	0.13	0.46% [2.3e-08-27]	4.1% [0.0033-44]
CS10 Blast Hole Drillers	108	0.014 [0.013-0.016]	1.9 [1.8-2.1]	0.017 [0.016-0.02]	0.019	0.041 [0.036-0.05]	0.048	2.7% [1.3-4.9]	19% [14-25]
CS12 Warehousing	1	0.02 [0.003-0.13]	2.3 [1.4-11]	0.029 [0.0078-0.81]	0.23	0.07 [0.02-2.4]	0.76	11% [0.015-75]	37% [2.2-91]
CS14 Workshop	18	0.0028 [0.00034-0.0063]	2.7 [1.6-9.8]	0.0051 [0.0021-0.011]	0.0085	0.014 [0.0069-0.035]	0.027	0.16% [0.00023-3.3]	1.3% [0.056-7.9]
CS15 Service Crew	4	0.0047 [0.00048-0.011]	2.3 [1.3-11]	0.0071 [0.002-0.034]	0.017	0.016 [0.006-0.1]	0.056	0.12% [2e-09-11]	1.4% [0.00058-21]
CS18 Dozer Push	6	0.0093 [0.0065-0.011]	1.3 [1.1-2.1]	0.0097 [0.0075-0.013]	0.012	0.014 [0.011-0.029]	0.023	8.7e-09% [0-0.78]	0.0043% [0-7.7]
CS20 Open Cut Other	17	0.0087 [0.0064-0.011]	1.6 [1.4-2.2]	0.0098 [0.0078-0.012]	0.012	0.019 [0.015-0.029]	0.026	0.011% [5e-06-0.93]	1.3% [0.075-8.1]
CS22 Pump Crew	8	0.014 [0.0087-0.022]	2 [1.6-3.3]	0.018 [0.012-0.035]	0.029	0.045 [0.027-0.11]	0.087	3.5% [0.21-19]	21% [6.6-44]
CS24 Quarrying / Stone Crushing	5	0.011	1.7 [1.3-3.2]	0.012	0.02	0.025 [0.016-0.077]	0.055	0.18% [5.9e-06-11]	5% [0.13-30]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
		[0.0061-0.017]		[0.0082-0.025]					
CS25 Mobile / Bypass Crushing (Coal)	7	0.0099 [0.0087-0.011]	1.1 [1-1.4]	0.01 [0.009-0.011]	0.011	0.012 [0.011-0.017]	0.015	0% [0-7.9e-05]	1.3e-13% [0-0.21]
CU01.1 Longwall Production (Uni Di)	782	0.019 [0.018-0.02]	2 [1.9-2]	0.024 [0.023-0.025]	0.025	0.058 [0.055-0.062]	0.061	7.7% [6.5-9]	34% [32-37]
CU01.2 Longwall Production (Bi Di)	1225	0.028 [0.027-0.028]	1.8 [1.7-1.8]	0.032 [0.032-0.033]	0.033	0.07 [0.068-0.073]	0.073	15% [14-16]	57% [55-59]
CU02.1 Development - Cont mining and bolting	3055	0.015 [0.015-0.016]	1.8 [1.8-1.9]	0.018 [0.018-0.019]	0.019	0.041 [0.04-0.042]	0.042	2.4% [2.1-2.7]	21% [20-22]
CU02.2 Development - Place change	419	0.017 [0.016-0.018]	2 [1.9-2.1]	0.022 [0.02-0.023]	0.023	0.054 [0.049-0.059]	0.058	6.1% [4.7-7.7]	29% [26-32]
CU02.3 Development - Pillar Extraction	144	0.021 [0.019-0.023]	2 [1.9-2.2]	0.026 [0.024-0.03]	0.029	0.066 [0.057-0.078]	0.075	11% [7.5-14]	39% [34-45]
CU03 Underground Maintenance	134	0.011 [0.0094-0.012]	2.1 [2-2.4]	0.014 [0.013-0.016]	0.016	0.037 [0.032-0.046]	0.043	2.1% [1.1-4]	13% [9.7-17]
CU04 Outbye supplies	47	0.0097 [0.0084-0.011]	1.6 [1.4-1.8]	0.011 [0.0095-0.012]	0.012	0.02 [0.017-0.025]	0.024	0.011% [0.00022-0.19]	1.7% [0.39-5]
CU05 Longwall moves	5	0.015 [0.0076-0.027]	2 [1.5-4.3]	0.02 [0.012-0.053]	0.038	0.048 [0.026-0.18]	0.12	4.4% [0.12-27]	23% [5.8-54]
CU06 Outbye construction / infrastructure	112	0.01 [0.0087-0.011]	2 [1.8-2.2]	0.013 [0.011-0.014]	0.014	0.031 [0.026-0.037]	0.036	0.93% [0.34-2.2]	9% [5.9-13]
CU07 Ventilation device installers	11	0.012 [0.0073-0.018]	2.1 [1.6-3.7]	0.016 [0.011-0.03]	0.025	0.042 [0.026-0.1]	0.078	2.9% [0.22-15]	17% [5.5-36]
CU08 ERZ Controllers (Outbye Deputies)	38	0.015 [0.012-0.019]	2.4 [2-3.1]	0.022 [0.017-0.031]	0.029	0.064 [0.046-0.1]	0.089	8.7% [4-16]	29% [20-39]

CSH SEGs	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
CU09 Surface Maintenance	1	0.02 [0.0031-0.13]	2.3 [1.3-11]	0.029 [0.0077-0.83]	0.23	0.07 [0.02-2.4]	0.77	11% [0.015-75]	38% [2.4-92]
CU11 Belt Splicers	2	0.0068 [0.00086-0.021]	2.3 [1.4-9.8]	0.0097 [0.0028-0.09]	0.039	0.023 [0.0078-0.29]	0.13	0.47% [3.6e-08-26]	3.8% [0.0023-44]
CU15 Stone Driveage	56	0.011 [0.01-0.012]	1.5 [1.4-1.7]	0.012 [0.011-0.014]	0.013	0.023 [0.02-0.027]	0.026	0.026% [0.0016-0.24]	3% [1.2-6.8]
CU16 Secondary support	17	0.012 [0.0086-0.016]	2 [1.6-2.8]	0.015 [0.011-0.022]	0.02	0.037 [0.026-0.067]	0.057	1.9% [0.19-9]	14% [5.5-28]
CU17 Gas drainage	12	0.013 [0.0073-0.021]	2.5 [1.9-4.5]	0.02 [0.013-0.044]	0.035	0.059 [0.034-0.16]	0.12	7.1% [1.4-22]	24% [11-43]
CU18 Shift co-ordinator / mgmt	9	0.012 [0.0069-0.019]	2.2 [1.6-4]	0.017 [0.011-0.035]	0.028	0.043 [0.025-0.12]	0.09	3.4% [0.21-18]	17% [5.4-39]
CU19 Production Support (Bullgang)	1	0.03 [0.0047-0.19]	2.3 [1.4-11]	0.043 [0.012-1.4]	0.37	0.11 [0.03-4]	1.2	24% [0.43-85]	60% [8.4-97]
CU20 Returns	1	0.03 [0.0047-0.2]	2.3 [1.3-11]	0.043 [0.012-1.4]	0.37	0.11 [0.03-4]	1.2	24% [0.42-86]	60% [8-97]
CU21 Surface other	3	0.02 [0.012-0.033]	1.5 [1.1-3]	0.022 [0.015-0.049]	0.036	0.037 [0.024-0.15]	0.092	0.73% [1.2e-09-30]	26% [2.4-67]
CU22 Underground other	3	0.006 [0.00036-0.02]	3.2 [1.7-19]	0.012 [0.0028-0.21]	0.066	0.034 [0.0085-0.46]	0.2	2.3% [0.0077-28]	8.5% [0.35-45]

QLD RSHQ SEG Inhalable Dust Exposures

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m³ [90% CI]	EF 5 mg/m³ [90% CI]	EF 2. 5 mg/m³ [90% CI]	EF 1.25 mg/m³ [90% CI]
QCP001 CHPP Production	242	0.7 [0.63-0.78]	2.7 [2.5-2.9]	1.2 [1-1.3]	1.3	3.6 [3.1-4.3]	4.1	0.39% [0.2-0.74]	2.5% [1.6-3.7]	10% [7.9-13]	28% [24-32]
QCP002 CHPP Maintenance	150	0.63 [0.54-0.72]	2.9 [2.6-3.2]	1.1 [0.93-1.3]	1.3	3.6 [2.9-4.5]	4.3	0.44% [0.18-0.99]	2.5% [1.4-4.2]	9.5% [6.8-13]	26% [21-31]
QCP003 CHPP Laboratory	110	0.8 [0.69-0.94]	2.7 [2.4-3]	1.3 [1.1-1.6]	1.5	4.1 [3.3-5.3]	5	0.55% [0.21-1.3]	3.3% [1.8-5.6]	13% [8.9-17]	33% [27-39]
QCP004 CHPP HME	49	0.3 [0.24-0.38]	2.4 [2.1-2.9]	0.45 [0.36-0.6]	0.56	1.3 [0.98-1.9]	1.7	0.0045% [0.00019-0.061]	0.085% [0.0098-0.51]	0.91% [0.23-2.8]	5.7% [2.6-11]
QCP005 Belt Splicers	13	1.3 [0.85-2]	2.4 [1.9-3.5]	1.9 [1.3-3.6]	3	5.5 [3.3-12]	9.9	1% [0.066-7]	6.3% [1.4-19]	23% [10-41]	52% [34-69]
QCP006 CHPP Other	10	0.4 [0.25-0.64]	2.3 [1.8-3.6]	0.58 [0.37-1.2]	0.95	1.6 [0.92-3.9]	3.1	0.0071% [3.6e-06-0.81]	0.15% [0.001-3.3]	1.5% [0.072-10]	8.8% [1.9-26]
QCP007 ROM HME	36	0.39 [0.29-0.52]	2.8 [2.3-3.5]	0.65 [0.48-0.98]	0.88	2.1 [1.4-3.4]	3	0.07% [0.0044-0.58]	0.6% [0.099-2.5]	3.3% [1.1-8]	12% [6.5-21]
QCP008 CHPP Shutdown Maintenance	20	0.48 [0.32-0.73]	3.1 [2.4-4.4]	0.9 [0.57-1.7]	1.4	3 [1.8-6.4]	5.3	0.32% [0.021-2.5]	1.8% [0.28-7]	6.9% [2.2-17]	19% [9.8-33]
QCS001 Pre-strip and Overburden Removal	101	0.35 [0.3-0.4]	2.3 [2.1-2.5]	0.49 [0.42-0.58]	0.55	1.3 [1.1-1.7]	1.6	0.0022% [0.00021-0.016]	0.058% [0.012-0.22]	0.81% [0.31-1.9]	5.9% [3.5-9.4]
QCS002 Coal Removal	95	0.3 [0.26-0.34]	2.2 [2-2.5]	0.41 [0.35-0.49]	0.47	1.1 [0.92-1.4]	1.3	0.00061% [3.8e-05-0.0064]	0.022% [0.0035-0.11]	0.4% [0.13-1.1]	3.7% [2-6.5]
QCS003 Open Cut Inspection Services	35	0.22 [0.17-0.28]	2.4 [2-2.9]	0.31 [0.24-0.43]	0.4	0.89 [0.64-1.4]	1.2	0.00039% [2.7e-06-0.018]	0.012% [4e-04-0.18]	0.21% [0.023-1.2]	2% [0.54-5.9]
QCS004 Road Maintenance	65	0.29 [0.26-0.34]	2 [1.8-2.2]	0.37 [0.32-0.43]	0.42	0.88 [0.73-1.1]	1.1	6.6e-06% [5.2e-08-0.00036]	0.0011% [4.5e-05-0.016]	0.068% [0.0095-0.34]	1.5% [0.53-3.6]
QCS005 Boilermaker	48	0.65 [0.5-0.86]	3.2 [2.7-4]	1.3 [0.94-1.9]	1.7	4.4 [3-7.1]	6.3	0.94% [0.24-2.9]	4% [1.7-8.4]	12% [7.2-20]	29% [21-38]
QCS006 Field Maintenance	222	0.39 [0.36-0.44]	2.6 [2.4-2.8]	0.61 [0.54-0.7]	0.68	1.8 [1.6-2.2]	2.1	0.028% [0.0091-0.08]	0.34% [0.16-0.67]	2.4% [1.5-3.7]	11% [8.4-14]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2. 5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
QCS007 Blast Crew	244	0.61 [0.55-0.67]	2.5 [2.4-2.7]	0.94 [0.84-1.1]	1	2.8 [2.4-3.3]	3.2	0.14% [0.058-0.3]	1.2% [0.7-2]	6.5% [4.8-8.7]	22% [19-26]
QCS008 Tech Services	43	0.18 [0.15-0.21]	2 [1.8-2.3]	0.22 [0.19-0.27]	0.26	0.54 [0.42-0.73]	0.68	1.2e-07% [3.9e-11-5.8e-05]	3.7e-05% [1.3e-07-0.003]	0.0044% [0.00011-0.076]	0.19% [0.023-1]
QCS009 Exploration Drillers	48	0.49 [0.38-0.62]	2.7 [2.3-3.3]	0.8 [0.62-1.1]	1	2.5 [1.8-3.8]	3.4	0.12% [0.016-0.67]	0.97% [0.26-2.9]	5% [2.2-10]	17% [11-25]
QCS010 Blast Hole Drillers	115	0.37 [0.32-0.42]	2.5 [2.3-2.8]	0.57 [0.48-0.68]	0.65	1.7 [1.4-2.1]	2	0.018% [0.0034-0.08]	0.24% [0.078-0.67]	1.9% [0.96-3.6]	9.3% [6.3-13]
QCS011 Belt Splicers	9	1.4 [0.8-2.3]	2.5 [1.9-4.1]	2.1 [1.3-4.7]	3.7	6.1 [3.3-17]	13	1.4% [0.061-11]	7.7% [1.3-25]	25% [10-47]	54% [32-74]
QCS012 Warehousing	51	0.29 [0.24-0.34]	2 [1.8-2.3]	0.37 [0.31-0.45]	0.43	0.91 [0.73-1.2]	1.1	2.2e-05% [1.4e-07-0.0014]	0.0024% [7.9e-05-0.039]	0.1% [0.013-0.58]	1.8% [0.59-4.6]
QCS013 Administration	10	0.16 [0.079-0.31]	3.3 [2.3-6.1]	0.32 [0.16-1]	0.72	1.1 [0.51-3.8]	2.7	0.023% [3.1e-05-1.3]	0.18% [0.0015-3.6]	0.99% [0.037-8.4]	4% [0.47-17]
QCS014 Workshop	156	0.31 [0.28-0.35]	2.5 [2.3-2.7]	0.47 [0.41-0.55]	0.53	1.4 [1.2-1.7]	1.6	0.0062% [0.0012-0.027]	0.11% [0.034-0.29]	1.1% [0.52-2]	6.2% [4.2-8.9]
QCS015 Service Crew	99	0.45 [0.4-0.51]	2.1 [1.9-2.3]	0.59 [0.52-0.68]	0.66	1.5 [1.3-1.8]	1.7	0.0011% [9.4e-05-0.0097]	0.05% [0.01-0.2]	0.96% [0.38-2.1]	8.1% [5.1-12]
QCS016 Tyre Fitters	65	0.53 [0.43-0.65]	2.8 [2.5-3.4]	0.91 [0.72-1.2]	1.1	2.9 [2.2-4.2]	3.9	0.25% [0.051-0.89]	1.6% [0.56-3.7]	6.8% [3.7-12]	20% [14-28]
QCS017 Dragline	73	0.35 [0.3-0.41]	2.3 [2.1-2.6]	0.49 [0.41-0.6]	0.57	1.4 [1.1-1.8]	1.7	0.0025% [0.00015-0.026]	0.064% [0.0099-0.31]	0.87% [0.28-2.2]	6.2% [3.3-10]
QCS018 Dozer Push	38	0.46 [0.37-0.56]	2.1 [1.9-2.5]	0.61 [0.49-0.78]	0.73	1.6 [1.2-2.2]	2	0.0019% [3.5e-05-0.046]	0.071% [0.0057-0.53]	1.2% [0.27-3.8]	9% [4.3-16]
QCS019 Emergency Response Personnel	1	5.7e-05 [4.8e-08-0.06]	2.3 [1.4-10]	0.00012 [8e-08-0.13]	0.048	0.00031 [2e-07-0.36]	0.12	0% [0-0.0081]	0% [0-0.031]	0% [0-0.092]	0% [0-0.31]
QCS020 Open Cut Other	33	0.27 [0.2-0.35]	2.7 [2.2-3.4]	0.43 [0.32-0.64]	0.58	1.3 [0.91-2.2]	1.9	0.0099% [0.00025-0.17]	0.13% [0.011-0.95]	1.1% [0.21-4]	5.6% [2.2-12]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 10 mg/m³ [90% CI]	EF 5 mg/m³ [90% CI]	EF 2. 5 mg/m³ [90% CI]	EF 1.25 mg/m³ [90% CI]
QCS021 Control Room Other	5	0.12 [0.053-0.25]	2.5 [1.7-5.5]	0.18 [0.095-0.68]	0.44	0.52 [0.24-2.5]	1.6	4.5e-05% [2.2e-14-0.59]	0.002% [4.4e-10-1.9]	0.038% [1.2e-06-5.1]	0.49% [0.00072-12]
QCS022 Pump Crew	95	0.49 [0.43-0.56]	2.2 [2-2.4]	0.66 [0.57-0.78]	0.75	1.8 [1.5-2.2]	2.1	0.0055% [0.00062-0.037]	0.15% [0.036-0.48]	1.8% [0.83-3.6]	11% [7.6-16]
QCS023 Highwall / Auger	6	1 [0.57-1.7]	2.1 [1.6-3.7]	1.3 [0.81-3.1]	2.4	3.4 [1.9-11]	7.6	0.11% [6.4e-05-5.5]	1.6% [0.024-16]	11% [1.5-36]	38% [16-65]
QCS024 Quarrying / Stone Crushing	21	0.63 [0.39-1]	3.6 [2.8-5.3]	1.4 [0.85-3.1]	2.5	5.1 [2.8-12]	9.5	1.5% [0.23-6.1]	5.2% [1.5-14]	14% [6.2-26]	29% [18-44]
QCS025 Mobile / Bypass Crushing (Coal)	13	0.82 [0.46-1.4]	3.3 [2.5-5.5]	1.7 [0.94-4.4]	3.4	5.9 [3-17]	13	1.9% [0.19-9.3]	6.6% [1.5-19]	18% [7.1-35]	36% [21-54]
QCS026 Civil Construction	46	0.4 [0.31-0.51]	2.7 [2.3-3.2]	0.64 [0.5-0.89]	0.82	2 [1.4-3]	2.7	0.049% [0.0044-0.35]	0.49% [0.093-1.8]	3% [1.1-7]	12% [6.9-20]
QCS027 Coal Haulage	23	0.4 [0.31-0.51]	2 [1.7-2.5]	0.51 [0.4-0.69]	0.64	1.2 [0.9-1.9]	1.7	0.00013% [1.4e-07-0.022]	0.012% [0.00014-0.29]	0.38% [0.029-2.6]	4.8% [1.4-13]
QCS028 Rehabilitation	11	0.37 [0.25-0.57]	2.2 [1.8-3.2]	0.52 [0.35-0.93]	0.79	1.4 [0.83-3]	2.4	0.0016% [2.6e-07-0.33]	0.053% [0.00019-1.8]	0.81% [0.029-6.9]	6.4% [1.1-21]
QCS029 Surface Coating / Preparation	13	1.2 [0.79-1.9]	2.5 [2-3.7]	1.9 [1.2-3.6]	3	5.5 [3.2-12]	9.9	1% [0.063-7]	6.1% [1.3-18]	22% [9.4-39]	49% [32-67]
QCS030 Domestic Cleaners	35	0.52 [0.42-0.66]	2.2 [1.9-2.7]	0.72 [0.57-0.97]	0.9	2 [1.4-2.9]	2.7	0.012% [0.00038-0.18]	0.25% [0.028-1.4]	2.6% [0.73-7]	14% [7.5-23]
QCS031 Industrial Cleaners	28	0.94 [0.64-1.4]	3.4 [2.7-4.6]	2 [1.3-3.6]	3	6.9 [4.2-13]	11	2.5% [0.65-7.5]	8.4% [3.4-17]	21% [12-32]	40% [29-53]
QCS032 Groundskeeping	16	0.7 [0.51-0.96]	2.1 [1.7-2.8]	0.92 [0.68-1.4]	1.3	2.3 [1.6-4.2]	3.6	0.014% [6.4e-05-0.56]	0.37% [0.015-3.4]	4.1% [0.77-14]	22% [10-37]
QCS033 Shutdown Maintenance	25	0.56 [0.41-0.76]	2.5 [2.1-3.3]	0.87 [0.62-1.3]	1.2	2.6 [1.7-4.5]	3.9	0.094% [0.0043-0.95]	0.92% [0.13-4.2]	5.4% [1.7-13]	19% [11-31]
QCU001 Longwall Production	131	3.5 [3-4.2]	3.3 [3-3.8]	7.3 [5.9-9.4]	8.8	26 [20-34]	32	19% [15-24]	39% [33-44]	61% [56-67]	81% [76-85]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2. 5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
QCU002 Development Production	203	3.4 [3.1-3.8]	2.5 [2.3-2.7]	5.3 [4.7-6]	5.8	16 [13-19]	18	12% [9.5-16]	34% [30-39]	63% [59-68]	86% [83-89]
QCU003 Underground Maintenance	155	1.5 [1.3-1.7]	2.7 [2.5-3]	2.5 [2.1-2.9]	2.8	7.7 [6.4-9.5]	9.1	2.8% [1.7-4.6]	11% [8.4-15]	31% [26-36]	58% [53-63]
QCU004 Outbye Supplies	54	0.85 [0.65-1.1]	3.2 [2.7-4]	1.7 [1.2-2.5]	2.3	5.8 [4-9.1]	8.2	1.7% [0.59-4.3]	6.5% [3.2-12]	18% [12-26]	37% [29-46]
QCU005 Longwall Moves	103	2.3 [2-2.6]	2.2 [2-2.4]	3.1 [2.7-3.7]	3.5	8.3 [7-10]	9.7	2.9% [1.6-5.3]	16% [12-21]	46% [40-53]	79% [73-84]
QCU006 Outbye Construction/ Infrastructure	201	1.9 [1.6-2.1]	3.1 [2.8-3.4]	3.5 [3-4.2]	4	12 [9.8-15]	14	6.8% [4.8-9.2]	19% [16-23]	40% [35-44]	64% [59-68]
QCU007 VCD Installer	107	2.8 [2.4-3.3]	2.8 [2.5-3.2]	4.8 [4-6]	5.7	15 [12-20]	19	11% [7.5-15]	29% [24-35]	55% [48-61]	78% [73-83]
QCU008 ERZ Controller	162	1.8 [1.6-2.1]	3.1 [2.8-3.5]	3.4 [2.9-4.2]	4	12 [9.4-15]	14	6.5% [4.4-9.3]	18% [15-23]	39% [34-44]	63% [58-68]
QCU009 Surface Maintenance	98	0.3 [0.25-0.36]	2.9 [2.6-3.3]	0.53 [0.43-0.67]	0.63	1.7 [1.3-2.3]	2.1	0.046% [0.0089-0.19]	0.39% [0.12-1]	2.3% [1.1-4.3]	8.9% [5.7-13]
QCU010 Control Room Operator	23	0.12 [0.098-0.13]	1.5 [1.4-1.8]	0.13 [0.11-0.15]	0.15	0.24 [0.19-0.32]	0.29	0% [0-1.9e-12]	0% [0-8.6e-09]	6.2e-11% [0-1.1e-05]	2e-06% [4.2e-11-0.0031]
QCU011 Belt Splicers	12	0.84 [0.54-1.3]	2.5 [2-3.7]	1.3 [0.83-2.5]	2.1	3.8 [2.2-8.7]	7	0.33% [0.0079-3.9]	2.5% [0.25-12]	12% [3.3-28]	33% [17-52]
QCU012 Boilermaker (Surface)	7	0.95 [0.42-2.1]	3.4 [2.3-6.8]	2 [0.91-8.2]	5.4	6.8 [2.8-30]	20	2.5% [0.12-16]	8.2% [1.2-28]	21% [6.3-45]	41% [19-66]
QCU013 Administration	20	0.12 [0.091-0.15]	1.9 [1.7-2.5]	0.15 [0.12-0.2]	0.19	0.35 [0.26-0.57]	0.5	1.3e-09% [0-6.3e-05]	1e-06% [1.2e-11-0.0026]	0.00025% [1.2e-07-0.052]	0.021% [0.00016-0.6]
QCU015 Stone Drivage	13	1.5 [1.1-2.1]	2 [1.7-2.8]	2 [1.4-3.1]	2.7	4.8 [3.2-9.2]	7.7	0.38% [0.01-4.2]	4.5% [0.74-16]	24% [11-42]	60% [42-77]
QCU016 Secondary Support	118	2.2 [1.9-2.6]	2.6 [2.4-3]	3.5 [3-4.3]	4.1	11 [8.8-14]	13	6% [3.7-9.1]	20% [15-25]	45% [39-51]	72% [66-77]
QCU017 Gas Drainage UG	59	1.1 [0.96-1.3]	2.2 [2-2.5]	1.5 [1.3-1.9]	1.8	4.1 [3.2-5.5]	5.1	0.26% [0.053-1]	2.9% [1.2-6.1]	16% [10-23]	45% [37-54]
QCU018 Shift Co-Ordinator / Management	22	0.56 [0.36-0.85]	3.2 [2.5-4.7]	1.1 [0.7-2.2]	1.8	3.8 [2.2-8.2]	6.8	0.71% [0.072-3.8]	3.1% [0.69-9.6]	10% [3.9-21]	24% [14-38]
QCU019 Production Support / Bullgang	211	2.8 [2.5-3.1]	2.8 [2.6-3]	4.7 [4.1-5.5]	5.3	15 [13-18]	17	11% [8-14]	28% [24-33]	54% [50-59]	78% [75-82]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 10 mg/m^3 [90% CI]	EF 5 mg/m^3 [90% CI]	EF 2. 5 mg/m^3 [90% CI]	EF 1.25 mg/m^3 [90% CI]
QCU020 Returns	2	14 [4.4-47]	2.3 [1.5-7]	20 [8.3-170]	78	52 [20-590]	270	68% [23-95]	91% [46-100]	99% [65-100]	100% [81-100]
QCU021 Surface Other	30	0.29 [0.22-0.4]	2.7 [2.2-3.4]	0.48 [0.35-0.73]	0.65	1.5 [0.99-2.5]	2.2	0.017% [0.00046-0.25]	0.2% [0.017-1.3]	1.5% [0.32-5]	7.1% [2.8-15]
QCU022 Underground Other	6	2.4 [1-5.4]	3.1 [2.1-6.6]	4.5 [2.1-20]	12	15 [6.1-72]	46	9.6% [1.3-33]	24% [7.7-52]	48% [23-73]	72% [44-90]
QCU023 Gas Drainage Surface	32	0.39 [0.27-0.56]	3.5 [2.8-4.8]	0.85 [0.56-1.5]	1.3	3 [1.9-5.8]	5	0.47% [0.065-2.2]	2% [0.5-6]	6.8% [2.7-14]	17% [9.9-28]
QCU024 Drilling Other	27	0.38 [0.27-0.54]	2.9 [2.3-3.8]	0.66 [0.46-1.1]	0.96	2.1 [1.4-3.9]	3.3	0.092% [0.0046-0.88]	0.7% [0.091-3.3]	3.6% [1-9.8]	13% [6.1-23]
QCU025 Warehousing	58	0.33 [0.27-0.39]	2.3 [2.1-2.7]	0.46 [0.38-0.58]	0.55	1.3 [1-1.7]	1.6	0.0019% [8.4e-05-0.027]	0.052% [0.006-0.3]	0.72% [0.19-2.2]	5.3% [2.6-9.9]
QCU026 Tech Services	50	0.65 [0.51-0.83]	2.7 [2.4-3.3]	1.1 [0.83-1.5]	1.4	3.4 [2.5-5.1]	4.6	0.33% [0.06-1.3]	2.1% [0.74-5.2]	9% [4.9-15]	26% [18-35]
QCU027 Domestic Cleaners	20	0.42 [0.35-0.51]	1.6 [1.5-1.9]	0.48 [0.4-0.6]	0.57	0.96 [0.75-1.4]	1.2	8.8e-09% [1.1e-14-0.00013]	3e-05% [5.4e-09-0.012]	0.017% [0.00015-0.47]	1.4% [0.19-6.6]
QCU029 Remote Mining Operations	8	0.33 [0.15-0.71]	3.5 [2.4-6.9]	0.73 [0.34-2.9]	1.9	2.5 [1.1-11]	7.2	0.3% [0.0029-5.3]	1.4% [0.056-11]	5.2% [0.58-21]	14% [3.6-35]

QLD RSHQ SEG Respirable Dust Exposures

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
QCP001 CHPP Production	987	0.082 [0.079-0.086]	2.2 [2.2-2.3]	0.11 [0.11-0.12]	0.12	0.31 [0.29-0.33]	0.33	0.016% [0.0091-0.029]	0.1% [0.063-0.16]	1.3% [0.98-1.7]
QCP002 CHPP Maintenance	578	0.084 [0.079-0.089]	2.3 [2.2-2.4]	0.12 [0.11-0.13]	0.12	0.33 [0.3-0.36]	0.35	0.024% [0.011-0.049]	0.13% [0.075-0.23]	1.5% [1.1-2.1]
QCP003 CHPP Laboratory	550	0.16 [0.15-0.17]	2.4 [2.3-2.5]	0.23 [0.21-0.25]	0.24	0.65 [0.59-0.71]	0.7	0.43% [0.27-0.67]	1.6% [1.1-2.2]	9% [7.5-11]
QCP004 CHPP HME	209	0.054	2.3 [2.1-2.5]	0.076	0.083	0.21 [0.18-0.24]	0.23	0.0022% [0.00033-0.012]	0.017% [0.0038-0.063]	0.31% [0.13-0.7]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m³ [90% CI]	EF 1 mg/m³ [90% CI]	EF 0.5 mg/m³ [90% CI]
		[0.048-0.061]		[0.068-0.085]						
QCP005 Belt Splicers	44	0.13 [0.12-0.16]	1.8 [1.6-2]	0.16 [0.14-0.19]	0.18	0.35 [0.29-0.45]	0.42	0.0014% [2.7e-05-0.036]	0.027% [0.0016-0.26]	1.2% [0.29-3.6]
QCP006 CHPP Other	74	0.089 [0.074-0.11]	2.3 [2-2.7]	0.13 [0.11-0.16]	0.15	0.36 [0.28-0.48]	0.45	0.04% [0.0044-0.25]	0.21% [0.039-0.83]	2.1% [0.81-4.5]
QCP007 ROM HME	237	0.041 [0.037-0.046]	2.3 [2.2-2.5]	0.059 [0.053-0.066]	0.065	0.17 [0.14-0.19]	0.19	0.0011% [0.00021-0.0054]	0.0087% [0.0021-0.031]	0.16% [0.068-0.37]
QCP008 CHPP Shutdown Maintenance	50	0.059 [0.047-0.074]	2.4 [2.1-3]	0.089 [0.07-0.12]	0.11	0.26 [0.19-0.38]	0.34	0.015% [0.00078-0.16]	0.081% [0.0086-0.51]	0.85% [0.21-2.8]
QCS001 Pre-strip and Overburden Removal	1,325	0.049 [0.047-0.051]	2.2 [2.1-2.2]	0.066 [0.064-0.069]	0.069	0.17 [0.17-0.19]	0.18	0.00046% [0.00021-0.00096]	0.0046% [0.0025-0.0082]	0.13% [0.089-0.19]
QCS002 Coal Removal	1,128	0.056 [0.053-0.058]	2.1 [2-2.1]	0.073 [0.07-0.076]	0.075	0.18 [0.17-0.2]	0.19	0.00031% [0.00013-0.00071]	0.0037% [0.0018-0.007]	0.13% [0.084-0.19]
QCS003 Open Cut Inspection Services	369	0.045 [0.042-0.049]	2.1 [2-2.3]	0.061 [0.056-0.066]	0.064	0.16 [0.14-0.18]	0.17	0.00022% [4.2e-05-0.00097]	0.0024% [0.00067-0.0082]	0.081% [0.036-0.17]
QCS004 Road Maintenance	654	0.041 [0.038-0.043]	2.3 [2.2-2.4]	0.057 [0.054-0.061]	0.06	0.16 [0.15-0.17]	0.17	6e-04% [2e-04-0.0017]	0.0051% [0.0021-0.012]	0.12% [0.066-0.2]
QCS005 Boilermaker	75	0.21 [0.16-0.26]	3.4 [2.9-4.2]	0.43 [0.33-0.62]	0.57	1.5 [1.1-2.3]	2.1	5.1% [2.7-9]	9.7% [5.9-15]	23% [17-30]
QCS006 Field Maintenance	1,344	0.052 [0.05-0.055]	2.5 [2.4-2.5]	0.078 [0.075-0.082]	0.081	0.23 [0.22-0.24]	0.24	0.0095% [0.0053-0.016]	0.052% [0.033-0.079]	0.6% [0.45-0.79]
QCS007 Blast Crew	1,220	0.072 [0.07-0.075]	2.1 [2.1-2.2]	0.096 [0.093-0.1]	0.1	0.25 [0.24-0.27]	0.26	0.0031% [0.0016-0.0057]	0.026% [0.015-0.042]	0.53% [0.39-0.71]
QCS008 Tech Services	258	0.049 [0.044-0.054]	2 [1.9-2.2]	0.062 [0.057-0.068]	0.067	0.15 [0.14-0.17]	0.17	3.8e-05% [2.7e-06-0.00038]	0.00065% [8.4e-05-0.004]	0.039% [0.011-0.12]
QCS009 Exploration Drillers	290	0.07	2.8 [2.6-3.1]	0.12 [0.11-0.14]	0.13	0.39 [0.34-0.46]	0.45	0.17% [0.075-0.36]	0.55% [0.29-1]	3% [2-4.4]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
		[0.062-0.078]								
QCS010 Blast Hole Drillers	1,028	0.057 [0.054-0.06]	2.3 [2.2-2.4]	0.081 [0.077-0.085]	0.084	0.23 [0.21-0.24]	0.24	0.0047% [0.0023-0.0091]	0.031% [0.018-0.052]	0.47% [0.34-0.66]
QCS011 Belt Splicers	6	0.062 [0.0081-0.16]	3.7 [2-17]	0.15 [0.052-1.8]	0.66	0.47 [0.17-3.8]	2	0.56% [0.0012-11]	1.3% [0.012-14]	4.6% [0.27-24]
QCS012 Warehousing	313	0.062 [0.056-0.067]	2.2 [2.1-2.4]	0.085 [0.078-0.094]	0.092	0.23 [0.21-0.26]	0.26	0.0039% [0.001-0.014]	0.028% [0.0093-0.075]	0.48% [0.25-0.86]
QCS013 Administration	74	0.03 [0.023-0.036]	2 [1.8-2.4]	0.038 [0.031-0.046]	0.044	0.094 [0.075-0.12]	0.12	1.1e-06% [8.3e-10-0.00028]	2.5e-05% [7e-08-0.0021]	0.0029% [6.4e-05-0.05]
QCS014 Workshop	1,141	0.041 [0.039-0.043]	2.3 [2.3-2.4]	0.06 [0.057-0.063]	0.062	0.17 [0.16-0.18]	0.18	0.0013% [0.00059-0.0028]	0.0096% [0.0052-0.017]	0.18% [0.12-0.26]
QCS015 Service Crew	532	0.049 [0.046-0.053]	2.2 [2.1-2.3]	0.068 [0.063-0.073]	0.071	0.18 [0.17-0.2]	0.2	0.00082% [0.00024-0.0025]	0.0073% [0.0029-0.018]	0.17% [0.097-0.3]
QCS016 Tyre Fitters	498	0.079 [0.073-0.085]	2.6 [2.5-2.8]	0.13 [0.12-0.14]	0.13	0.38 [0.34-0.43]	0.42	0.11% [0.055-0.2]	0.41% [0.25-0.65]	2.7% [2-3.6]
QCS017 Dragline	482	0.047 [0.044-0.051]	2.4 [2.3-2.6]	0.071 [0.065-0.077]	0.075	0.21 [0.19-0.23]	0.22	0.0053% [0.0019-0.014]	0.031% [0.014-0.066]	0.41% [0.24-0.66]
QCS018 Dozer Push	486	0.052 [0.048-0.056]	2.4 [2.3-2.6]	0.076 [0.07-0.082]	0.081	0.22 [0.2-0.24]	0.24	0.0065% [0.0023-0.017]	0.038% [0.017-0.08]	0.5% [0.3-0.79]
QCS019 Emergency Response Personnel	23	0.024 [0.016-0.034]	2.1 [1.7-3.1]	0.032 [0.023-0.048]	0.044	0.083 [0.055-0.15]	0.13	1.7e-06% [1.8e-12-0.007]	3.7e-05% [3.7e-10-0.031]	0.0028% [1.6e-06-0.29]
QCS020 Open Cut Other	224	0.05 [0.045-0.056]	2.5 [2.3-2.8]	0.077 [0.068-0.088]	0.085	0.23 [0.2-0.27]	0.26	0.013% [0.0031-0.043]	0.062% [0.021-0.17]	0.65% [0.32-1.2]
QCS021 Control Room Other	31	0.038 [0.024-0.055]	2.7 [2.1-4]	0.063 [0.044-0.1]	0.089	0.19 [0.13-0.35]	0.3	0.011% [0.00012-0.3]	0.048% [0.0012-0.69]	0.47% [0.045-2.7]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
QCS022 Pump Crew	575	0.064 [0.06-0.067]	2.1 [2-2.2]	0.085 [0.08-0.09]	0.089	0.22 [0.2-0.24]	0.23	0.0013% [0.00045-0.0037]	0.013% [0.0055-0.028]	0.31% [0.19-0.5]
QCS023 Highwall / Auger	31	0.087 [0.072-0.1]	1.8 [1.6-2.1]	0.1 [0.087-0.13]	0.12	0.23 [0.18-0.32]	0.29	5.7e-05% [7.9e-08-0.0083]	0.0015% [9.8e-06-0.06]	0.14% [0.0094-1.1]
QCS024 Quarrying / Stone Crushing	83	0.072 [0.063-0.083]	2 [1.8-2.3]	0.092 [0.081-0.11]	0.1	0.23 [0.19-0.28]	0.27	0.00066% [2.6e-05-0.0097]	0.0081% [0.00068-0.064]	0.27% [0.066-0.93]
QCS025 Mobile / Bypass Crushing (Coal)	42	0.088 [0.071-0.11]	2 [1.8-2.5]	0.11 [0.093-0.14]	0.14	0.28 [0.22-0.4]	0.37	0.0035% [5.6e-05-0.086]	0.034% [0.0015-0.35]	0.74% [0.14-2.9]
QCS026 Civil Construction	430	0.056 [0.051-0.062]	2.8 [2.6-3.1]	0.097 [0.087-0.11]	0.11	0.31 [0.27-0.36]	0.35	0.078% [0.035-0.16]	0.28% [0.15-0.49]	1.8% [1.2-2.5]
QCS027 Coal Haulage	195	0.069 [0.063-0.077]	2.2 [2.1-2.4]	0.096 [0.087-0.11]	0.11	0.26 [0.23-0.31]	0.3	0.0072% [0.0015-0.029]	0.049% [0.014-0.14]	0.73% [0.36-1.4]
QCS028 Rehabilitation	184	0.049 [0.044-0.056]	2.3 [2.1-2.5]	0.07 [0.062-0.079]	0.077	0.19 [0.17-0.23]	0.22	0.002% [0.00029-0.011]	0.015% [0.0032-0.059]	0.27% [0.11-0.64]
QCS029 Surface Coating / Preparation	29	0.17 [0.14-0.22]	2.1 [1.8-2.6]	0.23 [0.18-0.31]	0.28	0.58 [0.43-0.88]	0.79	0.17% [0.011-1.3]	0.83% [0.12-3.6]	7.3% [2.8-16]
QCS030 Domestic Cleaners	405	0.093 [0.087-0.098]	2 [1.9-2.1]	0.12 [0.11-0.12]	0.12	0.28 [0.26-0.31]	0.3	0.0017% [0.00048-0.0054]	0.02% [0.0079-0.047]	0.61% [0.36-0.98]
QCS031 Industrial Cleaners	178	0.093 [0.082-0.11]	2.8 [2.6-3.1]	0.16 [0.14-0.19]	0.18	0.51 [0.42-0.63]	0.6	0.35% [0.15-0.77]	1.1% [0.55-2]	5.2% [3.4-7.6]
QCS032 Groundskeeping	87	0.1 [0.088-0.12]	2.4 [2.1-2.8]	0.15 [0.13-0.18]	0.18	0.43 [0.34-0.57]	0.53	0.1% [0.017-0.43]	0.44% [0.12-1.3]	3.4% [1.7-6.4]
QCS033 Shutdown Maintenance	191	0.1 [0.094-0.11]	2.2 [2.1-2.4]	0.14 [0.13-0.16]	0.16	0.39 [0.34-0.46]	0.44	0.048% [0.015-0.14]	0.25% [0.1-0.57]	2.6% [1.6-4.1]
QCU001 Longwall Production	1,119	0.44 [0.42-0.45]	2.3 [2.2-2.4]	0.62 [0.59-0.65]	0.64	1.7 [1.6-1.8]	1.8	6.8% [5.9-7.8]	16% [14-17]	43% [41-45]
QCU002 Development Production	1,431	0.28	2	0.35	0.36	0.88	0.91	0.79%	3.3%	20%

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
		[0.27-0.29]	[2-2.1]	[0.34-0.37]		[0.84-0.92]		[0.62-0.99]	[2.8-3.9]	[19-21]
QCU003 Underground Maintenance	636	0.19 [0.18-0.2]	2.1 [2.1-2.2]	0.25 [0.24-0.27]	0.26	0.66 [0.61-0.72]	0.7	0.33% [0.21-0.5]	1.4% [1-1.9]	10% [8.6-12]
QCU004 Outbye Supplies	126	0.15 [0.14-0.17]	2.1 [2-2.3]	0.2 [0.18-0.23]	0.23	0.53 [0.45-0.64]	0.61	0.13% [0.036-0.39]	0.66% [0.26-1.5]	5.9% [3.7-9]
QCU005 Longwall Moves	429	0.22 [0.21-0.24]	1.9 [1.9-2]	0.28 [0.26-0.29]	0.29	0.66 [0.61-0.71]	0.7	0.18% [0.098-0.31]	1.1% [0.73-1.6]	11% [9.1-13]
QCU006 Outbye Construction/ Infrastructure	784	0.18 [0.17-0.18]	2.1 [2-2.1]	0.23 [0.22-0.24]	0.24	0.58 [0.54-0.62]	0.61	0.15% [0.096-0.24]	0.82% [0.59-1.1]	7.5% [6.3-8.7]
QCU007 VCD Installer	308	0.29 [0.26-0.31]	2.4 [2.3-2.6]	0.42 [0.38-0.47]	0.46	1.2 [1.1-1.4]	1.3	3% [2.1-4.2]	7.7% [5.9-9.8]	26% [23-30]
QCU008 ERZ Controller	555	0.25 [0.24-0.27]	2.2 [2.1-2.3]	0.35 [0.33-0.37]	0.37	0.94 [0.87-1]	1	1.3% [0.93-1.8]	4.3% [3.4-5.4]	20% [18-22]
QCU009 Surface Maintenance	190	0.059 [0.051-0.066]	2.3 [2.1-2.6]	0.084 [0.074-0.095]	0.093	0.24 [0.2-0.28]	0.27	0.0065% [0.001-0.033]	0.04% [0.0094-0.14]	0.56% [0.24-1.2]
QCU010 Control Room Operator	59	0.033 [0.022-0.043]	1.9 [1.6-2.4]	0.04 [0.03-0.051]	0.048	0.091 [0.071-0.12]	0.11	4.4e-08% [2.9e-13-0.00018]	2.4e-06% [2.3e-10-0.002]	0.00059% [1.7e-06-0.039]
QCU011 Belt Splicers	46	0.14 [0.12-0.16]	1.9 [1.7-2.2]	0.17 [0.14-0.2]	0.19	0.39 [0.31-0.51]	0.48	0.0079% [0.00025-0.11]	0.083% [0.0075-0.57]	2% [0.6-5.3]
QCU012 Boilermaker (Surface)	34	0.12 [0.071-0.2]	5.7 [4.1-8.8]	0.54 [0.28-1.4]	1.1	2 [1.1-4.9]	3.9	7.1% [3-14]	11% [5.5-19]	20% [12-31]
QCU013 Administration	112	0.05 [0.041-0.058]	1.9 [1.7-2.2]	0.061 [0.053-0.07]	0.068	0.14 [0.12-0.17]	0.17	8e-06% [4.8e-08-0.00048]	0.00019% [4.1e-06-0.0047]	0.019% [0.0019-0.12]
QCU015 Stone Drivage	191	0.24 [0.22-0.26]	1.8 [1.7-1.9]	0.29 [0.27-0.31]	0.31	0.65 [0.58-0.73]	0.71	0.12% [0.044-0.3]	0.91% [0.46-1.6]	11% [8.5-14]
QCU016 Secondary Support	348	0.2 [0.18-0.21]	2.2 [2.1-2.3]	0.27 [0.25-0.29]	0.28	0.71 [0.64-0.8]	0.78	0.47% [0.27-0.79]	1.9% [1.3-2.7]	12% [9.6-14]
QCU017 Gas Drainage UG	177	0.17 [0.15-0.18]	1.9 [1.8-2]	0.21 [0.19-0.22]	0.22	0.48 [0.43-0.55]	0.53	0.032% [0.009-0.099]	0.27% [0.11-0.6]	4.4% [2.8-6.5]
QCU018 Shift Co-Ordinator / Management	93	0.095 [0.084-0.11]	1.9 [1.8-2.1]	0.12 [0.1-0.13]	0.13	0.28 [0.24-0.34]	0.32	0.0011% [5.4e-05-0.014]	0.015% [0.0015-0.099]	0.54% [0.16-1.5]
QCU019 Production Support / Bullgang	619	0.24 [0.22-0.25]	2 [2-2.1]	0.3 [0.29-0.32]	0.31	0.75 [0.7-0.81]	0.8	0.44% [0.28-0.65]	2% [1.5-2.7]	14% [12-16]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 1.5 mg/m^3 [90% CI]	EF 1 mg/m^3 [90% CI]	EF 0.5 mg/m^3 [90% CI]
QCU020 Returns	21	0.2 [0.14-0.27]	2.3 [1.9-2.9]	0.28 [0.2-0.42]	0.37	0.75 [0.51-1.3]	1.1	0.64% [0.06-3.8]	2.3% [0.43-8.2]	13% [5.3-25]
QCU021 Surface Other	126	0.071 [0.062-0.08]	2 [1.8-2.2]	0.091 [0.081-0.1]	0.1	0.22 [0.19-0.27]	0.26	0.00058% [3.1e-05-0.007]	0.0073% [0.00078-0.048]	0.25% [0.072-0.75]
QCU022 Underground Other	22	0.17 [0.13-0.22]	2 [1.7-2.5]	0.22 [0.17-0.3]	0.27	0.53 [0.38-0.85]	0.75	0.093% [0.003-1.1]	0.56% [0.05-3.5]	6% [1.8-15]
QCU023 Gas Drainage Surface	80	0.05 [0.039-0.062]	2.5 [2.1-3]	0.076 [0.062-0.095]	0.09	0.22 [0.17-0.3]	0.28	0.0079% [0.00036-0.089]	0.043% [0.0043-0.29]	0.52% [0.13-1.7]
QCU024 Drilling Other	97	0.077 [0.066-0.088]	2.1 [1.9-2.4]	0.1 [0.087-0.12]	0.11	0.25 [0.21-0.32]	0.3	0.002% [9.9e-05-0.024]	0.02% [0.0021-0.13]	0.49% [0.14-1.4]
QCU025 Warehousing	167	0.061 [0.054-0.068]	2.1 [1.9-2.3]	0.08 [0.072-0.089]	0.087	0.2 [0.18-0.24]	0.23	0.00063% [5.3e-05-0.0053]	0.0066% [0.00099-0.033]	0.2% [0.067-0.55]
QCU026 Tech Services	155	0.1 [0.093-0.12]	2.3 [2.1-2.6]	0.15 [0.13-0.17]	0.17	0.42 [0.36-0.51]	0.49	0.083% [0.024-0.25]	0.38% [0.15-0.88]	3.2% [1.9-5.2]
QCU027 Domestic Cleaners	111	0.091 [0.084-0.097]	1.4 [1.4-1.5]	0.097 [0.091-0.1]	0.1	0.16 [0.15-0.18]	0.18	4.2e-13% [0-1.9e-09]	1.8e-09% [8.3e-13-7.6e-07]	0.00012% [2.8e-06-0.0026]
QCU029 Remote Mining Operations	17	0.058 [0.031-0.087]	2.4 [1.8-4.2]	0.086 [0.056-0.15]	0.13	0.24 [0.15-0.52]	0.42	0.0093% [6.4e-06-0.71]	0.053% [0.00019-1.6]	0.69% [0.027-5.4]

QLD RSHQ SEG Respirable Quartz Exposures

RSHQ SEG	**n**	**GM [90% CI]**	**GSD [90% CI]**	**AM [90% CI]**	**AM $UCL_{1,90}$**	**95^{th}%ile [90% CI]**	**95^{th}%ile $UCL_{1,90}$**	**EF 0.05 mg/m^3 [90% CI]**	**EF 0.025 mg/m^3 [90% CI]**
QCP001 CHPP Production	987	0.0017 [0.0015-0.0019]	3.5 [3.2-3.8]	0.0036 [0.0033-0.004]	0.0039	0.013 [0.012-0.014]	0.014	0.31% [0.18-0.5]	1.5% [1-2]
QCP002 CHPP Maintenance	579	0.0017 [0.0014-0.0019]	3.2 [2.9-3.7]	0.0033 [0.003-0.0037]	0.0036	0.011 [0.01-0.013]	0.013	0.18% [0.082-0.36]	1% [0.63-1.6]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m^3 [90% CI]	EF 0.025 mg/m^3 [90% CI]
QCP003 CHPP Laboratory	550	0.0038 [0.0034-0.0042]	3.3 [3.1-3.7]	0.0078 [0.007-0.0089]	0.0086	0.027 [0.024-0.032]	0.031	1.6% [1.1-2.3]	5.9% [4.6-7.3]
QCP004 CHPP HME	209	0.0016 [0.0012-0.002]	2.6 [2.3-3.3]	0.0026 [0.0022-0.003]	0.0029	0.008 [0.0067-0.0098]	0.0094	0.021% [0.0026-0.12]	0.25% [0.069-0.73]
QCP005 Belt Splicers	44	0.0032 [0.0022-0.0041]	2.6 [2-3.7]	0.005 [0.0038-0.007]	0.0064	0.015 [0.011-0.024]	0.021	0.16% [0.0092-1.3]	1.4% [0.27-4.8]
QCP006 CHPP Other	74	0.0019 [0.0012-0.0026]	3.4 [2.6-5.1]	0.0041 [0.0031-0.0061]	0.0055	0.014 [0.01-0.023]	0.02	0.39% [0.058-1.6]	1.8% [0.55-4.4]
QCP007 ROM HME	237	0.0019 [0.0016-0.0023]	2.7 [2.3-3.2]	0.0031 [0.0027-0.0036]	0.0035	0.0097 [0.0082-0.012]	0.011	0.047% [0.0095-0.18]	0.46% [0.18-1.1]
QCP008 CHPP Shutdown Maintenance	51	0.0033 [0.0024-0.0041]	2.2 [1.8-3]	0.0046 [0.0037-0.0059]	0.0055	0.012 [0.0093-0.018]	0.016	0.033% [0.00074-0.46]	0.55% [0.071-2.4]
QCS001 Pre-strip and Overburden Removal	1,326	0.0031 [0.0029-0.0032]	3 [2.9-3.2]	0.0057 [0.0053-0.0061]	0.006	0.019 [0.017-0.021]	0.02	0.6% [0.43-0.82]	2.9% [2.4-3.6]
QCS002 Coal Removal	1,128	0.0026 [0.0024-0.0028]	2.9 [2.7-3.1]	0.0046 [0.0043-0.0049]	0.0048	0.015 [0.014-0.016]	0.016	0.25% [0.16-0.39]	1.6% [1.2-2.1]
QCS003 Open Cut Inspection Services	369	0.0031 [0.0028-0.0035]	2.8 [2.5-3.1]	0.0052 [0.0047-0.0058]	0.0057	0.017 [0.014-0.019]	0.019	0.31% [0.15-0.62]	2% [1.3-3.1]
QCS004 Road Maintenance	654	0.002 [0.0018-0.0022]	3.5 [3.2-3.9]	0.0044 [0.004-0.005]	0.0048	0.016 [0.014-0.018]	0.018	0.51% [0.3-0.83]	2.2% [1.6-3]
QCS005 Boilermaker	75	0.0014 [7e-04-0.0021]	4.5 [3.2-7.9]	0.0043 [0.0029-0.0081]	0.0067	0.016 [0.011-0.029]	0.025	0.84% [0.18-2.7]	2.7% [0.97-5.9]
QCS006 Field Maintenance	1,344	0.0021 [0.002-0.0023]	3.7 [3.4-4]	0.005 [0.0046-0.0055]	0.0054	0.018 [0.017-0.02]	0.02	0.77% [0.56-1.1]	3% [2.4-3.6]
QCS007 Blast Crew	1,220	0.0048	3 [2.9-3.2]	0.0089	0.0094	0.03 [0.028-0.033]	0.032	1.8% [1.4-2.2]	6.9% [6-7.9]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
		[0.0045-0.0051]		[0.0084-0.0096]					
QCS008 Tech Services	258	0.0016 [0.0012-0.002]	3.7 [3-4.7]	0.0037 [0.0031-0.0046]	0.0044	0.013 [0.011-0.017]	0.016	0.4% [0.14-0.95]	1.7% [0.92-3]
QCS009 Exploration Drillers	290	0.0041 [0.0034-0.0048]	4.3 [3.7-5]	0.012 [0.0096-0.015]	0.014	0.044 [0.035-0.057]	0.054	4.2% [2.9-5.9]	11% [8.3-13]
QCS010 Blast Hole Drillers	1,026	0.0033 [0.003-0.0035]	3.5 [3.3-3.7]	0.0071 [0.0065-0.0078]	0.0076	0.025 [0.023-0.028]	0.028	1.4% [1.1-1.9]	5.1% [4.3-6.1]
QCS011 Belt Splicers	6	0.00097 [3.4e-05-0.0035]	4.1 [2-28]	0.0029 [6e-04-0.051]	0.015	0.0089 [0.0018-0.072]	0.037	0.18% [4.9e-05-6.7]	0.77% [0.004-11]
QCS012 Warehousing	313	0.0026 [0.0022-0.0031]	3.6 [3.1-4.2]	0.0059 [0.0051-0.0071]	0.0068	0.021 [0.018-0.027]	0.025	1% [0.57-1.8]	3.9% [2.6-5.5]
QCS013 Administration	74	0.00079 [0.00025-0.0015]	4.3 [2.7-9.5]	0.0024 [0.0015-0.0045]	0.0036	0.0085 [0.0055-0.015]	0.013	0.21% [0.014-1.3]	0.77% [0.13-2.8]
QCS014 Workshop	1,140	0.0012 [0.0011-0.0014]	3.4 [3.1-3.8]	0.0026 [0.0024-0.0029]	0.0028	0.0093 [0.0084-0.01]	0.01	0.13% [0.069-0.24]	0.71% [0.48-1]
QCS015 Service Crew	533	0.0027 [0.0024-0.003]	3 [2.8-3.3]	0.0049 [0.0045-0.0055]	0.0054	0.016 [0.015-0.019]	0.018	0.4% [0.22-0.7]	2.2% [1.5-3]
QCS016 Tyre Fitters	497	0.003 [0.0027-0.0034]	3.6 [3.3-4.1]	0.007 [0.0062-0.0081]	0.0078	0.025 [0.022-0.03]	0.029	1.5% [0.98-2.2]	5.1% [3.9-6.6]
QCS017 Dragline	482	0.0029 [0.0026-0.0033]	3.5 [3.2-3.9]	0.0065 [0.0057-0.0074]	0.0072	0.023 [0.02-0.027]	0.026	1.2% [0.75-1.8]	4.4% [3.3-5.7]
QCS018 Dozer Push	487	0.0033 [0.003-0.0037]	3.5 [3.2-3.9]	0.0073 [0.0065-0.0084]	0.0082	0.026 [0.023-0.031]	0.03	1.5% [1-2.3]	5.4% [4.2-6.9]
QCS019 Emergency Response Personnel	23	0.0021 [0.00095-0.0031]	2.5 [1.8-4.9]	0.0032 [0.0021-0.0054]	0.0046	0.0091 [0.0059-0.019]	0.016	0.022% [2.3e-05-1.1]	0.29% [0.0055-3.3]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
QCS020 Open Cut Other	224	0.0013 [0.00092-0.0016]	4.2 [3.4-5.5]	0.0036 [0.0029-0.0047]	0.0044	0.013 [0.01-0.018]	0.017	0.53% [0.2-1.2]	1.9% [1-3.3]
QCS021 Control Room Other	31	0.0015 [0.00058-0.0026]	3.7 [2.4-8]	0.0036 [0.0022-0.0081]	0.0063	0.012 [0.0073-0.029]	0.023	0.34% [0.014-2.7]	1.5% [0.2-5.9]
QCS022 Pump Crew	575	0.0036 [0.0033-0.004]	3.2 [3-3.5]	0.0072 [0.0065-0.008]	0.0078	0.025 [0.022-0.029]	0.028	1.3% [0.83-1.8]	4.9% [3.9-6.2]
QCS023 Highwall / Auger	31	0.0031 [0.002-0.0041]	2.3 [1.8-3.4]	0.0044 [0.0033-0.0062]	0.0057	0.012 [0.0085-0.02]	0.018	0.037% [0.00039-0.79]	0.59% [0.043-3.5]
QCS024 Quarrying / Stone Crushing	83	0.0019 [0.0012-0.0027]	4.2 [3.1-6.2]	0.0052 [0.0037-0.0086]	0.0075	0.02 [0.013-0.033]	0.029	1.1% [0.3-2.9]	3.4% [1.5-6.8]
QCS025 Mobile / Bypass Crushing (Coal)	42	0.0033 [0.002-0.0047]	3.4 [2.5-5.3]	0.0069 [0.0048-0.012]	0.01	0.024 [0.015-0.045]	0.038	1.2% [0.22-4.3]	4.6% [1.6-10]
QCS026 Civil Construction	430	0.0023 [0.0019-0.0028]	5.6 [4.8-6.7]	0.01 [0.0082-0.013]	0.013	0.04 [0.032-0.051]	0.048	3.8% [2.7-5.1]	8.4% [6.7-10]
QCS027 Coal Haulage	195	0.0025 [0.0021-0.0029]	2.9 [2.5-3.4]	0.0044 [0.0038-0.0052]	0.005	0.014 [0.012-0.018]	0.017	0.23% [0.068-0.62]	1.5% [0.72-2.7]
QCS028 Rehabilitation	185	0.0025 [0.002-0.0031]	3.9 [3.3-4.9]	0.0063 [0.0051-0.0083]	0.0078	0.023 [0.018-0.032]	0.029	1.4% [0.65-2.6]	4.5% [2.8-6.9]
QCS029 Surface Coating / Preparation	29	0.0019 [0.00078-0.0034]	4 [2.6-8.6]	0.0051 [0.003-0.013]	0.0098	0.018 [0.01-0.047]	0.036	0.88% [0.074-4.7]	3% [0.65-9.3]
QCS030 Domestic Cleaners	405	0.0052 [0.0047-0.0057]	2.9 [2.7-3.2]	0.0091 [0.0082-0.01]	0.01	0.03 [0.026-0.035]	0.033	1.6% [1.1-2.5]	6.9% [5.4-8.7]
QCS031 Industrial Cleaners	178	0.004 [0.0033-0.0049]	4.2 [3.6-5.2]	0.011 [0.009-0.016]	0.014	0.043 [0.033-0.06]	0.055	4% [2.5-6.3]	10% [7.5-14]
QCS032 Groundskeeping	87	0.004	3.9 [3.1-5.4]	0.01	0.014	0.037 [0.026-0.059]	0.052	3.1% [1.3-6.1]	8.7% [5.3-13]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
		[0.0028-0.0053]		[0.0073-0.015]					
QCS033 Shutdown Maintenance	191	0.0015 [0.001-0.0019]	4.6 [3.7-6.2]	0.0048 [0.0037-0.0068]	0.0062	0.018 [0.014-0.026]	0.024	1.1% [0.46-2.2]	3.2% [1.8-5.2]
QCU001 Longwall Production	1,118	0.0032 [0.0029-0.0036]	5 [4.6-5.5]	0.012 [0.01-0.013]	0.013	0.045 [0.04-0.052]	0.05	4.4% [3.6-5.2]	10% [8.9-11]
QCU002 Development Production	1,439	0.0022 [0.002-0.0024]	4.8 [4.4-5.3]	0.0075 [0.0067-0.0084]	0.0082	0.029 [0.026-0.033]	0.032	2.3% [1.8-2.8]	6% [5.2-6.9]
QCU003 Underground Maintenance	641	0.0013 [0.0011-0.0016]	4 [3.5-4.7]	0.0035 [0.0031-0.0041]	0.0039	0.013 [0.011-0.016]	0.015	0.46% [0.25-0.79]	1.7% [1.2-2.5]
QCU004 Outbye Supplies	126	0.0015 [0.00099-0.002]	3.3 [2.6-4.7]	0.0031 [0.0024-0.0041]	0.0038	0.011 [0.0081-0.015]	0.014	0.16% [0.024-0.71]	0.87% [0.27-2.3]
QCU005 Longwall Moves	429	0.00077 [0.00054-0.001]	4.8 [3.9-6.3]	0.0027 [0.0022-0.0034]	0.0032	0.01 [0.0083-0.013]	0.012	0.4% [0.17-0.83]	1.4% [0.78-2.2]
QCU006 Outbye Construction/ Infrastructure	784	0.0014 [0.0012-0.0017]	4.1 [3.6-4.7]	0.0039 [0.0034-0.0044]	0.0043	0.015 [0.013-0.017]	0.016	0.59% [0.35-0.94]	2.1% [1.5-2.9]
QCU007 VCD Installer	308	0.0013 [0.001-0.0017]	4.2 [3.5-5.4]	0.0037 [0.0031-0.0048]	0.0045	0.014 [0.011-0.018]	0.017	0.58% [0.25-1.2]	2.1% [1.2-3.3]
QCU008 ERZ Controller	556	0.00075 [0.00054-0.00098]	6.4 [5.1-8.3]	0.0042 [0.0033-0.0057]	0.0052	0.016 [0.013-0.02]	0.019	1.2% [0.7-1.8]	2.9% [2-4]
QCU009 Surface Maintenance	190	0.00021 [5.5e-05-0.00051]	9 [5.1-22]	0.0024 [0.0014-0.0076]	0.0052	0.0078 [0.005-0.013]	0.012	0.63% [0.19-1.7]	1.4% [0.62-2.9]
QCU010 Control Room Operator	59	0.00022 [8.6e-07-0.0012]	3.6 [1.7-36]	0.00063 [8.9e-05-0.0018]	0.0014	0.0018 [0.00017-0.0037]	0.0033	0.00063% [8.5e-11-0.25]	0.006% [2.1e-07-0.45]
QCU011 Belt Splicers	46	8e-04	4.4 [2.7-12]	0.0026	0.0047	0.0091 [0.0053-0.02]	0.016	0.26% [0.012-2]	0.99% [0.13-3.9]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95^{th}%ile [90% CI]	95^{th}%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
		[0.00021-0.0017]		[0.0015-0.0066]					
QCU012 Boilermaker (Surface)	34	0.0011 [0.00035-0.0021]	3.8 [2.4-9.4]	0.0029 [0.0017-0.0069]	0.0051	0.01 [0.0059-0.023]	0.019	0.23% [0.0063-2.2]	1% [0.1-4.7]
QCU013 Administration	112	0.00043 [6e-05-0.0011]	3.3 [2-9.5]	0.00097 [5e-04-0.0016]	0.0014	0.0032 [0.0018-0.0048]	0.0043	0.0036% [2.3e-06-0.19]	0.036% [0.00041-0.52]
QCU015 Stone Drivage	191	0.0053 [0.0044-0.0063]	4.1 [3.5-4.9]	0.014 [0.011-0.019]	0.017	0.053 [0.041-0.072]	0.067	5.5% [3.6-7.9]	13% [10-17]
QCU016 Secondary Support	348	0.00097 [0.00069-0.0013]	4.6 [3.7-6.2]	0.0032 [0.0026-0.0041]	0.0039	0.012 [0.0097-0.016]	0.015	0.51% [0.22-1.1]	1.7% [0.98-2.8]
QCU017 Gas Drainage UG	177	0.0011 [0.00072-0.0016]	3.9 [3-5.6]	0.0029 [0.0023-0.0039]	0.0036	0.011 [0.0081-0.015]	0.014	0.26% [0.059-0.85]	1.1% [0.44-2.4]
QCU018 Shift Co-Ordinator / Management	95	0.00087 [0.00038-0.0015]	4.1 [2.8-7.6]	0.0024 [0.0017-0.004]	0.0034	0.0087 [0.0061-0.015]	0.013	0.19% [0.018-1.1]	0.82% [0.18-2.6]
QCU019 Production Support / Bullgang	619	0.0012 [0.00099-0.0015]	4.3 [3.7-5.2]	0.0036 [0.0031-0.0042]	0.0041	0.014 [0.012-0.016]	0.016	0.56% [0.31-0.96]	2% [1.3-2.8]
QCU020 Returns	21	0.0016 [0.00042-0.0031]	4.5 [2.6-13]	0.0049 [0.0025-0.021]	0.013	0.017 [0.0085-0.058]	0.041	0.94% [0.049-5.7]	2.9% [0.46-11]
QCU021 Surface Other	126	0.00095 [0.00051-0.0014]	3.9 [2.9-6.3]	0.0025 [0.0018-0.0036]	0.0032	0.009 [0.0066-0.014]	0.012	0.19% [0.027-0.83]	0.85% [0.25-2.3]
QCU022 Underground Other	22	3.4e-07 [2.3e-10-0.00057]	2.2 [1.3-8.2]	8.3e-07 [3.7e-10-0.00081]	0.00043	2.2e-06 [8.8e-10-0.0019]	0.0011	0% [0-0.00054]	0% [0-0.00025]
QCU023 Gas Drainage Surface	83	0.00099 [0.00041-0.0017]	6 [3.9-12]	0.005 [0.0031-0.013]	0.0096	0.019 [0.012-0.037]	0.031	1.4% [0.43-3.8]	3.5% [1.5-7]
QCU024 Drilling Other	97	0.00095	6.6 [4.3-13]	0.0058	0.011	0.021 [0.013-0.041]	0.035	1.8% [0.64-4.2]	4.1% [2-7.5]

RSHQ SEG	n	GM [90% CI]	GSD [90% CI]	AM [90% CI]	AM $UCL_{1,90}$	95th%ile [90% CI]	95th%ile $UCL_{1,90}$	EF 0.05 mg/m³ [90% CI]	EF 0.025 mg/m³ [90% CI]
		[0.00043-0.0016]		[0.0035-0.015]					
QCU025 Warehousing	167	0.0013 [0.00082-0.0017]	2.6 [2.1-3.6]	0.0021 [0.0017-0.0025]	0.0024	0.0062 [0.0051-0.0079]	0.0074	0.0064% [0.00022-0.085]	0.093% [0.011-0.47]
QCU026 Tech Services	158	0.0017 [0.0012-0.0021]	2.7 [2.2-3.5]	0.0027 [0.0023-0.0033]	0.0031	0.0084 [0.0068-0.011]	0.01	0.028% [0.0025-0.19]	0.3% [0.068-0.98]
QCU027 Domestic Cleaners	117	0.00054 [0.00017-0.0011]	5.8 [3.5-13]	0.0026 [0.0017-0.0057]	0.0044	0.0095 [0.0062-0.016]	0.014	0.47% [0.085-1.7]	1.3% [0.43-3.2]
QCU029 Remote Mining Operations	17	0.0015 [0.00037-0.003]	3.3 [2-9.9]	0.0033 [0.0017-0.01]	0.0068	0.01 [0.0056-0.034]	0.024	0.16% [0.00047-3.3]	0.96% [0.031-6.9]